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**Engineering Education in the 21st Century
Quality, Globalization and Local
Relevance**

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The papers included in this book were selected to match the theme of the book following a peer review process organized by the IFEE2010 technical committee. The views, arguments, sources of information, language use, and contents of the articles included in the book are those of the authors and their sole responsibility.

The Editors are currently Professors of Engineering at the University of Sharjah. The editors are indebted to the authors for their valuable contributions and to all colleagues who helped make IFEE2010 a successful and rewarding experience.

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The first five conferences were held at the University of Sharjah, United Arab Emirates, which currently hosts the IFEE. The events were devoted to addressing a variety of issues, under the following themes:

1. IFEE2001: The Changing Role of Engineering Education in the Information Age - Innovation and Tradition
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4. IFEE2006: Integration of Teaching and Research with Community Service
5. IFEE2010: Engineering Education in the 21st Century: Quality, Globalization and Local Relevance. The 5th IFEE was held jointly with the European SDPROMO Conference - Sustainability in Higher Education.

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For the Editors
Prof. A. Shanableh
IFEE Founder and General Chair

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Quality Assurance in Engineering Education

DIMENSIONS OF QUALITY IN ENGINEERING EDUCATION

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ABSTRACT: Engineering education makes vital contributions to the economic development of nations. Engineers graduating at the undergraduate level are expected to design, operate and maintain production and service systems. Engineers graduating at the post graduate level are expected to innovate and invent new technologies. In the world there are several systems for engineering education. These systems differ in structure and approaches. Examples of these systems are the European, the Australian and American systems. Each one of these systems has its features and uniqueness.

Quality is an important goal in all educational systems. Quality in engineering education is defined as the ability of the graduates to achieve excellence and accomplish certain outcomes. Each of the above mentioned educational systems has an approach for quality assurance that expected to ensure the quality of graduate of engineering education. The approaches differ in content and processes.

This paper reviewed different approaches, models and practices for quality assurance and improvement of engineering education in different educational systems and environments. These systems include the British, Australian and American. Then the paper outlined the impact of globalizations on the quality assurance systems. Then the paper projected the quality dimensions in production and service systems on the output of engineering education, the engineer. The dimensions of quality defined may be used as a basis for unifying quality assurance systems worldwide.

KEYWORDS: Educational Systems; Dimensions of Quality; Quality Assurance; Globalization.

INTRODUCTION

Engineering is the process of using natural sciences, mathematics and customer requirement to create products, services, systems and processes to serve the needs of mankind. In addition operate and maintain systems. Theodore Von Kármán [1] once said that scientists discover the world that exists, while engineers create the world that never was. Engineering education is the system for preparing engineers. There are many engineering educations systems in the world. The American System that has more breadth than the British System where depth is the focus. In a typical American Educational System a student preparing for a degree in engineering takes a total of 128 credit hours: 32 credit hours are in mathematics and science, 32 credit hours of humanities and social sciences, 9 credit hours of engineering, 9 credit hours of free electives, and 6 credit hours of business and communication. The remaining 40 credit hours are in the engineering major selected.

In the British and the Australian Systems most of the subjects taught are in the major and whatever is left of the subjects are technical. This raises the question of equivalency between the two dominating models in the world. In addition what are the dimensions of quality in engineering education in order to assess the quality level of the output of both systems.

The National Academy of Engineers (NAE) in its 2005 report [2] suggests that the essence of engineering—the iterative process of designing, predicting performance, building, and testing—should be taught from the earliest stages of the curriculum, including the first year. The Accreditation Commission (EAC) of Accreditation Board for Engineering and Technology (ABET), United States, states engineering graduates upon graduation should be able to:

- a. apply knowledge of math, science, and engineering;
- b. design and conduct experiments, as well as analyze and interpret data;
- c. design a system, component or process to meet desired needs;
- d. function in multidisciplinary team;
- e. identify, formulate and solve engineering problems;
- f. understand professional and ethical responsibilities;
- g. communicate effectively;
- h. assess the impact of engineering solutions in a global and societal context.
- i. engage in life-long learning;
- j. understand contemporary issues; and
- k. use the techniques, skills and modern engineering tools necessary for engineering

The Engineers Australia Accreditation Board (2005) [3] has identified similar generic characteristics that are stated below:

- a. ability to apply knowledge of basic science and engineering fundamentals;
- b. ability to communicate effectively; not only with engineers but also with the community at large;
- c. in depth technical competence in at least one engineering discipline;
- d. ability to undertake problem identification, formulation and solution;
- e. ability to utilize a systems approach to design and operational performance;
- f. ability to function effectively as an individual and in multi-disciplinary and multi-cultural teams, with the capacity to be a leader or manager as well as an effective team member;
- h. understanding of social, cultural, global and environmental responsibilities of the professional engineers and the need of sustainable development;
- i. understanding of the principles of sustainable design and development;
- k. understanding of professional and ethical responsibilities and commitment to them; and
- l. expectation of the need to undertake lifelong learning, and capacity to do so.

The Japan Accreditation Board for Engineering Education (JABEE) (2004) [4] formalized similar competencies.

It seems there is an agreement on the outcomes and competencies engineering graduates should be able to perform after graduation, however the challenge how to ensure that the graduates can perform them and how to accommodate competencies that will be needed in the future. The next section reviews three main quality assurance models in the world

and outlines the impact of globalization on quality assurance, followed by a section that defines the dimensions of quality in engineers. Finally the paper is concluded.

QUALITY ASSURANCE IN ENGINEERING EDUCATION

Quality assurance in engineering education has several models and approaches. In this paper the salient features of three models are presented. The three models are the British model, the Australian model and the American Models.

The British model has three arms. The first arm is the Quality assurance Agency that sets the standards especially the national qualification framework. The second arm is the professional bodies such as the Engineering Council. The third arm is the universities themselves through the external examiners systems. The external examiners system has been established in 1832 by university of Durham to ensure the quality of its programs are equivalent to Oxford and Cambridge. The British systems depends on auditing academic programs and providing a rating based on stars system. The drawback of the system is rigid and extensive.

In Australia the Council for Higher Education works with states and territories to achieve and maintain a consistent national standard approach to the standards of Australian higher education and to the accreditation of new institutions. In addition professional bodies such as the Engineering Council play a role in recognizing degrees offered. Their approach is similar to the British system for quality assurance but less extensive [5].

In the United States the main body for quality assurance of engineering education is ABET and accreditation is voluntary. The market forces institutions to seek accreditation. There are also six regional associations covering various regions of the USA. They have no legal control over universities or courses, but promote standards of quality and criteria of excellence. Universities and colleges which meet these standards are admitted to membership of the relevant association, which is perceived by the public as quality. Only institutions with accreditation status may receive federal financial grants, and private foundations also usually confine their assistance to accredited institutions. The U.S. Secretary of Education has power to grant recognition to accrediting agencies, and has used this power to require agencies to include as criteria for accreditation outcomes such as test results, job placement rates and progression to graduate or professional study by students.

The above three quality assurance systems differ in many aspects and in the age of globalization they must converge to provide a universal quality assurance system. The Washington accord signed in 1989 is a big step in that direction. The goal of the Washington Accord is to promote the mutual recognition of accredited degrees among signatories under the premise that they are "substantially equivalent." The accord was first signed by engineering education accreditation organizations in Australia, New Zealand, Canada, the US, Ireland, and Great Britain. Latter many other many signatories,

including Hong Kong, South Africa, Japan, Germany, Singapore, and Malaysia, have actively sought to join the Washington Accord over the last few years.

Globalization has serious impact on engineering education. In a globalization era the competencies required from engineers evolve and may include the following outcomes:

- multi-culture teamwork;
- high literacy in technology;
- integrative and global thinking skills;
- a respect for diversity and a knowledge of contemporary professional, societal and global issues;
- understanding issues from a global and multilateral.

Washington Accord and Bologna Declaration (1999) are two major steps to address globalization [6].

DIMENSIONS OF QUALITY IN ENGINEERING EDUCATION

The dimensions of quality In product and service has been identified in [7] and shown in Table 1 with examples.

Table 1: Dimensions of quality for products and service.

Number	Dimension of Quality	Product/Automobile	Service/Auto Repair
1.	Performance	Everything works and all fit well	All work done at agreed price no rework
2.	Aesthetics	Appearance interior design	Friendliness, courtesy, Competency, quickness Clean work/waiting area
3.	Special features	Gauge/control placement Cellular phone, CD player	Location, call when ready Computer diagnostics
4.	Reliability	Infrequent breakdown	Work done correctly ready when promised
5.	Safety	Antilog, airbags	Separate waiting area
6.	Durability	Useful life in miles, resistance to rust and corrosion	Work hold up over time
7	Perceived quality	Known brand, top rated car.	Award winning
8	Service after service	Handling problems	Handling of problems

The dimensions of quality for products and service are projected as dimensions of quality for engineers as shown in Table 2.

Table 2: Dimensions of quality for Engineers.

Number	Dimension of Quality	Engineer
1.	Performance	Design, build, operate and maintain products systems and processes, excellent communication skills, global team working skill and innovative.
2.	Aesthetics	Respect, friendliness, courtesy and sensitive.
3.	Special features	Excellent communication skills, knowledgeable about different cultures, global issues and impact of engineering solutions. Masters new technology.
4.	Reliability	Dependable, professional and ethical with high integrity.
5.	Safety	Follows safety standards and very conscious about safety.
6.	Durability	Up to data, creative and lifelong learner.
7	Perceived quality	Reputation of his university as top ranked.
8	Service after service	Customer focus

CONCLUSION

In this paper, well known quality assurance systems for engineering education are reviewed. The impact of globalization on these systems is outlined. The dimensions of quality in products and services have been projected on engineers. The elements relevant to each dimension are defined. These dimensions can be refined in future research and embedded in quality assurance systems.

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LESSONS LEARNED FROM THE EXPERIENCE OF HAVING TWO ACCREDITATION VISITS IN THE SAME YEAR

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ABSTRACT: Accreditation is a nongovernmental and voluntary process of evaluation concerned with improving educational quality and assuring the public that member institutions meet established standards. Unlike Europe that still lacks a common system for accreditation of educational programs, US universities, with engineering or engineering technology programs have to meet the standards and requirements of two different accrediting institutions. The university as whole is accredited by a Regional Accreditation agency. The engineering and engineering technology programs are additionally accredited by ABET. While it is very rare that an institution will have both accreditation agencies visiting in the same year, it does occasionally occur. Southern Polytechnic State University has recently had to deal with this occurrence. In preparing for these visits, several challenges were encountered that contributed to making the task more arduous than usual. This paper discusses some of the issues encountered in preparing for the two visits and the efforts made to reconcile the ABET and SACS (Southern Association of Colleges and Schools) accreditation requirements. In the process, there were some lessons learned that can be very useful to survive the accreditation visits. The objective of this paper is to share those lessons and experience with colleagues.

KEYWORDS: Accreditation; ABET; University; Experience, SACS, Evaluation

INTRODUCTION

Southern Polytechnic State University (SPSU) is a Science, Engineering and Technology focused university located in Marietta, Georgia. It is an urban institution with a population of approximately 4,500 students who are predominantly commuters. The university serves a sizeable population of non-traditional students. As such, many programs offer courses at night as well as during the daytime. Being located in southeastern United States, the university is accredited by the Southern Association of Colleges and Schools (SACS).

The ECET Department at SPSU offers three Baccalaureate degree programs in Engineering Technology: the B.S in Electrical Engineering Technology (BSEET), the B.S. in Computer Engineering Technology (BSCpET) and the B.S. in Telecommunications Engineering Technology (BSTCET). All three programs are ABET accredited. During the last accreditation cycle, ABET allowed the option of going by the old criteria or opting for the new accreditation criteria. Since the university and the Technology departments did not have any of the continuous improvement requirements in place at that time, the faculty opted to utilize the old criteria for accreditation of the six E.T. programs offered on campus.

During the fall semester of the 2008/2009 academic year, all of the Engineering Technology programs on campus were up for re-accreditation by ABET, Inc. [1]. Around this same time frame, the university was also preparing for its accreditation cycle

through SACS [2]. Since this was not a normal occurrence, and in order to minimize the duplication of efforts, the administration felt that it was necessary, and important, to coordinate the preparations for the ABET visit, while at the same time preparing for the SACS visit which scheduled for March, 2009. Unfortunately, in preparing for these visits, several challenges were encountered that contributed to making the task more arduous than usual. This paper examines some of the issues and challenges encountered in preparing for the two visits and examines some of the contributing factors that made the effort more arduous than usual. The paper also discusses some of the efforts made to reconcile the ABET and SACS accreditation requirements, and makes recommendations that can assist this institution, and others like it, with their preparations for future accreditation visits, should they be confronted with a similar situation.

CHALLENGES TO THE PROCESS

Administrative Change

Some of the main challenges encountered during the whole re-accreditation process can be attributed to administrative changes within the institution. Prior to the previous accreditation cycle, the university administration had opted for an administrative structure that had one of the six Engineering Technology programs, Civil Engineering Technology, being moved from the School of Engineering Technology and Management (ET&M) to the new School of Architecture, Civil Engineering Technology and Construction. This meant that two different Deans were now responsible for coordinating the ABET re-accreditation process for our Technology programs. Compounding this problem, the administration of the School of ET&M has changed through three Deans and two Interim Deans between accreditation cycles. In addition, the university itself had gone through three Academic Vice-Presidents during the same time frame. This meant that accreditation initiatives were not successfully followed up by succeeding administrators, thereby delaying the implementation of some of the requirements for re-accreditation, most notably, the continuous improvement cycle. The changes in the upper administration also resulted in changes at the departmental level. The ECET department went from having a Department Head to having a Department Chair with increased responsibilities. Since the 2006-2007 academic year, the ECET department had established an ABET Task Force Committee (TFC) to work on ABET re-accreditation issues for the three programs in the department. This committee was headed by a senior faculty member who had previously worked on program reaccreditation and had experiences as a ABET program evaluator. The rest of the committee was made up of the program coordinators for the EET, CpET, and the TCET programs along with one other senior faculty member with ABET program evaluation experience. This committee was tasked to develop criteria and procedures for all programs to satisfy the ABET re-accreditation criteria. It worked closely with the Department Chair and the Dean to coordinate its efforts with those of other programs within the School of Engineering Technology and Management. The ECET Department Chair served as an Ex-officio member of the TFC to provide critical support and input, as well as coordinating the timely receipt of information from other departments on

campus. Coordination with the Dean responsible for the Civil Engineering Technology program was left up to the Dean of Engineering Technology and Management.

Procedural Changes

Initially, SPSU did not have a coordinator for accreditation issues. Instead, a faculty member was appointed as “SACS Liaison” in 2006 to coordinate the university’s SACS accreditation efforts. Since the Engineering Technology programs were up for re-accreditation within the same time frame as the SACS visit, it was decided that the coordinator would work in concert with the affected Deans, and their Department Chairs, to co-ordinate their re-accreditation efforts. This individual worked diligently in trying to establish policies and procedures for achieving a successful outcome. However, due to the sheer volume of effort required and the fact that the faculty member had other responsibilities, the administration decided to hire a full time individual with the title of Director of Institutional Effectiveness and Planning during the 2007-2008 academic year. Part of the responsibilities for this individual was to take over the duties of the “SACS liaison”. This individual had a strong background of working with SACS accreditation, but was not as familiar with ABET requirements. The result was that significant changes were made to the procedures that had already established by the “SACS Liaison” for fulfilling the re-accreditation requirements. As would be expected, this added a measure of confusion, and more complexity into the campus processes.

THE ABET/SACS CONUNDRUM

The goal of ABET accreditation is to ensure minimum quality standards are adhered to by individual programs. In visiting programs for re-accreditation, ABET evaluators look for evidence of procedures that have been established for continuous improvement, evidence that these procedures have been followed, and that the continuous improvement loop has been closed. They will also look to see that the course offerings meet the stated outcomes and objectives for the program, and that the courses are being offered as stated. Faculty qualifications are also reviewed.

Accreditation by SACS on the other hand applies to the whole university. Besides looking at programs and faculty qualifications, SACS also looks at the administration, library, and other support entities within the university. Off-campus program offerings are of particular concern in terms of quality and similarity of standards with on-campus offerings.

Since the goals of the two accrediting entities differ, there are complex issues involved in attempting to use the same procedures to prepare for accreditation by these two bodies.

Terminology

One of the most obvious differences occurs in their use of terminology. In its general criteria for evaluating Engineering Technology programs, ABET utilizes the following terminology [1]:

Program Educational Objectives – Program educational objectives are broad statements that describe the career and professional accomplishments that the program is preparing graduates to achieve.

Program Outcomes – Program outcomes are narrower statements that describe what students are expected to know and be able to do by the time of graduation. These relate to the skills, knowledge, and behaviors that students acquire in their matriculation through the program.

Assessment – Assessment is one or more processes that identify, collect, and prepare data to evaluate the achievement of program outcomes and program educational objectives.

Evaluation – Evaluation is one or more processes for interpreting the data and evidence accumulated through assessment practices. Evaluation determines the extent to which program outcomes or program educational objectives are being achieved, and results in decisions and actions to improve the program.

Continuous Improvement - a documented process incorporating relevant data to regularly assess its program educational objectives and program outcome, and to evaluate the extent to which they are being met.

SACS on the other hand refers to a Quality Enhancement Plan (QEP) defined as follows [2]:

The Quality Enhancement Plan (QEP), submitted four to six weeks in advance of the on-site review by the Commission, is a document developed by the institution that (1) includes a broad-based institutional process identifying key issues emerging from institutional assessment, (2) focuses on learning outcomes and/or the environment supporting student learning and accomplishing the mission of the institution, (3) demonstrates institutional capability for the initiation, implementation, and completion of the QEP, (4) includes broad-based involvement of institutional constituencies in the development and proposed implementation of the QEP, and (5) identifies goals and a plan to assess their achievement. The QEP should be focused and succinct (no more than seventy-five pages of narrative text and no more than twenty-five pages of supporting documentation or charts, graphs, and tables).

While there are clearly some overlaps in the requirements for ABET and SACS accreditations, there were some differences in interpretation of the terminologies used. One of the first issues encountered was in reconciling the term “outcomes” between the

ABET requirements and the SACS requirements. There were some major differences in interpreting what was meant by ABET Inc., compared to what was meant by SACS.

Requirements

At first, we were advised by the ‘SACS Liaison’ of our university that if we meet the ABET requirements we would certainly meet SACS requirements. It turned out that it was true only to some extent, not entirely. For example, in preparation for the SACS visit, we were asked by the liaison to do the following:

- Establish our Assessment Methods for our Programs. Establish a matrix of assessment for each method chosen. Create a matrix mapping the method, frequency of assessing, data collection media, how collected, from whom collected, responsible party for collection, who evaluates the data, how often evaluations are done for improvement. Establish our Performance Criteria for EACH assessment method.
- Since TAC/ABET had exactly the same requirements, in our case (ECET Programs) this was not an additional load. However, as it turned out we could meet SACS requirements by utilizing two of the tables developed by the ECET ABET Task Force Committee as shown in Tables 1 and 2 below [3].

Table 1: Program outcomes table.

Program Outcome	Course Linkage	Performance Criterion
Demonstrate an appropriate knowledge of the fundamentals of computer engineering technology, mathematics and science	ECET2110	80% of students should score 70% or more
Demonstrate an appropriate mastery of knowledge, techniques, skills and modern tools of the technical components of the curriculum	ECET3220	80% of students should score 70% or more

Table 2: Summary of results of program outcomes table.

Program Outcome	Course Linkage	Performance Criterion	Student Scores
Demonstrate an appropriate knowledge of the fundamentals of computer engineering technology, mathematics and science	ECET2110	80% of students should score 70% or more	82% of students scored 75%
Demonstrate an appropriate mastery of knowledge, techniques, skills and modern tools of the technical components of the curriculum	ECET3220	80% of students should score 70% or more	78% of students scored 72%.

As we found out there are many overlaps, but what makes SACS requirements to some degree distinct from the TAC/ABET requirements are the following:

- Institution has to demonstrate that each educational program for which academic credit is awarded a) is approved by the faculty and the administration, and b) establishes and evaluates program and learning outcomes.
- The institution identifies expected outcomes for its educational programs and its administrative and educational support services; assesses whether it achieves these outcomes; and provides evidence of improvement based on analysis of those results.
- the institution provides evidence of ongoing professional development of faculty as teachers, scholars, and practitioners
- The institution publishes policies on the responsibility and authority of faculty in academic and governance matters.

MAKING IT ALL WORK

The work for SACS preparation started in the summer of 2006 and continues. Table 3 shows the timeline established by the institution for preparing for the visits.

The ABET visit took place in October of 2008, and the institution is still awaiting the final report from ABET, Inc. Due to delays in getting some of the continuous assessment tools in place, it is anticipated that there will be some recommendations for improvement in this area. The use of the TFC was considered to be a very effective way to get a lot of the preparation work done. Since the TFC included the program coordinators, it was effective in distributing the workload, and in getting the majority of faculty members involved in the effort. The team also worked together in proofreading and critiquing the individual program self-study reports before submission to ABET. This allowed us to get most of the kinks out of those documents.

RECOMMENDATIONS AND CONCLUSIONS

Trying to survive the ABET and SACS double whammy has proven to be an arduous and difficult task as best. It can sometimes prove to be a frustrating and unpleasant experience to go through, but the results are well worth it. Some valuable lessons have been garnered from the experience that will prove helpful during future re-accreditation visits and should provide some useful insight for programs that face the same dilemma in the future. Based on the experiences, and insight gained, the authors would like to make the following recommendations:

1. Start planning for your visits as early as possible. In the ideal case, as soon as the current accreditation cycle is completed.

Table 3: Timeline for the Preparation for ABET and SACS visits

Semester	Activity
Summer 2006	• Establish Leadership Team (President, SACS Liaison). • Set up the Office of Planning & Assessment • Set up SACS Preliminary Budget (SACS Liaison, Leadership Team). • Set up SACS Preliminary Calendar (SACS Liaison, Leadership Team)
Fall 2006	• Begin holding Leadership Team meetings (SACS Liaison) • Develop Documentation for campus information on QEP & Self-Study • Continue Leadership Team meetings throughout rest of SACS time-table • Develop SACS Website (SACS Liaison) • Solicit ideas for Quality Enhancement Plan Project from campus • Solicit volunteers for both QEP and Self-study committees (President, SACS Liaison)
Spring 2007	• Conduct workshops with Dept. Heads on Assessment (Deans, SACS Liaison) • Begin work on Dept & support area comprehensive self-studies (Leadership team, Dept. Heads, Division Heads) • Complete work on Department and Support areas self-studies (Leadership Team) • Begin writing Core Requirement & Comprehensive, Standards document (Self-Study Committees)
Summer 2008	• Complete writing Core Requirement & Comprehensive, Standards document (Self-Study Committees) • Complete writing Quality Enhancement document
Fall 2008	• Off-site review conducted – 2nd week in Nov. (Leadership Team) • Plan for visit in spring (Leadership Team)
Spring 2009	• SACS on-site review (March 15-April 30) – (campus) • Quality Enhance Plan due – 6 weeks prior to on-site visit (SACS Liaison)

2. Establish an institution-wide liaison person whose sole responsibility is dealing with accreditation matters. It would help greatly if the individual is familiar with all the agencies responsible for accreditation of the different programs on campus and understands their various requirements and terminology. They should be able to advise individual departments on best practices for meeting their goals.
3. Establish departmental task forces (TFCs) with responsibility for the establishment of all criteria necessary to meet the goal of obtaining re-accreditation for their programs. It is imperative that the department chair and all program coordinators are part of this effort. Moreover it is of the utmost importance that the Faculty Task Force committee has a clear and strict timeline for its activities as shown in Figure 1.
4. Ensure that by its composition, the TFC has enforcement capability to ensure that the faculty members comply with requests for information in a timely manner.
5. Ensure that all faculty members, full-time as well as part-time, are fully aware of their responsibilities vis-à-vis accreditation and continuous improvement expectations.

6. Ensure that the preparation work is evenly divided among faculty, as best as possible.
7. Lastly, if at all possible, avoid major administrative changes in the middle of the process, especially close to a visitation when policies and procedures have already been established.

The authors did not get an opportunity to compare their experiences with those at other institutions who have recently gone through a similar effort. This will be a follow-up effort to this paper in an effort to develop a set of best practices.

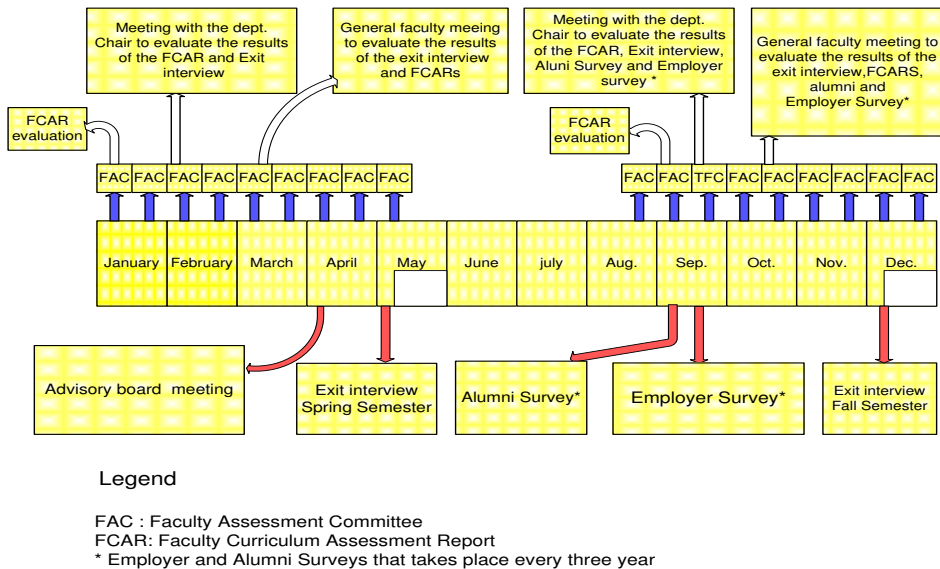


Figure 1. Timeline for the process of assessment and evaluation of the Program Evaluation Objectives and Outcomes.

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ACCREDITATION AND ISO CERTIFICATION AS TOOLS FOR ENSURING EXCELLENCE AND TOTAL QUALITY IN EDUCATION

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ABSTRACT: Since its founding in 1962, the Technological Institute of The Philippines (TIP) has endeavored to continuously re-define the meaning of academic life, in terms of its own identity and processes as well as the level of excellence and quality of the educational services it offers to its clientele. TIP is one among a select number of schools in the Philippines with a Quality Management System (QMS) certified compliant to the International Organization for Standardization (ISO). As a way of ensuring excellence and total quality in education, the school voluntarily submitted itself to the accreditation process through the Philippine Association of Colleges and Universities Commission on Accreditation (PACUCOA) as the accrediting agency under the umbrella of the Federation of Accrediting Agencies of the Philippines (FAAP). This paper discusses 1) a brief description of the accreditation process in the Philippines, 2) the actions taken by the school to comply with accreditation and ISO standards, 3) how these efforts contributed in the realization of its mission to transform students into graduates with full competence in their respective fields of study, and 4) the outcomes of accreditation and ISO Certification processes.

KEYWORDS: Accreditation and ISO standards; Total Quality in Education; Continual Improvement of Academic Processes; Faculty Development Program; Strategic Alliances; Competent Graduates

INTRODUCTION

The Technological Institute of the Philippines (TIP) is a private tertiary institution offering programs in engineering, architecture, computer science, information technology, information management, business, maritime and education. Since its founding in 1962, the Technological Institute of the Philippines has endeavored to continuously re-define the meaning of academic life, in terms of its own identity and processes as well as the level of excellence and quality of the educational services it offers to its clientele. TIP is one among a select number of schools in the Philippines with a Quality Management System (QMS) certified compliant to the international standard ISO 9001:2000.

Consistent with its commitment to pursue the accreditation of the greatest number of its curricular offerings as a way of ensuring excellence and total quality in education, the Technological Institute of the Philippines voluntarily submitted itself to the accreditation process through the Philippine Association of Colleges and Universities Commission on Accreditation (PACUCOA) as the accrediting agency.

The PACUCOA is a private educational agency, which gives formal recognition to an educational institution by attesting that its academic program maintains above-average standards in its educational operations, in terms of its aims and objectives. It is one of the accrediting agencies recognized by the Commission on Higher Education (CHED) and is under the Federation of Accrediting Agencies of the Philippines (FAAP), the umbrella organization of accrediting agencies in the Philippines [1].

In the light of these directions and opportunities, this paper sought to discuss: (1) a brief description of the accreditation process in the Philippines, (2) the actions taken by the school to comply with accreditation and ISO standards, (3) how these efforts contributed in the realization of its mission to transform students into graduates with full competence in their respective fields of study, and (4) the outcomes of accreditation and ISO Certification processes.

To answer the foregoing questions and to be able to depict the TIP experience in accreditation and ISO certification, this descriptive study conducted a document review of the following: school's strategic plan, review of the strategic plan by stakeholders, department processes, and annual reports.

THE ACCREDITATION PROCESS IN THE PHILIPPINES

The Commission on Higher Education (CHED) encourages the use of the mechanism of voluntary accreditation as a tool to meet the standards of quality over and above the minimum required for government recognition.

The levels of accreditation in the Philippine setting are [2]:

Candidate status - For programs which have undergone a preliminary survey visit and are certified by the federation/network as being capable of acquiring accredited status within two years;

Level 1 accredited status - For programs which have been granted initial accreditation after a formal survey by the accrediting agency and duly certified by the accreditation federation/network, effective for a period of three years;

Level II re-accredited status - For programs which have been re-accredited by the accrediting agency and duly certified by the accreditation federation/network, effective for a period of three or five years based on the appraisal of the accrediting agency;

Level III re-accredited status - For programs which have been re-accredited and have met the additional criteria/guidelines set by the federation/network for this level. Level III re-accredited undergraduate programs must satisfy the first two of the following criteria and two others of the succeeding ones; (a) A reasonably high standard of instruction; (b) A highly visible community extension program; (c) A highly visible research tradition; (d) A strong faculty development tradition evidenced by an appropriate budget allocation and/or systematic plan for faculty development programs; (e) A highly credible performance of its graduates in licensure examinations over the last three years; (f) Existence of working consortia or linkages with other schools and/or agencies; and (g) Extensive and functional library and other learning resource facilities.

Level IV accredited status - For accredited programs which are highly respected as very high quality academic programs in the Philippines and with prestige and authority comparable to similar programs in excellent foreign universities

There are nine survey areas under PACUCOA accreditation namely; (1) Purposes and Objectives, (2) Faculty, (3) Instruction, (4) Library, (5) Laboratory, (6) Physical Plant and Facilities, (7) Student Personnel Services, (8) Social Orientation and Community Involvement, and (9) Organization and Administration [1].

ACTIONS TAKEN BY THE SCHOOL TO COMPLY WITH ACCREDITATION AND ISO REQUIREMENTS

The Technological Institute of the Philippines (TIP), in its effort to attain the highest level of accreditation for all programs and maintain its ISO 9001:2000 certification has initiated actions to align all school programs and processes along accreditation and ISO certification requirements [3].

1. Implementation of a Quality Management System

The Technological Institute of the Philippines developed and implemented a quality management system to provide training and education services that consistently meet all customer and applicable statutory, regulatory and accreditation requirements [4]. This was also intended to address customer satisfaction through effective and efficient application of the system, including continual improvement and the prevention of non-conformity.

2. Continual Improvement of Academic Processes

The following academic processes were adopted and re-aligned toward accreditation and ISO certification standards [5]:

Regular review of mandatory requirements. Review of curricula, syllabi, Weekly Lesson Activity Plans (WLAPs) and other instructional materials are undertaken annually with the end in view of integrating new developments or technologies.

Every academic department is mandated to create its own academic advisory board whose task is to conduct periodic re-assessment of curricular offerings. This is to keep the programs of study relevant to the needs of the industry. The advisory board is composed of academic experts, industry experts, faculty members, alumni, and students. The academic advisory board is expected to derive possible changes to the curriculum based on requirements set by industry involving the application of new practices and technologies in the work place.

Integration of program enhancements. To effectively respond to changing patterns and requirements of employment and the needs of the community and industry, the school proactively addresses key issues derived from continuing dialogues with partners and from listening mechanisms such as feedback, suggestions and even complaints from stakeholders.

Several technology integration initiatives designed to directly impact all curricular offerings are being implemented such as: (a) integration of industry software in selected programs (b) the inclusion of the speech laboratory component in all English subjects, and (c) the conduct of lecture series on relevant topics, among others.

A 9-hour speech laboratory component was integrated in all English subjects in response to the feedback of industry partners that some TIP graduates have difficulty expressing themselves during the job interview.

Involvement of industry practitioners in the instructional process. TIP keeps a pool of industry professionals and practitioners who teach specific courses aligned with their areas of specialization and who help in the improvement of curricula through the sharing of their industry practices and experiences. These special lecturers for professional courses from the industry partners assure strong industry participation on campus and a reliable supply of well qualified and industry literate faculty members. Aside from teaching assignments, their participation in the instructional process also includes (a) curriculum development, (b) setting of program objectives, (c) identification of industry-required competencies, (d) provision of opportunities for students' industry immersion, and (e) training of faculty members, among others.

The underlying assumption was that the participation of industry practitioners can contribute to the desired outcome of the continual improvement of the school's educational process for greater customer satisfaction.

Regular monitoring and evaluation of academic processes. The school employs various systems of monitoring the effectiveness of teaching and learning in relation to curriculum content and learning outcomes of each program.

Customer feedback mechanism. All organizational units are required to establish and maintain their respective stakeholder feedback mechanisms to enable measurement and monitoring of stakeholder satisfaction. These feedback mechanisms include surveys, focused group discussions, and stakeholder assemblies. Among the inputs gathered are suggestions concerning curriculum design and instructional process. These, in turn, have generated among TIP's academic managers, a keener awareness of the direction of industry demands and a heightened sensitivity to available technology.

Student competency assessments. Competency examinations in identified critical courses are conducted to provide assessment of the students' learning outcomes. These are used to measure the effectiveness of the faculty member handling the subjects in the delivery of instructions. These competency examinations are also used to evaluate the extent of learning achieved by students. Committees composed of faculty members with the required expertise for the subject formulate the examination questions. The committee is in charge of ensuring that the topics included in the examination cover the course syllabus and that the degree of difficulty of the examination is within the standards set by the school.

Deficiencies identified from the results of the Competency Examinations and Periodic Faculty Evaluations are addressed through various initiatives such as academic counseling, tutorial classes, faculty coaching and mentoring

Test item analysis. Test item analyses are conducted in the final summative assessment in all subjects to evaluate the validity and reliability of test instruments. Furthermore, the test item analysis helps the faculty members to evaluate the designed distribution of the degree of difficulty of the items given during the examinations. It also enables the faculty member to assess the overall performance of the students and serve as a tool on the part of the faculty member for the necessary adjustment of his teaching approach.

Student faculty evaluation. Student faculty evaluation is conducted to determine the performance of the faculty as perceived by the student. In this evaluation,

students are to evaluate their faculty members regarding various aspects among which include the teaching methodologies and how these contribute in the conduct of classroom activities and the achievement of the specific learning objectives intended for the meeting.

Annual curricular program review. Annual curricular program review is conducted to monitor the performance of each curricular program with regard to student profile, teaching and learning quality, resources and market responsiveness.

Comprehensive curricular program review. A comprehensive curricular program review is conducted at least every four years for a 4-year course and every five years for a 5-year course. The comprehensive curricular program review shall verify program quality, viability, and compatibility with TIP's strategic direction, and responsiveness to the needs of the industry.

Curricular program evaluation survey. Curricular program evaluation survey is conducted annually with graduating students as respondents to evaluate the attainment of program objectives.

Course evaluations. Course evaluations are conducted on selected professional subjects at the end of every semester. The purpose of these evaluations is to be able to solicit student evaluation on the aspects of course objectives, content, methodology, facilities/resources, among others.

Industry perception survey. In its effort to continuously improve and enhance its curricular programs, TIP conducted an industry perception survey aimed 1) to identify the skills and competencies required by industry, 2) to determine the acceptability of TIP graduates by industry, and 3) to identify gaps or areas for curricular development.

3. A Comprehensive Faculty Development Program

The Technological Institute of the Philippines upholds the belief that among other factors, the competence of the faculty of instruction makes a difference in the quality of students' performance and scholastic achievement.

The academic credential of the faculty is one of several universally accepted criteria for content competence. Thus, the institution continuously implements creative mechanisms to recruit qualified teachers with graduate and post-graduate degrees, or develop and enable new members of the faculty to obtain the same over a specified period of time.

In addition to academic preparation, the institution also recognizes that the industry or professional experience of the teacher reinforces his theoretical knowledge thereby contributing to better teaching process. This qualification criterion guides the institution in the hiring of new teachers as well as in the implementation of the faculty development program.

Aggressive recruitment of industry lecturers (industry practitioners teaching part-time) is continuously implemented as a means to balance content knowledge with practice expertise in the different disciplines. As matter of policy, industry lecturers are assigned subjects along their current industry function or experience.

The faculty loading policy mandates that all graduate and post-graduate degree holders, among other criteria, be given priority in loading assignment. This scheme enables the academic departments to seamlessly load the qualified faculty with subjects related to their graduate studies, training, certification (if any), or industrial experience.

The Vice President for Academic Affairs is the lead implementer of the school's Faculty Development Program in coordination with the Human Resources Department (HRD), the Center for Teaching Excellence (CTE) Office, and the respective Dean/Chair of the different academic departments.

The Faculty Development Program is intended to develop the faculty members in the following areas [6]:

Academic qualifications and professional competence. Various support initiatives are in place to enable non-master's degree holders obtain their aligned graduate as well as post-graduate degrees over a prescribed period. These initiatives include, but not limited to 1) extending interest-free cash advance to qualified faculty members at the start of every term for graduate school matriculation support; 2) facilitating the application of qualified faculty members to various scholarship windows for graduate education available from government agencies such as the CHED and the DOST; 3) extending direct financial assistance to qualified faculty members in order for them to finish their master's or doctoral degrees.

The institution also provides an enabling mechanism for specific members of the faculty who lack industry exposure to gain the necessary industry experience along their discipline. The institution developed a policy to progressively enable qualified members of the faculty obtain paid industry immersion during the summer terms.

Discipline-related competence. The institution values continuous upgrading of faculty competence in relation to recent developments in their respective academic field. All academic departments are directed to identify new trends and technologies in their respective discipline and conduct at least one (1) internal discipline-related seminar or workshop. In addition, faculty members are also encouraged to attend external discipline-specific seminars, workshops or conferences

The members of the faculty are motivated to become active in organizations aligned with their professional affiliation. Towards this end, the institution provides support by extending cash advances to faculty members for their annual membership fees in these organizations.

Pedagogical competence. The Center for Teaching Excellence (CTE) is the lead office tasked to conduct continuing training initiatives in order to phase-in new hires into the teaching profession. In addition to the regular training program being implemented by the CTE and along the institutional thrust to develop teachers to become excellent educators, the TIP also offers the Teaching Certificate Program (TCP), an 18-unit postgraduate course that trains non-education teachers with the art and science of pedagogy and qualifies them to take the government Licensure Examinations for Teachers (LET).

The school provides supportive administrative and physical structures to enable faculty members employ innovative strategies to facilitate learning. TIP has a Faculty Research Center, which supports the computing needs of teachers when they prepare multimedia presentations for specific topics in the syllabus. Facilities for multimedia presentations were also provided.

Research competence. The TIP Research and Development Office (RDO) was established to manage the institutional research program and ensure the fulfillment of the school's research objectives. The RDO undertakes various activities to enhance the research capability of faculty members. For the past five years, the school's research program yielded a bountiful harvest of about 200 researches per campus aligned with the CHED's and Department of Science and Technology (DOST) research agenda for national development. Research have been presented in national and international conferences and forums, and subsequently published. Through these national and international exposures, among other benefits, exchange of valuable information and insights with other research communities was generated, serving as inputs for the improvement of research and for possible collaboration in the future.

The high output level of researches over a period of five years was mainly due to the school administration's support to the faculty in terms of technical assistance through the RDO, research incentives, research competitions at different categories, financial support for paper presentations (local and international) and publication of finished researches through various research journals.

Personal professional development. The faculty members are enjoined to continually update their knowledge about their respective fields through membership in professional organizations and the pursuit of graduate degrees. As indicated previously, the institution towards this end provides modest subsidies.

As part of the total incentive package offered to teachers, progressive professional development is rewarded based on merit. Such financial incentives are given to faculty members who (1) obtain a professional license when the discipline so requires; (2) obtain a specified number of graduate units toward an aligned graduate or post-graduate degree; (3) obtain an aligned graduate or post-graduate degree; and (4) obtain a professional certification, among others.

Performance reviews by students and the Department Chair are conducted every semester, before the scheduled midterm examinations. A review may also be conducted in the event of a promotion or change in duties and responsibilities of a concerned faculty member. Performance evaluation is used to determine whether a faculty member performs his job satisfactorily. It is also a tool used to improve instructional competency.

During formal performance reviews, the Department Chair/Dean evaluates the faculty member in the areas of: (1) Mastery of the Subject Matter, (2) Methods and Strategies, (3) Punctuality and Attendance, (4) Classroom Management, (5) Command of the Language of Instruction, (6) Attitude Towards the Students, (7) Personality, (8) Observance of School Policies, and (9) Human Relations, among others.

Evaluations are conducted to identify the faculty member's strengths and weaknesses with the end in view of improving his overall performance. The results of these evaluations are collated, analyzed, and summarized. These are then discussed with the concerned teacher and serve as basis for: (1) possible promotion in rank, (2) financial incentives, (3) commendations if the results are noteworthy, and (4) corrective actions if non-conformities are identified.

The institution believes that the optimum gauge of the effectiveness of the faculty development program is the consequent improvement of the quality of teaching. In this regard, the measurement mechanism employed by the institution towards determining the quality of teaching utilizes several input measures: (a) the results of the faculty evaluation by supervisors, students and peers, (b) course evaluation of specific subjects conducted at the end of every term, and (c) the results of student satisfaction assessments. All data indicate that the faculty development program has helped improve the quality of teaching.

4. Strategic Alliances

As an institution committed to bring and maintain high standard of instruction to students competent in their fields of study and imbued with the proper values, the school has networked strategically with other local and international colleges and universities and has kept close alliances with professional organizations and industry. Through these linkage arrangements, various areas of cooperation were realized intended to enhance the institution's capability to deliver its functions of instruction, research, productivity/linkages and extension services to its students and other stakeholders.

5. Strengthening of the School's Community Outreach Program

Consistent with its vision to be a school steeped in community service, TIP maintains active community development programs to strengthen community relations and make the adopted community residents self-reliant.

The Office of Social Orientation and Community Involvement (SOCI) was established by the institution to ensure proper planning, implementation, monitoring and evaluation of community projects.

In order to effectively contribute to local, regional and national development through its extension programs, the school implements mechanisms such as: (1) Conduct of a yearly needs assessment survey to identify the immediate needs of the community; (2) Comprehensive strategic planning for the adopted community aimed at helping them become self-reliant community; and (3) Evaluation and monitoring of implemented community projects.

TIP has implemented community projects through various activities discussed in the succeeding paragraphs [7]:

Projects for the adopted communities. As a contribution to local community development, community development projects were undertaken by TIP and

participated by the faculty, non-teaching personnel and students where local adopted communities were the major beneficiaries. The School provided the community residents, as project participants, technical assistance leading to the acquisition of specific employment or entrepreneurial skills as well as initiatives intended to develop discipline and self-reliance formation. More than 50 families from the adopted communities benefited economically from these sustainable development projects.

Projects for the adopted high schools. The school has adopted several high schools in response to the call of the government for such support from the private sector. There are two continuing programs developed and deployed which were intended to benefit the adopted High Schools: the Computer Literacy Program and the Math Clinic. As an outcome, students from these adopted high schools were able to attain better performance in the Secondary Achievement Test for Mathematics due partly to the Math Clinic. In addition, students from the adopted high schools not only improved their ICT competency but even garnered winning places in Inter-School competitions in computer applications. More than two thousand (2000) high school students from the different public high schools in four identified Divisions of City Schools benefited from these expanded Computer Literacy and Math Clinic programs.

Other environment related projects/undertakings. In line with the school's commitment of promoting care for the environment and the desire to contribute to the general welfare of the society, TIP is actively involved in environmental projects such as:

Adopt-Ipo Dam Project. The school partnered with the Department of Environment and Natural Resources (DENR), Manila Water and Sewerage System (MWSS), Manila Water, and Municipality of Norzagaray for the adopt the Ipo Dam project. Volunteer students, faculty members and staff have been actively involved in tree planting and maintenance of the adopted lot area. The Technological Institute of the Philippines was recently awarded by the Manila Water Company as one of the 18 institutions recognized for their efforts in promoting environmental awareness among its constituents

Involvement of TIP Officers and Faculty Members as Assessors on Cleaner Production. Selected Officers and Faculty Members of TIP who were trained as cleaner production assessors are deployed as technical consultants for the implementation of Green Framework of Innovative

Strategies on Sustainable consumption and Productivity in Marikina City.

6. Provision of Extensive and Functional Learning Facilities

The Technological Institute of the Philippines envisions itself as the leading school in the fields of Engineering and in all its other academic offerings. To support this vision, the school is committed to provide up-to-date library resources and facilities that are conducive to learning. The procurement of relevant and updated library resources and upgrading of laboratory facilities is a continuing process.

7. Student Development Programs

Processes involving career planning and development for students, from admission to graduation, are in place and effectively working. These processes include among others:

Pre-process matching. As part of the admission process, incoming students are interviewed by the Guidance Counselors to determine their individual course preference. A leveling of expectation is conducted to inform the students of the unique requirements of the program they prefer, including special abilities and aptitudes expected from them. Through these interviews, the school ensures the effective matching of abilities and aptitudes of students to the demands of the program to which they intend to enroll.

In-process matching. The Guidance and Counseling Center has a testing schedule per year level, which includes the conduct of Academic Aptitude Tests to second year students. Results are discussed to students so that they could become aware of their aptitudes.

Educational guidance is continuously provided to students through focus group and general assembly meetings with their respective Deans/Department Chairs. These provide a mechanism to enable students to cope with the difficulty of college life. These also serve as venue for the leveling of expectations pertaining to teacher competency, adequacy of facilities and other academic-related concerns. The Guidance and Counseling Center also provides regular counseling assistance to all students with emphasis on students with identified special needs.

REALIZATION OF TIP'S MISSION TO TRANSFORM STUDENTS INTO COMPETENT GRADUATES

The school's effort to comply with accreditation and ISO standards has resulted in an improved performance of students and graduates as they excelled in the following areas [8]:

Licensure Examinations. The school's efforts to improve the instructional delivery have resulted in a significant improvement on performance in licensure examination as TIP graduates consistently performed higher than national passing percentage in Marine Engineering, Civil Engineering, Electrical Engineering and Education programs. TIP has also produced a good number of topnotchers in licensure examinations.

National Competitions. TIP students were declared winners in prestigious national competitions such as Ten Outstanding Students of the Philippines, Petron Art Contest, Shell Art Competition, National Quiz Bees, among others.

Employability of Graduates. The graduate tracer study conducted by the alumni office for the past five years shows an employment rate of 91.6%

Acceptability of TIP Graduates by the Industry. A survey conducted to assess the acceptability of TIP graduates by the industry revealed a mean rating of 4.13 on a scale of 1 to 5, where 5 being the highest score.

OUTCOMES OF ACCREDITATION AND ISO CERTIFICATION PROCESS

In the recent years, TIP had the privilege to receive recognitions for exemplary performance in the provision of quality education such as :

Autonomous Status and Deregulated Status. In November 2009, the Commission on Higher Education (CHED) awarded TIP Quezon City Autonomous Status and TIP Manila Deregulated Status. Autonomous status the highest possible award given by CHED to a higher education institution. This is in recognition of its exemplary performance shown in the provision of quality higher education, research and extension work. With TIP Quezon City's autonomous status, it joined the exclusive league of 42 autonomous schools from 1,741 higher education institutions nationwide.

Centers of Development. TIP was recognized as CHED Centers of Development (COD) in three programs namely, 1) Computer Engineering for TIP Quezon City and TIP Manila, 2) Civil Engineering for TIP Quezon City, and 3) Information Technology Education for TIP Manila and TIP Quezon City which includes the programs Information Technology, Computer Science, and Information Systems.

Levels of Accreditation. TIP has various accreditation levels for its different program offerings under the Federation of Accrediting Agencies of the Philippines-Philippine Association of Colleges and Universities Commission on Accreditation (FAAP-PACUCOA). As of July 2011, all of the qualified programs of TIP are accredited at various levels. TIP Quezon City has 7 Level III accredited programs namely, Civil Engineering, Computer Engineering, Electrical Engineering, Industrial Engineering, Marine Engineering, Computer Science and Business Administration. Nine out of 14 programs of TIP Manila are Level II accredited namely, Civil Engineering, Computer Engineering, Electrical Engineering, Mechanical Engineering, Industrial Engineering, Marine Engineering, Marine Transportation, Computer Science and Business Administration.

In 2006, TIP was awarded by the PACUCOA under Category A as one of the top five schools with the highest number of accredited programs without majors: TIP Manila was Number 1 with 11 accredited programs while TIP Quezon City was Number 2 with 10 accredited programs.

In 2007, TIP Manila was a special awardee of the PACUCOA as the school with the highest number of Level I and Level II accredited programs.

TIP Quezon City was a special awardee of the PACUCOA as the school with the First Marine Engineering Program to have been granted Level III Reaccredited Status in the National Capital Region (NCR) and the First Computer Science Program to have been granted Level III Reaccredited Status in the Philippines and in the National Capital Region (NCR).

ISO Certification [9]. TIP is one among a select number of schools in the Philippines with a Quality Management System (QMS) certified compliant to the international standard ISO 9001:2000.

ISO 9001:2000 specifies requirements for a quality management system where an organization 1) needs to demonstrate its ability to consistently provide

product that meets customer and applicable regulatory requirements, and 2) aims to enhance customer satisfaction through the effective application of the system, including processes for continual improvement of the system and the assurance of conformity to customer and applicable regulatory requirements [10].

The certification covers the entire operation and services of the institution's provision of tertiary education in engineering, architecture, business, information and communications technology, and maritime education including training for the national and international industries. TIP's ISO 9001: 2000 Certificate of Conformity was issued by Det Norske Veritas (DNV) Certification Ltd[10]., a certifying body accredited by the United Kingdom Accreditation Service (UKAS).

SUMMARY AND CONCLUSIONS

Based on TIP's experience, the following practices helped toward full compliance with accreditation and ISO certification requirements: 1) Implementation of quality management system , 2) Continual improvement of academic processes, 3) A comprehensive faculty development program, 4) Networking and linkages, 5) Strengthening of the school's community outreach program, 6) Provision of Extensive and Functional Learning Facilities, and 7) A strong student development program , among others.

With its various initiatives and their resulting outcomes, TIP has succeeded to a certain extent in its commitment to excellence and total quality in education. However, there is still much to be desired. Quality circles are continually exploring possible areas of improvement. These efforts are meant to bring customer satisfaction to a higher level and enable TIP to achieve its vision to be the leading school in all its academic offerings.

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PROGRAM STAKEHOLDERS PERCEPTION OF ABET

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ABSTRACT: This paper presents the results of a study aimed at identifying/evaluating the perceptions of some program stakeholders; namely: students, alumni, and faculty, of ABET. Three different surveys were prepared and distributed to these program stakeholders. Stakeholders of ABET accredited and ABET-not accredited programs at Jordan University of Science & Technology (JUST) participated in this study. Analysis of these surveys showed that students believe that having ABET is a right for them from their departments, and they would be proud if their programs were ABET accredited. Faculty survey showed that most of the faculty members of the ABET accredited programs: are proud of being ABET accredited, strongly support obtaining ABET accreditation, and agree that obtaining ABET accreditation is very important for themselves, students, and graduates. Moreover, they think that ABET requirements enhanced their teaching and the quality of teaching in their departments and help their departments achieve their strategic plans.

KEYWORDS: ABET; Stakeholders; Accreditation; Surveys; JUST

INTRODUCTION

Quality of higher education has become one of the most deeply held values. However, the characteristics of quality and measures of effectiveness for higher education are neither easily identified, clearly understood, nor universally accepted. Therefore, it is difficult to identify a common set of appropriate and universally applicable criteria that enable reliable and sound evaluation of all institutions of higher education [1].

Accreditation, a peer-review process that assures the quality of the education students receive, can identify the quality standards required to meet the needs of a profession [2]. ABET accreditation is assurance that a college or university program meets the quality standards established by the profession for which it prepares its students [3]. Accreditation assures the stakeholders of a program's quality. Students and parents can be certain that their chosen program/university is peer recognized. Peer recognition is one of the key psychological motivating factors that can affect decision making. Many of students prefer to join a program/school that is peer recognized. Sponsors who wish to provide financial supports to a program will not do so if there are any doubts about a program's recognition or quality. Accreditation enables employers to recruit graduates they know are well-prepared. It also gives colleges and universities a structured mechanism to assess, evaluate, and improve the quality of their programs.

Accreditation in Jordan becomes a new seal of collegiate quality. Recently, the ministry of Higher Education and Scientific Research obligated all programs in the higher education to be locally accredited by the Commission of Accreditation of Higher Education Institutions (CAHEI). This local accreditation is considered to be the cornerstone of self-regulation process and has dual functions of fostering quality improvement and providing quality assurance. Similar to most of international accreditation processes, this can be fulfilled through a collegial process of institutional self-assessment and critical peer evaluation based upon criteria established by CAHEI. Although an accreditation evaluation is not an institutional audit, it does ensure that the institution meets minimum standards of quality.

Along with its seeking for local accreditation, the Faculty of Engineering at JUST was the first in the country to seek ABET accreditation to demonstrate its programs' commitment to providing its students with a quality education similar to that of US similar-accredited programs. It initiated its plans and strategies to apply for ABET accreditation through a joint effort with the Ministry of Higher Education in 2006. At the end of 2007, JUST decided to proceed on its own to apply for ABET for three programs: Chemical, Biomedical, and Industrial Engineering Programs. These three programs have been accredited by ABET in 2009. One of the first and yet very important steps through the preparation process was the identification and involvement of program constituencies or stakeholders in each stage of the preparation. The participation of program stakeholders has been a must due to the potential benefits of including stakeholders and tapping their expertise in the evaluation as a way to increase the likelihood of evaluation utilization [4-6].

The objective of this study is to identify/evaluate the perceptions of some program stakeholders; namely: students, alumni, and faculty, of ABET.

METHOD

Three different surveys; namely alumni, students, and faculty members surveys, were conducted to investigate program stakeholders' perception of ABET. The participants were chosen from ABET accredited and non-accredited programs. The survey questions varied from one constituency to another, as shown in Tables 1-3. The participants were asked to rate each statement in the survey from 1 to 5 depending on the extent to which they agree or disagree with each statement, where 5 indicates strongly agreement, and 1 indicates strongly disagreement.

RESULTS AND DISCUSSION

Faculty Members Survey

The Faculty members survey was distributed to faculty members of ABET and non-ABET accredited programs. Thirteen faculty members of ABET accredited programs and 12 faculty members of ABET non accredited programs participated in this study. The results of the survey are summarized in Table 1. As Table 1 shows, while about 70% of faculty members of ABET accredited programs think that obtaining ABET is very important/important to them, and to their graduates, and 62% of them think that obtaining ABET is very important/important to current students, about 40% of ABET non accredited programs think that obtaining ABET is very important/important to them, 58% of them think ABET is very important/important to their graduates, and surprisingly 75 % of them think that obtaining ABET is very important/important to current students, despite the fact that only 50% of them are strongly supportive to obtain ABET. This may be attributed to the belief of these faculty members that their departments are among the best and as such there is no need for ABET accreditation. Although about 55% of faculty members of ABET accredited programs, before obtaining ABET, were strongly in favour of applying for ABET accreditation, 70% of them became strongly supportive for ABET after obtaining it. This may be attributed to the increase in self-confidence of the faculty members after obtaining ABET and to the benefits they experienced during the preparation process as well as their belief that obtaining ABET can help their departments achieve their strategic plans (about 70%).

Students Survey

The students survey was distributed to students of ABET and non-ABET accredited programs, where 80 students of ABET accredited programs and 25 students of ABET non accredited programs participated in this study. The results of the survey are summarized in Table 2. As Table 2 shows, all participants of ABET accredited programs: are very proud/proud that their departments have been ABET accredited, think that obtaining ABET is a right for them, and if they were given the choice, they would choose a department that has been ABET accredited. However, only 50% of these students think that ABET accreditation has improved the quality of teaching in their departments. On the other hand, 60% of the participants of non-ABET accredited programs think that obtaining ABET is very important/important to them, and 84% of them think that obtaining ABET is a right for them.

Table 1: Results of faculty member's survey.

Question	5		4		3		2		1	
	A	N/A	A	N/A	A	N/A	A	N/A	A	N/A
1 How important is obtaining ABET accreditation to you?	54.0	25.0	15.4	16.7	7.8	50.0	7.8	8.3	15.4	0
2 How important is obtaining ABET accreditation to your graduates?	46.1	8.3	23.1	50.0	7.8	16.7	15.4	8.3	7.8	0
3 I am proud that my program has been ABET accredited.	23.1	-	30.8	-	15.4	-	7.8	-	23.1	-
4 How important is obtaining ABET accreditation to your current students	38.5	25.0	23.1	50.0	15.4	8.3	15.4	8.3	7.8	0
5 ABET accreditation has enhanced my teaching	23.1	-	7.8	-	23.1	-	7.8	-	38.5	-
6 ABET accreditation has improved the quality of the teaching process in my department	30.8	-	15.4	-	15.4	-	23.1	-	15.4	-
7 I strongly support obtaining ABET accreditation	54.0	16.7	15.4	33.3	7.8	33.3	7.8	8.3	15.4	8.3
8 Before obtaining ABET accreditation, I was strongly in favour of applying for ABET accreditation	23.1	-	30.8	-	15.4	-	7.8	-	23.1	-
9 ABET requirements helped our department achieve its strategic plans	54.0	-	15.4	-	7.8	-	7.8	-	15.4	-
10 Our department and program are among the best and as such there is no need for ABET accreditation	15.4	16.7	15.4	25.0	15.4	8.3	7.8	33.3	46.1	8.7

(Scale 1-5: 5 indicates strongly agree and 1 indicates strongly disagree; A: indicates ABET accredited, N/A indicates ABET not accredited)

Table 2: Results of students' survey.

Question	1		2		3		4		5	
	A	N/A	A	N/A	A	N/A	A	N/A	A	N/A
1 I am proud that my department is ABET accredited.	75.0	-	25.0	-	0	-	0	-	-	0
2 How important is it to you as a student that your department be ABET accredited?	50.0	24.0	25.0	36.0	25.0	24.0	0	16.0	0	0
3 It is my right as a student, that my department obtain ABET accreditation	75.0	68.0	25.0	16.0	0	16.0	0	0	0	0
4 If given the choice, I would choose a department that has been ABET accredited	75.0	68.0	25.0	24.0	0	8.0	0		0	0
5 ABET accreditation has improved the quality of the teaching process in my department	25.0	-	25.0	-	50.0	-	0	-	0	-

(Scale 1-5: 5 indicates strongly agree and 1 indicates strongly disagree; A: indicates ABET accredited, N/A indicates ABET not accredited)

Alumni Survey

The alumni survey was distributed to graduates of ABET accredited programs, where 28 alumni participated in this study. The results of the survey are summarized in Table 3. Of the 28 participants, 75 % were proud that they have graduated from ABET accredited program, and 50 % believe that obtaining ABET is a right for the students. However, only 46% think that obtaining ABET is very important/important to them, and less than 30% think that Graduating from an ABET accredited program may help graduates obtain a job and less than 40% would preferably choose engineers for a position in their institution who have graduated from ABET accredited programs. These results, although are surprising, can be justified. All participants have graduated before their programs were accredited, thus they did not have the chance to experience the benefit of being graduated from ABET accredited programs.

Table 3: Results of Alumni Survey.

(on scale 1-5; where 5 indicates strongly agree and 1 indicates strongly disagree)

Question	5	4	3	2	1
1 I am proud that I graduated from a department that is ABET accredited.	50.0	25.0	14.3	7.1	3.6
2 How important is it to you as a graduate that your department be ABET accredited?	25.0	21.4	25.0	14.3	14.3
3 It is my right as a student, that my department obtain ABET accreditation	25.0	25.0	17.9	25.0	7.1
4 Graduating from an ABET accredited program may help me obtain a job.	14.3	14.3	35.7	21.4	14.3
5 As a decision maker, I would preferably choose engineers for a position in my institution who have graduated from ABET accredited programs	21.4	17.9	46.4	10.7	3.6

SUMMARY AND CONCLUSIONS

The three Engineering program stakeholders share many insights and opinions regarding ABET accreditation. Faculty members, students, and alumni agree on the importance of having accreditation and most of them agree that ABET accreditation is a right for students. Stakeholders of ABET accredited programs emphasized their pride in their programs for obtaining ABET.

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ACCREDITATION EXPERIENCE OF THE MECHANICAL ENGINEERING PROGRAM AT UNIVERSITY OF BAHRAIN

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ABSTRACT: Institutions of higher education are becoming increasingly involved in conducting assessment of their academic programs and administrative support systems. Department of Mechanical Engineering (DOME) of University of Bahrain (UOB) has worked strongly during the last six years towards acquiring ABET accreditation for its B.Sc. program. To satisfy ABET nine criteria, many hurdles were being faced: the most difficult ones were the establishment of Program Educational Objectives (PEO's) and Program Outcomes (PO's). This has gone through a number of trials and modifications by the Departmental Accreditation Committee (DAC) that was formed to prepare for accreditation. Though, the ABET definitions of objectives as "broad statements that describe the career and professional accomplishment ---", and outcomes as "narrower statements that describe what students are expected to know and be able to do ---", seem to be simple and straight forward, nevertheless, the DAC in consultation with the Program Industrial Advisory Committee (PIAC) kept revising and rephrasing the objectives and outcomes each time it discovered a need for more elaboration and/or confusion of the two criteria. Professional expertise from industry and the program alumni were the main tools for the assessment of PEO's and PO's, while faculty and senior exit students assessed only the PO's. Assessment of PEO's and PO's showed the strengths and weaknesses of the educational process. Subsequently, continuous improvement strategies were set to elaborate on the strengths and to overcome the weaknesses. The implementation of these strategies was made by revising the curriculum, teaching methods, lab facilities ... etc. The self-study of the program showed a good improvement of students and graduate performance. As a results of this process, the program has been successfully accredited by ABET in September 2009.

KEYWORDS: Accreditation; Mechanical Engineering Program; Program Educational Objectives; Program Educational Outcomes; Continuous Improvement.

INTRODUCTION

Evolutionary changes in the way graduates work, are causing educational institutions across the world to rethink about their curricula and educational procedures and processes. The collective goal is to have flexible programs that seek continuous improvement for quality. Therefore evaluating and updating of programs are critical for their survival and growth. Clear understanding of programs goals and objectives, coupled with assessment procedures to indicate whether established targets are being met, are key elements of such improvement. Evaluation of programs is preferred to be carried out and approved through accrediting agencies to show that the improvement is in the right direction. The Accreditation Board for Engineering and Technology (ABET), is the recognized accreditation body for programs in applied science, computing and technology [1]. It is the responsibility of the institution seeking accreditation of a program to demonstrate clearly that the program meets the following criteria:

- 1) Students
- 2) Program educational objectives (PEOs)
- 3) Program outcomes (POs)
- 4) Continuous improvements
- 5) Professional component
- 6) Faculty
- 7) Facilities
- 8) Institutional support and financial resources
- 9) Program criteria

Department of Mechanical Engineering (DOME) of University of Bahrain (UOB) prepared a self-study report of the Mechanical Engineering Program (MEP) [2], which was submitted to ABET early 2008. In October 2008, ABET evaluators visited DOME and evaluated the MEP documentation and facilities. Three weaknesses have been reported by the evaluators in the following criteria:

- 1) Program Educational Objectives
- 2) Program Outcomes
- 3) Curriculum "Major Design Experience"

These weaknesses have been corrected during the first semester of 2008/09 [3].

In this paper, the development process of the criteria of PEO's and PO's is presented, and the difficulties encountered during this process, in addition to the result of continuous improvement conducted for MEP, are discussed.

PROGRAM EDUCATIONAL OBJECTIVES

The DOME has established program educational objectives (PEO's) that aim to build in the graduate when graduating: a solid foundation of technical knowledge and full preparation to join professional careers. The graduates are expected to solve challenging problems and be creative by applying tools and skills learned during study. They are expected to be part of teamwork and take the lead in their major. The PEOs are defined by ABET as "Program educational objectives are broad statements that describe the career and professional accomplishments that the program is preparing graduates to achieve" [1]. The objectives of Bachelor of Science in Mechanical Engineering (BSME) are developed by the DOME and in cooperation with the Program Industry Advisory Committee (PIAC) and the Program Advisory Student Council (PASC). The PEO's are developed to be consistent with the University mission "The Mission of the University of Bahrain is excellence in the generation, dissemination, and application of knowledge through quality teaching, research and community service targeted to support and

enhance the developmental process in Bahrain” [4, 5] and in accordance with the ABET accreditation criteria. The PEOs of MEP are designed to prepare graduates to have:

- 1) foundation in mathematics, science and engineering,
- 2) technical background of Mechanical Engineering needed for practice and graduate studies,
- 3) tools to work in professional environment, teamwork, to engage in life-long learning, and to communicate effectively,
- 4) broad education that include humanities and social sciences,
- 5) the ability to use software packages and access to current instrumentation, and
- 6) knowledge of professional and ethical responsibilities to apply to Mechanical Engineering, and awareness of environmental and economical considerations.

These objectives are consistent with University mission [2]. These PEOs were assessed by employers and alumni to show whether they are important and relevant or not [2]. The analysis of the assessment result of PEO's showed that PEO number 4 is less important and the other objectives need rephrasing. Therefore, the department has rephrased the Program Educational Objectives. A joint meeting of DAC, PIAC, and PSAC was held in February, 2007 to discuss the proposed modified objectives. The final version of PEO's was then discussed and approved by the DOME Council in March, 2007. These PEO's are as follows:

The graduate of the Mechanical Engineering Program at UOB will have:

- 1) A strong foundation in the fundamentals of mechanical engineering including technical and economical ability to analyze, solve and realize engineering design and operational methods.
- 2) The ability to engage in updated mechanical engineering practice and research needed for professional practice and/or graduate studies.
- 3) A wide range of generic skills, including effective communication and project management skills, participation in team-working and multi-disciplinary teams, and the ability to engage in life-long learning.
- 4) Awareness of the professional ethical attitudes and responsibilities towards society and environment when practicing the profession.

Again, these PEOs are consistent with the University mission [2].

PROGRM OUTCOMES

The POs were established step by step while establishing the PEOs as detailed in Section 2. The first version of POs was established according to the definition of ABET “Program outcomes are narrower statements that describe what students are expected to

know and be able to do by the time of graduation. These relate to the skills, knowledge, and behaviors that students acquire in their matriculation through the program”, ABET criterion 3 (a-k) [1] and to satisfy the PEOs. These POs are as follows and the student of MEP at UOB will have:

- 1) An ability to identify and formulate engineering problems and apply knowledge of mathematics, science and/or engineering to solve these problems
- 2) An ability to design and conduct experiments, as well as to analyze and interpret data
- 3) An ability to design a system, component, and/or process to meet desired needs taking into consideration the realistic constraints such as; safety, economy, impact on the environment, engineering ethics, ... etc.
- 4) An ability to function professionally and with ethical responsibility as an individual and/or on multidisciplinary teams; and to possess, an ability to communicate effectively
- 5) A knowledge of contemporary issues and broad education necessary to understand the impact of engineering solutions in a global and societal context
- 6) A recognition of the need for and an ability to engage in life-long learning
- 7) An ability to use the techniques, skills, and modern engineering tools (including computational tools) necessary for engineering practice
- 8) An ability to work professionally in thermal, manufacture, and/or mechanical systems, including the design and realization of such systems

POs were assessed by senior exit students, faculty through course assessment, alumni and employers.

ACHIEVEMENTS, ASSESSMENT AND CONTINUOUS IMPROVEMENT OF PEOs AND POs

Achievement of PEOs and POs

The achievement of PEOs is measured by employers and alumni using a survey designed according to the PEOs statements [2,8]. Important indicator of achieving the PEOs is the assessment of POs by alumni, senior exit students and faculty since POs are mapped to the PEOs as shown in Table 1. To achieve the PEOs, the POs have to be attained by student throughout his study in the program. Therefore, to ensure the achievement of all POs they have been related to the program curriculum [2]. Evidences of achievement were taken from 2 to 4 courses per PO selected according to POs/Curriculum mapping [3]. All these mappings have been approved by the DOME Council [2].

Table1: Relationship of Program Educational Objectives (PEO's) and Program Outcomes (PO's).

	PEO-1	PEO-2	PEO-3	PEO-4
PO-1	√	√		
PO-2		√		
PO-3		√		
PO-4			√	√
PO-5	√		√	√
PO-6	√	√	√	√
PO-7	√	√	√	√
PO-8		√	√	√

Ongoing Evaluation of PEOs and POs

Continuous improvement involves modifications of courses objectives and contents to help achieving the POs, and hence periodical assessment of the PEOs is required. This continuous improvement could be achieved by improving the POs based on any shortcoming observed in the program objectives evaluation. Then the program performance and curriculum have to be modified based on the unachieved program outcomes. The POs are evaluated every year by alumni and every 2 to 3 years by employers and PIAC. Furthermore, the POs are evaluated by students and faculty members every year. The results of POs evaluation together with the result of PEOs assessment will be discussed every year by the DOME Council in order to propose any modification action if needed.

Assessment of PEOs

PEOs are assessed by three constituencies: PIAC, employers, and alumni. Two surveys, one for PIAC and employers and the other for alumni, have been designed for ongoing evaluation process of the extent to which these PEOs are attained [2,3]. Since this is the first time to evaluate the MEP based on the ABET criteria, the DAC committee in cooperation with the DOME Council and constituents decided a 70% to be the metric goal for all the program educational objectives and outcomes. The results of evaluation are detailed in Table 2 for PIAC, employers and alumni.

Table 2: Average of assessment result of PEO's for the academic years 2006/07 and 2007/08.

PEOs	Assessment Method (out of 5)			Metric Goal
	PIAC	Employers	Alumni	
1	3.69	4	4	3.5
2	3.57	4	4	
3	3.25	4.04	3.65	
4	2.82	3.86	3.65	

Assessment of POs

The assessment of the POs is conducted at two different levels, namely, at the course objectives level and at the program outcomes level. The courses are assessed each semester by the student using the Course Assessment Form [2] (available online on the University Accreditation Website (<http://aao.uob.edu.bh><http://aao.uob.edu.bh/>)) and by the instructor of the course. These course assessment instruments will gauge the degree to which prescribed course objectives are being achieved.

The course is assessed by the faculty at the end of each semester through mid-term test, assignments, project, and final exam. Each item of these is evaluated individually and entered to the course objective/program outcomes mapping table in the Faculty Course Assessment Report [2]. The average of this map is introduced to the curriculum/outcomes map to evaluate the whole program outcomes [2]. The averages of the outcomes determined from the curriculum assessment are summarized in Figure 1.

Program outcomes are also assessed by senior exit survey, alumni and employers (Tables 3 to 5). The senior exit survey contains 5 categories of questions as shown in Table 3. Semester I – 2007/08 shows relative improvement over the previous semesters due to the implementation of some of the proposed actions such as: modifying the advising process, adding lab equipment and improving lab sheets and reports, offering term projects for 300 and 400 courses, and modifying the senior project to be senior design project.

The achieved improvement by senior exit survey shown in Table 4 is explained by the implementation of some of the proposed actions [2]. However, most of outcomes will be considered for continuous improvement.

Furthermore, Table 4 shows the evaluation results of POs by alumni and employers. The results suggest the need for continuous improvement of POs.

Table 3: Summary of Senior Exit Survey.

Semester	No. of Responses	Survey Category					
		Metric Goal	Advising	Curriculum and Instruction	Facilities and Laboratories	Professional preparation	Program Rating
II - 2004/05	6	3.5	3.50	3.24	3.31	3.64	3.1
I - 2005/06	8	3.5	3.36	3.25	2.92	3.46	3.32
II - 2005/06	11	3.5	3.3	3.38	3.02	3.30	3.31
I - 2006/07	10	3.5	3.01	3.03	3.18	3.22	3.37
II - 2006/07	6	3.5	3.2	3.35	3.35	4.17	3.85
I - 2007/08	8	3.5	4.06	3.75	3.58	3.8	3.87

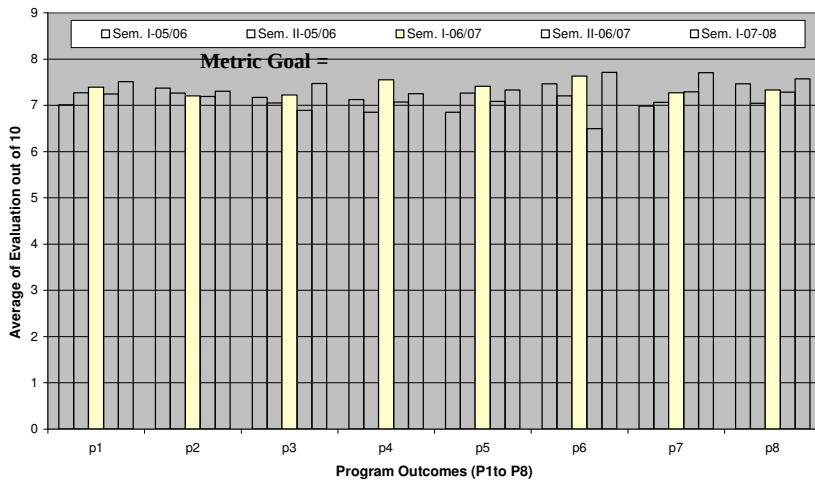


Figure 1: Comparison between the curriculum-PO's mapping results for semesters I 2005/06 to II - 2007-08.

HANDLING OF ABET REVISION AND COMMENTS

The MEP has been evaluated by ABET evaluators who visited the DOME in October 26-28, 2008. Three weaknesses have been reported in the received draft statement from the chair of Engineering Accreditation Commission (dated February 12, 2009) in the following criteria:

- 1) Program Educational Objectives
- 2) Program outcomes
- 3) Curriculum "Major Design Experience"

The weaknesses documented in the received draft statement from the chair of Engineering Accreditation Commission (dated February 12, 2009) are as follows:

Table 4: Results from Senior Exit, Alumni and Employer Surveys

POs	Sem. I-06/07	Sem. II-06/07	Sem. I-07/08	Year 2006	
	Senior Exit Survey (out of 5)			Alumni (out of 5)	Employers (out of 10)
PO-1	3.60	4.00	3.75	4.07	7.71
PO-2	3.75	3.50	4.00	3.50	7.43
PO-3	3.25*	3.92	3.94	3.33*	7.14
PO-4	3.35*	3.96	3.79	3.35*	8.00
PO-5	2.90*	3.83	4.00	3.58	7.29
PO-6	Not Applicable			3.20	8.14
PO-7	3.15*	3.35*	3.88	3.87	8.43
PO-8	3.27*	3.95	3.84	3.58	7.86

*Value below the metric goals of 70%

These weaknesses have been corrected during the first semester of 2008/09. The actions taken to correct them are detailed and discussed in this section.

Criterion 2 - Program Educational Objectives: defines educational objectives as "broad statements that describe the career and professional accomplishments that the program is preparing the graduate to achieve." ABET comment is: While the program has established and published program educational objectives, they appear to be statement focused on student technical skills and knowledge at the time of graduation rather than career and professional accomplishments aligned with the needs of constituencies. The wording of the objectives appears to lack the strength of compliance with the definition of program educational objectives to ensure that the quality of the program will be sustained based on the constituents' expected accomplishments of graduates over their careers. Criterion 2 also requires "a process of ongoing evaluation of the extent to which these objectives are attained, the result of which shall be used to develop and improve the program outcomes so that graduates are better prepared to attain the objectives." While a process for evaluation of the objectives has been developed and is being used, the process is largely based upon the attainment of program outcomes at the time of graduation and not on the attainment of career and professional accomplishments following graduation. In response to the comments of ABET evaluators on PEOs criterion, the DOME has rephrased new PEOs to reflect the definition of ABET. The modified PEOs have been discussed and approved by the DOME Council after being prepared by the DAC, PIAC, and PSAC. The PEO's are as follows:

The graduates of the Mechanical Engineering Program will:

- a. engage in productive careers in a broad range of the mechanical engineering profession in both the public and private sectors including, but not limited to; oil, gas and petrochemical industries, power plants, water desalination plants, aluminum production and processing industries, and building services.
- b. engage in ongoing professional development activities by pursuing graduate studies and /or other learning opportunities;
- c. advance in responsibility and leadership in their careers.

PEOs surveys were designed and sent to a randomly selected number of the program alumni and employers to evaluate to what extent the PEOs have been achieved. The results of the surveys show satisfaction of these constituents [3].

Criterion 3 - Program Outcomes: ABET comment is: Criterion 3 requires that programs must demonstrate that their students attain outcomes "a" through "k" as well as program - specific outcomes, and that there must be an assessment and evaluation process that periodically documents and demonstrates the degree to which the program outcomes are attained. The ABET program outcomes a" through "k" are combined to generate a new set of outcomes. Although the program has assessed the degree to which these new outcomes are attained, it has not demonstrated the degree to which a" through "k" are

attained as required by the criterion. While integrating program outcomes a" through "k" in itself is acceptable, the assessment process must be capable of distinguishing attainment of outcomes a" through "k". In addition an examination of course descriptions and display materials revealed inconsistencies to the degree that outcomes were addressed.

Based on the recommendation of the ABET evaluators, the DOME has adopted new 13 (a-m) outcomes for the MEP which are mainly (a-k) ABET Criterion 3 and (l-m) for mechanical engineering program requirements by professional societies. These outcomes have been discussed and approved by the Department Council after being prepared by the DAC, PIAC, and PSAC. The outcomes are:

The students of Mechanical Engineering Program at UOB will have:

- a) an ability to apply knowledge of mathematics, science, and engineering.
- b) an ability to design and conduct experiments, as well as to analyze and interpret data.
- c) an ability to design a system, component, or process to meet desired needs within realistic constraints such as economic, environmental, social, political, ethical, health and safety, manufacturability, and sustainability.
- d) an ability to function on multi-disciplinary teams.
- e) an ability to identify, formulate, and solve engineering problems.
- f) an understanding of professional and ethical responsibility.
- g) an ability to communicate effectively.
- h) the broad education necessary to understand the impact of engineering solutions in a global, economic, environmental, and societal context.
- i) a recognition of the need for, and an ability to engage in, life-long learning.
- j) a knowledge of contemporary issues.
- k) an ability to use the techniques, skills, and modern engineering tools necessary for engineering practice.
- l) an ability to work professionally in thermal and mechanical systems and/or manufacturing processes.
- m) an ability to realize the design of a mechanical system, component, or process.

These POs have been mapped to the program educational objectives as shown in Table 5. POs have been related to the program curriculum as discussed in Section 3. Evidences of achievement were taken from 2 to 4 courses per PO selected according to POs/ curriculum mapping.

As requested by ABET evaluators, direct assessment of POs has been carried out during the first semester of 2008/09 using various assessment tools of program courses [4]. Part of this table is shown in Table 6.

Table 5: Relationship between the PEOs and POs.

PEOs	POs												
	a	B	c	d	e	f	g	h	i	j	k	l	m
PEO -1	√	√	√	√	√	√	√	√	√	√	√	√	√
PEO-2								√	√	√			
PEO-3				√		√	√	√	√	√			

Criterion 5 - Curriculum: ABET comment is: Criterion 3 states that "Students must be prepared for engineering practice through a curriculum culminating in a major design experience based on the knowledge and skills acquired in earlier course work and incorporating appropriate engineering standards and multiple realistic constraints." Examination of some display materials as senior design project reports showed that appropriate engineering standards and multiple realistic constraints were not uniformly included as part of the design component of the curriculum, resulting in less than full compliance with the criterion.

Table 6: Achievement of some ME Program Outcomes Semesters II 07/08 and I 08/09.

Program Outcomes	Course No.	No. of Students	Percentage of passed students %	Average of students marks %	Do POs Met metric goal (70%)?	Type of assessment
a	MEG 370	12	83.3	74.6	Yes	Quiz
	MEG 384	7	71.4	70.6	Yes	Test
	MEG 262	10	80	82.5	Yes	Quiz
	Average	29	79.29	76.36	Yes	
b	MEG 333	4	100	78.7	Yes	4 Experiments
	MEG 311	5	100	88.1	Yes	2 Experiments
	MEG 384	6	100	86.7	Yes	1 Experiment
	MEG 431	2	100	80	Yes	1 Experiment
	Average	17	100	84.44	Yes	
c	MEG 464	9	88.9	79.22	Yes	Project
	MEG 364	8	75	71	Yes	Project
	MEG 493	10	100	74.14	yes	Project
	Average	27	88.89	75.14	Yes	

The approved metric goal by ME council, PIAC, and PASC is 70%

In response to the comments of ABET evaluators on curriculum criterion, the DOME has already decided in September 2008 to change the title of Senior Project to be Senior Design Project to reflect the design experience knowledge and skills that acquired in earlier course work through inclusion of appropriate engineering standards and multiple realistic constraints [2].

CONCLUSIONS

During the last period of 2004 to 2009, the Department of Mechanical Engineering of the University of Bahrain has worked hard to improve its educational process and facilities to satisfy the requirement of ABET criteria for the sake of accreditation. Many hurdles were being faced: the most difficult ones were the establishment of Program Educational Objectives (PEO's) and Program Outcomes (PO's). This has gone through a number of trials and modifications by the Departmental Accreditation Committee (DAC) that was formed to prepare for accreditation.

Professional expertise from industry and the program alumni were the main tools for the assessment of PEO's and PO's, while faculty and senior exit students assessed only the PO's. Assessment of PEO's and PO's showed the strengths and weaknesses of the educational process. Subsequently, continuous improvement strategies were set to elaborate on the strengths and to overcome the weaknesses. The implementation of these strategies was made by revising the curriculum, teaching methods, lab facilities ... etc. As a results of this process, the program has been successfully accredited by ABET in September 2009.

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ON THE USE OF QUALITY TOOLS FOR IMPROVEMENT OF THE LEARNING PROCESS IN ENGINEERING EDUCATION

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ABSTRACT: The paper is dedicated to make a review of basic concepts on process improvement and to show the possibility of applying these concepts within the sphere of engineering education. A special focus will be made on the use of the basic quality tools by educators to improve the quality of the learning process in engineering courses at higher education institutions. A case study of an introductory engineering course delivered to first year engineering students at the University of Hail will be presented and discussed using these tools and techniques. The use of these tools by faculty members revealed great areas of improvement in the management of the course and the delivery of its contents.

KEYWORDS: Engineering Education; Continuous Process Improvement; Quality Tools; TQM in Education.

INTRODUCTION

In the era of competitive markets and globalization, the quality concept has emerged as a strategic issue at all levels and in all industries including the education business. Quality in engineering education is a subject of actual concern for educators, educational leaders and to industrial business sectors. International quality standards and excellence models such the ISO 9000 standards and the EFQM model require organizations' quality systems to be built on processes, rather than requirements, departments or functions. Consequently, process management has become more relevant, and proper process identification and management are becoming critical challenges for quality professionals, educators and higher education leaders. Many organizations use total quality management (TQM) tools to identify, analyze and assess qualitative and quantitative data that are relevant to their processes. One of the simplest and most effective tools used by engineers in manufacturing processes for problem solving and quality improvement, are the basic quality tools known as the magnificent seven. The Japanese quality guru, Kaoru Ishikawa [1] who is the inventor of the seven basic quality tools stated that 95% of quality related problems in any organization can be resolved using these tools; This important statement has been proven in the field by different organizations and researchers including in higher education institutions [2-7]. It is worth mentioning that these simple tools which are listed under the Body of Knowledge (BoK) in the American Society of Quality Certification program, are usually taught to engineering and technical students.

In pursuit of quality, educators are continuously engaged in a process of finding opportunities for improvement of the learning process, the quality of learning experiences and the way education is delivered. In the present paper we will go back to review basic

concepts on process improvement and quality management and to examine the possibility of applying these concepts within the sphere of engineering education. A special focus will be made on the use of the basic quality tools by educators to solve problems and to improve the quality of the learning process in engineering courses at higher education institutions. A case study of an introductory engineering course delivered to first year engineering students at the University of Hail will be presented and discussed.

BASIC CONCEPTS OF CONTINUOUS PROCESS IMPROVEMENT

Why do we need to improve processes and quality?

Edwards Deming [8], in his book "out of the crisis" published in mid-eighties, answered this fundamental question with his famous Deming Chain Quality Reaction shown in Figure 1. The benefits from quality and process improvements to any organization including the higher educational institutions are:

- Improve Quality (Faculty, Students, courses).
- Costs decrease (Fewer mistakes, better use of faculty time and knowledge sources)
- Productivity Improves (Students projects, Advanced level in teaching)
- Capture the market (Meet most of stakeholders expectations (government, society, industries, students)
- Stay in Business (Get international accreditation)
- Provide jobs and more jobs (Reputation, higher retention rate for both faculty and students).

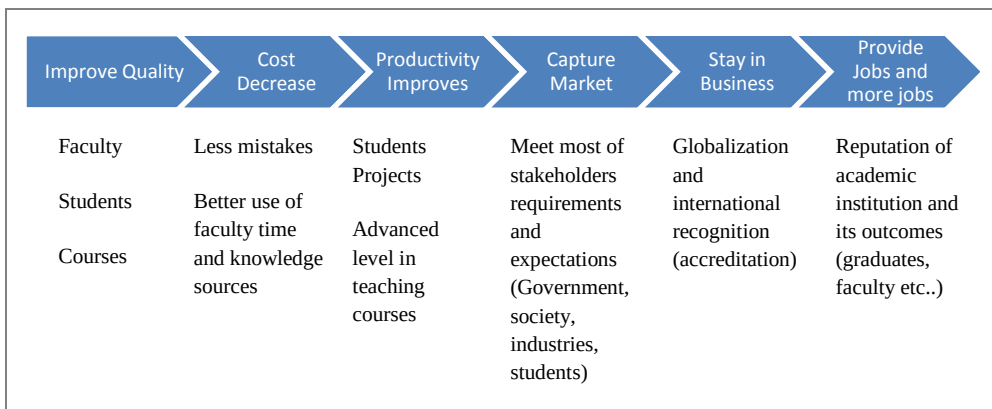


Figure 1: Deming chain quality reaction as for educational institutions.

How to ensure Continuous process improvement? The PDCA Cycle

The most common process of continuous improvement is the PDCA Cycle, which was first developed by Walter Shewhart in the 1920s, and promoted effectively from the 1950s by quality guru Dr. Edwards Deming, as a strategy to achieve breakthrough improvements in processes. The four steps in the cycle which is also known as the Deming Wheel, are as shown on figure 2: **PLAN** what is to be done and how it should be done; next, carry out the plan (**DO** it). Third, **CHECK** and analyze the results obtained and finally, **ACT** on the results by identifying what worked as planned and what did not, make a prioritization of the improvement opportunities and then carry on the improvements in the system.



Figure 2: The Deming wheel (PDCA Cycle) of continuous process improvement [9].

Seven phases have been identified by quality scholars to implement the PDCA cycle in the improvement process of an organization [1,10]:

- Phase 1 - Identify the Opportunity for improvement
- Phase 2 - Analyze the Current Process
- Phase 3 - Develop Optimal Solutions
- Phase 4 - Implement Changes
- Phase 5 - Study the Results
- Phase 6 - Standardize the Solution
- Phase 7 - Plan for the Future

The Seven Basic Quality Tools

Once the quality improvement process is understood, the addition of quality tools can make the process proceed in a systematic manner. Many quality tools are available for quality professionals for this purpose. Organizations use total quality management tools to identify, analyze and assess qualitative and quantitative data that are relevant to their processes. These tools can be generally classified into three major categories, namely: (a) the basic seven quality tools, (b) the seven new tools for management and planning and (c) other tools. The seven basic quality tools are simple tools that can be used by any professional to ease the quality improvement process; These are: flowcharts, check sheets, Pareto diagram, cause and effect diagram, histogram, scatter diagram, and control charts. These tools were originally developed by Kaoru Ishikawa, one of the pioneers of the Japanese quality movement. Ishikawa's original list did not include flowcharts; instead, it had graphs as one of the tools. These seven basic tools have been considered a part of Statistical Process Control (SPC), a quality management techniques that uses a set of tools to analyze, control, manage, and improve process quality. But not all seven tools are quantitative, let alone statistical. The flowchart is simply a visual description of a process while the cause-and-effect diagram is a brainstorming-based problem-solving procedure. Check sheets and Pareto diagrams are simply commonsense tools. Histograms, scatter diagrams, and control charts are the only statistical tools in the list. Kume in his book "Statistical Methods for Quality Improvement" [11] stressed that these simple tools should be taught to all members of Japanese corporations, from leadership to bottom line workers for the sake of quality improvement. Table 1 shows the seven tools and their applications within the PDCA cycle for process improvement.

Table 1: The 7 basic quality tools and their use in the PDCA improvement cycle.

Methodology							
Tools		Identify Opportunity	Analyze Process	Develop Solutions	Implement Solutions	Evaluate Results	Standardize Solutions
Flow Charts		✓	✓	✓			✓
Check Sheets		✓		✓	✓	✓	✓
Pareto Chart		✓			✓	✓	✓
Histogram		✓					✓
Cause and Effect Diagram		✓	✓	✓	✓		✓
Scatter Diagram			✓	✓		✓	✓
Control Chart		✓		✓		✓	✓

Quality pioneer Ishikawa stated that 95% of quality-related problems in any organization can be solved with these basic tools. This statement has been proven by many

organizations and researchers as it will be shown later. The key to their success in problem-solving and process improvement initiatives are their simplicity, ease of use and their graphical nature. The tools were originally meant to make process analysis less complicated for the average factory worker in Japan, but now they constitute standard analytical tools to analyze quality problems and develop and identify optimum solutions and standardize them. They can easily be taught to any member of the organization. These tools have been widely used in manufacturing and services embracing process-improvement initiatives such as Total Quality Management (TQM) and Six Sigma.

These tools have been extensively described in textbooks [11-16] and more recently by Aichouni [2-3]. A brief description of these tools is shown in the following section (Figure 3):

1. **Flowchart:** is a graphical display of the process steps in proper sequence. It shows all process steps under analysis by the quality improvement team, identify critical process points for control, suggest areas for further improvement, and help explain what is really done?
2. **Check sheet:** A structured, prepared form for collecting and analyzing data; a generic tool that can be used to identify how often a problem occurs.
3. **Pareto chart:** Shows on a bar graph which factors are more significant. What are the major problems in the process?
4. **Histogram:** The most commonly used graph for showing frequency distributions, or how often each different value in a set of data occurs. What the variations look like?
5. **Cause-and-effect diagram (also called Ishikawa or fishbone chart):** Identifies many possible causes for an effect or problem and sorts ideas into useful categories.
6. **Scatter diagram:** Graphs pairs of numerical data, one variable on each axis, to look for a relationship between process variables and factors.
7. **Control charts:** Graphs used to study how the process changes over time. It helps to identify the variations to be controlled and how this can be achieved?

RECENT APPLICATIONS OF THE BASIC QUALITY TOOLS IN MANUFACTURING, SERVICES AND EDUCATIONAL ORGANIZATIONS

As it was mentioned earlier, according to Ishikawa 95% of quality related problems in any organization can be resolved using the seven basic quality tools; This important statement can be proven from the amount and quality of research papers and articles published by quality practitioners and researchers in many different areas including manufacturing, construction and services [5,7,17]. It is important to note that these tools are listed under the Body of Knowledge (BoK) in the ASQ Certification Programs. Many conferences organized by professional societies around the world have been devoted to these tools; For example:

- ASQ Southwest Conference, Seven Basic Quality Tools, October 14, 2006, Main theme Back to basics – The 7 Basic Quality Tools : A full description of this event can be obtained from the Standards Newsletter of the measurement quality division of the ASQ at the web link (www.asq.org/measure/pdf/2006-12-the-standard-short.pdf).
- 2005 ASQ/Iowa Quality Centre Spring Conference, April 14, 2005: The conference was organized under the major theme : "Back to Basics", where most of keynote speakers addressed the use of the basic quality tools with the PDCA cycle to achieve process improvement in services such healthcare, education and warranty administrations.

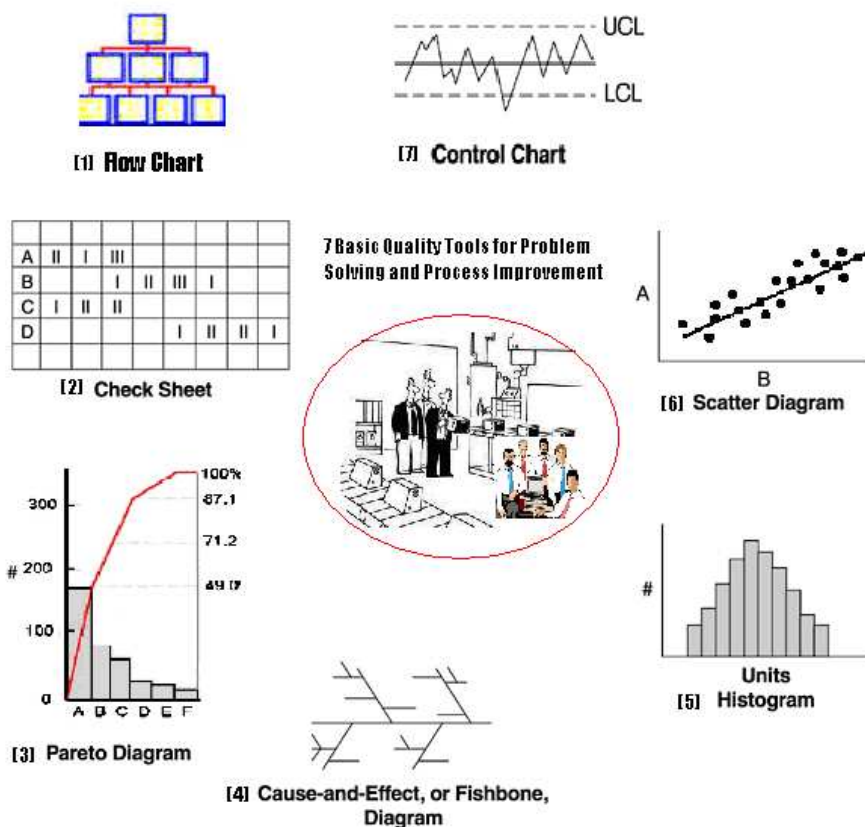


Figure 3: The Graphical Nature of the Seven Basic Quality Tools.

Table 2 summarizes a sample of research articles which show the effectiveness of the basic quality tools in problem solving and continuous process improvement in different organizations. These studies conducted by quality practitioners show that within

nowadays competitive environment, manufacturing and service organizations can continuously improve their processes to meet ISO 9000 requirements and achieve breakthrough improvements and business excellence using the basic quality tools together with the deployment of quality awards standards. The benefits gained by organizations fit well with the Deming chain reaction, which are quality improvement, costs decrease, productivity improvement, defect rate reduction, customer satisfaction and increased profits. It has to be stressed here that higher education institutions and faculty members can indeed get a lot of benefit out of this basic, simple and cost effective tools in order to improve the educational process. Recent studies presented by Steyn [9], Blonton [18] and Marks and O'Connell [19] show the effectiveness of such tools in improving the educational process in higher education institutions. These studies show clearly that there is no shortage of improvements for educational institutions to work on. However, choosing what to work on and what to improve is the question.

Table 2: Applications of the basic quality tools in organizations

Author	Publication Year	Applications Area
Blonton, P [18]	2002	Education
Marks and O'Connell [19]	2003	Higher Education
Carla A. C. [20]	1992	Human Resources
Gunther and Hawkins [7]	1999	Service Organizations
Dias and Saraiva [6]	2004	Manufacturing and services
Sahni, A. [17]	1998	Medical Devices Industry
Herrman [21]	2002	Feed Manufacturing
ReVelle and Margetts [22]	2010	Construction Industry
Mukhopadhyay and Nataraja [5]	2004	Mechanical Manufacturing
Calabrese et al. [23]	2007	Pharmaceutical Industry
Tennant et al. [24]	2007	Healthcare

USE OF QUALITY TOOLS FOR ENGINEERING COURSE IMPROVEMENT

In this section, the continuous process improvement approach using the seven basic quality tools will be adopted for improvement of an engineering course delivered at the University of Hail as a case study. An introductory engineering course delivered to first year engineering students at the University of Hail with total number of 536 students enrolled during the first semester 2009/2010. The students were subdivided into 20 sections, each section containing around 25 students. The PREP004 course titled "Introduction to Engineering" has as an objective to introduce preparatory year students to the basic concepts of engineering, the engineering profession, including the disciplines of mechanical, electrical, chemical, civil, and computer engineering. The course prepares students for success in their engineering education and their professional careers through the integration of engineering skills such as technical problem solving, engineering design, ethical decision-making, teamwork, oral and written communications, and engineering graphics. This course is a common course for students enrolled in

mechanical, civil, chemical, electrical, industrial engineering and management information systems, and computer engineering departments.

In order to study the educational process at the university and identify the major problems and the areas of improvement, the final results of the 536 students enrolled in the PREP004 course were obtained from the registration database and analyzed. These included the grades of the PREP004, English course, Mathematics, Physics and the GPA in High School for each student. A preliminary statistical analysis of the student's grades revealed the following results:

- A high drop rate of 34.3 percent (with grades DN, WF, WP, W)
- A failure rate of 9.2 percent (F)
- A success rate of 56.5 percent.

The histogram for the students population presented in figure 4, shows that a high drop rate is present in the course which is considered as a real quality problem in the educational process at the university. Causes should be identified and solved in order to improve the quality at the university especially at the first preparatory year. The overall performance of the students who finished the course up to the final stage, is acceptable since the grades were normally distributed from the highest grade (A+) to the lowest one (D). The failure rate represented about 9 percent was considered to be an acceptable rate by the course instructors. However, when examining the results for each section, considerable variability was found between the sections. For example, some sections exhibited an acceptable performance with a normal distribution (Figure 5-a) while other sections exhibited extremely poor performance (Figure 5-b) and other sections had very good performance (Figure 5-c). This high variability among the sections was considered by the faculty members to be a sign of poor quality and more important this was considered as an area of improvement. It must be mentioned here, that as stated by Deming [8], process variability is the enemy of quality; It is indeed a disease that threatens all sort of organizations and leadership should understand this process variability and work on the system to reduce and control it.

A root cause analysis for the problem identified earlier which concerns the high drop and failure rates in the course, was performed using the fishbone diagram through multiple brainstorming sessions with faculty members and students of the current academic semester. The results of this analysis which is presented in figure 6, revealed that there are many areas of improvement to be tackled in order to improve the quality of the educational process in this area of engineering education at the university. This would include:

- Improving the educator and student contact.
- Improving communication between students and the faculty and the university system through academic advising.
- Improving teaching methods by adopting e-Learning, m-Learning and all new instructional educational methods.

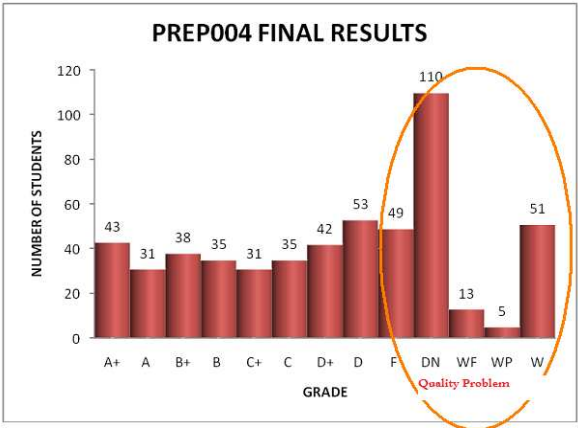
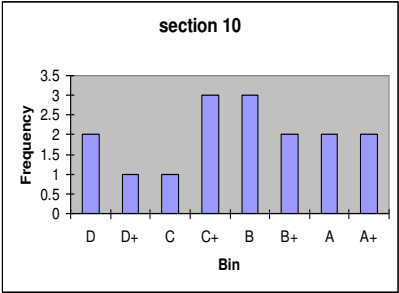
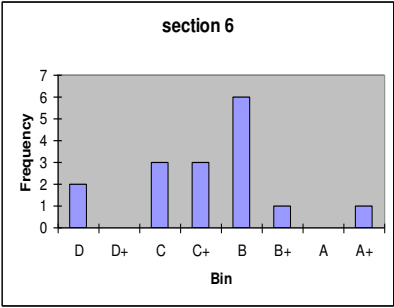
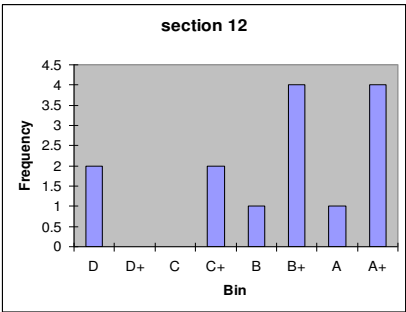
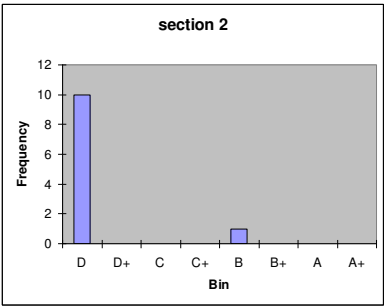


Figure 4: Frequency distribution of the final grades of the 536 engineering students.



a. Sections with normal performance



b. Section with poor performance

c. Section with good performance

Figure 5: Frequency distributions showing variability between sections.

The authors believe that the fishbone analysis would need careful consideration and analysis by decision-makers and leaders at educational institutions as well as by educators themselves since it revealed the hidden real causes for our students' failure to catch-up with engineering education especially in Arab countries with similar social habits and culture. In order to identify the possible relationship between the student performance in the engineering course with other variables such as their performance in English, mathematics, physics courses and their GPA in higher school, scatter diagrams were plotted for each variable and showed weak correlations between student performance in the engineering course and their performance in English and the remaining subjects indicating that other causes identified from the fishbone analysis should be investigated further in order to improve the educational process at the preparatory year program.

SUMMARY AND CONCLUSIONS

Total Quality Management has assisted business organizations to compete in a global market. It is a promising approach for improving various processes, including learning processes, in higher education. This approach aims at continuously meeting and exceeding the needs and requirements of the customer by employing an efficient measurement system which consists of a bench of quality tools and techniques.

The paper showed that understanding the engineering educational process so it can be improved in a systematic and cost effective approach using relevant quality tools. The paper suggests the use of the seven basic tools known as the magnificent seven to extract from raw process data very important information for the improvement of the educational process. These basic tools are of graphical nature (e.g., Figure 6) and are very easy to use and efficient, that any engineering instructor can master easily and use them for improvement. Briefly, these seven tools can help engineering educators and decision-makers at higher education institutions answer very important questions such as:

- The flow chart - What is done? And what are we really doing?
- Pareto analysis – What are the big problems we are facing?
- Cause and Effect Diagram – What are the causes for the problem?
- Histogram – What is going on in our process ? What is the nature of the variation?
- Check sheets – How often does it occur?
- Scatter Diagram – What are the relationship between factors?
- Control Charts – Which variations are to be controlled and how?

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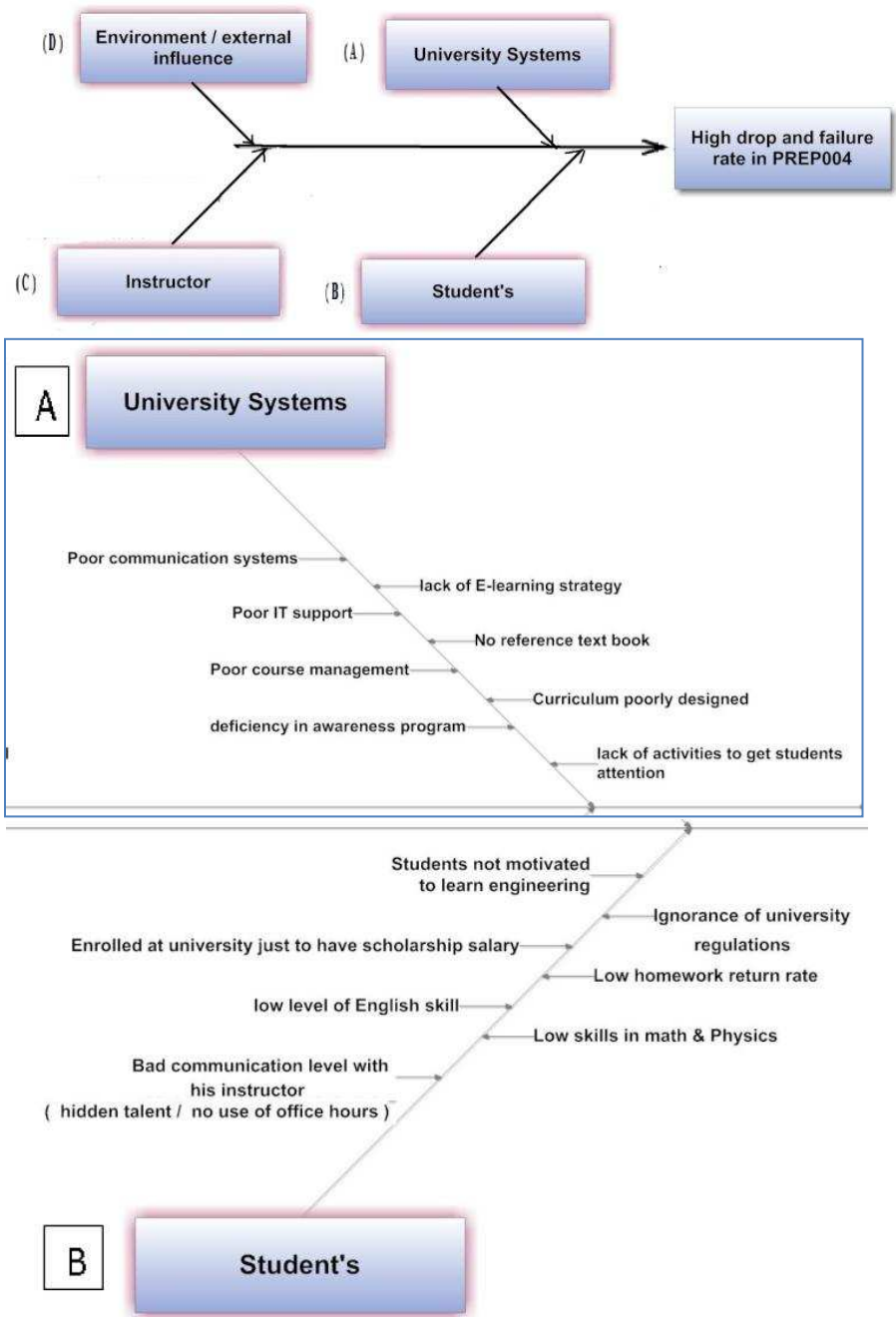


Figure 6 (Part A): Cause and Effect Analysis of the drop and failure rates in the engineering course.

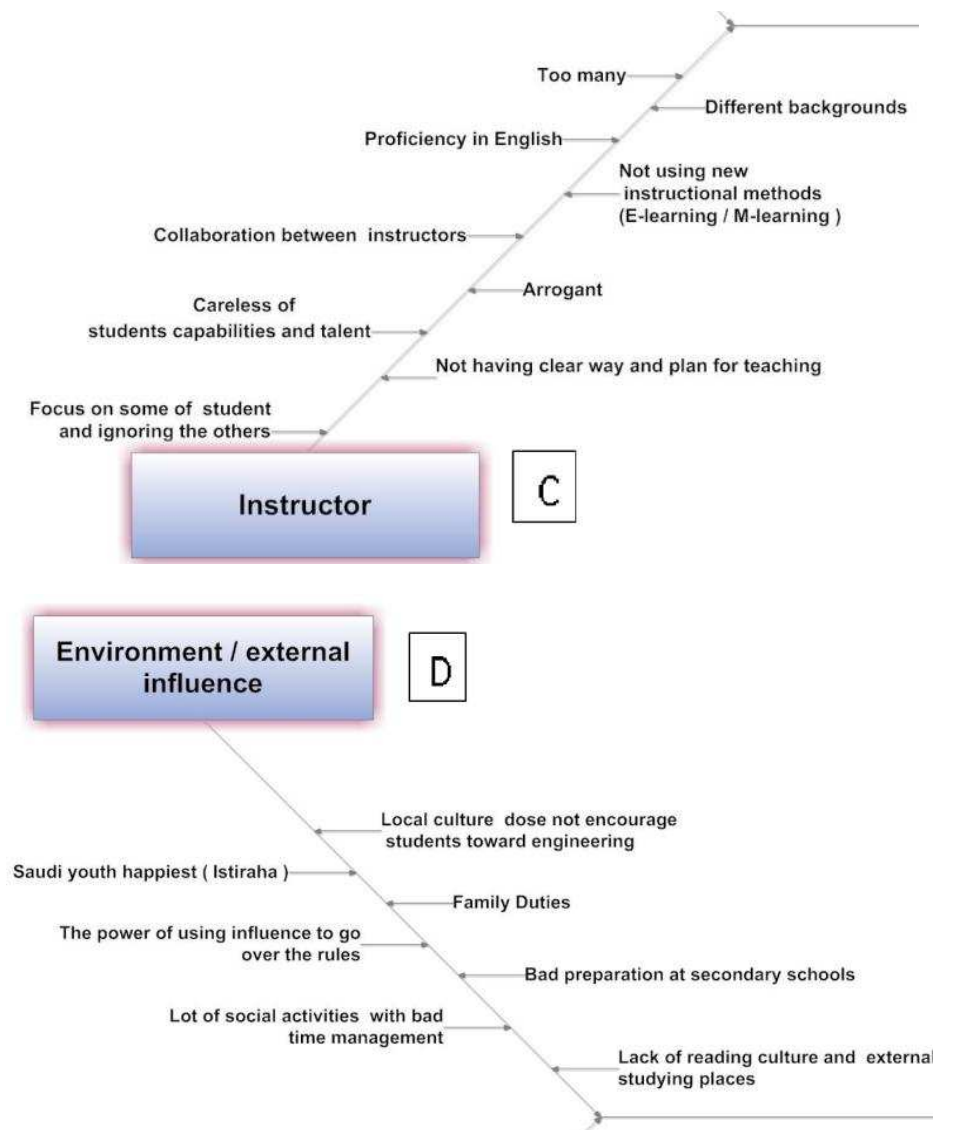


Figure 6 (Part B): Cause and Effect Analysis of the drop and failure rates in the engineering course

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THE ENGINEERING EDUCATION IN ALGERIA IN THE NEW SYSTEM (LMD): THE CASE STUDY OF THE FACULTY OF ENGINEERING, UNIVERSITY OF TLEMCEM

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ABSTRACT: The Algerian government has begun, in recent years, a global reform of the system of higher education to meet new system requirements imposed by the new socio-economical data. The choice fell on the "LMD: Bachelor-Master-Doctorate" system which examines and defines the ways and means to teach, study and evaluate differently in higher education. After five years of implementation, it is useful to evaluate (at least, locally) some important points of this system, where the purpose is the search for quality in the university. An investigation was then conducted at the Faculty of Engineering of the University of Tlemcen through a questionnaire made of 13 questions given to students. The results obtained, after analysis were very encouraging, even though the survey revealed some difficulties and other shortcomings closely related to the adaptation of the university community to the new system.

KEYWORDS: Evaluation; LMD; Questionnaire; Reform; Survey; Educational System.

INTRODUCTION

The Algerian University, like all universities in the world, symbolizes the knowledge and learning. Modern times have changed the role of the university whose main new tasks are summarized in the guideline of the Algerian Ministry of Higher Education and Scientific Research [1]. These missions are as follows:

- Provide quality training.
- Making a real osmosis with the socio-economic environment developing all possible interactions between the university and the outside world.
- Develop mechanisms for continuous adaptation to changing jobs.
- Be more open to global developments, especially those of science and technology.
- Encourage diversity and international cooperation by the most appropriate terms.
- To lay the foundations for good governance based on participation and consultation.

The Algerian university has gone through several reforms, according to the changing in socio-economical needs of the country as well as those of science and technology. The most important one is the 1971 which has structured higher education in Algeria and was intended mainly to "arabize and algerianize" all higher education. This system worked for a good time but in recent years it has shown its limits. In a systemic approach, the "university" system requirements were no more satisfied with the "classic" approach and an improvement or change was necessary. It was noted, especially the following deficiencies:

- Educational programs no longer meet the new socio-economical data.
- Training mono disciplinary in classical approach where concept of general culture is completely absent.
- A significant failure rate due primarily to uncertainty about the future among students.
- Lack of motivation among teachers and students.
- Centralized management of the university.

Given all these problems, reactions were necessary. Thus, the Algerian government has decided, from 2001 to diagnose the situation in order to provide immediate and sustainable solutions for higher education. A new “university system” has imposed itself.

Following the recommendations of the National Committee of the Education Reform, a reform plan was adopted by the Cabinet in April 30, 2002 and the Ministry of Higher Education and Scientific Research has adopted a ten-year strategy to develop the sector for the period 2004-2013, one of whose main themes is the development and implementation of an overall and deep reform of higher education, the first step is the establishment of a new architectural educations, including an updating and upgrading of various educational programs, and a reorganization of the educational management.

The choice fell on the new "LMD: Bachelor-Master-Doctorate" system to meet the expectations of society and also to be in concordance with the new guidelines and global trends in higher education. This system examines and defines the ways and means to teach, study and evaluate differently in higher education.

THE LMD SYSTEM

In a systemic approach, the LMD is a set of elements that interact, forming an integrated whole, working for a common goal. And as each system, the LMD has a well-defined lifecycle starting by the need the statement, then continue on design, production, use and lasting by phase-out and disposal (Figure 1). These steps are necessary for the successful accomplishment of objectives.

Currently, in Algeria, the system is in the use phase since most of Algerian universities have adopted the LMD. For this it is useful to note that the government has already injected through educational, scientific, human, material and structural colossal means to meet all requirements defined by new data and global trends. The progression along the life cycle of the system requires an effective approach to the review, evaluation and feedback.

With systematical approach, the LMD is designed so that all system components, including teachers and students have become involved in training and are no more spectators as in the “classic” system: the teacher has the opportunity to offer training courses tailored to the available resources and skills based on a pedagogical team and the student has the opportunity to choose the path that suits him. The student participates

actively in his training; the number of hours is therefore restricted to the training outside the university. In addition, student is better supported through a tutoring system in which the accompaniment is more active.

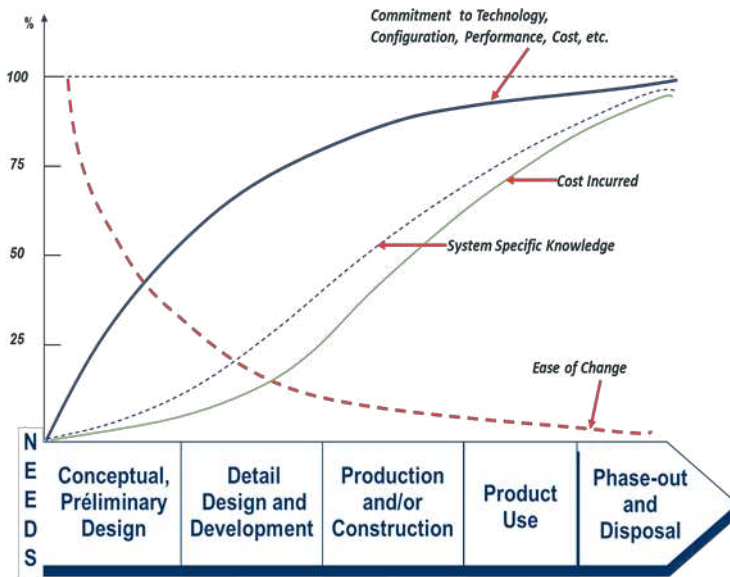


Figure 1: System life cycle [2].

UNIVERSITY ABOUBAKR BELKAID OF TLEMCEM

The University Aboubakr Belkaid of Tlemcen is one of the first Algerian universities to have opted for this new educational system "LMD: Bachelor-Master-Doctorate" whose main objectives are:

- Improving the quality of university education.
- The adequacy between university education and the needs of the working world.
- Development of academic training vocationally.

These objectives have led the university to do otherwise, by adopting a new culture of learning based on open, competitive and effective exchanges with all national and international partners who can participate in training.

The LMD system has been implemented at the University of Tlemcen since its first year of application, in 2004-2005 when many academic and professional LMD training offers were proposed to newly enrolled students.

The Faculty of Engineering

Like other faculties of the University Aboubakr Belkaid, Tlemcen, the Faculty of Engineering opted for the LMD system in its first year. It has received its first LMD students in 2005-2006 (in 2nd year) in two different domains, computer engineering (I) and science and technology (ST).

Despite the apprehension of students which is justified with any new system, 03 ST bachelor programs and 01 computer engineering bachelor program have started with a very small number of students. Today the LMD system has been extended to almost all departments (Table 1) and the faculty has proposed 27 bachelor programs, including six professionals and 22 master programs including two professionals. The first bachelor students graduated in June 2007, while the first master students graduated in June 2009.

Table 1. Number of bachelor and master programs by department.

Department	Bachelors	Masters
Biomedical Electronics	1	1
Automatics	5	5
Civil Engineering	5	5
Mechanical Engineering	9	5
Hydraulics	5	2
Computer Engineering	1	2
Telecommunications	1	1
Business Engineering	0	1
Total	27	22

With the number of bachelor and master programs offered, the number of students opting for this new system continues to grow up from one year to another as shown in Figures 2 to 4.

In addition to purely academic training, students have benefited from internships, field trips and visits to companies through the relationship developed in the framework of the LMD, between university and industry which is seen as a strategic axis to the socio-economical development and the terms that govern are based on an organized and structured approach.

Also, our university has been working to promote and strengthen the synergy with its immediate socio-economical environment on one hand, and international on the other through organizing regular forum "University-Enterprises" and exchanges of student interns as part of cooperation with foreign universities [3].

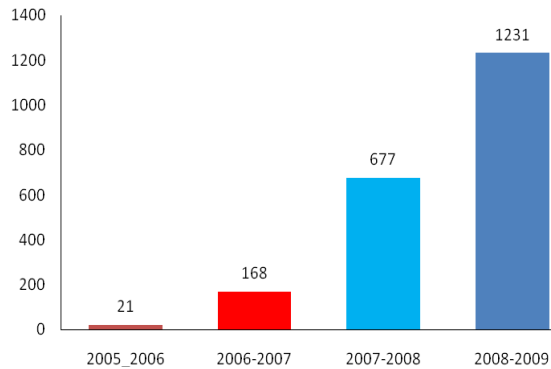


Figure 2: Evolution of LMD students over the past four years.

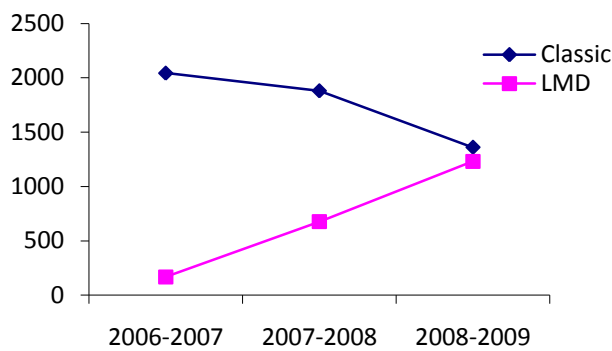


Figure 3: Evolution of students enrolled in classical and LMD systems over the past three years.

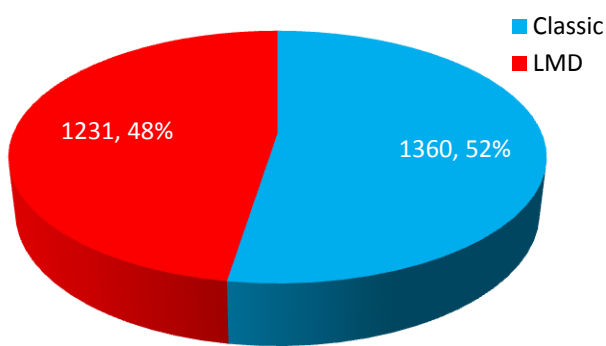


Figure 4: Comparison between classic and LMD students in 2008-2009.

THE LMD AT THE FACULTY: FIVE YEARS LATER

System Evaluation

Like any system, the LMD is submitted to the principle of evaluation which should be continuous throughout the life cycle, beginning with the design phase and extends through the use phase and support and ends when the system is disposed. Evaluation refers to the examination of the system (or a system component) in terms of relative value, quality of performance, effectiveness, estimated cost, etc.

The objective of the evaluation is to determine, using a combination of prediction activities, analysis and measurement, the true characteristics of the system to ensure that the system fulfills its mission successfully [2]. For our LMD system, the objectives of the evaluation are multiple; the most important ones are [4]:

- Audit the system (research into the causes of success or failure)
- Provide teachers with detailed feedback to make adjustments to improve teaching and promote learning
- Promote quality education and training
- Encourage communication between students and teachers
- Provide a budget, construction schedule, training...
- Determine the need for teachers...
- Check the extent of changes induced by an innovation of a new system etc (in case of LMD)

The LMD system can well develop a culture of evaluation that affects all elements of the system and in particular [5]:

- Characteristics of students and teachers
- Students and teachers performance
- Programs and didactics means
- Teaching /learning process
- Learning contexts
- Organization of the institution, its functioning and performance
- System itself: the LMD

So what should be evaluated? Given that the purpose of evaluation is the search for quality in the university, we can evaluate several aspects of the system; the most important are [6]:

- The level of satisfaction of the objectives of pedagogy (methodology of knowledge transmission, means of control of learning, list contents ...)
- The actualization of contents
- The effectiveness of teaching methods
- Consistency and reliability of instruments to assess knowledge and skills...

Thus, after five years of LMD training at the Faculty of Engineering, three years for bachelor and two years for master, we wanted to mark the graduating of the first master students by a simple evaluation process in order to lead, locally, corrective actions if necessary and thus solve interface problems and ensure good compatibility between system components.

The evaluation was done using the principle of closed questionnaire, which is simple to use and operate. This questionnaire was given to students to give their opinion on certain aspects of the LMD system.

Analysis of Results

Once collected the different filled questionnaires, a recount has been made to analyze the results. This questionnaire was given to 387 students from the 2nd year bachelor to the second year Master. The different given questions can be grouped into six main sections:

1. Importance of teaching units of foreign language and discovery
2. Student participation in pedagogical activities
3. Teacher-Student Relationship
4. System of Student Assessment
5. Pedagogical accompaniment of students
6. Pedagogical means for training

The responses are grouped into five categories: Very good, good, medium, low and very low with an opportunity to choose NC (not concerned) if the student finds difficult to make a decision.

Through the responses (Figure 5), it is understandable that this type of units is very important for students who pursue technical training. Over 60% of students felt that such education can be beneficial and it reinforces the philosophy of the LMD system based on the need to introduce general culture and discovery units related to other specialties or disciplines to broaden the academic culture and facilitate the bridging of reorientation.

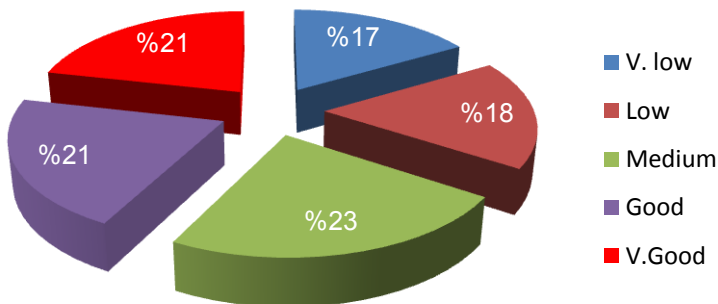


Figure 5: Importance of foreign languages and discovery units.

One of the most important objectives of the LMD system is the active participation of student in his training, from choosing the path that suits his desire to strengthening training far from the university. This involvement allows student to improve his independence and develop in him the spirit of initiative, unlike the classical system where the student was as spectator in the receiving position of the information. Seventy-three percent of students feel involved in their training (Figure 6).

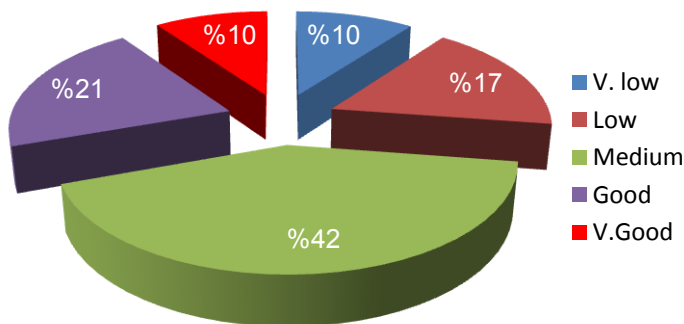


Figure 6: Students participation in training.

According to responses (Figure 7), only 37% of students are not satisfied with the pedagogical relationships established between teachers and students. This percentage is a little bit low and can be reduced more if teachers adhere closely to the philosophy of the system by changing their way of teaching. But the means should follow: Video projectors, computers, systems of distance learning, Internet, Intranet ...

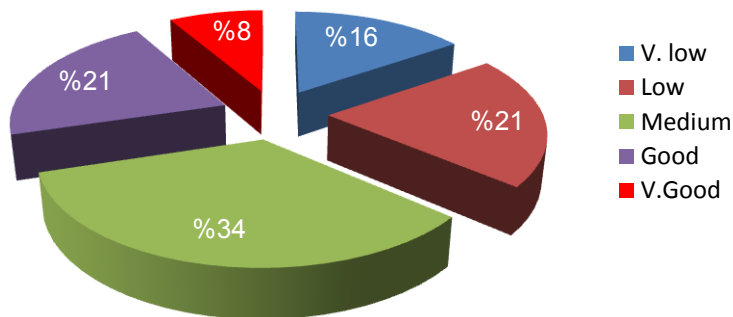


Figure 7: Teachers-students relationships.

The LMD system favors the evaluation based on continuous assessment which is based on a set of notes or assessments collected at defined stages of the learning process to support student progress. It is a formative assessment and provides feedback to students on their learning and to teachers about the effectiveness of their teaching. Most students (67%) are satisfied with this type of assessment (Figure 8).

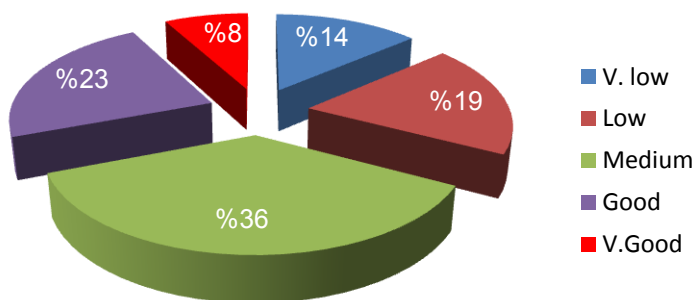


Figure 8: System assessment for students.

After the finding and the response of students (Figure 9), it is clear that there remain more things to do to improve in practice, pedagogical accompaniment of students, although the LMD system has given special attention to this point from several angles as the introduction of subsystems such as "team teaching" and "tutoring". In my opinion, it is still early (five years is not much) to say that these elements currently meet all system requirements.

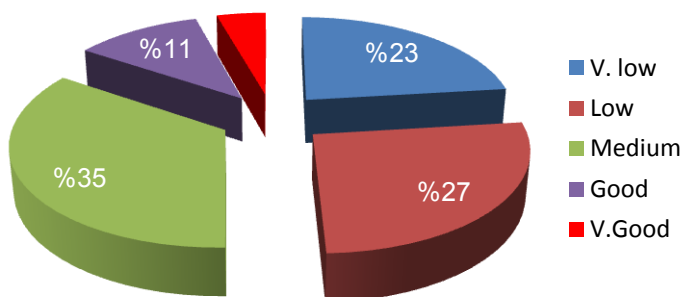


Figure 9: Pedagogical accompaniment.

Although the government has put enormous resources (material and financial), in recent years to support the system during operational phase, the results of the survey show that more resources are still needed. Only 53% of students are satisfied with the current material conditions (Figure 10).

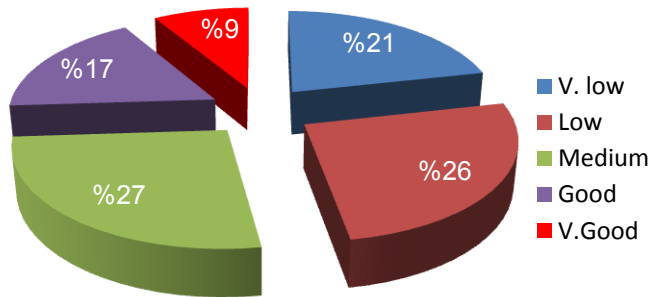


Figure 10: Teaching means for training.

CONCLUSIONS

The Algerian government has invested a lot in recent years on the new system, the LMD: Bachelor-Master-Doctorate, for the reform of higher education to ensure quality training that enables to hoist the Algerian university to the status of international university. The requirements for operating and maintaining this system are multiple and require time and resources to be satisfied.

The survey conducted at the Faculty of Engineering of the University of Tlemcen, with the help of students, for the LMD system has revealed some important points:

- The choice of "secondary," units known as general culture and discovery units create student motivation.
- The student, a key component of the system, is being more active throughout the life cycle of the system.
- The pedagogical relationships between teachers and students are more regulated and facilitate the transmission of information and knowledge.
- The system of evaluating students, in its new philosophy, is promising good results.
- Between practice and theory, pedagogical accompaniment needs more attention.
- Finally, the teaching means must follow to properly support the system during its use phase.

In summary, we cannot generalize this study to the entire system; other assessment surveys are necessary which must be continuous in time and space.

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A QUANTIFIABLE QUALITY ASSURANCE SYSTEM FOR ENGINEERING COURSES

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ABSTRACT: Engineering courses represent the core of engineering education. Measuring the quality of engineering courses is therefore an essential component in the assurance of the overall quality of engineering education. Local and international accreditation programs such as Accreditation Board for Engineering and Technology (ABET) also place emphasis on the role of engineering courses and insist on implementing a viable system for assuring their quality. A variety of educational and learning criteria are used by engineering colleges to assess the quality of engineering courses and to meet the requirements of national and international accreditation programs. In ABET, for example, meeting course outcomes stated in course syllabus is a key criterion for assessing course quality. These outcomes are often mapped with the outcomes of evaluated engineering program. However, ABET accreditation program does not specify the quality assurance system to be adopted by the evaluated program in order to prove their effort, display readiness, and successfully achieve course outcomes. Engineering programs vary in methods and systems used to synthesize various course elements in an integrated quality assurance system. These systems range from a checklist of various course constituents to sophisticated assessment techniques and auditing systems. The qualitative nature of these assessment systems makes it difficult to measure course progress, compare courses, and develop standard performance levels. This paper presents a quality assurance system that synthesizes various course constituents including the course work, instructing, delivery method, evaluation, accreditation, and continuous improvement. The system also quantifies the course quality attributes using ten Key Performance Indicators (KPIs). It then utilizes Analytical Hierarchy Process (AHP) to determine an overall course score based on the course rating in ten KPIs. The approach can be utilized for ABET accreditation, controlling and managing engineering courses, and general faculty development.

KEYWORDS: Quality Assurance; Education; Engineering; Course Assessment; Accreditation; Analytical Hierarchy Process.

INTRODUCTION

The need for developing a quality assurance system for technical educational programs in the academic institutions is widely recognized [1]. This is mainly due to the important role of technical education in economical and industrial development as well as to the growing number of engineering programs offered by universities (both public and private). In many countries, technical and engineering education is considered as a driving force capable of supporting the country's economy by graduating engineering specialists, professionals, and researchers. Toward this end, engineering education needs to undertake certain changes in curricula as well as in industry and society relation in order to equip engineers with the competitive knowledge and skills demanded by the market [2].

As emphasized by ABET [3], the engineering courses continue to play the main role in preparing engineers with the required engineering knowledge and skills. This paper is devoted to the development of a quality assurance system for technical courses in

engineering programs. The system is developed from key essential components that assure the quality of technical education while being easy to implement and driven by quantitative Key Performance Indicators (KPIs). Introduction of such system will lead to increased competitiveness and attractiveness of engineering programs as well as achieving program outcomes and meeting the requirements of accreditation systems.

Course teaching quality represents the core of the proposed system. A course quality assurance system means that each course instructor is responsible for monitoring its progress through critical evaluation of the course by stakeholders, and making changes to the course in response to their evaluation of various indicators [4]. Course stakeholders include current students and faculty members. The critical evaluation of the course is derived from student's evaluations, peer reviews, and accreditation requirements. The evaluation covers anything involved in the offering of the course, course portfolio, instructor portfolio, the progress of the student through the course, the induction of students, the teaching, and the infrastructure, such as access to computers and technology.

COURSE QUALITY ASSURANCE SYSTEM

The proposed approach is characterized by the collection and analysis of relevant data, with reference where possible to standards, the design and execution of an improvement process, the evaluation of the improvement, and a report on activity which is provided to the next level of organization external to the unit undertaking and responsible for the quality assurance. At the individual course level, the data will include those provided by the Course Performance Report, and those gathered by the faculty. The faculty member is responsible for undertaking the improvement process.

The analysis for each course will include not only analysis of relative data but also some means of comparing standards, such as comparison of data against national averages, or comparison with similar data from other universities, or benchmarking exercises if available.

The system provides guidelines and check list for course quality assurance. The system is developed using effective teaching guidelines and international standards. The proposed system includes six main modules:

1. Course Portfolio
2. Instructor Portfolio
3. Course Evaluation
4. Course Peer Review
5. Course Key Performance Indicators (KPIs)
6. Course Performance Report

Each module establishes and cultivates a certain quality attribute that contributes to the total quality of the engineering program. These modules are integrated into a systematic quantitative approach for establishing and maintaining a quality teaching system.

The course portfolio is the first developed taking into consideration key learning objectives and pinpointing means to achieve these objectives. It includes information specific to a particular course such as syllabi, course materials, sample assignments, and an explanation for the rationale behind the assignments, and how the teaching methods and the course materials help students achieve course objectives.

The instructor portfolio will be complementary to course portfolio. It describes and documents multiple aspects of the instructor credentials and teaching ability. It is a formative portfolio that is created for the purpose of personal and professional development.

The actual implementation of teaching philosophy and learning objectives will be measured through “Course Evaluation”. This includes a focused survey of students during the course and at end-of-class. The instructor can also add to the evaluation oral feedbacks from students.

The system includes a peer review for checking the quality of course portfolio, instructor portfolio, and class evaluation. Selected internal and external reviewers can participate in the peer review by filling peer review form.

Course data and evaluation are then analyzed and quantified using a specified set of Key Performance Indicators (KPIs). These KPIs are determined for critical teaching quality attributes. KPIs are aggregated in an overall score to drive continuous improvement. Course data, KPIs, changes, and improvement actions are summarized in a concise Course Performance Report. The report is updated each time the course is granted.

Proposed Procedure

The proposed course quality assurance system is implemented based on a systematic procedure that includes the 10 main steps:

1. Review course data (use course performance report and course portfolio (if not available, develop course portfolio)).
2. Update course portfolio and check for the availability of course resources.
3. Conduct critical evaluations (two by the instructor after exams and one by university).
4. Submit updated course portfolio and course evaluations to peer review
5. Compute course KPIs based on evaluations and peer review
6. Analyze overall course results and collect further data if required
7. Evaluate improvement actions and design course changes based on analyses
8. Undertake the improvement
9. Evaluate the improvement
10. Update course performance report

For successful implementation of the proposed quality assurance system, all the system procedure is represented in a flow chart that relates different constituents. The flow chart is shown in Figure 1.

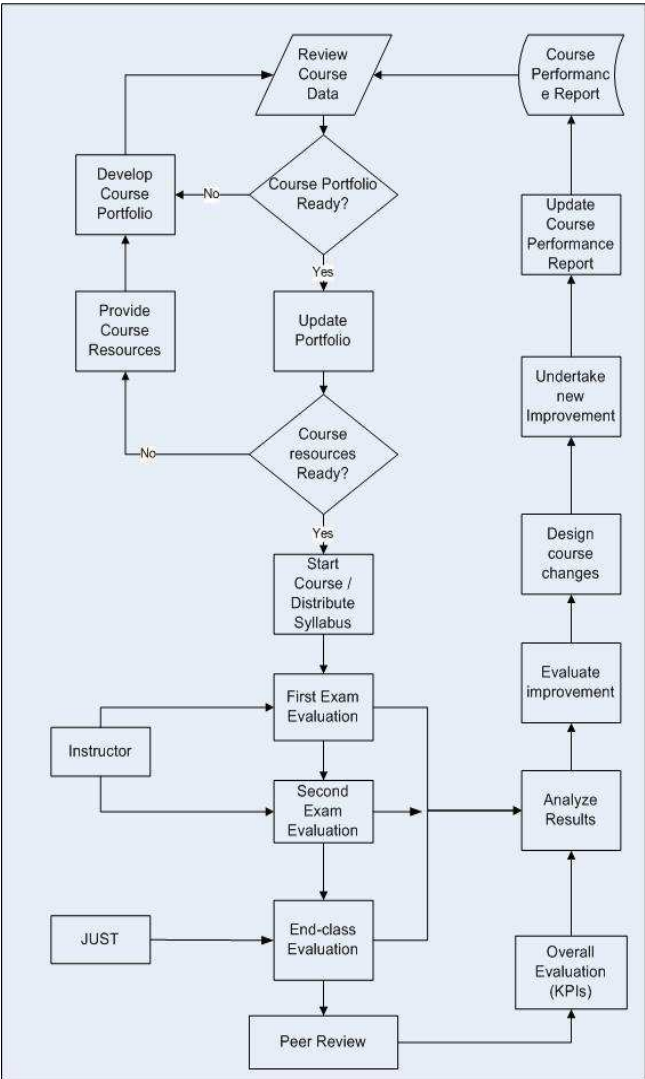


Figure 1: Flow chart of the course quality assurance system.

QUANTITATIVE COURSE KPIs

Course development, progress, and improvement actions are assessed based on their impact on a quantitative set of Key Performance Indicators (KPIs) and based on their compatibility with the overall objectives of the underlying engineering program. Although KPIs are defined to be quantitative measures, setting values for each course KPI actually summarizes both critical qualitative and quantitative measures of the course at a certain attribute.

A (0-100) score can be assigned to each KPI based on the source of assessment (e. g., student's evaluation and peer reviews, etc.). An overall course grade can be then determined by averaging out KPI scores. The proposed system emphasizes the fact that the selected course KPIs vary in their relative importance. This characteristic is essential in order to arrive at realistic and comprehensive course assessment.

In proposed system, the relative importance of each KPI is determined using Analytical Hierarchy Process (AHP) [5] and computed with the aid of ExpertChoice™ software tool [6]. In the proposed quality assurance system, course quality is measured in terms of the following KPIs. Each KPI is assigned a score of 0-100 by a certain assessment source or method as shown in Table 1.

Table 1: Quantitative Course KPIs.

KPIs	Source of (0-100) Score Assessment
1- Course Portfolio (CP)	Peer Review
2- Instructor Portfolio (IP)	Academic Department/Head
3- Delivered Material (DM)	Students Evaluation (Questions:1-10)
4- Instructor Effort (IE)	Students Evaluation (Questions:11-20)
5- Course Exams (CE)	Average of two exam evaluations
6- Students Performance (SP)	Average class grade
7- Accreditation Compatibility (AC)	ABET committee
8- Course Improvements (CI)	Course Focus Group
9- Course Resources (CR)	Instructor
10- Course Performance Report (PR)	Course Focus Group

The overall course score is determined as a weighted-sum of the course scores at the 10 KPIs and their relative importance weights (assessed using AHP). The next section shows how KPIs weights are assessed using AHP.

Analytical Hierarchy Process (AHP)

The analytic hierarchy process (AHP) is a multi-attribute decision making methodology which was first developed and applied by Saaty in 1977 [5]. Since its introduction, many different problems of multi-attribute decision making have been successfully investigated with the mathematical techniques of this approach. The application areas span from job selection to investment decisions. AHP, as a decision support tool, uses a multilevel hierarchical structure of objectives, criteria, sub criteria and alternatives. According to Saaty AHP methodology is based on the principles of decomposition, comparative judgments and synthesis of priorities. Decomposition structures the problem according to its main components: focus, set of criteria for evaluation, and the decision alternatives. Comparative judgments are required for pairwise comparison of criteria and investment alternatives so as to derive the criteria weights and relative priorities of investment alternatives. Finally the priorities of alternatives and the criteria for weights are synthesized into an overall rating based on which the best alternative is decided.

AHP also emphasizes on team decision-making thereby getting members of different departments involved in decision-making. The involvement of different departments with

in-depth knowledge on technical, strategic and economic issues makes sure that all the important criteria are included in the rating of different alternatives. The application of AHP ranges from investment risk to resource allocation and organization planning in fields, such as economics, politics, marketing, and management. Although the principles underlying AHP for decision support have been the subject of extensive debate, AHP has several advantages including ease, numeric translation of judgment, built-in consistency tests, and the use of appropriate measurement scales. In this project, we deal with the application of AHP in estimating KPIs relative importance weights.

In general, applying AHP in decision-making problems involves the following four fundamental steps:

1. *Model building*: Feasible decision alternatives are specified first prior to specifying criteria for the evaluation of alternatives. These criteria are further grouped into logical categories. A hierarchal structure is used to graphically represent the developed AHP model.
2. *Pairwise Comparison of categories and criteria*: The relative importance of criteria within each category and of each category within the group of categories is established through pairwise comparisons using a square matrix structure. The values of importance are taken from Saaty's 1-9 scale as shown in Table 2. The diagonal values in the matrix are set to 1 indicating equal importance of comparison an attribute with itself. The values underneath the diagonal are reciprocals of values above the diagonal. The developed pairwise matrix is subject to several operations in order to determine the relative importance weights of criteria or criteria categories.

Table 2: Saaty's (1-9) Scale of Relative Importance.

Scale	Definition	Explanation
1	Equal importance	Two activities contribute equally to the objective
3	Weak importance	Experience and judgment favor one activity over another
5	Essential or strong importance	Experience and judgment strongly favor one activity over another
7	Demonstrated importance	An activity is strongly favored and its dominance demonstrated in practice
9	Absolute importance	The evidence favoring one activity over another is of the highest possible order of affirmation
2, 4, 6 & 8	Intermediate values between the two adjacent judgments	When a compromise has to be made

The matrix entries are divided by corresponding column totals to obtain the normalized matrix. The total number of entries in that row divides the total of each of the rows having the normalized entries to attain the criteria weight.

3. *Pairwise comparison of alternatives*: Each alternative in the comparison or decision structure is rated with respect to every decision criterion in the evaluation model using the same (1-9) Saaty scale. Pairwise comparison is applied to obtain ratings for

qualitative data. If quantitative data's are available then the rating is done by existing or estimated performance data.

4. *Alternatives Rankings:* Finally ratings of the alternative are combined with the ratings of the criteria to form an overall rating for each decision alternative. The alternative with the highest rating is ranked the best choice, taking into account the relative importance of each criterion and the relative desirability of the alternatives with respect to each criterion.

The AHP is automated using spreadsheets and commercial software packages to make it easy for managers and decision-makers in applying the method. ExpertChoice™ is a commercial package that is commonly used in business and the industry to apply the AHP method.

Example of quantitative course assessment

In this section, we present the results of applying AHP method using ExpertChoice software package to assess the relative importance weights for the 10 KPIs defined earlier. These weights are essential to quantitatively measure the course quality in the proposed system.

1. *Pairwise comparison matrix of KPIs:* This matrix provides the relative importance of KPIs pairs using Saaty scale (1-9). Project team entered these pairwise comparisons based on their experience in education. For example, when comparing CP with AC, project time assigned 3 (indicating weak importance). Below the diagonal, AC relationship with CP will be the reciprocal (i.e. 0.33). The diagonal of the matrix is a vector of equal importance value (i.e. 1) and the part below the diagonal is a reciprocal of the part above the diagonal. Using ExpertChoice™ software, the developed matrix is shown in Table 3.
2. *Relative importance weights for KPIs:* The output generated from the software provides weights to each defined KPI along with a priority number (rank) for each KPI. The threshold for inconsistency ratio in AHP is 10%. Since the solution resulted in less than 10% inconsistency, it is considered acceptable. Table 4 shows the ranks of KPIs (from 1 to 10) and their corresponding relative importance weights in an ascending order.

The Pareto chart in Figure 2 provides values of KPIs weights values and priorities in an ascending order: From the chart, we notice that Instructor Effort (IE) has obtained the highest weight of relative importance (0.181) followed by Delivered Material (DM) with 0.166 weight, Course Resources (CR) with 0.130 weight, and Students Performance (SP) with 0.127 weight. These four KPIs contribute over 60% of course overall evaluation. Thus the focus of course improvement should be directed at these four KPIs. The last three KPIs (Instructor Portfolio (IP), Accreditation Compatibility (AC), and Course Improvement (CI)) are almost similar in weights (around 0.042).

3. *Determining overall course score (Evaluation)*: The overall score (evaluation) of the course is determined as a weighted-sum of course scores at KPIs using the assessed KPIs weights. For our course example, the course KPIs priorities (ranks), scores, and weights along with the resulting overall course score (a weighted sum of the 10 KPIs scores) are summarized in Table 5.

Table 3: Pairwise comparison matrix of course KPIs.

	CP	IP	DM	IE	CE	SP	AC	CI	CR	PR
CP	1	3	0.33	0.25	2	2	3	2	0.5	2
IP		1	0.33	0.2	0.2	0.2	2	2	0.5	1
DM			1	0.5	3	3	2	2	1	3
IE				1	2	1	2	2	2	2
CE					1	1	3	5	0.5	3
SP						1	6	5	0.5	3
AC							1	1	0.33	1
CI								1	0.33	1
CR									1	1
PR										1

Table 4: KPIs ranks and relative importance weights.

Rank	KPI	Weight
1	Instructor Effort (IE)	0.181
2	Delivered Material (DM)	0.166
3	Course Resources (CR)	0.13
4	Students Performance (SP)	0.127
5	Course Exams (CE)	0.108
6	Course Portfolio (CP)	0.106
7	Performance Report (PR)	0.052
8	Instructor Portfolio (IP)	0.045
9	Accreditation Compatibility (AC)	0.042
10	Course Improvement (CI)	0.042

Inconsistency = 0.09 with 0 missing judgments

SUMMARY

This paper presented a quantitative approach for assuring the quality of engineering courses. The approach recommends 10 KPIs to quantify the multiple aspect of an engineering course quality. AHP is used to assess relative importance weights for the course KPIs and to estimate an overall score of the course. The overall score (evaluation)

of the course is determined as a weighted-sum of course scores at KPIs. The overall course score can be used to compare courses, to measure performance, and assess conformance to university and accreditation standards. Course improvement actions can be then recommended at each cycle of course evaluation. Monitoring and improving the quality of engineering courses is likely to result in an overall improvement of the underlying engineering program. The approach can be adapted to be used for assessing ABET course outcomes and other local and international engineering accreditation programs.

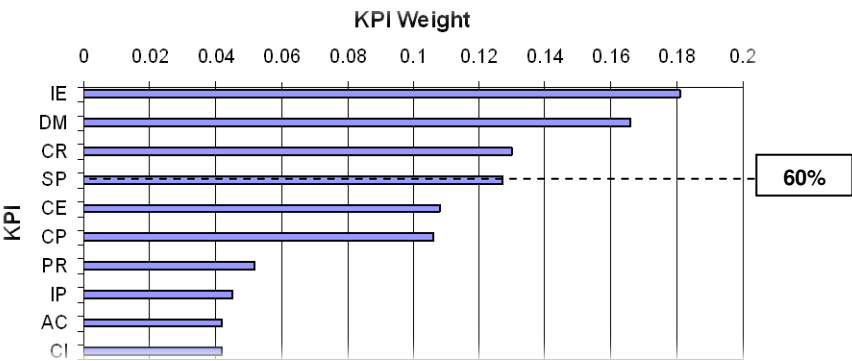


Figure 2: Pareto chart of KPIs weights.

Table 5: KPIs ranks, weights, and scores.

Rank	KPI	Weight	Score
1	IE	0.181	85
2	DM	0.166	78
3	CR	0.130	90
4	SP	0.127	68
5	CE	0.108	65
6	CP	0.106	90
7	PR	0.052	75
8	IP	0.045	80
9	AC	0.042	55
10	CI	0.042	80

Overall Course Score (weighted Sum): 78.40

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INTELLIGENT EVALUATION IN EDUCATIONAL CONTEXT

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ABSTRACT: The idea is to conceive an intelligent computing system of decision-making aid. In the context of teaching learning, the quantification of the human behaviors is the key to this system's innovation. That gives an opportunity of measuring the professional acts of the teachers in class and makes possible to locate the practices compared to the pedagogical theories, and especially compared to the constructive approach. In addition, this system helps to identify the student's styles of learning; therefore it places, at the disposal, information which facilitates to the teachers the adaptation of their pedagogical methods so that the student can benefit of an optimal assimilation.

With this intelligent computing system the students can also profit from an innovating alternative: result of the web based performances analysis in summative evaluation. It is a generated report, for each student, automatically at the end of the seizure of the marks stipulating in details their weak points and specifying the adequate remedies in terms of activities to be realized to proceed to reflexive regulations in order to raise their levels of assimilation. A successful system is starting from observable behaviors in classrooms and of performances seized remotely via the Web, to quantify in a rational way the cognitive and emotional states of the actors of the context of teaching learning.

The general objectives of the system would be: classifying the profiles of the teachers starting from their professional competences based on their pedagogy, behavior and attitude, classifying the learners' profiles by analyzing their interactions and analyzing their performances in summative evaluations, adapting the resources of the teacher's pedagogical methods in order to have a better coherence with the profiles of identities, the profiles of motivation and the profiles of comprehension of learner.

KEYWORDS: Evaluation; Statistics; Fuzzy Logic; Learner Profile; Teacher Profile; Educational Context.

INTRODUCTION

Since few years, several expert systems in educational field have appeared. They aim to classify and assist the decision making whose complexity increases with the development of the tools and the techniques related to decisional data processing. This observation is not limited to technical field but also related to the educational field and more precisely to the diagnosis and the evaluation of the process of teaching-learning. On the basis of a medical vision, the diagnosis is an activity of identification of the causes of a physical or human system's dysfunction starting from the observation of its revealing symptoms. Frequently, the dysfunctions are diagnosed starting from a whole of associated symptoms named characteristic syndrome. The relevance of the diagnosis is strongly dependent on the complete observability of the device.

We could, also, add that the etymology of the diagnosis term means "knowledge through signs". Therefore, a diagnosis of the profiles of the actors of teaching learning can be

interpreted as the knowledge of the cognitive state of the actor (teacher and/or learner) of the context through his actions and his reactions at the time of an activity of teaching training.

To teach and learn are equivalent to buy and to sell: to sell is to provoke the purchase, to teach it is to provoke, to stimulate, to guide the learning. The existential learning is more striking in the life of the learner than the school learning. An excellent experimented teacher is capable of educational performance that the theories which are results of the educational researches in learning cannot either explain or plan.

The purpose of the learning is not the knowledge but the action. It is difficult to find objectively another means of measure of the learning except for the evaluation of observable and measurable behavior. To teach is an extensive concept. It does not mean passing on the information, but especially provoking, organizing, facilitating, managing a learning. In other words, "teaching is not telling". So why do we need to evaluate the process teaching-learning! Here are several reasons:

1. It assures the evolution of the instructions which encourage the reflexive practices and the collaboration between teachers.
2. It allows to identify and to measure the development of the activities of the teaching team.
3. The process of selection which it engenders can be validated.
4. It represents a fruitful, relevant, and reliable link of communication which can be the fruit of a well-structured process of evaluation.
5. The personal decisions of keeping back, transfer, promotion exclusion etc. can be more relevant through the effective process of the evaluation.
6. To be able to assign an intense program of training and assistance to the new and incompetent teachers to heighten their professional level and protect the learners of their educational failures.

THE INTELLIGENT COMPUTING SYSTEM

From there comes the idea to conceive an intelligent computing system of decision-making aid, in this context, which is a reliable tool in the hands of the secondary education's inspector. A system able to manage the variable characteristics of the learner and the teacher in order to facilitated a reliable decision making of what must be recommended for each whole of circumstances, thus avoiding the recourse to the intuition and subjective and non-describable decision making in deterministic terms. An able system, starting from observable behaviors in classrooms and of performances seized remotely via the Web, to quantify in a rational way the cognitive and emotional states of the actors of the context of teaching learning. This expert system aims to the following general objectives (Figure 1):

- To classify the profiles of the teachers starting from their professional competences based on their pedagogy, behavior and attitude.

- To classify the learners' profiles by analyzing their interactions and analyzing their performances in summative evaluations.
- To adapt the resources of the teacher's pedagogical methods in order to have a better coherence with the profiles of identities, the profiles of motivation and the profiles of comprehension of learner.

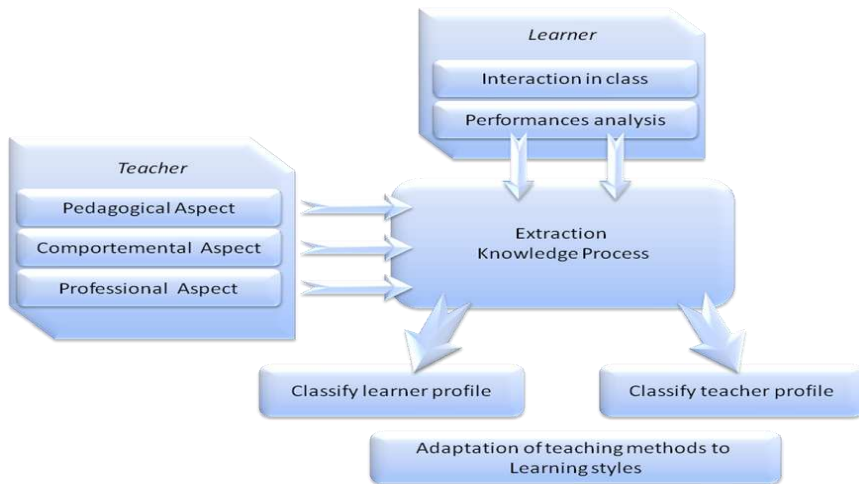


Figure 1: Adaptation of teaching methods to learning styles.

The organizational structure of this expert system is hybrid. Indeed, it is computer software installable on the laptop of the inspector and whose entries are seized, on the one hand, in class by the inspector. He interacts with the system using an interface man machine based on grids of teaching and didactic functions which we will detail later on. On the other hand, the marks of the students' summative evaluations are collected by the remote system starting from a Web site placed at the disposal of the students.

By trying to derive the essential factors which characterize the different approaches defining the learning, we notice that the role of the student is essential. While building the knowledge he builds himself and by building himself, acquires knowledge. This interactive process of teaching and learning is modeled in five categories (Figure 2) according to Lebrun [1].

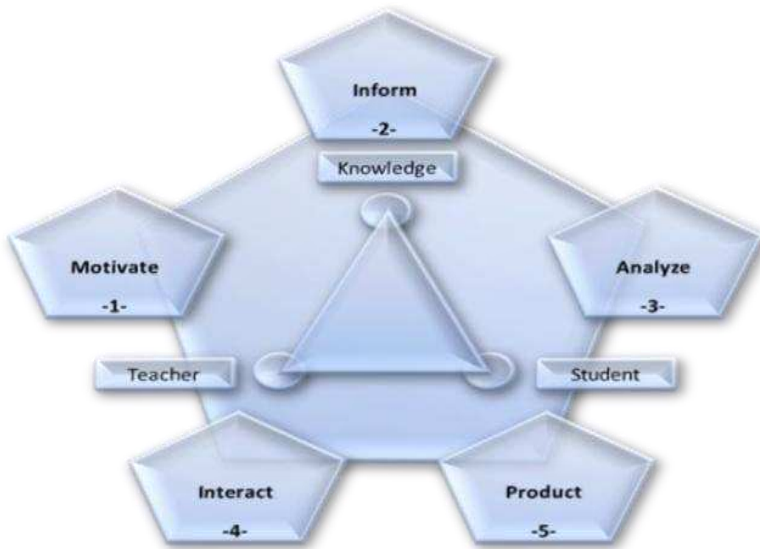


Figure 2: The interactive process (five categories) of teaching and learning modeled by Lebrun

THE STAGES OF A SEQUENCE OF TEACHING-LEARNING

In learning process (Figure 3), we proceed generally by the introduction of a connexion with a new situation, by evoking a problem familiar with the context known by students. So that we can present an authentic opportunity to judge their knowledge and their skills. And because the sense is given through the structure of what is presented to the student as object of understanding, we give means of apprehension of this structure to reach the meaning. On one hand, this context would be rewarding only if it brings the student to grant a value to the task which is proposed by identifying elements, facts, operations which make sense for him. On the other hand, this context has a power of evocation and a potential of enlargement because of its direct connexion with reality, demands and needs: that provokes coverage and a control by the student.

The following stage illustrates the importance of the access and the collection of the information. So, we proceed to the collection of information from the context, points of view of the students and their various representations, the centers of resources are places of meeting, the information is put in its context.

The stage of analysis teaches gradually to the learners to build tools of searching information, the structuralization, the comparison, the categorization and the confrontation. It is to develop the capacity to manipulate the world of the descriptions, relating and manipulating the various forms of representation.

The stage of interaction exploits the interactive and cooperative character of the learning, emphasizes the importance of factors relative to the communication and to the teamwork, and because without action feedback is unproductive for a learner, we use the intrinsic feedbacks with regard to the action or extrinsic with regard to the representations, what allows the student to be situated.

Finally, the stage of personal production illustrates the importance of the activity of creation, the role of the self-assessment, the promotion of the change and the reflection «méta »: learn to learn. It is a stage of recontextualisation during which the student builds personal information

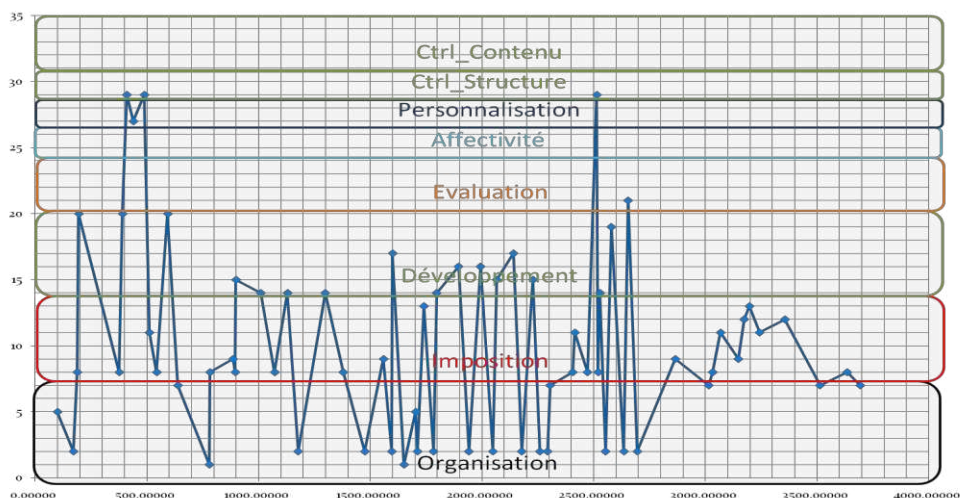


Figure 3: Different stages during a teaching session

TEACHERS' ACTING PROFILES

The educational relation is a set of verbal and non-verbal exchanges which characterize the educational act. These exchanges are influenced by the educational methods practiced by the teacher. DeLandsheere and Bayer [2] classified these exchanges according to seven categories, called educational functions, which cover the essential events of the school life (Figure 4). Every educational function is characterized by a set of measurable acts, which, once identified, translate in their existence, and their chronology the action plan of the teacher, his way reasoned to organize a practice, which adjusts beforehand the operations to be achieved. This consciousness does not result only from its theoretical knowledge but especially from the implementation of this knowledge on the ground.

Verbal and non verbal behavior	Function of								
	Organization	Concretization	Imposition	Personalization	Development	Evaluation		Affectivity	
						+	-	+	-

Figure 4: The seven educational functions

PEDAGOGICAL ASSESSMENT

The function of organization fixes the conditions and the context where the act of teaching learning must be given. The function of imposition is relative to the contents of teaching or to the context of departure facilitating the stimulation. The teacher to assure the development of intellectual and psychomotor faculties of the student implements the function of development conceived by educational and didactic techniques.

The function of personalization appeals in the required meadows and the acquired meadows of the student, including his appropriate difficulties. The function of positive and negative evaluation informs the student of the quality of his performance. The function of negative or positive affectivity connected to the person of the student. Finally, the function of concretization, which characterizes the didactic, visual, hearing means and the techniques, used to canalize the information to the student to aim an optimal acquisition of the knowledge.

Every verbal and nonverbal act of the teacher must be categorized in the adequate educational function, the corresponding temporal durations must be measured during the progress of the session. A tool of acquisition was conceived, offering a friendly interface formed by the grid of the functions and its criteria. We need just to click every criterion detected in the educational act so that the algorithm counts the durations of the corresponding acts, it collects them and makes the accumulation by category. The collected data are registered in a spreadsheet. This algorithm was beforehand validated before its systematic use to make sure that its degree of adequacy and precision is sufficient. This being realized, we operate it and we proceed to the data collection.

As first approach, we opted for the visualization of the statistical results in the form of histograms in two axes representing the educational functions on the X axis and the final accumulation of the frequencies on the Y axis (Figures 5 and 6). This has an effect, not only, on the comparative visualization of the quantities of the frequencies of the educational functions between them, but especially, between the same functions measured during successive visits.

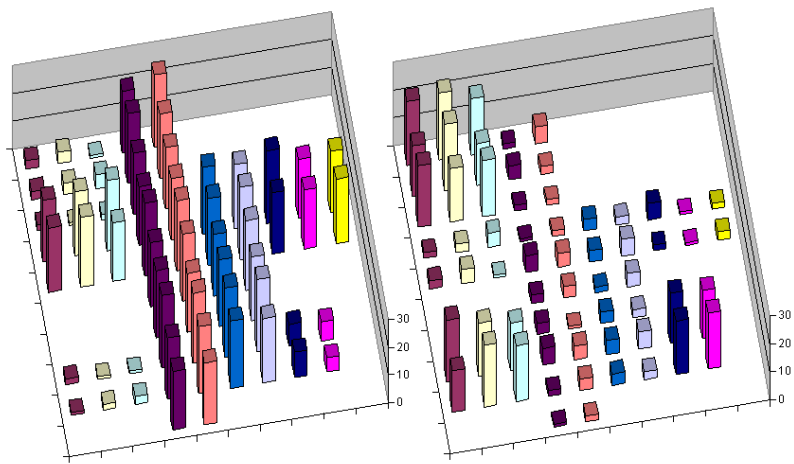


Figure 5: Assessment of interaction teacher-learners in the classroom.

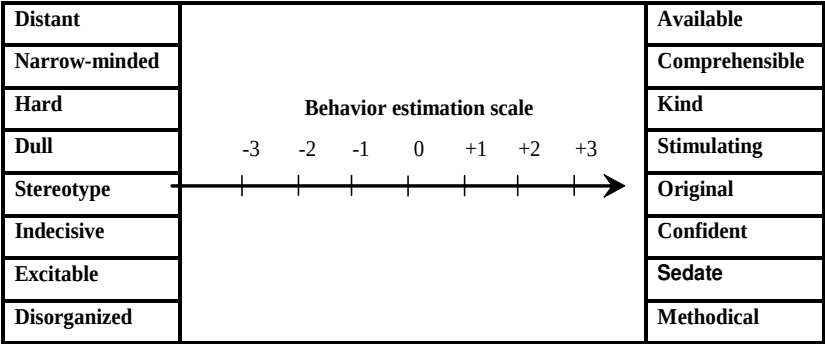


Figure 6: Behavior estimation scale (Ryans grill).

BEHAVIOR ASSESSMENT

Because the teacher is not perceived by his learners only on the cognitive plan but also from the point of view of the being: " we teach what we know with what we are ", it would be pertinent to proceed to the evaluation of attitudes, the behavior and the methods of the teacher, especially that within his personality, the same order is preserved if we went from what is the most spontaneous to what is the most built, the most finalized and the most organized.

CONCLUSIONS

Through this paper which proposes a qualitative study of the process teaching-learning various pedagogical functions were analyzed and highlighted. Thanks to the intelligent computing system, the real-time observation of the activity of teaching allowed to bring a new glance on the understanding of attitudes and behaviors of teachers and students at the same time.

In fact, during our research the teachers felt a major interest to the reports established to the point that they applaud them as soon as the session is ended. They often ask for clarifications on the meanings of the educational functions of which their performances are lacking. We notice that in several cases, following the last visit, the function of development becomes more dominant than imposition. We also notice that the personalization appears and the negative or being lacking affectivity appears positively. In certain cases, and especially for the oldest of the teachers, they find difficult to give up and change the practice of imposition for the benefit of development. In spite of this, we notice that the practices of development evolve even when the imposition stagnates.

All the visited, former or new teachers saw in their professional practices a relative evolution towards the acts which facilitate the concentration of the student in the exercise of their function of teaching-learning.

Finally, we think that learning must be significant. In other words, it has to fit into a network of things and elements known and lived by the learner. The effective and successful teacher is the one capable of varying his style and strategies of teaching. The concept of style is more operational than those more classic, extensive and restrictive as: method, system, technique, attitude, skills, etc.

The evolution and the development of the teaching-learning is a unique opportunity offered by a fair, valid, understandable and reassuring evaluation. The intelligent observer or computing system raises the profile and the style of the teacher and helps him to correct his defects and to strengthen his assets. It also allows to quantify and to qualify the educational functions of the teacher. It could help to produce what we call an "Educational ID card" of the teacher which can be periodically updated. This ID card can be used to estimate performance of teachers and to establish a qualitative diagnosis of the actors of educational system on a regional or national scale.

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PROGRAM EDUCATIONAL OBJECTIVES AND OUTCOMES ASSESSMENT – THE CIVIL ENGINEERING PROGRAM AT THE UNIVERSITY OF SHARJAH AS CASE STUDY

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ABSTRACT: During four years (2006-2010), the Civil Engineering Program (CEP) offered by the Department of Civil and Environmental Engineering (CEE) at the University of Sharjah (UoS) went through two accreditation cycles: accreditation by the Commission for Academic Accreditation (CAA) of the Ministry of Higher Education (MOHE) in the United Arab Emirates (UAE); and accreditation by the US Accreditation Board for Engineering and Technology (ABET). The discussion in this article is focused on assessment of: Program Educational Objectives (PEO); Program Outcomes (PO); and Program Criteria (PC). Assessment, combined with documentation of objective evidence, is meant to demonstrate that the PEOs, POs and PC are adequately addressed, assessed and achieved. In this article, the assessment approach used by the CEP is described and the evaluation results are presented and discussed.

Keywords: Civil Engineering; ABET Accreditation; Program Assessment; Course Assessment; Program Educational Objectives; Program Outcomes; University of Sharjah.

INTRODUCTION

The University of Sharjah (UoS) was established in 1997 with five colleges, including the College of Engineering. The College of Engineering started with two departments; Department of Civil and Environmental Engineering (formerly called Department of Civil Engineering); and Department of Electrical, Electronics, and Computer Engineering. Since 1997, the Department of Civil and Environmental Engineering offered one undergraduate program; the Civil Engineering Program. The first batch of students (69 students) was admitted into the Civil Engineering Program (CEP) in 1997 following the "1997 CEP". Since 1997, the program has undergone significant modifications and improvements, with the latest version of the program designated as "2010 CEP".

Accreditation of the CEP is mandatory according to the requirements of the Commission for Academic Accreditation (CAA) of the Ministry of Higher Education and Scientific Research (MOHE) in the United Arab Emirates (UAE). The MOHE requires that initial (or in-principle) accreditation is gained before offering a new program for the first time. As such, the civil engineering program gained initial accreditation from MOHE in 1997, then gained full accreditation after graduating the first batch of students from the program.

The CEP program leads to a degree titled: Bachelor of Science in Civil Engineering (BSCE). However and to advance sustainable development education in the program, the Department decided to offer, under the umbrella of the civil engineering program, a new

"Concentration in Environmental Engineering." The concentration is simply based on the choice of three of the four civil engineering electives in the curriculum from the basket of environmental engineering electives. In addition, students who chose the concentration are required to focus their capstone senior design project on environmental engineering design and/or environmental and sustainability considerations. In effect, the environmental engineering concentration is an internal arrangement in the Department.

Program assessment requires a documented assessment process that involves identifying, collecting, and preparing data to evaluate the achievements of program outcomes and program educational objectives. Furthermore, program assessment is needed to indicate the level to which the program outcomes are being achieved, with evidence that the assessment results are applied to further develop and improve the program. Therefore, the main purpose is to assess whether a program is meeting its stated objectives and achieving the learning outcomes and that there is a rational basis on which program revisions and improvements can be based.

The following sections describe a comprehensive assessment process that is used by the CEE Department at the UOS in assessing its undergraduate academic program for meeting program objectives and achieving stated learning outcomes. The system provides two levels of assessment: course and program; and includes collecting, organizing and analyzing data for each program educational objective or program outcome.

DEPARTMENT MISSION AND PROGRAM EDUCATIONAL OBJECTIVES

Outlining a realistic vision and developing a mission statement are among the first steps for any academic department. To achieve and realize the mission, the program educational objectives (PEOs) should be extracted from the mission statement. On the other hand, accrediting bodies, such as the UAE's CAA and ABET, require that programs satisfy certain criteria and demonstrate the achievement of specific outcomes. The criteria usually pertain to the desired standards that a program should meet.

The mission of the CEE Department at UoS is to support the development needs of the United Arab Emirates community and the region through providing quality educational programs, contributing to the discovery and application of knowledge through research, and serving the community and the Civil Engineering profession. The undergraduate civil engineering program at the UoS aims to produce graduates who:

- PEO(1). are prepared to practice the civil engineering profession responsibly for the benefit of the community.
- PEO(2). will achieve, upon few years of practice, levels of technical knowledge and professional expertise necessary for career advancement and assuming leadership positions in the Civil Engineering profession.
- PEO(3). will pursue scientific inquiry and lifelong learning opportunities, such as self-directed learning, graduate studies, participation in professional activities, and continuing education.

The linkage between the Civil Engineering Program Objectives and the undergraduate educational missions of the College of Engineering and the University of Sharjah is shown in Figure 1.

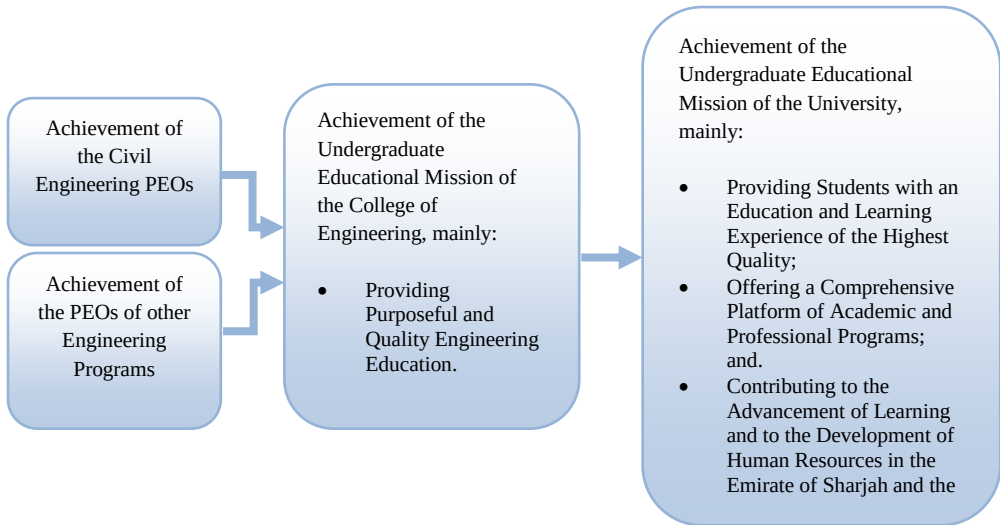


Figure 1: Linkage between the Civil Engineering Program Educational Objectives and the College and University Undergraduate Educational Missions.

PROGRAM EDUCATIONAL OBJECTIVES ASSESSMENT

The CEP employs a number of tools to assess the achievement of the Program Educational Objectives (PEOs) and Program Outcomes (POs). For the past 10 years, the Department has used a well-established tool to assess the achievement of the PEOs and the program outcomes (POs) in every assessment cycle [1-4]. The assessment tools for both the PEOs and POs can be classified under the following two categories:

1. Internal assessment, which is mainly focused on assessing the level of achievement of the courses learning outcomes and hence the program outcomes; and
2. External assessment, which is mainly related to assessing the adequacy, relevance and degree of achievement of the PEOs and POs.

The following assessment tools are used by the CEP to directly assess the achievement of the PEOs:

1. PEOs Survey
2. Alumni Survey
3. Employers Survey

In addition, the following assessment tools are used by the CEP and are considered to be indirectly related to assessing the achievement of the PEOs:

1. Exit Survey of Graduating Students
2. Internship (Student Training) Survey by Employers

Therefore, the results of these five surveys were utilized to assess the achievement of our PEOs. The results are described in the following section.

PEOs Assessment Results and Discussion

In this section, the PEOs assessment results are discussed and appropriate conclusions are made. It is worth mentioning that the assessment results were normalized on a 4-point scale, with the minimum achievement level set to be 2.0 (C grade).

PEOs Survey Results

The PEOs Survey involved asking the relevant program constituency (prospective students and their families, students in the program, members of Department Advisory Board, employers, alumni, and faculty members) direct questions related to the following:

1. Adequacy and relevance of the proposed PEOs,
2. Level of achievement of the PEOs, and
3. Achievements of alumni a few years after their graduation.

The following two questions in the survey for example relate to assessing the views of the constituents on the adequacy and relevance of the PEOs:

- Question 1. How well do our PEOs reflect your ideas of what a civil engineering program should prepare its graduates to achieve? Also, to what degree do you consider our PEOs to be relevant?
- Question 2. Do you consider our PEOs helpful for meeting the career goals of our graduates?

A summary of the answers provided by the CEP constituents on the adequacy and relevance of the PEOs are shown in Figure 2 for PEO(1), Figure 3 for PEO(2), and Figure 4 for PEO(3).

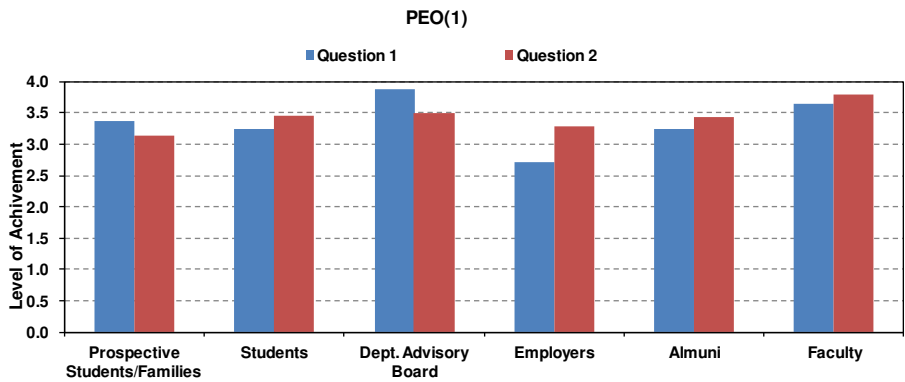


Figure 2: Adequacy/Relevance of PEO(1) According to the Responses to Questions 1 and 2 Received from the Program Constituencies.

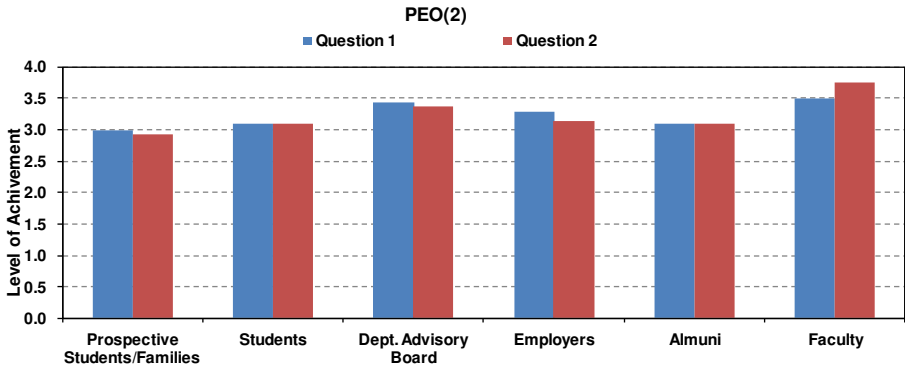


Figure 3: Adequacy/Relevance of PEO(2) According to the Responses to Questions 1 and 2 Received from the Program Constituencies.

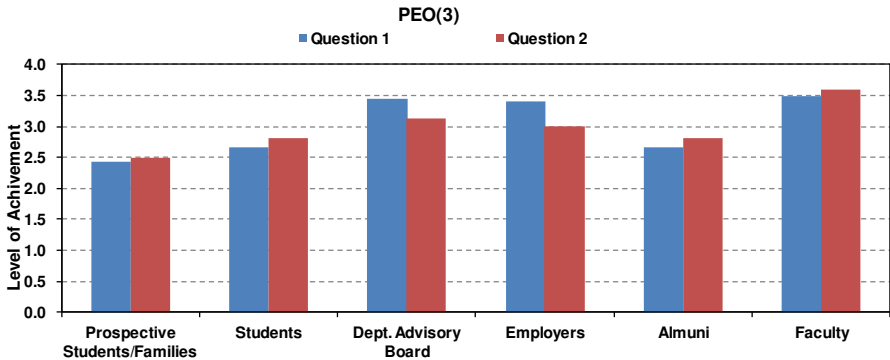


Figure 4: Adequacy/Relevance of PEO(3) According to the Responses to Questions 1 and 2 Received from the Program Constituencies.

The results clearly show that the level of agreement/satisfaction with the three PEOs was in the range of 2.4 to 3.7 (out of 4); all are well above our minimum satisfactory threshold of 2.0 adopted for the CEP. The results also indicate more satisfaction of the program constituents with PEO(1) and PEO(2). As shown in Figure 4, the prospective students and their families indicated a relatively lower level of satisfaction with PEO(3), which is understandable considering that their immediate concerns may be different than those of the other constituents. On the other hand, the faculty members in the Department consider PEO(3) to be of high importance to the graduates and as such more efforts will be spent on educating students on the value of pursuing scientific inquiry and lifelong learning opportunities, such as self-directed learning, graduate studies, participation in professional activities, and continuing education.

The achievement of the PEOs was assessed based on the responses received from the CEP alumni and their employers on the relevant questions in the survey, as summarized in Figures 5 and 6, respectively. As the data in Figure 5 indicate, the alumni rated the achievement of the PEOs in the range of 2.7 to 3.1 out of 4.0. This level of achievement is considered satisfactory given that the survey was conducted during the peak of the economic downturn when some of our alumni lost their jobs, or were forced to accept significant salary cuts, or had to change their jobs. Similarly, Figure 6 shows that the employers of our graduates rated the achievement of the PEOs, based on their knowledge of our graduates, in the range of 2.8 to 3.3 out of 4.0, slightly higher than what our alumni indicated.

In addition and during the same PEOs Survey, our alumni were asked to answer the following questions on a Yes/No basis (and also to provide relevant information about positions held and experience accumulated):

- Question 1. I am fully considered as a practicing engineer in the organization.
- Question 2. I uphold the principles of ethics and responsibility towards the profession and the wider society.
- Question 3. I have achieved, upon few years of practice, levels of technical knowledge and professional expertise suitable for career advancement;
- Question 4. I have achieved, upon few years of practice, levels of technical knowledge and professional expertise necessary for assuming a leadership positions
- Question 5. I am pursuing scientific inquiry and lifelong learning opportunities, such as self-directed learning, graduate studies, participation in professional activities, and continuing education.

Figure 7 summarizes our alumni answers to these questions. With positive (Yes) answers ranging from 80 to almost 95 percent, our graduates believe that they have achieved an important degree of self-confidence in their abilities and the recognition they feel as practicing engineers. This result is very encouraging and confirms the adequacy, relevance and achievement of our PEOs.

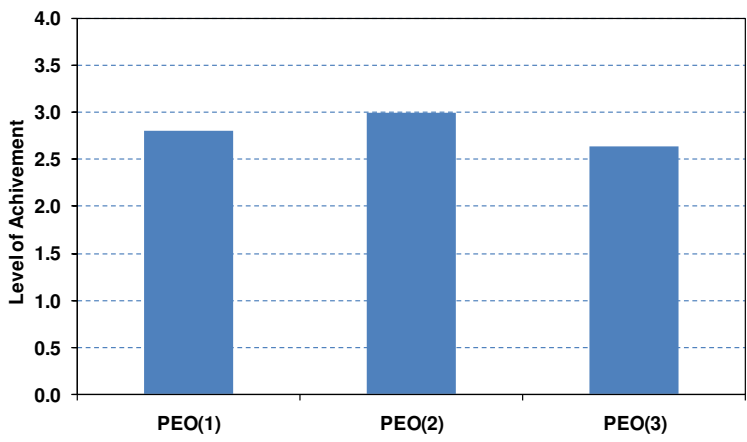


Figure 5: Achievements of PEOs Based on Alumni Responses.

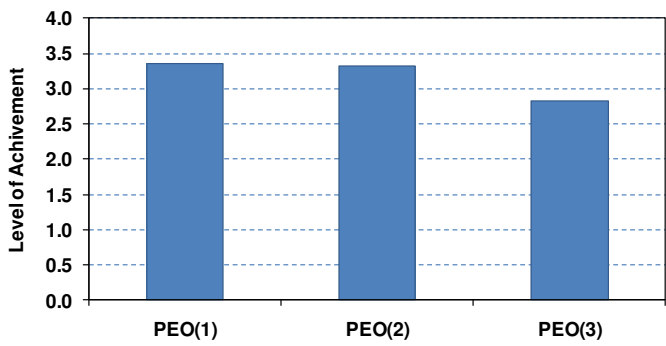


Figure 6: Achievements of PEOs Based on Employer Responses.

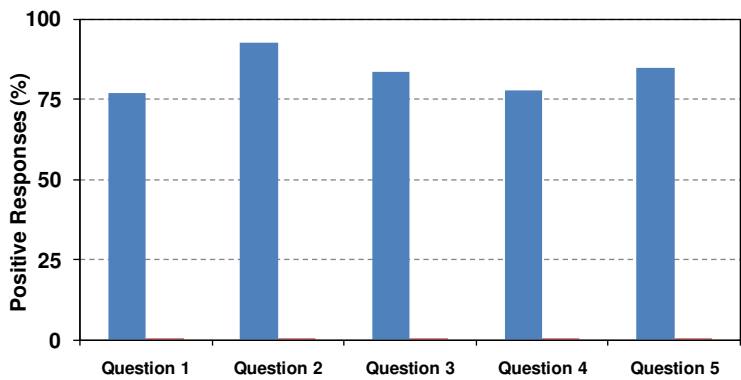


Figure 7: Alumni Professional Achievements Based on Responses to the Below Questions in the PEOs Survey.

Alumni, Employer, Exit and Internship Surveys Results

In addition to the PEOs Survey which was specifically conducted to assess the relevance, adequacy, and achievement of our PEOs, the Department conducts an Alumni Survey every accreditation cycle to establish the degree of achievement of the PEOs and POs. The alumni survey asks a total of 39 questions across the following three issues:

1. Satisfaction with education at the University of Sharjah;
2. Acquired knowledge/competencies/skills/abilities; and
3. Self-assessment and confidence.

The data in Figure 8 indicate that the weighted average responses to questions addressing the three issues listed above. The results clearly indicate that the level of achievement of all PEOs were above 2.5 out of 4.0, well above the program minimum acceptable achievement threshold of 2.0.

The Employer Survey includes 14 question linked to the program PEOs. The data in Figure 8 show the weighted average responses to the 14 questions. The results clearly indicate that the level of achievement varies in the range of 2.75 to 3 out of 4 (above C+), which is well above the program minimum acceptable achievement threshold of 2.0. The results indicate that the employers were satisfied with the performance of the program alumni as practicing engineers.

The Exit Survey contains questions that directly and indirectly address the PEOs. The summarized results of this survey are shown in Figure 8. The results show that the satisfaction level of the graduating students indicates that the PEOs were met adequately (between 2.5 to 3 out of 4).

The Internship Survey involved a total of 16 questions to employers/supervisors related to the following two issues:

1. General Impressions about students' preparation; and
2. Students' skills and abilities.

A summary of this survey results is shown in Figure 8. The level of PEOs achievement was above 3.2 (above B), thus reflecting the employers' satisfaction with students' work, attitudes and skills as trainees.

A summary of the PEOs assessment results discussed in the above sub-sections is presented in Figure 8. In conclusion, the results clearly indicate that the PEOs are being satisfied adequately, with the achievement level being between 2.5 to above 3 out of 4. The results of the students' internship and employers surveys stand out highest among the survey results.

Since the program PEOs are new and given that assessment results indicated that these PEOs were relevant, adequate and achieved satisfactorily, the Department will maintain

these PEOs for at least a few years before they are reassessed, unless there is a major reason requiring that they be considered sooner.

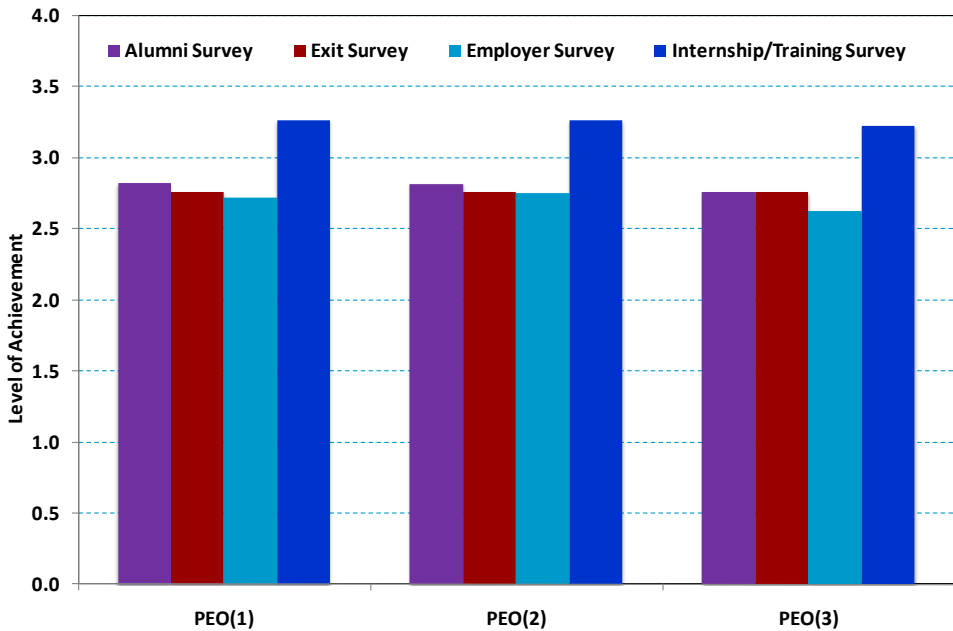


Figure 8: Summary of Achievement of the PEOs Based on the Combined Results of all Surveys.

PROGRAM LEARNING OUTCOMES ASSESSMENT

While students are expected to gain the benefits of the PEOs as a result of their education and accumulating engineering experience a few years after graduation, outcomes are those abilities that students are anticipated to possess upon graduation. The Civil Engineering Program adopted the ABET (a - k) POs as follows:

Upon completing the Civil Engineering Program at the University of Sharjah, students should attain the following outcomes:

- (a) an ability to apply knowledge of mathematics, science, & engineering.
- (b) an ability to design & conduct experiments, as well as to analyze & interpret data.
- (c) an ability to design a system, component, or process to meet desired needs within realistic constraints such as economics, environment, social, political, ethical, health and safety manufacturability and sustainability.
- (d) an ability to function in multi-disciplinary teams.
- (e) ability to identify, formulate & solve engineering problems.
- (f) an understanding of professional & ethical responsibility.

- (g) ability to communicate effectively.
- (h) the broad education necessary to understand the impact of engineering solutions in a global, economic, environmental and social context.
- (i) a recognition of the need for & an ability to engage in life-long learning.
- (j) a knowledge of contemporary issues.
- (k) an ability to use the techniques, skills & modern engineering tools necessary for engineering.

The program POs are linked and lead to the achievement of the PEOs, as shown in the following table:

Table 1. Mapping of PEOs Against the POs.

POs	PEO1	PEO2	PEO3
a	√	√	
b	√	√	
c	√	√	
d	√	√	
e	√	√	√
f	√	√	√
g	√	√	
h	√	√	√
i	√	√	√
j	√	√	√
k	√	√	√

PROGRAM OUTCOMES (POs) ASSESSMENT

The system used to assess the achievement of the program outcomes relies on obtaining feedback from the program constituents using a variety of tools. This system consists of two assessment levels, which are:

1. Course level assessment
2. Program level assessment

The elements of the course and program assessment are summarized in Tables 2 and 3, respectively. The assessment tools can also be classified under the following two categories, internal and external. Internal assessment is mainly focused on assessing the level of achievement of the courses learning outcomes and therefore the program outcomes. External assessment is related to assessing the adequacy and relevance of the program and the degree of achievement of the PEOs and POs.

Table 2: Elements of the Course Level Assessment.

Item	Direct Course Level Assessment
Objectives	Assess the achievement of the course learning outcomes (CLOs).
Person in Charge	Course Instructor and Course Coordinator
Coordination	Instructor/Coordinator → Assessment Coordinator in Department → Chairman/Accreditation Committee → Department Council of Faculty Members
Assessment tools/indicators	• Level of achievement of course learning outcomes from instructor point of view. • Level of achievement of course learning outcomes from student point of view. • Degree of coverage of course contents from instructor point of view. • Relation of individual assessment questions/items to course learning outcomes. • Achievement of course learning outcomes based on students' grades on assessment items. • Identification of issues of requiring improvement. • Proposals for improvements based on assessment results. • Students' evaluation of courses and instructors.
Frequency	Every time the course is taught.
Outcome	Course Learning Outcomes Assessment Report.

Table 3: Elements of the Program Level Assessment.

Item	Program Level Assessment
Objectives	Assess the achievement of the program outcomes (POs).
Person in charge	Assessment Coordinator in Department/Accreditation Committee/Department Chairman
Coordination	Assessment Coordinator in Department → Chairman/Accreditation Committee/Department Council of Faculty members
Assessment Tools	• Coverage of program learning outcomes based on course learning outcomes. • Achievement of program learning outcomes based on course learning outcomes assessment results. • Alumni survey. • Employers survey. • Exit survey of graduating students. • Feedback from visiting/invited experts, including reports of visiting accreditation teams. • Feedback from department advisory board. • Students' internship/training survey by employers.
Frequency	Varies from every semester (i.e., Exit Surveys) to every few years (i.e., Employer Survey).
Outcome	Assessment Reports as Appropriate.

The feedback obtained using the various tools is typically analyzed and used to identify improvements. The system that is used by the Department to complete the loop is

summarized in Table 4. It should be noted that the feedback obtained over the years confirmed that the POs were being met adequately. Nevertheless, significant improvements were introduced to the program to balance the curriculum, respond to changes in the body of knowledge, and enhance compliance with the local and ABET accreditation requirements.

PROGRAM OUTCOMES ASSESSMENT RESULTS AND ANALYSIS

The following is a summary of the feedback obtained using the various assessment tools discussed previously. In analyzing the results, the relationships of the questions in the different surveys to the POs were established then the level of achievement of the POs were based on the number of constituents responding, the average assessment they assigned, and the weights assigned to each question. The assessment results were standardized to a scale ranging from 0 to 4, with a threshold of 2.0 adopted as the minimum acceptable achievement level in terms of meeting any of the POs. Failing to achieve the minimum acceptable achievement level of 2 is of major concern and a major trigger for introducing the necessary improvements.

Direct Assessment of POs and Course Learning Outcomes (CLOs)

For the past 10 years, the Department has used a well-established tool to assess the achievement of the Courses Learning Outcomes (CLOs) every time a course is taught. The tool has been recently upgraded, as described in this article (Shanableh 2009) to provide a direct assessment of the achievement of the CLOs and therefore the POs based on a number of indicators. An example to illustrate the upgraded CLOs assessment tool is presented in Figure 9 to Figure 11 for one of the courses taught during the fall semester of 2009/2010. The assessment tool, which utilizes an Excel spreadsheet, automatically generates a report in two parts: Part 1 is shown in Figures 10 and Part 2 is shown in Figure 10. In Figure 9, the course data and CLOs are mentioned first then the assessment summary is presented using the following seven performance indicators:

- Indicator 1. Level of achievement of CLOs based on students evaluation of CLOs achievement. The indicated results are based on a students' survey that is conducted at the end of the semester to determine the level of achievement of course learning outcomes from the students point of view.
- Indicator 2. Level of achievement of course learning outcomes from the instructor's point of view.
- Indicator 3. Direct assessment results, which reflect the achievement of the CLOs based on students' grades on the various assessment items. The assessment items can be as detailed as the individual questions on the exams and assignments. These assessment results are calculated based on students' achievements on each assessment item that addresses each of the CLOs. The calculations behind these numbers are extensive.

Table 4: Assessment System and Outcomes-Completing the Loop.

Area for Improvement	Responsibility	Frequency	Documentation	Outcomes
Course Level Assessment				
Routine Issues- Examples: - Text book issues - Students' assessment issues - Coverage of course content - Appropriateness of teaching material - Teaching approaches - Students performance.	Routine issues: course instructor/ course coordinator	Routine issues: Every time the course is taught	Course learning outcomes (CLOs) assessment report(s) kept in course files Students' evaluation of courses and instructors kept with department and college	Enhance students' teaching and learning experience. Maintenance of quality of course and course delivery Achievement of CLOs Overall satisfaction of students
Major Issues- Examples: - Students dissatisfaction with instructor - Irregular grades. - Consistent lack of achievement of CLOs over few assessment cycles.	Major issues: department chairman/ department council/college dean	Major issues: as necessary		
Program Level Assessment				
Other Program Issues: - Adequacy and relevance of POs and PEOs. - Lack of achievement of PEOs and POs - Need for program modifications to meet requirements of accreditation/ changes in body of knowledge/ benchmarking/ assessment results, etc	Department chairman/ undergraduate program committee/ Accreditation committee/ department council of faculty members	Whenever the case for improvement becomes well established Every accreditation cycle	Raw data (completed survey forms) Data analysis reports. Program modification reports/ request forms Related communications and approvals of changes	Significant improvements introduced, as described under Criterion 4-Continuous Improvement. Results of improvements-meeting accreditation requirements; balancing the curriculum (i.e., coverage of technical and non-technical content); improving chances for achieving program outcomes and educational objectives.

Under the assessment summary in Figure 9, the distribution of grades on the various assessment items is indicated. This particular course is a design-based course that involved three design projects and a final exam. Below the distribution of grades, the performance of students (average grades) on the individual assessment items is summarized.

The second page of Part 1 of the report is shown in Figure 10, where the various questions on the different assessment items are linked to the CLOs. A "yes" is generated automatically and indicates that the question addresses the particular CLO to a level that is judged by the instructor to be equal to or above 3.5 out of 10. The threshold of 3.5 was chosen to ensure the significance of the links established between the questions and the CLOS. This linking provides the basis for assessing the balance in covering the CLOs in the assessment and is used to estimate the level of achievement of course learning outcomes based on students' grades on assessment items.

The first page of Part 2 of the report is shown in Figure 11. The sheet shows the distribution of the students grades and the links between the seven aforementioned indicators and the POs. The second page of Part 2 of the report (Figure 12) graphically shows the level of achievement of the CLOs and the POs (as a percentage) for the course at the end of the semester.

It should be mentioned that regardless of how accurate or representative this assessment system is, it provides faculty members and the Department with a systematic way to assess the achievement of the CLOs and the POs.

The Department's assessment coordinator compiles the assessment results for all courses taught throughout the academic year. Using the data in the individual course assessment reports, the level of achievement of POs are estimated for each indicator. For example, the degree of achievement of the POs based on Indicator 3 (students' grades), is presented in Figure 13. This indicator provides a direct measure of the achievement of the CLOs based on student performance (i.e., grades) on the various assessment items in the course. It should be noted that the results of Indicator 3 assessment generally constitutes the lower bound for the aforementioned seven indicators.

As shown in Figure 13, it can concluded that based on Indicator 3 (students' grades), our POs have been achieved adequately, with a level of achievement of approximately 2.5 (C+). The results of the other indicators showed a much higher level of POs achievement.

Exit Survey Results

The Exit Survey contains questions that directly and indirectly address the POs. The linkage between the survey questions and the POs is shown in Table 1. As shown in Figure 14, the student responses to most outcomes averaged above 2.5, hence indicating that the POs were adequately satisfied. It is worth mentioning that the Exit Survey is being updated to ask more direct questions related to the achievement of the POs.

 UNIVERSITY OF SHARIAH COLLEGE OF ENGINEERING Department of Civil & Environmental Engineering							
Course Number:	401464	Credits:	3	Session:	Spring 2009-2010		
Course Title:	Special Topics in Water/Environmental Engineering						
Prepared by:	Dr. Abdallah Shanabeh						
Outcome No.	Course Learning Outcomes-6 Max			Compared with Similar Courses offered Internationally	Planned Degree of Coverage in Course Syllabus	Contribution to achieving ABET a to k Program Outcomes	Is outcome directly assessable using projects, assignments &
CLO 1	knowledge of selected principles of hydraulics and hydrology relevant to developing preliminary design of water distribution, wastewater collection, and stormwater draining infrastructure systems.			Yes	Yes	a,e	Yes
CLO 2	Ability to develop preliminary design for a water distribution system through applying relevant hydraulics principles and taking into account relevant design considerations.			Yes	Yes	c, d,e, g, h, k, 9(a)	Yes
CLO 3	Ability to develop preliminary design for a wastewater collection system through applying relevant hydraulics principles and taking into account relevant design considerations.			Yes	Yes	c, d,e, g, h, k, 9(a)	Yes
CLO 4	Ability to develop preliminary design for a stormwater drainage system through applying relevant hydrology and hydraulics principles and taking into account relevant design considerations.			Yes	Yes	c, d,e, g, h, k, 9(a)	Yes
Did you ensure that coverage of course material match course/program outcomes							Yes
Did you design your exams/assignments/activities to meet stated course outcomes							Yes
Did you fill the exam/assignment/activity checklist that relates questions and requirements to program outcomes							Yes
Overall Assessment Results							
No.	Students' Evaluation of Outcome	Relative Instructor Evaluation of Achievement of	Direct Assessment Results (same as line 42)	Relative Degree of Addressing Outcome in Assessment	Relative Coverage of Outcome	Average of Assessment Results	Average Students' Grade in Course
CLO 1	74	75	77	100	70	79	75
CLO 2	77	80	74	83	80	79	75
CLO 3	74	75	69	83	75	75	75
CLO 4	77	75	77	83	75	78	75
Notes	Note: Copy Down Last Cell (above) for Additional CLOs		DO NOT Copy Down Last Cell above for Additional CLOs	DO NOT Copy Down Last Cell above for Additional CLOs			Note: Copy Down Last Cell above for Additional CLOs
Average	76	76	74	88	75	78	75
Direct Assessment							
Assessment Items	Project 1	Project 2	Project 3	Final Exam	Other	Total	
Out of (%)	20	20	20	40		100	
Overall Grades							
Item	CLO1	CLO2	CLO3	CLO4	CLO5	CLO6	
Project 1	76.9	76.9					
Project 2	80.4		80.4				
Project 3	83.1			83.1			
Final Exam	66.9	70.8	58.4	71.6			
Other							
Avg Level of Students Achievement (%)	77	74	69	77			

Figure 9: First page of part 1 of the CLOs assessment report.

Relationship of Exams/Assignment/Projects, Questions to Course Learning Outcomes						
Project 1	Students' Performance Statistics					
Item	CLO1	CLO2	CLO3	CLO4	CLO5	CLO6
Project 1	Yes	Yes				
Q2						
Q3						
Q4						
Q5						
Q6						
Q7						
Q8						
Q9						
Q10						
Level of Students Achievement (%)	76.9	76.9	0.0	0.0	0.0	0.0
Project 2	Students' Performance Statistics					
Item	CLO1	CLO2	CLO3	CLO4	CLO5	CLO6
Project 2	Yes		Yes			
Q2						
Q3						
Q4						
Q5						
Q6						
Q7						
Q8						
Q9						
Q10						
Level of Students Achievement (%)	80.4	0.0	80.4	0.0	0.0	0.0
Project 3	Students' Performance Statistics					
Item	CLO1	CLO2	CLO3	CLO4	CLO5	CLO6
Project 3	Yes			Yes		
Q2						
Q3						
Q4						
Q5						
Q6						
Q7						
Q8						
Q9						
Q10						
Level of Students Achievement (%)	83.1	0.0	0.0	83.1	0.0	0.0
Final Exam	Students' Performance Statistics					
Item	CLO1	CLO2	CLO3	CLO4	CLO5	CLO6
Q1	Yes	Yes				
Q2	Yes		Yes			
Q3	Yes			Yes		
Q4						
Q5						
Q6						
Q7						
Q8						
Q9						
Q10						
Level of Students Achievement (%)	66.9	70.8	58.4	71.6	0.0	0.0
Other	Students' Performance Statistics					
Item	CLO1	CLO2	CLO3	CLO4	CLO5	CLO6
Q1						
Q2						
Q3						
Q4						
Q5						
Q6						
Q7						
Q8						
Q9						
Q10						
Level of Students Achievement (%)	0.0	0.0	0.0	0.0	0.0	0.0
Required Documentation						
1	Teaching material related to each outcome					
2	Assessment items related to each outcome					
3	Corrected students work related to each outcome showing clear feed back to students to redo work and get correct answer					

Figure 10: Second page of part 1 of the CLOs assessment report.

									
University of Sharjah									
College of Engineering									
Instructor Assessment of the course and the learning objectives									
Course Code:	401464				Course Name:	Special Topics in Water/Environmental Engineering			
Department:	Civil Env Eng				Semester/Year:	Spring 2009-2010			
Instructor's Name:	Dr. Abdallah Shanableh								
The following information should be supplied based on the FINAL ROSTER of grades issued by the Registrar.									
1	Number of students who received W.								0
2	Number of students who received WP								0
3	Number of students who received WF								0
4	Number of students marked with I								0
5	Number of students marked with AU								0
6	Total number of students who failed the course								0
7	Number of students (excluding 1-5) who missed the Final Examination								0
8	Number of students (excluding 1-5) who took the Final Examination								35
9	Total number of students								35
W =	Withdrawn	IP =	In Progress		WP =	Withdrawn with Pass			CZ
IC =	Incomplete	AU =	Audit		WF =	Withdrawn with Fail			
II. DISTRIBUTION OF GRADES									
GRADE	A	B+	B	C+	C	D+	D	F	I
# Students	0	4	8	6	9	6	2	0	0
% Students	0.0	11.4	22.9	17.1	25.7	17.1	5.7	0.0	0.0
Level of Achievement of Program Learning Outcomes									
Undergraduate program objectives*	Target Level of Address	Students' Evaluation of Outcome	Relative Instructor Evaluation of Achievement of Outcome	Direct Assessment Results (same as line 42)	Relative Degree of Addressing Outcome in Assessment	Relative Coverage of Outcome	Average of Assessment Results	Average Students' Grade in Course	
a	1	0.76	0.76	0.74	0.88	0.75	0.78	0.75	
b		0.00	0.00	0.00	0.00	0.00	0.00	0.00	
c	1	0.76	0.76	0.74	0.88	0.75	0.78	0.75	
d	1	0.76	0.76	0.74	0.88	0.75	0.78	0.75	
e	1	0.76	0.76	0.74	0.88	0.75	0.78	0.75	
f		0.00	0.00	0.00	0.00	0.00	0.00	0.00	
g	1	0.76	0.76	0.74	0.88	0.75	0.78	0.75	
h	1	0.76	0.76	0.74	0.88	0.75	0.78	0.75	
i		0.00	0.00	0.00	0.00	0.00	0.00	0.00	
j	1	0.76	0.76	0.74	0.88	0.75	0.78	0.75	
k	1	0.76	0.76	0.74	0.88	0.75	0.78	0.75	

Figure 11: First page of part 2 of the CLOs assessment report.

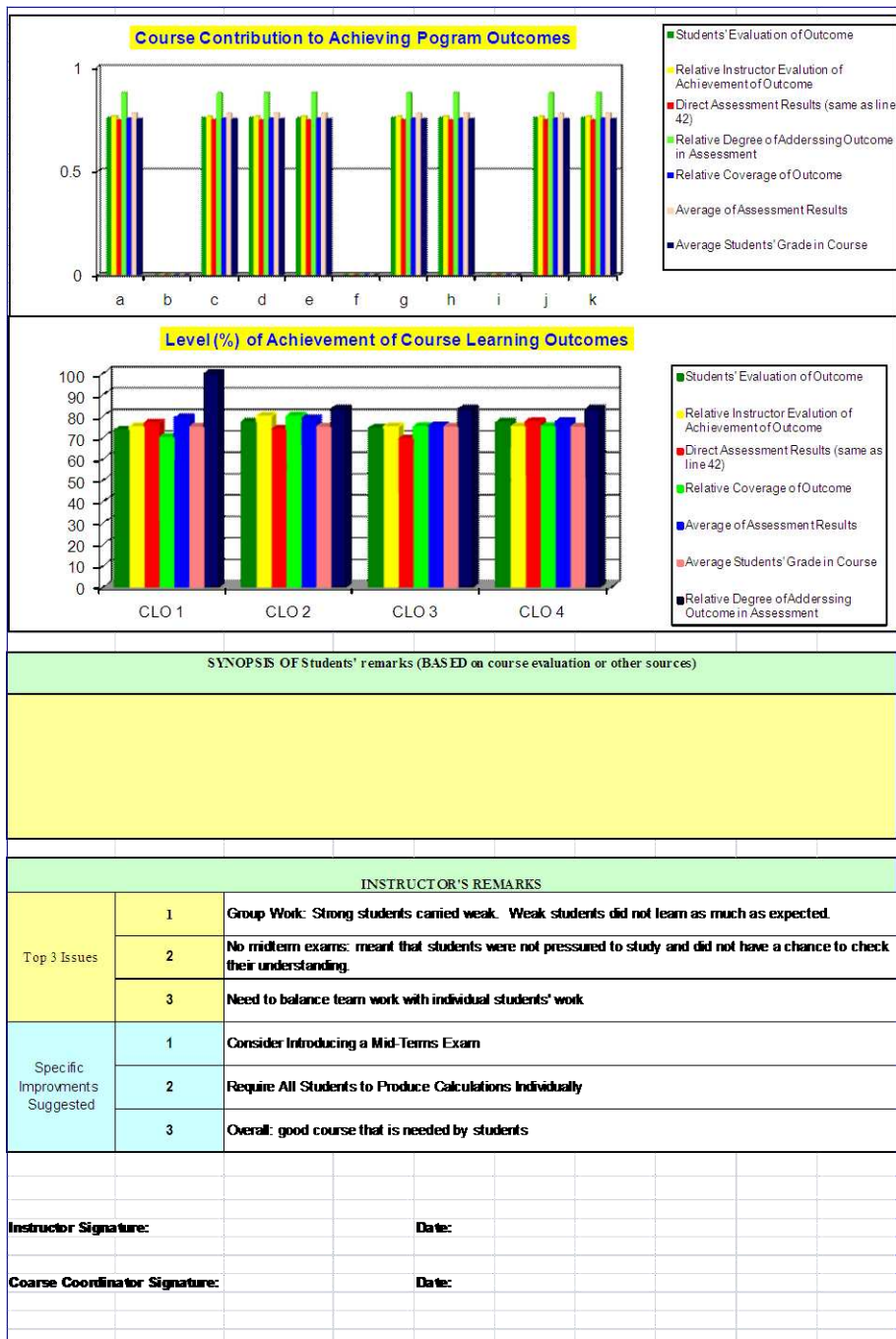


Figure 12: Second page of part 2 of the CLOs assessment report.

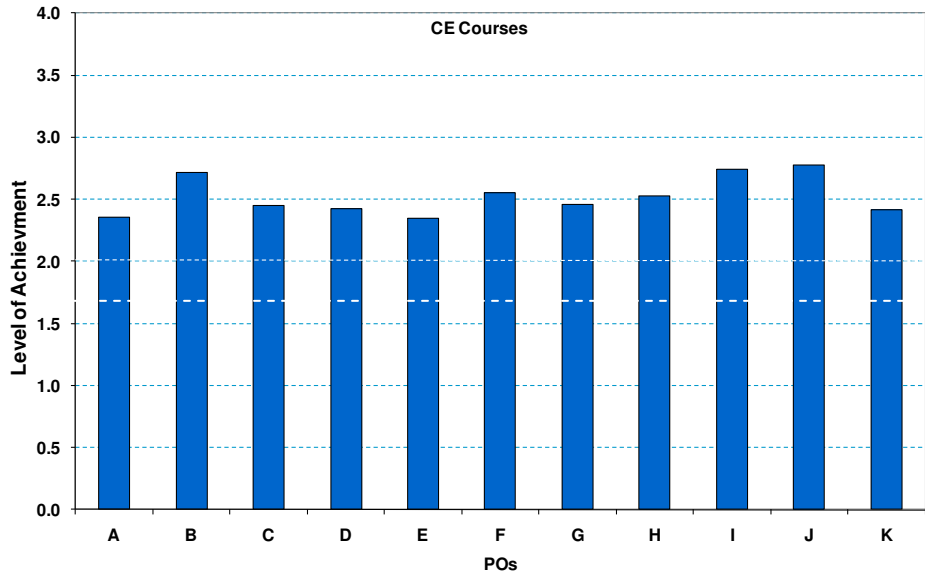


Figure 13: Assessment of POs Based on Achievement of CLOs, which are Based on Students' Grades During 2004-2010.

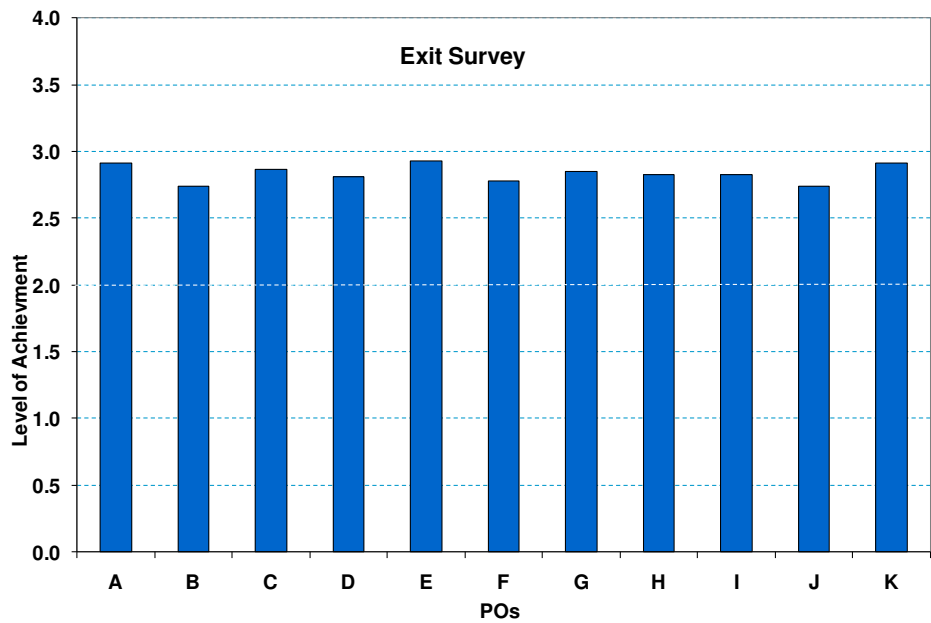


Figure 14: Achievement of the POs Based on the Results of the Students' Exit Survey.

Student Evaluation of Courses and Instructors

The student evaluation of courses and instructors is conducted for all courses at the University, and it is typically conducted by the University's Assessment Unit. The evaluation results are forwarded to the college dean, department chairman, and the instructor. A summary of the evaluation results in terms of achievement of the POs are shown in Figure 15. The average student responses to most outcomes were above 3.2, indicating general student satisfaction with their instructors and teaching and learning experience in the different courses.

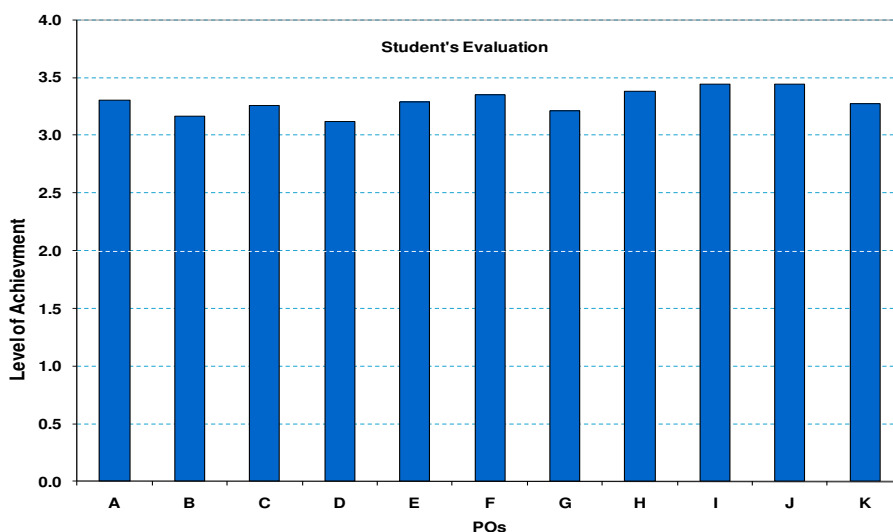


Figure 15: Achievement of the POs Based on the Results of the Students' Evaluation of Courses and Instructors.

POs Assessment Based on the Alumni Survey Results

The alumni survey asks a total of 39 questions across the following three issues:

1. Satisfaction with education at the University of Sharjah;
2. Acquired knowledge/competencies/skills/abilities; and
3. Self-assessment and confidence.

A summary of the survey results is presented in Figure 16. The results clearly indicate that the level of achievement varies in the range of 2.5 to 3 (above C+) and is well above the chosen minimum acceptable achievement threshold of 2.0. While the achievement results in Figure 16 are above satisfactory, the Department aspires for better results and remains committed to achieving further improvements.

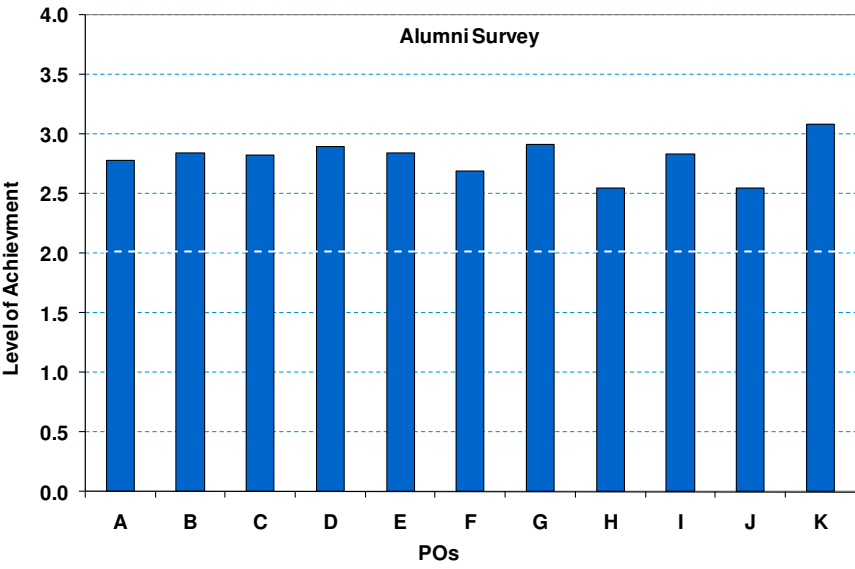


Figure 16: Achievement of the POs Based on the Alumni Survey Results.

POs Assessment Based on the Employer Survey Results

The employer survey asks a total of 14 questions linked to the POs. A summary of the Employers Survey results is presented in Figure 17. The results clearly indicate that the level of achievement of the POs was about 2.5 (C+) and is above the minimum acceptable achievement threshold of 2.0. The results also indicate that the respondent employers were generally satisfied with the performance of our graduates.

Internship/Training Survey Results

The Internship Survey asks employers/supervisors a total of 16 questions about two main issues:

- 1. General Impressions about students' preparation; and
- 2. Students' skills and abilities.

Figure 18 presents a summary of the assessment of POs based on the internship survey results. The achievement results are in the range of 3.1 to 3.3 (above B), which indicates a high level of supervisors' satisfaction with our students while in training.

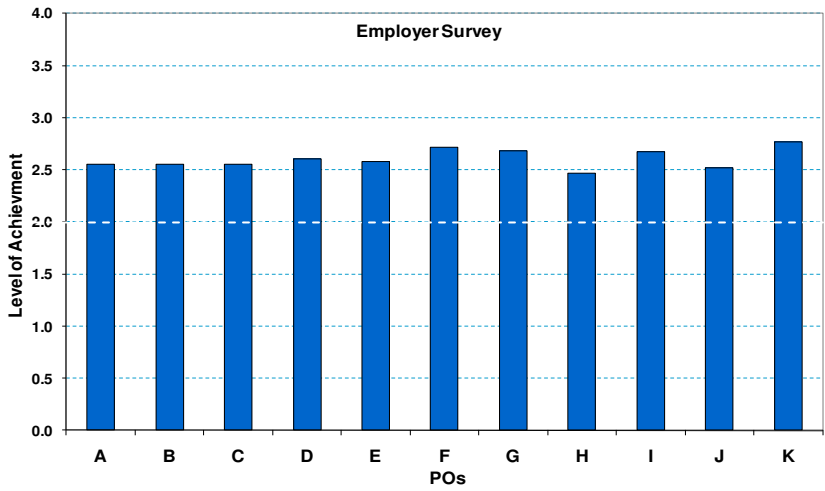


Figure 17: Achievement of the POs Based on the Employers Survey Results.

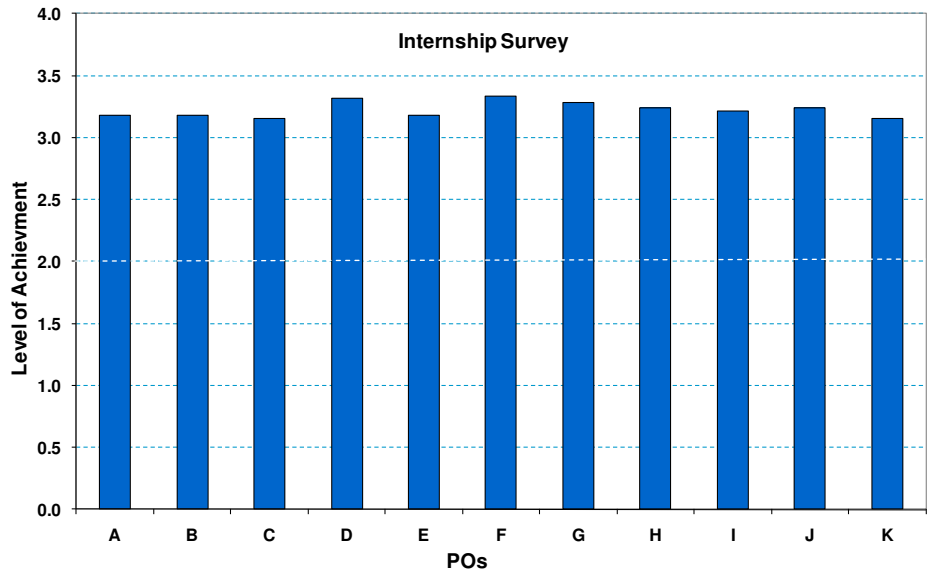


Figure 18: Achievement of the POs Based on the Internship/Training Survey Results.

Department Advisory Committee Survey Results

A survey was conducted in which the members of the Department Advisory Board (DAB) were asked about their assessment of achievement of the POs, based on their knowledge of the program and its graduates. Figure 19 presents a summary of the survey results. The achievement results were in the range of 2.3 to 3.0 (C to B).

A summary of the results discussed above is presented in Figure 20. The results clearly indicate that the set minimum achievement threshold of 2.0 has been met and even exceeded (results in the range of 2.3 to above 3.0).

Obviously, the Department aspires for better performance and therefore is strategically looking at raising the minimum achievement threshold to above 2.0 (for example 2.5 out of 4). Although the assessment results in Figure 20 indicate that an achievement level of 2.5 is already being met, adopting a threshold of 2.5 demands that we exceed the threshold and as such can serve as an extra incentive for the Department to excel.

ACHIEVEMENT OF PROGRAM CRITERIA

The ABET criterion 9 is called program criteria. The program criteria stipulates a number of requirements that must exist in a program. Some of the important issues to note when addressing some of the program criteria are the following:

1. The program must demonstrate that the program criteria are met by virtue of curriculum design, with associated evidence and direct student performance indicators
2. All of the curriculum-related program criteria must be achieved by individual graduates, as evidenced by the official students transcripts.

SUMMARY AND CONCLUSIONS

Considering performance criteria, practices and strategies, conflicting expectations and requirements of constituents, and program objectives, it becomes increasingly difficult to assess the performance of academic programs using the input from the different constituents. Since the assessment data has to be repeatedly collected, organized and analyzed during different assessment cycles that may last for a number of years, it is essential to adopt systematic procedures for analyzing, summarizing and evaluating the collected data that should be used to as the basis for developing academic program's improvement. The CEE department at the University of Sharjah utilizes a complex yet comprehensive system for properly collecting, analyzing and interpreting data. The system was used successfully in two accreditation cycles and gained good comments from the accrediting teams that visited the Department and assessed its program. The

system however requires significant resources and commitment from all constituents, and strong support from other university units and senior administration.

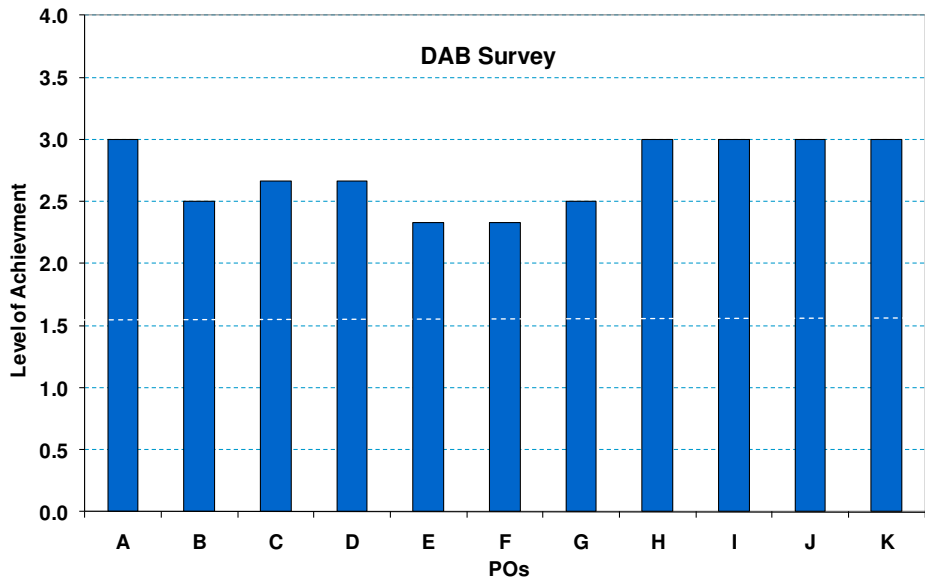


Figure 19: Achievement of the POs Based on the DAB Survey Results.

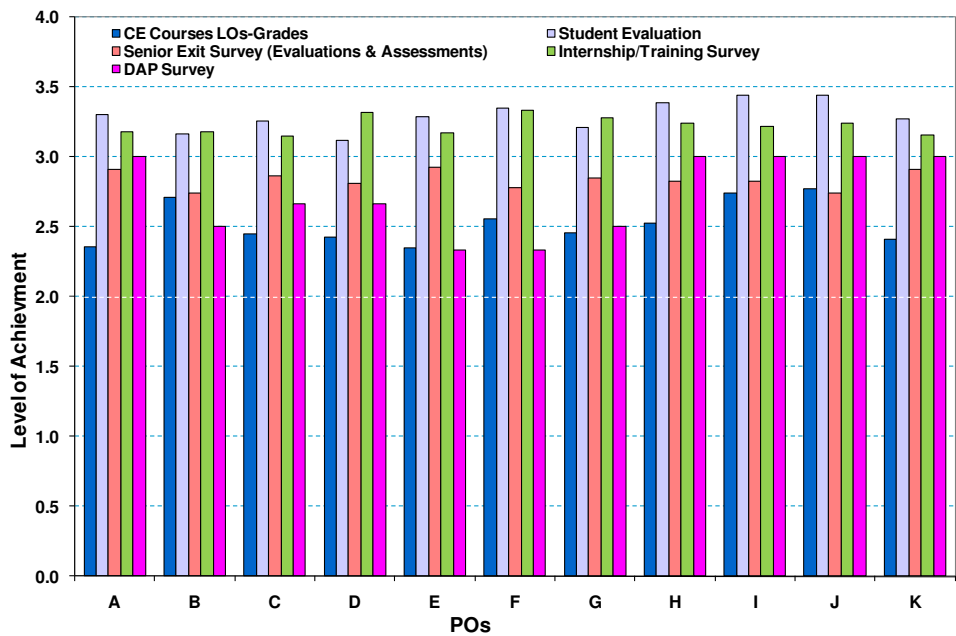


Figure 20: Summary of the Program Learning Outcomes Assessment Results.

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- [2] CAA Self-Study Report, Civil Engineering Program, Department of Civil and Environmental Engineering, University of Sharjah (2008), prepared by A. Shanableh et al.
- [3] Shanableh, A. (2009) Direct Assessment of POs and Course Learning Outcomes (CLOs) Excel Spreadsheet. Department of Civil and Environmental Engineering, University of Sharjah.
- [4] S. Barakat, A. Shanableh, M. Omar, From Course Learning Outcomes To Program Objectives-Based Assessment Process, Symposium on Engineering Education, UAE University, Al-Ain, United Arab Emirates 2009.

COURSE BINDER PREPARATION ACCORDING TO ABET EC-2000 - A CASE STUDY FROM THE ARABIC REGION

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ABSTRACT: The instructor of a course must evaluate students' performance and monitor the students' progress to foster their success in achieving course learning outcomes, thereby enabling them as graduates to attain the related program outcomes. ABET EC-2000 addresses the effectiveness of engineering education programs by focusing on assessment and evaluation process that assures the achievement of educational objectives and outcomes. Course level activities are the heart of the process in which a program has to satisfy ABET EC-2000 requirements. This paper documents how several of the ABET EC-2000 criteria are satisfied and how they are in turn used in creating Hydrology and Water Resources Engineering course binder to achieve specified outcomes and continuous improvement of the course. The course assessment and evaluation phase was enhanced by using a programmed Excel workbook, called HI-CLASS. It is developed by the Accreditation Unit of the Faculty of Engineering at King Abdul –Aziz University. An instructor of a course can easily evaluate his class achievement regarding a continuous improve of the course offering. By the end of the semester, the instructor will have documented results of the class achievement and the course contribution to the achievement of program outcomes.

KEYWORDS: Course Binder; ABET EC-2000; Course Learning Objectives; Program Outcomes.

INTRODUCTION

The Department of Civil Engineering at King Abdul-Aziz University has been ABET accredited since 2009. One of the courses required by all students in civil engineering program is Hydrology and Water Resources Engineering (CE 353). It is a 3-credit engineering science course. The prerequisite for CE 353 is Hydraulics (CE 352). It is offered every semester, with an average enrollment of about 30 students. The class meets twice a week for one hundred and twenty minutes. The paper describes how an instructor of a course can efficiently use the system designed by the Academic Accreditation Unit of the Faculty of Engineering at King Abdul –Aziz University to prepare his course binder. The objectives of this paper are to design the course, to assess the student learning, to assess the achievement of the course learning objectives (CLOs) and to write the assessment and improvement report according to ABET EC-2000 requirements.

To ensure the achievement of the CLOs, the instructor should prepare a course plan and view the CLOs as a list of skills and topics that the student must learn in the course. Under ABET EC-2000, courses must be taught and assessed with the achievement of the CLOs and the program outcomes (POs). The course documentation requires continuous improvement each semester and from instructor to other [1].

The instructor should evaluate the course achievement of the CLOs. If the assessment tool results demonstrate that students learned the skill, the CLO is achieved. Even though

the CLO has been achieved, the learned skills should be reinforced to insure retention as the course progresses. If the assessment tool results demonstrate that students have not learned the skill, the CLO has not been achieved. In this case, the instructor must revise his teaching plan and adjust it until student learning of the CLO is achieved. The revised plan could include adding supplemental instruction and making more assignments covering the CLOs not met. The revised plan must include further assessment of the skill. The cycle is then repeated throughout the course. Creating the course binder to achieve specified POs requires effort in three domains. These are described next and shown in Figure 1:

1. Planning (identifying course content and defining measurable CLOs for it);
2. Instruction (selecting and implementing the methods that will be used to deliver the specified content and facilitate student achievement of the objectives); and
3. Assessment and evaluation (selecting and implementing the methods that will be used to determine whether and how well the objectives have been achieved and interpreting the results).

The three stages are not purely sequential—the information collected in each of them feeds back to each of the others in a cycle that leads to continuous improvement [2].

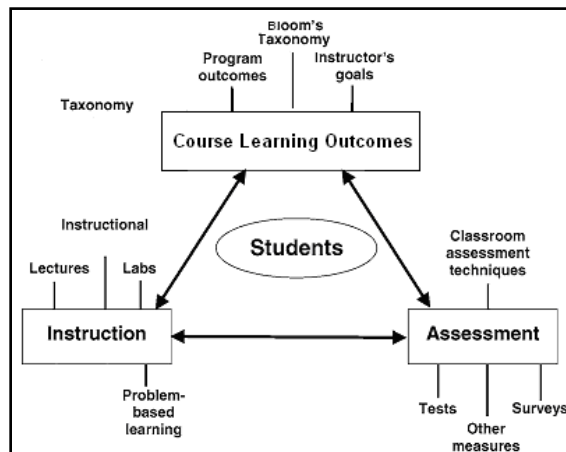


Figure 1: Course outcomes related domains planning, instruction and assessment

ASSESSMENT PROCESS

The course assessment and evaluation process involves two main processes [3]:

- a) Course design process.
- b) Course assessment and evaluation process.

The ABET committee of the civil engineering department has adopted the following course design process for all courses of the program to satisfy the ABET EC-2000.

CE 353 Course Design Process:

- Define the CE 353 Course Learning Objectives (CLOs) (Maximum 6 CLOs): Using descriptive process verbs related to different cognitive levels of learning [4] is highly recommended. Those verbs are good examples of observable action verbs suitable for course learning objective. They also indicate the required levels of learning. By the completion of the course, the students should be able to:
 1. Identify the Importance of water for human activities and the water resources engineering.
 2. Understand and review the global water resources especially in Saudi Arabia.
 3. Identify General requirements of water (quantity & Quality).
 4. Define the Global Hydrologic Cycle and calculate its items in Saudi Arabia.
 5. Analyze the rainfall and runoff data.
 6. Identify technical, economical and social factors affecting dam type, site selection, forces of gravity dams and factors cause dam failure
- Relate the CLOs to Program outcomes (POs)
- Define highest attainable Level of learning (LOL) for each Outcome: The LOL for three hundred level course is varied between 3 and 4 (application and analysis) as shown in Table 1. Where numbers in the table refer to the level of learning (LOL) according to Bloom's Taxonomy [5] as follows:
 - 1: Skill Level (Knowledge), 2: Skill Level (Comprehension), 3: Skill Level (Application), 4: Skill Level (Analysis), 5: Skill Level (Synthesis) and, 6: Skill Level (Evaluation)
- Relate the course topics to the CLOs: The course learning objectives has to be satisfied in the course topics as explained in table 2.
- Determine Instructional Tools to measure CLOs: Student learning outcomes will be measured through the following direct assessment tools:
 1. **Quizzes:** Three major quizzes will be held during the semester. Students will be aware of what are the learning objectives which are assessed by each quiz.
 2. **Homework Reports:** Nine home works will be given during the course.
 3. **Assignments:** Nine assignments will be given during the course.
 4. **Midterm Examination:** A comprehensive examination will be given to the class when around middle of the course will be offered.

5. **Term Paper and Presentation:** Students will be divided into teams. Each team will be asked to submit a term paper of student-formulated problems to fulfill the CLO. Internet Web Sites, References and Text Books can to be used.
 6. **Final Examination:** The final examination will be offered at the end and it will be the major assessment tool for assessing student learning outcomes.
- Form Course Articulation Matrix [4] (Objectives - Assessment Methods)
 - Relate the course learning objectives with the class activities, in class activities and the assessment tools as shown in the articulation matrix in Table 3.

Table 1: CLOs – POs Matrix.

Program Outcomes	3a	3b	3c	3d	3e	3f	3g	3h	3i	3j	3k
CE 353	3				4		4				3
Course Learning Objectives											
CLO # 1	3						4				
CLO # 2	3				4		4				3
CLO # 3	3				4		4				3
CLO # 4	3				4		4				3
CLO # 5	3				4		4				3
CLO # 6	3				4		4				3

Table 2: Mapping course topics to the CLOs.

#	Topic	Course Learning Objectives
1	Water Resources	Identify the Importance of water for human activities and the water resources engineering.
2	Water Demand	Identify and review the global water resources especially in Saudi Arabia.
3	Engineering Hydrology	Define the Global Hydrologic Cycle and calculate the Hydrologic items in Saudi Arabia. Analyze the rainfall and runoff data
4	Hydraulic structures	Identify technical, economical and social factors affecting dam type, site selection, forces of gravity dams and factors cause dam failure
5	Groundwater Hydrology	Identify and formulate the groundwater flow, aquifers and wells

Course Assessment and Evaluation Process

The course assessment and evaluation process includes direct and indirect assessment processes. The indirect assessment tools deal with three questionnaires or surveys. The three surveys are distributed to the students by the end of the semester. The first survey is CLOs and Instructional Tools. The second is course evaluation survey. The third is the outcome survey. Surveys are indirect measures that provide secondary evidence and will be used in conjunction with direct measures of graded students' performance.

Table 3: Course Articulation Matrix.

Civil Engineering Department CE-353 Hydrology and Water Resources (Course Articulation Matrix)																						
Course No.	In Class Activities					Out of Class Activities									Assessment Tools							
CE - 353	Lectures	Solve Problems	Take home quizzes	Oral presentation		Assignment Reports	Field Trip	Home work no 1	Home work no 2	Home work no 3	Home work no 4	Home work no 5	Home work no 6	Home work no 7	Home work no 8	Home work no 9	Home work no 10	Home work no 11	Home work no 12	Home work no 13	Home work no 14	Home work no 15
Topics & Learning Objectives																						
1	x	x	x	x			x	x									x					x
2	x	x	x	x			x		x	x								x	x			x
3	x	x	x	x			x	x			x	x							x	x		x
4	x	x	x	x			x	x					x	x						x	x	x
5	x	x	x	x			x	x							x					x		x
6	x	x	x	x			x	x								x					x	x

The direct assessment is the key element to demonstrate satisfying the requirements of ABET EC-2000. Assessment tools (AST) are used in the course level to assess both CLOs and POs that the course is expected to address.

The direct AST can be illustrated as follows:

1. Construct a mapping matrix relating each AST to the proposed CLO.
2. For a given AST, the score of each defined CLO in the (AST-CLO) mapping matrix is normalized by the total score of that AST.
3. The student result in each AST is multiplied by its weight factor (70%) and then multiplied by the normalized score of that AST addressing the same CLO and summed up for all of the AST in order to obtain the student score in the specific CLO.
4. Construct a mapping matrix relating each CLO to the different Program Outcomes PO.
5. For a given CLO, the score of each defined PO in the (CLO-PO) mapping matrix is normalized by to the total score of that CLO. The resulting matrix is CLO and PO Mapping matrix 1.
6. For a given PO, the normalized CLO scores are further normalized by the total score of that PO. The resulted matrix (CLO and PO Mapping matrix 2) provides a metric score illustrating the importance of each CLO with respect to the each PO.
7. The student score in CLO is multiplied by the metric score of that CLO addressing the same PO and summed up for all of the CLOs in order to obtain the student score in the specific PO.

9. Apply the performance target for each CLO and PO for each course
Performance target for CLO and PO
10. The student score in each learning objective and program outcome is at least 70% (according to the Civil Engineering department decision).

HI-CLASS is an EXCEL workbook, developed by the Academic Accreditation Unit of the Faculty of Engineering at King Abdul-Aziz University, is used to carry out the mapping of CLOs into POs and to obtain the degree of achievement of each student in the POs addressed by the course [6]. The HI-CLASS contains many sheets that can be illustrated as follows:

Master Work Sheet

In the beginning of the semester the instructor enters the main elements of the course design as explained above into a master sheet. The master sheet includes the following elements as shown in Figures 2 and 3:

- Name of the course
- Name of the instructor
- Number of the students in the course
- CLOs and its coverage hours based on Bloom's taxonomy
- Represented POs (ABET Outcomes a, e, g, k)
- The weight of each assessment tool (AST) as a percentage of total mark as shown in Table 4
- Instructional and learning tools mapped to CLOs (Text book, Handout lecture materials, PowerPoint Presentations, Internet search)
- Students' name list and students' attendance on session bases (if desired)
- Passing criteria for course learning objectives and program outcomes (default values are 0.7 and 0.6 respectively)

COURSE DESIGNATION:		CE-353 Hydrology and Water Resources Engineering	INPUT DATA:		1. COURSE DESIGNATION, INSTRUCTOR & NO. OF STUDENTS.															
INSTRUCTOR:		Dr. Maged Hassan Hussein			2. COURSE LEARNING OBJECTIVES MAPPED INTO POs IN TERMS OF LOs ("1", "2", or "3").															
NO. OF STUDENTS		21			3. HOURS OF IN-CLASS COVERAGE OF EACH COURSE LEARNING OBJECTIVE															
Mapping of course learning objectives into program outcomes					4. PASSING CRITERIA FOR CLOs & POs (DEFAULT VALUES: 0.6 & 0.6).															
					5. NAME & WEIGHT OF EACH GRADED ASSESSMENT TOOL (SUM UP TO 100).															
					6. PASSING CRITERIA FOR INDIRECT ASS. TOOLS (DEFAULT VALUE: 3 out of 5).															
					7. MAPPING OF INSTRUCTIONAL TOOLS TO COURSE LEARNING OBJECTIVES USING A SYMBOL (e.g. "x").															
					8. STUDENTS' NAME LIST (AT LEAST COM# & NAME).															
					9. STUDENTS' ATTENDANCE ON SESSION BASES & BONUSES (IF DESIRED).															
Course Learning Objectives			C.L.O. Coverage Hours	Program Outcomes													C.L.O. Passing Criteria	CHECK!		
				a	b	c	d	e	f	g	h	i	j	k	l	m	n		C.L.O. IS USEFUL	L.O.L. IS BETWEEN 2 & 3
1	Identify the Importance of water for human activities and the water resources engineering		9	2					2	2								0.7	O.K.	LOL passes OK
2	Understand and review the global water resources especially S. A		9	2					2	2								0.7	O.K.	LOL passes OK
3	Define the Global Hydrologic Cycle and calculate the Hydrologic items in SA		6	2					2	2								0.7	O.K.	LOL passes OK
4	Analyze the rainfall and runoff data		6	2					2	2								0.7	O.K.	LOL passes OK
5	Identify technical, economical and social factors affecting dam type, site selection, forces of gravity dams and factors cause dam failure		6	2					2	2								0.7	O.K.	LOL passes OK
6	Identify and formulate the groundwater flow, aquifers and wells		6	2					2	2								0.7	O.K.	LOL passes OK

Figure 2: Upper part of the master sheet.

COURSE GRADED ASSESSMENT TOOLS & LEARNING TOOLS				Graded Ass. Tools											
				% Weight	10	3	3	3	3	20	10	40	5	0	
DEPARTMENT OF Civil Engineering															
COURSE (CE 353) - SECTION (1&2) SEMESTER (01) - YEAR (2010)				E-Mail Address		Week #1					Week #2				
						W_1_1	W_1_2	W_1_3	W_1_4	Bonus	W_2_1	W_2_2	W_2_3	W_2_4	Bonus
	1	0260599	علي يحيى فقيه												
	2	0357802	ياسر صالح يانويان												
	3	0516206	معتز عباس مختار												
	4	0516454	هنايم سامي المروزي												
	5	0516525	عبدالله فهد السهلي												
	6	0517274	يوسف محمدرزاق جلون												
	7	0517871	خالد ناصر الشهري												
	8	0611205	عمر عبدالعزيز صالح												
	9	0612018	عائش صالح المطوي												
	10	0620671	عادي بدر الشيباني												
	11	0450471	محمد عبدالله العجلاني												
	12	0516222	انس سعود قريشي												
	13	0516323	طلال غازي السهلي												
	14	0516858	ابراهيم احمد آل دغوير												
	15	0516951	محمد هشام ابوالنجا												
	16	0517322	محمد عبدالحكيم شماغ												
	17	0517637	فارس طارق منوكل												
	18	0558577	محمد ميعني السهلي												
	19	0611173	زيد وليد ابوالمختار												
	20	0611207	سلطان ميارك الفيداني												
	21	0611422	خالد زيد الخلال												

Figure 3: Lower part of master sheet.

Table 4: Grades distribution.

Work Product	HW	Assignments	Quizzes	Midterm Exam	Term Paper	Final Exam
Maximum grade	10%	10%	10%	20%	10%	40%

Assessment Tools Work Sheets

The data and the results of each graded AST are to be entered in separate assessment work sheets that calculate the scores achieved by every student in each CLO and each PO addressed by the course, the class average, and the percentage of students exceeding specified passing criterion.

The design of each AST is consisting of a certain number of questions that assess some of the course topics and consequently some of the CLOs. The articulation matrix is used to map AST questions into CLOs. After grading the AST, HI-CLASS is used to carry out the following steps:

- Enter the students' grades in each question into a grading worksheet,
- Use the students' grades in the different AST questions to calculate their achievement in each CLO and in each PO addressed by the course,

- Sum up the students achievements in all AST to evaluate the average class achievements and the percentage of students exceeding certain achievement level.

COURSE ASSESSMENT RESULTS

The final direct and indirect AST results can be shown as following:

Results of All Direct Graded AST Work Sheet

The achievement of class learning objectives is shown in Figure 4 as a percentage of students exceeding criteria and the total class average achievement of CLOs. The class achievement and students who pass the course for program outcomes is shown in Figure 5 as a percentage of students exceeding criteria and the total class average achievement of POs.

RESULTS OF ALL GRADED ASSESSMENTS TOOLS				GRADED ASSESSMENT TOOLS																	Total	Grade
COURSE (CE 353) - SECTION (1&2) SEMESTER (01) - YEAR (2010)				#1	#2	#3	#4	#5	#6	#7	#8	#9	#10	#11	#12	#13	#14	#15				
				10	3	3	4	5	20	10	40	5							100			
	1	0260599	علي يحيى فقيه	8.6	1.7	1.4	0.4	1.4	8.7	7	28	5							62	D		
	2	0357802	باسم صالح يادويان																	F		
	3	0516206	معز عباس مختار		1.4			1.3	11										13	F		
	4	0516454	هاشم سامي المزوقي	5.6	1.1	0.8	3.6	2.1	9.4	7	20	2							51	F		
	5	0516525	عبدالله فهد السهلي	2.8	1.5	0.9	3.4	2	9.2	9	27	5							61	D		
	6	0517274	يوسف محمدرزار جاون	7.9	1.8	2.6	3.8	3.4	7	7.5	24	5							63	D		
	7	0517871	خالد ناصر الشهري	6.8	1.7	2.3		2.9	7.1	7.5	28	5							61	D		
	8	0611205	عمر عبدالعزيز صالح	8.2	1.5	2.1	3.4	2.5	17	8	34	5							82	B		
	9	0612018	عائض صالح المطيري	8.4	1.5	2.6	3.4	3.4	10	8	28	5							71	C		
	10	0620671	عادي بدر الشبيبي	7.9	1.8	3	4	1.6	17	10	37	5							87	B+		
	11	0450471	محمد عبدالله العجالي	1.3	1.1		3.8	1.4	7.6	7	21	3							46	F		
	12	0516222	انس سعود قبلي	7	2.4		3.8	1.3	14	10	32	5							76	C+		
	13	0516323	طلال غاري السهلي	7.5	2.1	2.6	3.8	3.2	13	9	27	3							71	C		
	14	0516858	ابراهيم احمد آل دغبرير	7.7	1.7	2.3	3	4.3	16	10	33	5							83	B		
	15	0516951	محمد هشام ابوالنجا	5.9	1.1	0.8	2	1.9	7.2	10	32	5							66	D+		
	16	0517322	محمد عبدالحكيم شماخ	8.7	2.3	3	3.4	3.4	17	9.5	32	5							85	B+		
	17	0517637	فارس طارق متوكل	7.2	1.2	2	3.6	2.4	5.4	7.5	22	2							53	F		
	18	0558577	محمد معيني السهلي	7.8	1.5	2.7	2.4	3.3	9.8	8	22	4							62	D		
	19	0611173	زياد وايد ابوالحمائل	7	1.9	2.6	4	3.2	12	9	26	5							71	C		
	20	0611207	سلطان مبارك الفيداني	5.3		2.1	2.6	1.6	13	7.5	23	5							60	D		
	21	0611422	خالد زيد الخنلان	7.7	1.3	2.4	2.8	1.6	14	10	34	5							80	B		

Figure 4: Class assessment of CLOs.

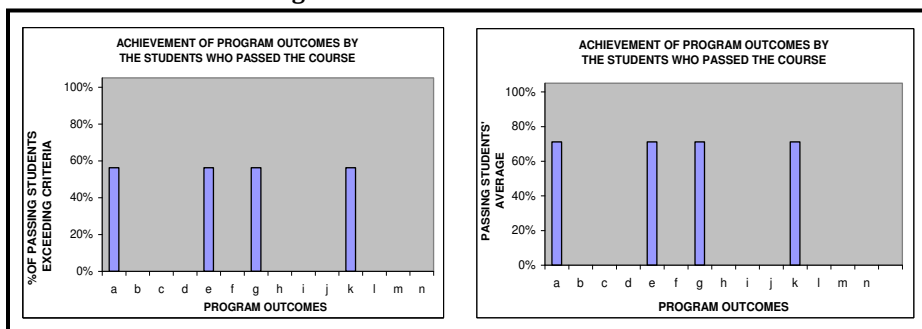


Figure 5: Class assessment of POs

Results for Indirect Assessment of CLOs and Instructional Tools Work Sheet

Figure 6 shows the students evaluation of CLOs is as a percentage of self-confident student and the total class average confidence level. Also, the students' evaluation of instructional tools as a percentage of satisfied student and the total class average satisfaction.

Results of Indirect Course Evaluation Work Sheet

The students' level of satisfaction is shown in Figure 7 as a percentage of satisfied student and the total average satisfaction.

Results of All Indirect Assessment for POs Work Sheet

The class achievement of program outcomes is shown in Figure 8 as a percentage of students exceeding criteria and the total class average achievement of POs.

End of Semester Assessment Report Work Sheet

The direct and indirect assessment tables are shown in Figure 9. The percentage of all students that exceeds 70%, the percentage of passing students that exceeds 70%, the class average and passing students' average. The instructor comments on the unsatisfactory results can be entered to this work sheet for the course continuous improvement.

COURSE BINDER

CE 353 course binder consists of seven dividers containing the course design data, course assessment and course evaluation.

Divider 1 (Course Design Data)

1. Prepare the CE 353 course syllabus according to ABET EC-2000 criteria.
2. Adjust course calendar according the dates of each semester.
3. Relate the course instructional methods and assessment tools
4. Map the course learning objectives into program outcomes with Performance Criteria (performance targets or passing criteria).
5. Prepare the articulation matrix as shown in Table 3.

Divider 2 (Course Assessment)

1. Show the indirect assessment tools (CLOs and instructional tools survey, course evaluation survey and the outcome survey as shown in Appendices 3, 4 and 5).
2. Show the direct CLO assessment tools (copies of blank question papers of HW, Assignments, Exams and Term paper).

3. Show the results of the direct CLO assessment tools as shown in figure 5.
4. Write the end of semester course assessment and improvement report as shown in figure 10.

Divider 3 (Supported Program Outcomes “a”)

1. Show the instructional methods used to address the outcome (a)
2. Select AST materials addressing the outcome (a)
3. Show the outcome assessment tools (direct and indirect)
4. Show the results of outcome assessment tools
5. Write the outcome assessment and improvement report

Divider 4 (Supported Program Outcomes “c”)

1. Show the instructional methods used to address the outcome (e)
2. Select AST materials addressing the outcome (e)
3. Show the outcome assessment tools (direct and indirect)
4. Show the results of outcome assessment tools
5. Write the outcome assessment and improvement report

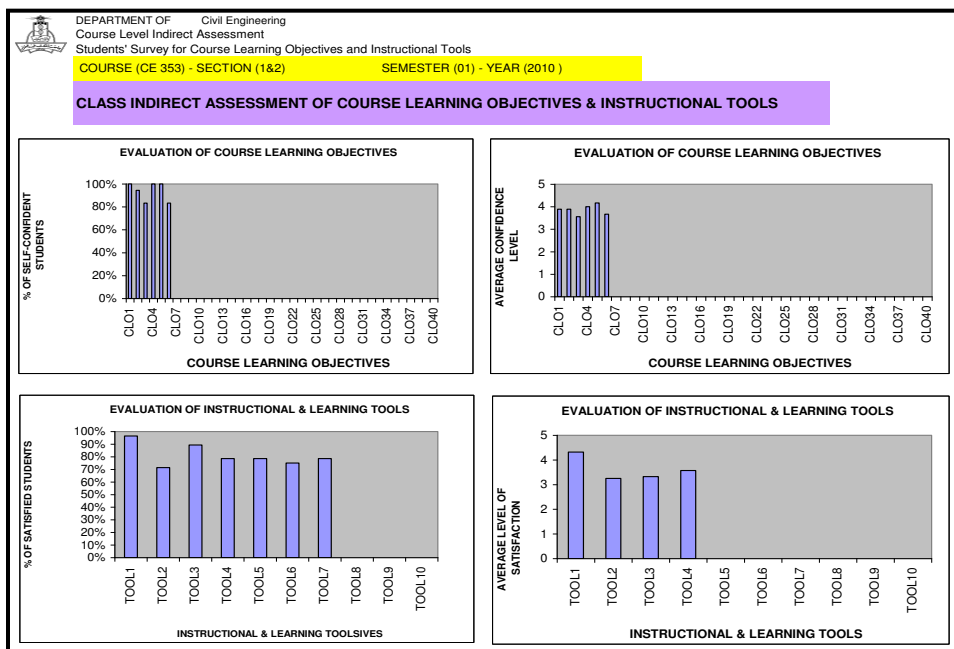


Figure 6: Indirect assessment of CLOs and instructional tools.

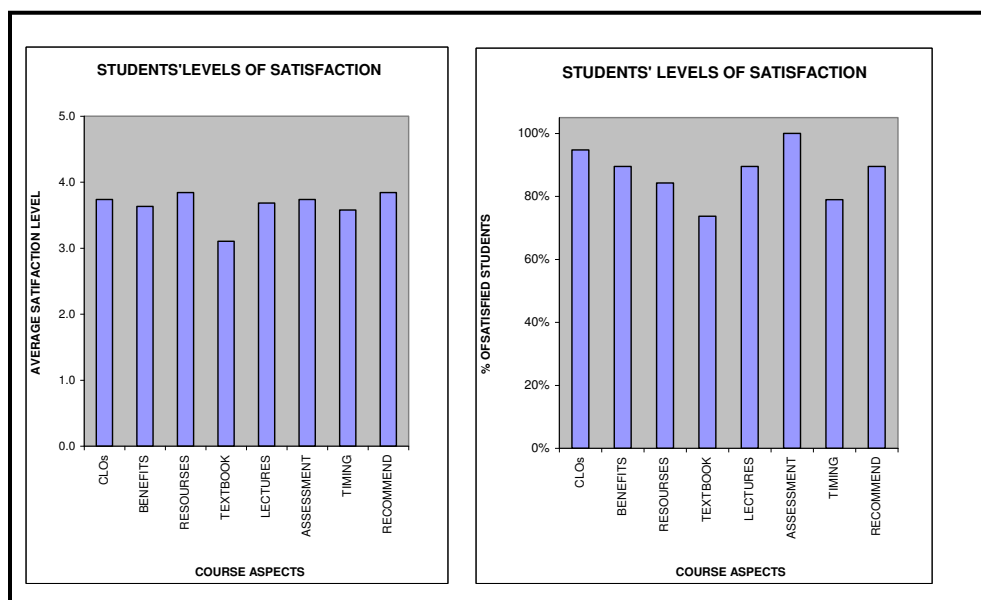


Figure 7: Students' level of satisfaction.

INDIRECT ASSESSMENT		a	b	c	d	e	f	g	h	i	j	k
PERCENTAGE OF STUDENTS SATISFYING CRITERION		78%				83%		83%				89%
AVERAGE CONFIDENCE LEVEL (out of 5)		3.5				3.7		3.7				3.7
AVERAGE CONFIDENCE LEVEL (%)		70%				73%		73%				74%

Figure 8: Indirect assessment for PO's.

Divider 5 (Supported Program Outcomes “g”)

1. Show the instructional methods used to address the outcome (g)
2. Select AST materials addressing the outcome (g)
3. Show the outcome assessment tools (direct and indirect)
4. Show the results of outcome assessment tools
5. Write the outcome assessment and improvement report

Divider 6 (Supported Program Outcomes “k”)

1. Show the instructional methods used to address the outcome (k)
2. Select AST materials addressing the outcome (k)
3. Show the outcome assessment tools (direct and indirect)
4. Show the results of outcome assessment tools

5. Write the outcome assessment and improvement report

Divider 7 (Student's Work Samples of Direct Assessment Tools)

Show copies of superior, average and poorest students work for each direct assessment tool.

COURSE (CE 353) - SECTION (1&2)										SEMESTER (01) - YEAR (2010)											
END OF SEMESTER ASSESSMENT REPORT OF COURSE - ADDRESSED PROGRAM OUTCOMES																					
Prepared by:											Dr. Maged Hassan Hussein										
The Number of Students Who Passed the Course is											16	Out of 21									
DIRECT ASSESSMENT																					
	a	b	c	d	e	f	g	h	i	j	k	l	m	n							
Outcome Passing Criteria on Average	0.7	NA	NA	NA	0.7	NA	0.7	NA	NA	NA	0.7	NA	NA	NA							
Outcome Passing Criteria on % Students	0.5	0	0	0	0.5	0	0.5	0	0	0	0.5	0	0	0							
% All Students Exceeding Criteria	43%				43%		43%				43%										
% Passing Students Exceeding Criteria	57%				57%		57%				57%										
Class Average(% - All Students	63%				63%		63%				63%										
Class Average(% - Passing Students	72%				72%		72%				72%										
Class Exposure	1764				1764		1764				1764										
Perceived Problems																					
INDIRECT ASSESSMENT																					
	a	b	c	d	e	f	g	h	i	j	k										
Outcome Passing Criteria (out of 5)	3	NA	NA	NA	3	NA	3	NA	NA	NA	3										
% Students Exceeding Criteria	78%				83%		83%				89%										
Class Average (out of 5)	3.5				3.7		3.7				3.7										
Perceived Problems																					
INSTRUCTOR'S COMMENTS ON ALL RED CELLS (Perceived Problems) ABOVE																					
Program		Previous Offering				Present Offering															
Outcome	% St. Exceeding	Class Av. all St.	Class Av. Pass St.	Exposure	Perceived Problems				Comments							Actions to be taken					
					The Class average is 63% > 60% The average passing students is 72% which is higher than 70%. No problems are investigated this semester				The course is satisfying the department's criteria							More improvements are required in the next semester					

Figure 9: End of semester assessment report.

SUMMARY AND CONCLUSIONS

This paper documents how several of the ABET EC-2000 criteria are satisfied and how they are in turn used in creating CE 353-Hydrology and Water Resources Engineering course binder to achieve specified outcomes and continuous improvement of the course. The course assessment and evaluation phase was enhanced by using a programmed Excel workbook, called HI-CLASS. Course design and assessment based on course learning objectives (CLOs) and program's outcomes (POs) were done for a compulsory course (CE 353) at the civil Engineering Department. The percentage of achievements (% scores) for each addressed outcome by each course were computed along with the number of outcomes addressed by each course. Results show that the overall achievement from the course is acceptable and within the set performance criterion. Further improvements of the course will lead to more improvements. Outcomes a, e need to spend more time for these two outcomes.

The instructor could easily evaluate the class achievement even after each assessment to continuously improve the course offering. By the end of the semester, the instructor will

have documented results of the class achievement and the course contribution to the achievement of program outcomes.

Instructor can benefit from these results for further improving his teaching leading to better outcomes gained by the students which is the ultimate goal of the assessment process.

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Instruction and Learning in Engineering Education

ANALYTICAL STUDY TO DEVELOP THE QUALITY OF INSTRUCTION WITHIN THE ENGINEERING FACULTY AT THE ISLAMIC UNIVERSITY OF GAZA

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ABSTRACT: The Faculty of Engineering at the Islamic University of Gaza (IUG) evaluates its academic and administrative performance on a regular and continuous basis in the purpose of improving its capabilities and services. This paper presents the major challenges confronting quality assurance of engineering education at IUG, which have been characterized by inadequate research network, insufficient funding and weak industry-institutions relationship, due to the current situation. The purpose of this research is to provide an analytical grades study assessment for engineering students at IUG for the period (2005-2009). Provide practical recommendations in order to improve the faculty of engineering grading system creditably, and thus take an action and reasonable steps towards enhancing and improving the current existing grading system to be consistent with relevant international standards. Study led to some internal actions in order to enhance quality-engineering education at IUG, academic staff should be engaged to serve as team members in the improvement process of existing mark distribution, development of specialized evaluation programs, as well as adopt new educational strategies.

KEYWORDS: Grades; Quality of Instructions; Grades Distribution; Grades Inflation.

INTRODUCTION

Quality assurance in engineering education is a multifaceted problem, further augmented by the number of parties interested in it and the multitude of their respective concerns. The quality system provides for a clearer articulation of the rights and responsibilities of students, faculty and staff [1]. In some countries, some engineering schools have formed coalitions with the objective of designing, implementing and assessing new approaches to undergraduate engineering education, as well as improving the overall quality of the educational experience [2]. Quality system documentation will guide teaching, learning and research in a convenient, predictable and generally acceptable way [3]. The documentation also improves understanding among the faculty and staff [4]. If good documentation is preserved, faculty operations can be streamlined, quality problems can be identified, corrected and prevented, and improvement results can be accomplished in a systematic manner [5]. Documentation of students grade is an important tool to oversee the academic process in the faculty. This paper aims to analyze the distribution of student marks in the Faculty of Engineering in the last five years (2005-2009) and assessing them against the standard grade system to draw conclusions and recommendation that may improve the performance of the faculty in the future.

BACKGROUND AND MOTIVATION

IUG is an independent academic institution located in Gaza which was established in 1978. IUG is a home of well-planned programs, a way to the different community levels and a place for researchers and good teachers. IUG is a member of four associations: International Association of Universities, Community of Mediterranean Universities, Association of Arab Universities, and Association of Islamic Universities.

The Faculty of Engineering has been established in the academic year 1992/1993 to meet the high demand for distinguished education in Palestine and the surrounding region. Since that date, the faculty has expanded in staff, departments, number of students, labs, and resources. The faculty has six different departments with six different majors, and plans are underway to commence new departments and new majors. Currently there are two thousands and three hundreds (2,300) students are enrolled in the six engineering departments, also during summer 2010 commencement, class twenty nine (29) was graduated, and yet two hundred engineers were placed in community to provide services to Palestinian society. In the academic year 2000/2001, the graduate program have started to provide highly qualified personnel capable of taking significant role in building the new emerging homeland and serving their community in the region and around. Great efforts are dedicated in the faculty for research, development and innovation. The faculty has several distinguished research centers and laboratories devoted to serve the Palestinian society. Moreover, the faculty evaluates its academic and administrative performance on a regular basis in the purpose of improving its capabilities.

This paper examines the roles of the Faculty of Engineering in the improvement and moderation of engineering programs at the Palestinian educational development. The paper analyses the current situation of the environmental engineering field in the Islamic University of Gaza and proposes some guidelines for future developments, particularly with respect to human and academic staff behavior in terms of marks grading criteria. Based on the result of this study, recommendations are drawn to improving the credibility of the grading system in the Faculty of Engineering at IUG. The progress in this issue will help making a major changes and development at the performance level; yet this requires making the necessary steps towards performance improvement.

METHODOLOGY

The article has been identified the three stages methodology instrument needed for this study, therefore the Deanery of admissions and records at IUG provided the required collected data as the first stage; yet grades were given for each department for the last five years (2005- 2009). Second stage was to make statistical analysis for the collected data. Finally as a third step is to assess and evaluate the results of this study. On the other hand, a workshop was conducted for academic staff in the Faculty of Engineering and key figures personnel in the university to present the study results, and set their prospective inputs and suggestions.

RESULTS AND DATA ANALYSIS

The Faculty of Engineering consists of six departments; Architecture, Civil , Computer, Electrical, Environment and Industrial. The study were conducted at the Bachelor degree level and for the major departmental courses only for the five years. The department of Environment was excluded as it is a new established department (established on August 2008).

Figure 1 shows the standard grade curves that the grades Excellent (A) , Very Good (B), Good (C), Satisfaction (D), Failed (F) the courses must be judged against. The graph indicates that the vast majority of students are within the range between 60% and 89%, while minor percentages are within the outstanding or failure sectors, 10% for each category.

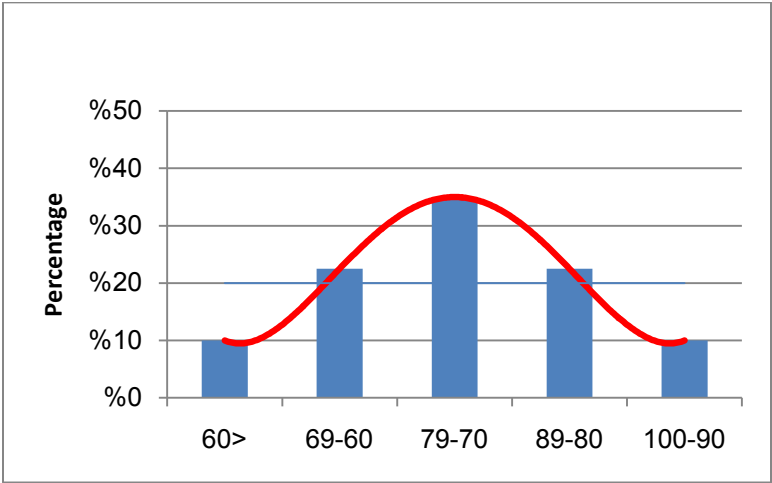


Figure 1: Faculty of Engineering Adopted Standard Grades Curve.

Figure 2 illustrates the grades distribution in the Civil Engineering Department. The whole marks range has been divided into five divisions, representing the five academic scales used to distinguish student levels at IUG. The graph in this first case shows that the grades are closed to the normal distribution of the standard curve.

Figure 3 illustrates the distribution of student marks in the Electrical Engineering Department for the last five years. The graph shows an excess on the excellent grades level, while other scales lies closer to the normal.

Figure 4 shows the grades for Computer Engineering Department, which reveals a large increase in the excellent grades level, the same as the Electrical Engineering Department, since both departments were separated recently.

Figure 5 reflects that there is a lot failure percentage, which are very low among the architecture students compared with other Engineering Departments , also there is a huge grades concentrations in the very good (80- 89) level.

Figure 6 shows the marks distribution of the Industrial Engineering Department for the last five years. It is noted that there is a little increase in the excellent grades level, while there is a decrease in the failure grades level.

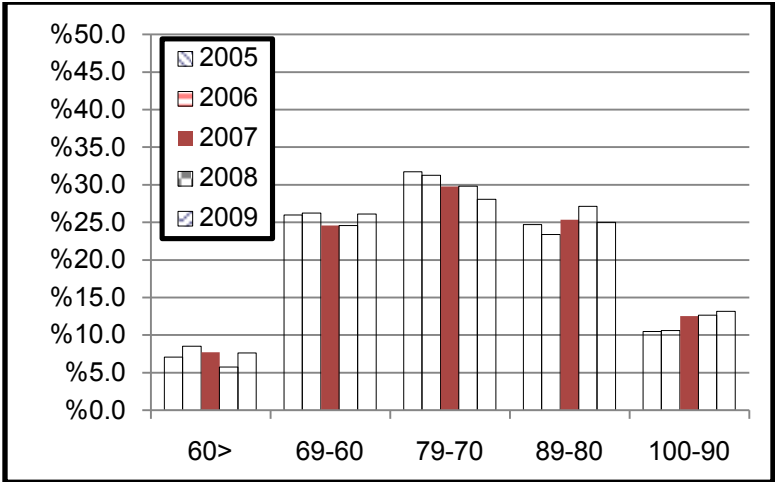


Figure 2: Grades for Civil Engineering Department (Years 2005 – 2009).

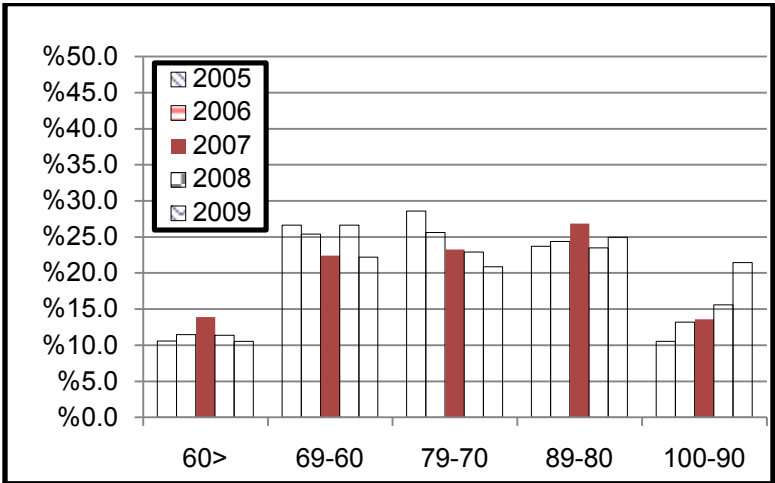


Figure 3: Grades for Electrical Engineering Department (Years 2005 – 2009).

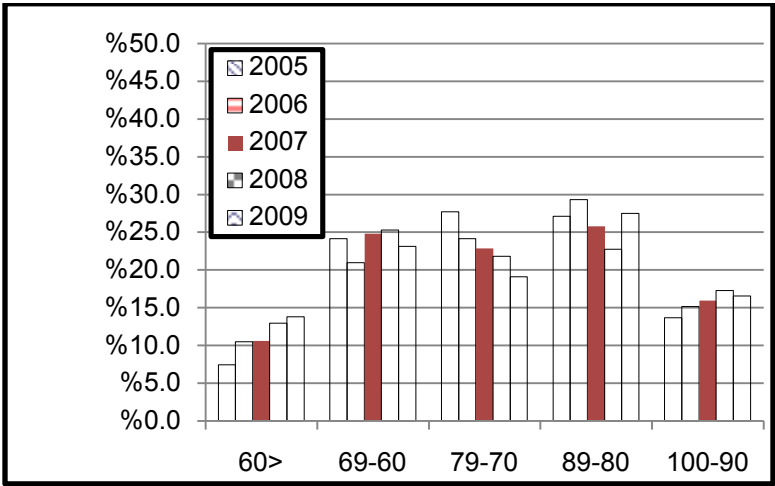


Figure 4: Grades for Computer Engineering Department (Years 2005 – 2009).

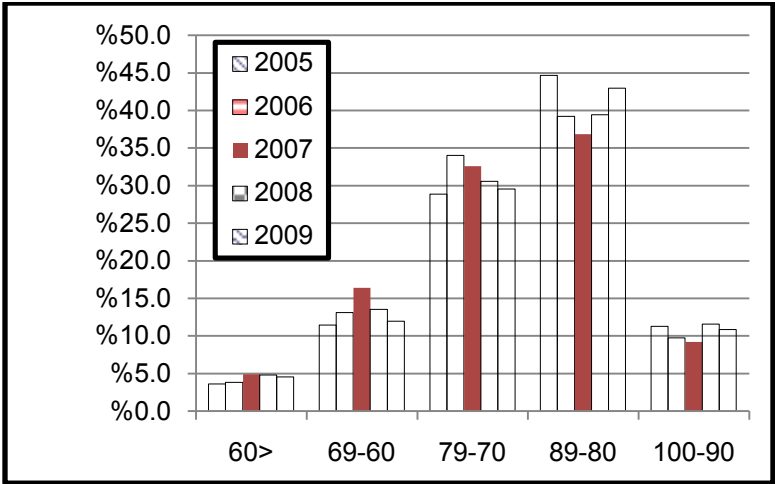


Figure 5: Grades for Architecture Engineering Department (Years 2005 – 2009).

Figure 7 gives an over view of the average grades distribution for the year (2005-2009) among academic Engineering Departments (Civil, Architecture, Electrical Computer, and the Industrial) higher percentage of "Very Good" scale in the Department of Architecture, while the same Department has the least failed students compared to other departments.

This reflects the special nature of the teaching activities in the Architecture Department, which mostly depends on the assessment of architectural projects in the design studio courses. The evaluation of these courses depends on the accumulation of efforts during the whole semester and do not depend on a final exam only. In addition, the work in these courses can be evaluated as a collective one. All these factors make the students' marks of

such courses lie within the "Very Good" level and reduce the possibility of one being failed.

Figure 8 shows that the total picture of the faculty of Engineering as a whole, gives an idea that the grades distribution in general are approximately close to the standard grades curve shown in Figure 1, but it needs more improvement in this aspect in some areas, especially to lower the grades in the Excellent level in some departments and to increase the percentage in the failed section in others. Yet the graph shows the changes and grades distribution in the last five years is not significant.

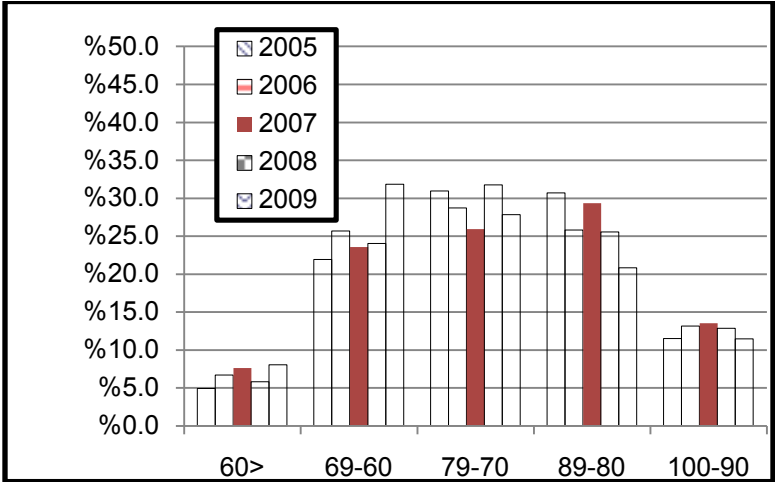


Figure 6: Grades for Industrial Engineering Department (Years 2005 – 2009).

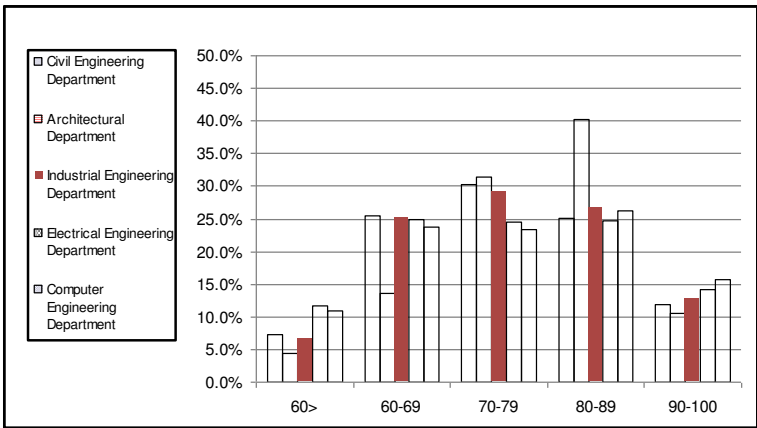


Figure 7: Comparison among Engineering Departments (Years 2005 – 2009).

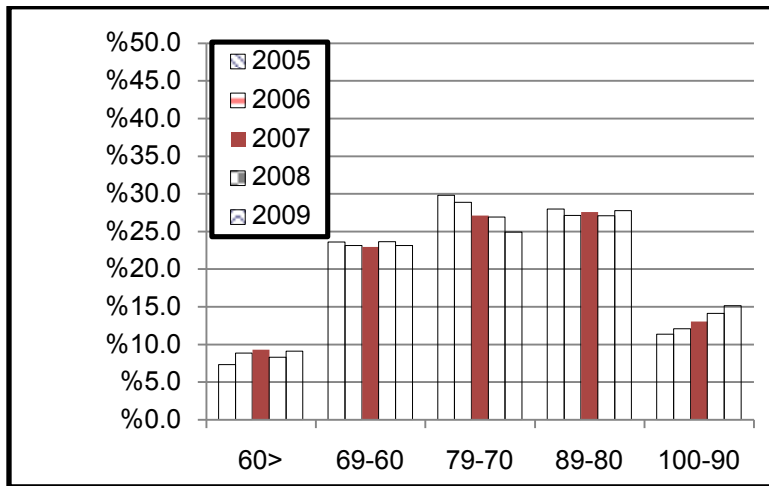


Figure 8: Faculty of Engineering Grades Distribution (Years 2005 – 2009).

CONCLUSION AND RECOMMENDATION

The study shows that:

- There is an inflation in grades among the Electrical and the Computer Engineering departments, therefore these two departments are not satisfying the standard curve.
- The test measurement parameters adopted are not accurately consistent with the relevant standards.
- The Architecture Department suffers from up normal results within the very good range (80-89).
- The Civil and Industrial Engineering Department need some improvement to their grades scale (to match Figure 1) by concentrating on more of challenging problems in their final exam reducing.
- The paper concludes that practical content and analytical data related to marks feedback and assessment is an important criterion for maintaining a high level of quality engineering programs.
- The performance should be adjusted to address more reliable grading system. Academic staff should be engaged to serve as team members to enhance the quality of assessment and recommendations.
- The development of an engineering education must include the improvement of existing mark distribution, development of specialized evaluation programs, and incorporation of new educational strategies.
- As an immediate result of this study and the workshop associated with this, instructors should pay more attention to grades awarding, especially for senior project courses.

- The results obtained and presented in this paper will serve a base for more and a continuous work to conduct an extensive evaluation to other area such as our graduate programs and university required core courses.
- Finally the expected performance should be adjusted to address more reliable grading system.

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AN INQUIRY-DISCOVERY SEPARATION BASED INSTRUCTION TECHNIQUE FOR PROMOTING EXPERIENTIAL DESIGN LEARNING

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ABSTRACT: Proposed in this paper is a constructivist instruction method for promoting engineering design learning by senior undergraduates. The method is realized in two separate stages including inquiry and discovery activities. At the inquiry stage, students are given a product-development problem and required to exercise designing by drawing on their own abilities and prior knowledge, under limited guidance from instructor. To further deepen the exposure, students are not allowed to consult assisting references until the design problem and solution proposals have reached certain maturity in the students' minds. At the discovery stage, students are encouraged to make an extensive use of assisting sources and references, analyze the found solutions, and compare them with what they have developed. Students hence are first given enough time to deploy their creativity potential to develop necessary solution frameworks, before they can access professional or commercially-available design solutions. The discovery activity helps students fill gaps in the developed frameworks and mind maps. The paper emphasizes separating the inquiry and discovery stages from each other so as to stimulate intuitive thinking and creativity, and to maximize learning outcomes from the discovery activity. It is also argued that this separation helps learners build non-hierarchical mind maps, provides for better appreciation for the design solutions, and accelerates the learning process. The proposed strategy is recommended to practice with senior undergraduates working on product development projects. The approach is most useful at the early design phases including problem understanding and design conceptualization. The technique can be used repeatedly within the same design project, as at system-level design development, as well as at detail design phases. Limitations and challenges encountered in the implementation of the proposed methodology are discussed.

KEYWORDS: Design Instruction; Inquiry-Discovery Learning; Constructivist Approach; Reverse Engineering; Experiential Learning; Project-Based Instruction.

INTRODUCTION

Engineering design is a central component of engineering curricula. In response to the ABET EC2000 requirements, many engineering programs around the world are continuing to revise their curricula to integrate design and manufacturing topics into various engineering courses. Methods for delivering this course material are also being developed with a general focus on experiential design learning by undergraduates [1].

Engineering design is a complex process to teach in a short time. Some instructors would even question the feasibility of directly "teaching" design, especially at the undergraduate level. The main reason behind this is that design is an open-ended problem that has no well-defined mathematical model; the design process involves creative thinking, decision making, iterative analysis, and visualization skills, among others. It is the consensus of design instructors that design should be learned through "doing" design, rather than by attending design lectures or demonstrations [2].

The main point that has motivated this work is the author's observation that students, given a design problem, immediately rush to seek assistance from different sources and references, especially from the Internet. While the use of references and literature sources should generally be encouraged, it should be controlled in project-based learning settings. The problem here is that students search for solutions in references and web pages before making serious attempts at proposing solutions on their own. This behavior is usually denied by instructors who seek to engender design skills in the students. It is the opinion of this author that rushing to see what others have done before trying one's own abilities hinders and slows down the learning process. It is generally accepted that design learning is accomplished through developing of intuitive and critical thinking skills, rather than through surveying or "browsing" of references.

In addition to the above points, it has been noted that senior undergraduates normally become aware of several design texts and a wide variety of references addressing theoretical and practical aspects of the design process. A side effect of this is that students often become overwhelmed with the breadth of design approaches and the variability of terminology [3]. One task of the design instructor is to convey to the students that engineering design is not about solving equations, nor is it about memorization of terminologies or knowing of procedures. Yet another task for the instructor is to provide students with a generic and relatively stable structure for the design process that they can use with a wide range of design problems.

Based on the above points, and given the relatively short time traditionally allocated for design courses in engineering curricula, different methods of instruction are sought for to accelerate the learning process and to make a more efficient use of the course time.

This paper describes an instruction methodology for promoting and strengthening the learning experience of undergraduates at product design courses. The method has been used by the author at a product design course for senior students of industrial engineering at Jordan University of Science and Technology (JUST). The approach can be viewed as a modified procedure to promote the well-known discovery-based learning environment. The core of the method consists in creating a stimulating environment by alternately exposing the students to inquiry and discovery learning stages. At the inquiry-development stage, students are given an ill-defined problem to design a certain type of product. To intensify inquiry and deepen the challenge, students are not allowed to consult literature or any assisting sources until they exhaust their own potential and create their own conceptual solutions. By controlling the students' access to possible existing design solutions, students are left to work on their own, with a limited guidance from the instructor. In this environment, the instructor acts as a facilitator. Knowing that existing solutions would be revealed later, student teams usually tend to compete with each other to accomplish professional solutions. After the students have been given enough time to think out and develop their own solutions, and after enough discussions of the main challenges involved in the design case study have been made, students are allowed to look up assisting sources to find answers and solutions to the problem at hand. Observations of the author, in addition to informal surveys of students, have shown that the method leads to more rapid learning and better appreciation of the design solutions,

and helps students recognize their abilities. The learning process becomes more enjoyable and fruitful, with a higher achievement of the course objectives.

To summarize, the proposed instruction approach aims to amplify the performance of students at inquiry and discovery based learning settings. This is achieved by imposing separation between the two settings. This approach emphasizes that students should initially depend on their own abilities and prior knowledge, and that references and sources be referred to only with specific questions and issues that would have appeared at the inquiry stage. The culmination of the process often comes with the students discovering that professional designs and commercially-available products are similar to, or at least have intersection points with, solutions developed by them in the class. Furthermore, students are not left on their own for the whole course: a generic structure of the design process is introduced to them in parallel with these activities by making relevant reflections. By delaying the introduction of the design process's generic structure, students are seen to better appreciate it when it is presented to them, with a clearer understanding of the used terminology. In addition, students are seen to better realize the need to think and work in organized and systematic manners.

The next sections provide a brief background on design instruction, describe the proposed instruction procedure, and discuss limitations and challenges encountered in the practice.

ENGINEERING DESIGN INSTRUCTION

Many methods have been developed for the instruction of engineering design over the past decades. The basic principles underlying these developments emphasize an “induction” style of instruction, whether it is called problem-based learning, inquiry learning, discovery learning, or some variation of those themes. A paper that can be considered a landmark in the published research on engineering education was written by Felder and Silverman [4]. The authors proposed several models of teaching and learning and defined different dimensions for these processes. One of the models, the induction/deduction model, addresses the indirect, implicit approach (induction) versus the direct and explicit one (deduction). Induction is defined as a reasoning progression that proceeds from particulars (observations, measurements, data) to generalities (governing principles, laws, theories, rules). Deduction, on the other hand, is the opposite of induction. A deductive instructor starts by stating the governing principles and works down to the applications. In induction, one infers principles; in deduction one deduces consequences [4].

As Felder and Silverman [4] noted, mismatches exist between common learning styles of engineering students and traditional teaching styles of engineering professors. For non-design courses, deduction-based teaching can be preferable since deduction provides for a more structured delivery of the material. When it comes to design courses, however, deduction methods become somewhat inefficient, especially at the undergraduate level. Using a deductive style, an instructor would have to impose a relatively rigid procedure on the inherently flexible and creative design process. It has been noted that delivery of

generic and theoretical procedures of design aspects without immediate substantiation and implementation often causes most students to become inattentive and discouraged about the course. Achievement of the design course objectives using deductive instruction is complicated.

Traditional inductive presentation, on the other hand, has the problem that delivery is neither concise nor well-structured. The instructor would have to supervise students' work on a design case-study, guide the team work through loosely defined milestones, treat and analyze the design of a particular product, and eventually require the students to make sense of their observations and come to general conclusions. This is the approach this author had been practicing over several years of instructing product design to industrial-engineering students. In the past three years however, and due to relatively low achievements of students, it became evident that certain modifications and improvements were necessary to improve students' performance.

In the literature, the inductive approach described above is known as a constructivist one [4]. Constructivism argues that humans generate knowledge from their experiences. Piaget [5] articulated mechanisms by which knowledge is internalized by learners. Piaget suggested that humans utilize assimilation and accommodation processes to construct new knowledge from their experiences. By assimilating, individuals incorporate the new experience into an already existing framework, without changing that framework. Accommodation, on the other hand, is the process of reframing one's mental representation to fit new experiences. From here, it can be understood that the prior availability of a suitable framework is necessary for effective and rapid learning. Inductive instruction methods, therefore, are more suitable for senior undergraduates who have developed certain framework which enables them to learn design skills on real or nearly-real design problems.

Constructivist-based methods such as inquiry and discovery-based techniques emphasize that the responsibility of learning should reside increasingly with the learner. It is argued that students construct their own understanding and should be actively involved in the learning process. Students eventually look for meaning and will try to find regularity and order even in the absence of full or incomplete information [6, 7].

Another important assumption of constructivist instruction methods concerns the level and source of motivation for learning. Glasersfeld [6] suggests that motivation to learn is strongly dependent on the learner's confidence in his or her potential for learning. Confidence and belief in potential to solve new problems are derived from first-hand experience of mastery of problems in the past and are much more powerful than external acknowledgement or motivation.

A point of caution that is worth of mentioning here is that students must not be challenged with problems far beyond their experiences. To prevent students from becoming disappointed, they should be given attainable design tasks. This links up with Vygotsky's "zone of proximal development," where students are challenged within close proximity to, yet slightly above, their current level of development [8,9]. By experiencing the successful completion of challenging tasks, students gain confidence and motivation

to embark on more complex challenges. Vygotsky [8] claims that instruction is good only when it proceeds ahead of development. In the context of the methodology proposed here, design assignments are of increasing complexity, with each assignment broadening student's development level and preparing them for the next assignment.

Implementation of inquiry/discovery based instruction of engineering design assumes an active learning environment in which students conduct design projects and case studies under supervision from the instructor-facilitator. With the paradigm shift to student-centered education [10, 11], proper organization of this environment is crucial to the success of the learning process and is the subject of the present paper.

THE PROPOSED INSTRUCTION METHOD

The instruction approach described below can be used to relieve some of the practical educational concerns and to revitalize the project-based learning environment. This approach is an alternative implementation procedure for inductive, discovery-based instruction. The procedure had been implemented four times by this author at facilitating product design classes delivered through 3-hour weekly sessions to senior undergraduates of Industrial Engineering.

As it was mentioned above, the main motivation behind the development of this approach was the observation that students, given a design assignment, immediately rushed to search design sources and web pages for solutions. Students usually find solutions in these sources, tailor them somewhat to their needs, and submit a report or an oral presentation on them. It was also noticed through team presentations that students often could not demonstrate clear understanding of the underlying solution principles. Without an adequate understanding of the design requirements and relevant background, this approach caused students to make misleading conclusions and interpretations, not to mention the loss of the targeted objectives of the course. Obviously, the main objective of a design course is to foster design skills in the students, - not just to let them learn how a particular product was designed by others.

To avoid the abovementioned behavior, it is suggested that the use of references and sources be limited to searching for answers to specific questions and issues that arise in the course of design, - questions that have been analyzed and articulated. Sources should not be searched for whole design solutions or designed products. By controlling the use of references, students start to feel free to "think" rather than to "browse," which is an objective in itself.

This paper claims that design learning is promoted if the inquiry and discovery stages are separated from each other. This claim is based on a premise that this separation more vigorously arouses students' interest and curiosity.

The proposed technique is best described using the following steps:

Step 1: Introduction of the design assignment

At this step, the instructor describes, in general terms, the product design problem to be addressed. This should only address the development of customer needs; no attempts are made at describing any design form or features. Students begin to puzzle over different aspects of the problem and customer categories. After having puzzled for enough time, the facilitator would provide hints by asking the students to define “for whom the design is intended,” calling it the customer. Students then start to develop possible customer needs and translate the needs into generic engineering characteristics. Different teams would have different targeted customers and hence develop different lists of requirements. This direction should be encouraged in order to promote diversity.

Step 2: Presentation, clarification, and justification of customer requirements

Here, students make short oral presentations to discuss their thoughts and to justify the inclusion of each customer requirement. The facilitator does not reject students' opinions and only corrects them if a misconception was presented. An important point here is to train the students to formulate engineering characteristics separately from any product form. Realizing that they are going to deliver oral presentations in front of classmates, teams are seen to prepare their thoughts more carefully. Students are required to document their thoughts and discussions for later reference.

Step 3: Development of design concepts

Based on the developed customer requirements, students begin to develop solution concepts. The instructor here only facilitates the process by asking questions when necessary. This phase is the one of highest creativity concentration. Generating multiple design concepts is crucial to the success of the process. Students would first quickly generate 3-4 concepts based on their experiences. The instructor continues to ask for one more concept. It is just at this moment that students start to develop particular frameworks and widened mind maps. This step begins in the current class and its conclusion is left to the next class meeting. Experience has shown that with the environment built correctly, students would continue to work on concept development and refinement over the whole week until the next meeting.

Students here are exposed to the vague and fuzzy environment of design conceptualization. They are challenged with a seemingly endless number of questions that need to be answered. Abstract thinking, intuition, and communication skills are all trained at this step. As a result, students would feel the real need for tools to organize their thinking and reasoning processes. Having it on high demand, the instructor would introduce students to a work organization technique. For instance, Quality-Function Deployment (QFD) and the associated with it House of Quality (HOQ) can be introduced here briefly (WHAT's vs. HOW's Room). Students now seem to grasp QFD and HOQ concepts rapidly and efficiently. They would appreciate them as mechanisms to realize

and organize the already developed frameworks. It is recommended that QFD and HOQ be introduced on a design project of low or moderate complexity (see the next section).

Step 4: Selection of preferred design concept

At this step, students present the proposed concepts and start to evaluate them based on the developed design requirements. Here too, students are exposed to a multi-criteria, multi-attribute, decision-making problem. Students recognize the need for a formalized evaluation technique to organize their work. Typically, senior industrial-engineering students would be aware of some of the decision-making techniques such as decision matrices or the analytic-hierarchy process (AHP). Simple and easy-to-use decision-support software packages are available and easily accessible. Students are challenged by subjectivity, abstraction, and decision-making under uncertainty. The instructor's task would be to facilitate coming to the conclusion that design decisions are normally made with incomplete information and that risk always exists. At the end of this phase, different teams would select different concepts for further consideration.

This activity can be very enjoyable. Student teams criticize selections made by their colleagues: debates and arguments usually are raised. To save time, the instructor would eventually help students “approve” selected concepts.

Step 5: Reverse engineering: consulting references, patent literature, manufacturer's catalogues and websites; inspecting commercially-available products

This is the discovery stage. Here, students are encouraged to look up existing solutions in the literature and in any possible sources. Students reverse-engineer the found solutions and would often find that the solutions are conceptually-identical to, or have similarities with, the solutions developed by them. Otherwise, analysis would reveal possibly missed customer requirements. Experience has shown that among the frequently left requirements are those of easy manufacturing and assembly. The instructor would intentionally leave these requirements unaddressed until they are inquired naturally. By comparing their solutions to those developed by professionals, students would more rapidly grasp the differences and give adequate appreciation for them. Recall that the ability to read the minds of other designers is a design skill by itself. Self-confidence is developed here by the students, which normally stimulates the learning process.

Step 6: Reconsidering design concepts and reselecting the most promising of them

At this step, students rebuild their minds. In particular, they would extend the design requirements list to include those suggested from professional designs, reformulate some of the requirements with more clarity, and select preferred concept on a new basis. Concept selection now is made with far better awareness and understanding. Student discussions go to a higher level of reasoning.

Step 7: Detailed design

This step involves modeling of design function and performance. When it comes to the design of product system interfaces, students are challenged with the fact that there too are multiple options; Steps 3-6 of this procedure have to be conducted for each product part or interface. Due to time limitations, it is usually infeasible to conduct this phase in full for all the product elements. The instructor would direct the students (and help them) to select one or two of the product's critical interfaces for further modeling and finalizing. Other product details may be assigned intuitively. At this expense, the instructor earns an opportunity to initiate a new design project and adventure.

It is important to note here that industrial-engineering programs usually involve basic design modeling courses of somewhat “lighter” content than that of the more classical engineering programs. Therefore, the instructor should be aware of the content of the foundation courses and select suitable design-modeling assignments accordingly.

Step 8: Prototyping

Physical or virtual prototypes are necessary for completing the picture and unrevealing possible weaknesses or unpredicted behavior of the developed design. In most cases, virtual prototypes (CAD/CAM simulations) are more feasible than physical ones. Initial CAD drawings often are developed in parallel with the design process. While physical prototypes are more beneficial to the learning process, they are dependent on the capacity of university facilities and the availability of funding. Students sometimes continue to further develop and prototype their products in subsequent capstone courses such as graduation projects. Virtual prototyping can best be given as homework assignments.

Step 9: Reflection

Without making appropriate reflections, the design learning experience is not completed. Frequently, design solutions are generic and would be met across different product types. Students are encouraged and assisted to make conclusions regarding the lessons learned from the conducted project.

Depending on the product type, a design project might extend from 3 weeks for simple products to 7 weeks for more complex ones. Some instructors would prefer to conduct one, semester-long, project and execute it in full detail. This approach would be more suitable for students of mechanical, electrical, chemical, or mechatronics engineering. For industrial-engineering students, it is advisable to conduct at least 3-4 different projects. This is because industrial engineers usually work within the scope of design management and need to develop skills to manage the process and communicate effectively with engineers from other fields.

DESIGN PROJECT SELECTION

As it is explained above, at least three or more projects are assumed to be conducted during one semester. It is proposed here to conduct design of products of incrementally increasing complexity. For instance, it is possible to conduct projects of three levels of complexity, with each level addressing the design of a certain class of products. Table 1. below gives suggested product types for each complexity level and approximate duration for each project in weekly sessions.

As seen from Table 1, project complexity increases as the course proceeds. Level-1 projects serve as introductory; they help establish the learning environment and grasp the basic terminology. These projects address every-day products that typically are known to all students. Level-2 projects address products of some complexity with a wider variety of customer requirements. They also require good prior knowledge of engineering basics. Finally, Level-3 projects are directed toward more complex products, the details of which are not well known to a typical undergraduate. Incrementally increasing product complexity over the course duration is recommended in order to sustain and broaden the design challenge and interest. As it was mentioned earlier, however, project complexity should not go far beyond the attainable scope of knowledge for the students.

Table 1: Suggested classification and order of design projects.

Project Complexity Level	Examples	Typical Duration (3-hr weekly sessions)
Level 1: Low-complexity products	Shopping cart; Kitchen knife; Ironing table; Children teaching aids (toys)	2-3 sessions
Level 2: Moderate-complexity products	Simple sports exerciser; Coffee mill; Office water heater/cooler; Concrete mixer	4-5 sessions
Level 3: More complex products	Car lifting system; Dish-washing machine; Elevator; Microwave oven.	6-7 sessions

CHALLENGES AND LIMITATIONS

The implementation of the proposed instruction approach has the following limitations and challenges.

1. There is no one guaranteed way to really impose separation between the inquiry and discovery stages, unless all the core work is conducted in the classroom. The instructor should seek appropriate ways to impose separation, depending upon student attitudes and culture. An acceptable level of success at imposing separation may be achieved by the

following measures. First, calling for positive attitude and explaining the benefits of the procedure normally works well with a good fraction of the class. Second, by realizing that students' misconduct usually occurs because students seek high grades, the instructor can nullify this point by customizing the grading policy. For instance, a grading system that evaluates the *process* more than the quality of the developed designs is recommended. To help evaluate the process, an assisting point that can be tracked here is that, ideally, a design solution should translate the design requirements developed earlier by a team into engineering characteristics for the product. If this translation process lacks logic or is unreasonable, the instructor may suspect cheating and investigate the case in more detail. A cheating team would normally fail to give convincing justifications and explanations for all details of a "stolen" solution. This author used to give zero grades in such cases, which, over time, minimized their occurrence.

2. A challenge usually faced with project-based design courses is that they typically are given one credit hour in the curriculum. Given the high workload-to-credit ratio, some students would not devote much of their time and effort to the course and would just seek to pass it. The course, therefore, should be given more credit hours in the curriculum. Otherwise, the grading policy should take this behavior of students into account.
3. Performance evaluation of students in the proposed learning environment presents a complex problem and places high workload on the instructor. It also causes stress on the students since exams are not conventional. For a one-credit-hour course, the pass-fail option may be considered, given that this option relieves students stress and would make them more available to the course. The challenge then becomes one of creating an attractive and exciting learning environment. In order to arouse students' interest in the course, it is recommended to organize exhibitions of selected designs at the end of each semester. This "publicity" usually causes students to work with more devotion and responsibility during the course.
4. Teamwork is an important element of the procedure. The instructor needs to promote teamwork dynamics as well as communicate with individual students. Certain students would feel lost in this environment, while others would become "leaders" dictating their solutions to the team. To control this occurrence, close contact with the teams is needed, which requires more time and effort. An experienced teaching assistant also is necessary.
5. Proper application of the proposed procedure places a limitation on the number of students in the class. A maximum of about 16 students (4 teams) in one class is recommended, to allow for successful management of the course.

SUMMARY AND CONCLUSIONS

An induction-based instruction method is proposed for capstone product development courses. The method involves an inquiry stage and a discovery stage. The two stages are suggested to separate from each other in order to create a more efficient learning

environment. At the inquiry stage, students learn critical thinking and creative problem solving skills by drawing on their own experience and knowledge. At the discovery stage, on the other hand, students learn to analyze and assess their solutions by comparing them with professional designs. As a result, students come to better appreciate their abilities at designing and become more enthusiastic about the course.

By imposing separation between the inquiry and the discovery stages, the exposure of students to problem solving is deepened and the extraction of their creativity potential is accomplished more fully. At the inquiry stage, students develop certain frameworks and mind maps, which might involve some voids, gaps, or misconceptions. Interest and curiosity are aroused at the inquiry stage. The discovery stage gives answers to the questions that students have been striving to answer during the inquiry stage. This approach promotes learning and helps more effectively engage students in design activities.

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ENHANCING STUDENTS' LEARNING THROUGH 3-TIER SELF EVALUATION MODEL: SUCCESSFUL IMPLEMENTATION AT A PUBLIC SECTOR ENGINEERING UNIVERSITY

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ABSTRACT: This paper shares an effective teaching–learning framework, the Three-Tier Model of Self Evaluation that coincides with the current academic developments and meets the professional demands of the present century. The model combines effectively two essential academic routines, teaching and testing; and provides an observable and a systematic procedure to consciously and continually gauge students' understanding, and acquisition of knowledge and skills regarding a taught concept. The paper describes the model in terms of its conceptual framework and then shares the implementation with an intact group of students during an undergraduate course at a public sector engineering university. It enables students to reflect upon and to analyze critically their learning i.e. their knowledge and skills output by adopting three levels of self-evaluation called Tiers which are evaluating one's performance against (1) the identified criteria, (2) peer performance and, (3) an acceptable and identified standard sample. This self-evaluation technique is introduced right after the formal classroom instruction of a topic with the help of pre and post assessments and a formal assignment/ project. The qualitative and quantitative data from the three stages of the evaluation as well as the difference in the pre and post test scores revealed the process to be an effective and enriching experience for the students in terms of content, skills and the measurable performance. The students' products improved substantially, and their involvement in the learning process increased considerably.

KEYWORDS: Three Tier Self Evaluation Model; Teaching- Learning Strategy; Acquisition of Knowledge and Skills.

OVERVIEW OF TERTIARY EDUCATION

“The growing internationalization of economies affects the world of work, with rapid and frequent change, the introduction of the new technologies and new approaches to organize companies. Employees need both to update specific job related skills and to acquire generic competencies that enable them to adapt to change. The knowledge, skills and attitudes of the workforce are a major factor in innovation, productivity and competitiveness and they contribute to the motivation, job satisfaction of workers and the quality of work” [1]. Educational scenarios across the globe are reflecting the spirit of change and experimentation owing to the transforming needs of the professions and workplaces on one hand and the economies and societies on the other. Industrial economies have shifted from manual to technical and scientific skills, and this change has serious implications for the students entering job market today [2]. Contemporary educational research and analysis of education, especially the higher education, stress the need for the traditional pedagogical practices to be aligned productively with the environmental changes and demands. Academic and professional institutes bear greater responsibility in training students for addressing economic, political, societal and global problems and for providing better solutions for improving quality of work and life , theirs

and of others around them. This implies that universities must be connected with their larger environments and must endeavor to produce professionals who are capable to meet the demands of the changing economy and workplace, who can serve the knowledge societies with professional practices and who are characterized to be life lifelong learners [1].

The higher education is no more limited to producing graduates with impressive degrees as an indication of their having accumulated sufficient technical knowledge in a specific domain to start their chosen careers. Today, higher education is primarily concerned with producing individuals who are independent learners and confident thinkers and have undergone sufficient training towards acquisition of specific skills which qualify them to assume roles and responsibilities which contribute to their professional and societal undertakings. “Our graduate schools of science and engineering are therefore important not only as sources of future leaders in science and engineering, but also as an indispensable underpinning of national strength and prosperity—sustaining the creativity and intellectual vigor needed to address a growing range of social and economic concerns [3]. There has been an increased emphasis on training students on the application of acquired knowledge on work related and actual methods for the development of the crucial professional skills, also to train them on the processes of enquiry, problem-based learning skills; engaging them actively in the learning process and to inculcate creativity instead of treating them as passive recipients of theoretical information[4]; and on developing higher order thinking skills, problem solving abilities and educational experiences of students to revolve around responsibility and judgment [5].

Professional education has been completely transformed under the wake of developments in the global and economic environment and in turn the changes that shaped the field of education. Today, professional medical education is vibrating with the competency based curriculum, self-directed and problem based learning with constant quality improvement and faculty development [6]. Similarly, engineering education is resonating with echoes of reinventing the engineering education to produce engineers possessing core knowledge and having the desired attributes of being problem solvers and lifelong learners. Engineering professionals and societies are all the more concerned about the quality and effectiveness of engineering education and regarding the possibilities within engineering education that would enable these technically grounded graduates to be better prepared to work in a constantly changing global economy [7].

DEVELOPMENTS IN ENGINEERING EDUCATION

Engineers and scientists are the people who provide the framework that support our industrial and technological frontiers in terms of the machines and mechanisms through research and development. Considering their importance to the present technological driven and industrial based environment and also to “all the ways in which scientists and engineers contribute..., it is time to review how they are educated to do so” [3]. Modern engineers work in teams when they conceive, design and implement the product, process, or system. Teams are often geographically distributed and international. Engineers

exchange thoughts, ideas, data and drawings, elements and devices with others around the work site and around the world [8]. “Engineering will only contribute to success if it is able to continue to adapt to new trends and provide education to the next generation of students so as to arm them with the tools needed for the world as it will be, not as it is today” [7]. “The demands on practicing engineers are changing, and the system for engineering education must necessarily change with those demands. Reinventing engineering education is definitely an important concern and it has a much wider scope than mere curricular changes. Engineering education comprises “the teaching, learning, and assessment processes that move a student from one state of knowledge and professional preparation to another state”. Furthermore, “engineering education must provide opportunities for team based problem solving”, and “where they are trained to be lifelong learners” [7]. “For reasons of both globalization and public interaction, engineers must have an understanding of people with different backgrounds and different cultural values and must be able to interact with them effectively. Thus, engineers must be more broadly educated than in the past, and they must be able to understand the wider context and effects of their work. Successful engineers in the global workplace need much more than technical knowledge and skills. Students today must be taught to be lifelong learners able to think critically and be adept at locating, evaluating, and assimilating information from many sources [9].

The needed change in engineering pedagogy is justified considering the changing milieu and the role that engineers were required to play in order to adequately respond to the transformed environments and this fact was endorsed by Charles M Vest, President Emeritus MIT (2007) “Perhaps I am so old fashioned I still believe that masterfully conceived, well delivered lectures are still wonderful teaching and learning experiences. They still have their place. But even I admit there is a good deal of truth in what my extraordinary friend, Murray Gell-Mann, Winner of Nobel Prize in Physics, 1929 likes to say, “We need to move from the sage on the stage to the guide on the side.” Studio teaching, team projects, open-ended problem solving, experiential learning, engagement in research, should be integral elements of engineering education [8]. “There are some things that are probably most efficiently learned by rote, such as number bonds, spellings, multiplication tables; these are skills that are most useful to us when they have been practiced sufficiently to become automatic. There are also bodies of knowledge (facts and information) that it is reasonable for society to expect teachers to teach and for pupils to learn, although there are still debates about what knowledge and whose knowledge is most important. However, the exponential increase in the amount of factual information in recent years and for the foreseeable future, coupled with the rapid changes in the nature of employment, indicate that there should be far greater emphasis on learning which can be transformed and applied to new circumstances than on learning facts and procedures applicable only in situations closely similar to those in which they were learned. Indeed, it is the need of the whole population to be able to translate and interpret what they learn” [10]. Therefore, effective teaching requires that educators adapt, develop, and hone their teaching skills to increase the level of student learning. In this fast-moving and rapidly transforming environments, it is important to assess how teaching is changing and whether the changes are effective [9]. Of the various factors affecting quality of engineering education, teaching process is one [11]. Faculty Inadequacy and poor student Performance were identified as major impediments in

engineering education programmers [12]. “In 2007, with support from the National Science Foundation, the National Academy of Engineering convened a committee of engineering educators, leaders in faculty professional development, and experts in teaching assessment to organize a fact-finding workshop and prepare a succinct consensus report that addresses the development and implementation of a system to measure the instructional effectiveness of engineering faculty members. The charge to the committee was to identify and assess options for evaluating scholarly teaching (referred to in this report as “teaching effectiveness”) which includes a variety of actions and knowledge related to faculty members’ content expertise, instructional design skills, delivery skills, understanding of outcomes assessment, and course management skills” [9]. Effective pedagogy need to facilitate “student learning of critical personal and interpersonal skills, and product, process, and system building skills, and simultaneously enhancing the learning of the fundamentals [8].

INTRODUCING THE THREE-TIER SELF EVALUATION MODEL

The teaching- learning model presented in this study is developed in the wake of all these changes in the global context especially with the trends shaping up higher education scenario. The 3- Tier Self Evaluation Model [13] is a teaching – learning technique which combines the benefits of a variety of current valuable academic practices (which are briefly referred to later in this paper) that establish the validity of the model’s conceptual framework and its applicability. It ensures structured and conscious teaching learning towards attainment of observable outcomes. It promotes students’ performance in terms of mastering the knowledge (content) and also skills (applications). The model provides opportunities to develop and strengthen cognitive abilities on one hand, and literacy on the other.

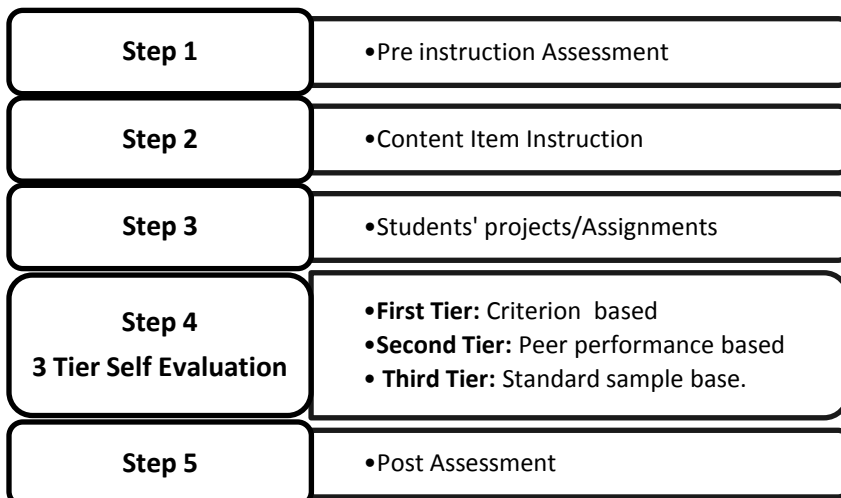


Figure 1: The Three-Tier Self Evaluation Model

STEP 1: The students are assessed on the contents (knowledge) and application (skills) about a prescribed curriculum item.

STEP 2: The students are taught the topic according to the plan.

STEP 3: The students are given a project based on the taught content item. The project can be any practical assignment or activity that provides an opportunity to apply the knowledge related to the taught content.

STEP 4: The students, under instructor's guidance, evaluate their completed project in three stages:

- **First Tier:** They evaluate their work against the criterion provided to them by the teacher as a checklist. (this criterion was also covered during the classroom instruction of the taught item.)
- **Second Tier:** They review their peers' work and then evaluate their work once again for greater insights into their understanding of the taught concept.
- **Third Tier:** They evaluate their work in comparison with an acceptable and standard sample project/assignment provided to them by the teacher.

STEP 5: Finally, the students are given a post-test similar to the one given at the beginning of the instruction to calculate the difference in students' knowledge and skills brought about by the teaching- learning process. Also, students improve their assignments for final submission for teachers' evaluation.

EDUCATIONAL PRACTICES & THEMES SUPPORTING THE MODEL

This model realizes that “an important aim of education is to bring about learning with understanding” [10] and views “learning as an interpretative process” [14]; thus, students are not passive recipients of knowledge that is provided to them by their teachers [15]. The model provides a framework for “deep learning” [10] and “real learning” that calls for opportunities of “interaction with people, ideas, things and events in the real world” [16], since Interaction has been identified as vital to learning process [17]. Social Interaction particularly with peers promotes the development of cognitive abilities and provides opportunity for self-criticism and self-correction [18]. Thus, the model is built on the “social constructivist approach to teaching and learning” [19] which “regards individual cognition as occurring within a social context and suggests that collaboration between individuals in a social learning environment is an essential aspect of any educational experience” [20]. It ensures greater understanding and more meaningful learning by providing an opportunity to formulate and reformulate knowledge through exploration and application; and recognizes the fact that students learn best through

experiences, and when they are involved in problem solving activities. This realization together with a changing emphasis from teacher- centric instruction to students' centered learning has led to the development of newer classroom methodologies like the project based learning, inquiry based instruction, problem based learning etc. [21].

The Three Tier Self Evaluation model is, quintessentially, a tool for formative assessment since "knowing about pupils' existing ideas and skills, and recognizing the point reached in development and the necessary next steps to take, constitutes what we understand to be formative assessment [10]. Also, "for students to be able to improve, they must develop the capacity to monitor the quality of their own work during actual production. This in turn requires that students possess an appreciation of what high quality work is, that they have the evaluative skill necessary for them to compare with some objectivity the quality of what they are producing in relation to the higher standard, and that they develop a store of tactics or moves which can be drawn upon to modify their own work. It is argued that these skills can be developed by providing direct authentic evaluative experience for students. Instructional systems which do not make explicit provision for the acquisition of evaluative expertise are deficient, because they set up artificial but potentially removable performance ceilings for students" [22]. Furthermore, learners who had awareness about the learning objectives and the assessment criteria and had the opportunities to reflect on their work showed significant improvement in their performance as compared to other learners who were taught on more traditional lines [23, 24]. Studies have revealed the possibility and the benefits of students' generated feedback on their own work [25]. Formative assessment allows students ownership of their learning process, and enables them to become self-regulated learners. Students' capacity to assess their work and to generate feedback is a trait which must be exploited beneficially to support greater learning at higher education level [26].

IMPLEMENTATION OF THE MODEL

Participants

The model was implemented at a public sector engineering university at undergraduate level with a class of third year students enrolled in a compulsory course, business communication and engineering ethics; hence all the students in this intact group comprised the study sample. The total number of students studying this course at various departments of this university constituted the population of about 1800 students. The students' previous academic background remains constant owing to the eligibility for admission to this undergraduate program. The sample size that was initially planned to collect the data was 60, the mortality hit this longitudinal study and eventually the sample size is reduced to $n=48$; which includes 75% females, and 25% males. The age range of the participants is 2 years with maximum age 21 and minimum 19 years.

The study was carried out by the investigator herself who was the course instructor as well. The research ethics were kept well focused with taking the participants in confidence and sharing with them this model of teaching and learning. Also, the

academic routine was undisturbed and no time wasted, since the model was implemented while teaching a prescribed curriculum item; and the steps of the model also coincided with the students' assessment and assignments procedures prevailing at the academia.

Instruments

1. **Pre-test:** administered at the outset of the study
2. **Criterion checklist**
3. **Evaluation sheets:** three corresponding with the three stages of evaluations: criterion, peer performance and sample- based
4. **Sample project**
5. **Post-test:** administered at the end of the study.

PROCEDURE

The student at the start of the teaching – learning of the new curriculum item were given a pre-test comprising two sections: first section contained objective type questions based on theory and the second section comprised one question checking students' skills in applying the theoretical concept. Following this pre study assessment, the students were taught the concept using direct teaching, students' solving the given cases and activities, classroom discussions and verbal question answers. After this two-weeks long classroom teaching and learning during which students were introduced to the theory as well as its applications, the students were given an individual project with a week's time to complete it. The 3 Tier Self Evaluation process began with the students bringing in their assignment ready for submission on the scheduled day. They were provided the "criterion" as a checklist (developed around four aspects of the assignment) in printed form along with the evaluation sheet. Each student evaluated his /her own project using the given criterion using a ten points' scale for each of the criterion and recorded their points on the evaluation sheet. The evaluation sheet also specifically enquired them to reflect upon the learning experience and provide their observations. The criterion sheets and the evaluation sheets were collected from the students after they had put in their reflections. Then, they were taken through the second tier of evaluation by providing them with the a new evaluation sheet with the same scoring and observation instructions, only this time they had to silently go through minimum three assignments of their peers. Once the students had completed review of their peers' projects, they were asked once again to self-evaluate their project and to score it using the given points scale and record their observations on the provided evaluation sheet. The students returned their second evaluation sheets and were then shown a standard acceptable sample project which was carefully illustrated by the teacher. The students were not given a copy of the sample but were only made to carefully analyze it. Following this, the students were asked to finally evaluate their individual projects using the same evaluation sheet and procedure. The students returned their evaluation sheets after recording their observations as done in the previous two stages of evaluation. The three evaluations were carried out in the same sitting by scheduling an extra class, this ensured consistency of evaluation.

Following the completion of three- stages of self-evaluation the students were given a similar post-test to ascertain the difference brought about in the students' knowledge and skills through the teaching learning process entailed in the preceding paragraph. The students also improvised their projects incorporating the learning experiences from the three stages of the self-evaluation.

DATA ANALYSIS

Descriptive Analysis

Table 1 summarizes the descriptive statistical analysis conducted to compare the Pre- and Post-tests of knowledge and skills. The mean score of pre and post-test of knowledge has a remarkable difference i.e. from 0.2917 to 5.0006 (out of 10). This shows that the three-tier model has enhanced the knowledge of participants significantly; although the variation has also increased in the knowledge of the participants. Similarly, the pre- and post-tests of skills also showing a considerable improvement in the skills of the participants; however in this case the standard deviation is not much changed.

Table 1: Descriptive Analysis of Pre- and Post-tests of knowledge and skills.

	N	Minimum	Maximum	Mean	Std. Deviation
Pretest Knowledge	48	0.00	2.00	0.2917	0.49286
Pretest Skills	48	0.50	3.00	1.7292	0.54537
Post-test Knowledge	48	1.67	10.00	5.0006	2.14691
Post-test skills	48	5.00	8.75	7.2448	0.90725

The descriptive analysis of three methods of evaluation (Table 2) reveals that the two methods criteria and peer evaluation has similar mean scores i.e. around 32 while the mean score of 'standard evaluation' is quite different and in fact low as compared to the other two. This strongly supports the idea that standard-based evaluation significantly from other methods of evaluations.

Table 2: Descriptive Analysis of three methods of evaluation.

	N	Minimum	Maximum	Mean	Std. Deviation
Criteria	48	20	39	32.03	3.497
Peer	48	20	39	31.67	4.039
Standard	48	11	32	23.27	5.580

The correlation matrix (Table 3) of three methods of evaluation also shows that the three methods of evaluation are strongly correlated and are all significant at 5%. There is a high correlation between criteria-based evaluation and peer evaluation. However, standard is more closely correlated to criteria-based evaluation as compared to peer-evaluation.

Table 3: Correlation Matrix.

	Criteria	Peer	Standard
Criteria	1	0.486**	0.416**
Peer	0.486**	1	0.355*
Standard	0.416**	0.355*	1

** Correlation is significant at the 0.01 level (2-tailed).

* Correlation is significant at the 0.05 level (2-tailed).

The paired t-test analysis (Table 4) of pre- and post-tests of knowledge and skills show that there is significant difference between pre and post-tests of both knowledge and skills. The 95% confidence intervals even reveal that a minimum increase of positive 4.07 in knowledge and 5.07 in skills occurred.

Table 4: Paired Sample t-test.

Post-test & Pre-test	Paired Differences				t	df	Sig. (2-tailed)
	Mean	Std. Deviation	Std. Error Mean	95% Confidence Interval of the Difference			
				Lower Upper			
Knowledge	4.71	2.17	0.31	4.07 5.34	15.03	47	.000
Skills	5.52	1.04	0.15	5.21 5.82	36.58	47	.000

FINDINGS

Through statistical analysis, the study has the following major findings:

- The 3- Tier Self Evaluation approach has created the difference in the learning of the students as revealed by the pre and post-test analysis
- Knowledge and skills both can be enhanced through this approach.
- Standard evaluation is different as compared to criterion and peer
- All three methods of evaluation are strongly linked with each other
- Overall three-tier approach is a successful model and can be implemented at tertiary level of education.

The students' reflections and feedback indicated the following major benefits of employing this instructional technique:

- Active involvement of students which enhanced their interest.
- Better opportunity for self-analysis of their work and performance and a chance for self-correction and improvement.
- Greater insights into the important aspects of the taught curriculum content in terms of its basic knowledge and applications.
- Awareness to various possibilities and ways to approach the subject while undertaking the projects. Identification of gaps and alternatives in a relaxed environment with no fear of criticism from instructor or peers.
- Enhanced confidence and self-esteem in case of students whose projects were identified to be better than their peers.

CONCLUSION

The study revealed the model to be a useful instructional practice which combines classroom teaching and testing on one hand and students' acquisition of knowledge and practice on another. The self-evaluation technique fits into the formative assessment philosophy providing the students a chance to master the concept and improve themselves before their final evaluations. The three tiers gradually broaden their understanding of the content and take them on systematic analysis of the possible applications. The strategy enabled students' to be active and autonomous learners and promoted the beneficial learner traits viz. reflection and reasoning. The model blends well with the current academic trends and offers possible solution to major challenges that teachers faced in public sector educational settings like: how to teach for knowledge and skills acquisition; how to combine theoretical teaching with applications and students' projects; how to carry out formative and continuous assessment alongside a lengthy and challenging curriculum; how to handle assessment, monitoring and feedback in large classroom settings, how to beneficially incorporate peer learning and social interaction to change the instructional environment at public sector institutes.

FUTURE RESEARCH AREAS

The study brings in the opportunity of exploring the following aspects of the implementation of the three tier evaluation model effectively for enhanced students learning and performance:

- An experimental study using a control group for a greater insight about the impact of the three stages of evaluation

- The study may be planned across different subjects and courses offered at undergraduate engineering education to see the subject specific trends.
- The model can be used for different academic programs at higher education.
- The model may be tested with different students' population specifically at different academic levels.

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INSTRUCTIONAL METHODOLOGY AND ENGINEERING EDUCATION IN ARAB COUNTRIES

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ABSTRACT: Globalization has focused considerable attention on educational needs relative to the branch of civil engineering and the problems concerned with repairing buildings damaged through wars, floods or earthquakes in Arab countries regions. The civil engineering education has become a key to open the major knowledge resources of problems that concern the society. With new technologies constantly being introduced across the world (the internet), there is an increasing need for improved engineering education or at most improved civil engineering education. Civil engineering education is rapidly evolving as the use and speed of technological innovation in the knowledge-based society accelerates of major problems. In recent years, there have been essential changes in the education tools and technology in terms of content and knowledge delivery. The quality of engineering education today is one of the main issues for the education experts in Arab countries. The complex global environment requires excellent technical skills. On the other hand, the global job market needs interdisciplinary knowledge and multidisciplinary skills. An integrated (interdisciplinary) approach toward a flexible education program is gaining popularity among educators. This paper addresses some critical challenges of civil engineering education in Arab countries; it stresses the importance of creating a highly integrated and learner-centered educational environment to provide multidisciplinary education. It also describes a few learning techniques that can be applied by Arab engineering educators for developing multidisciplinary skills.

KEYWORDS: Arab Countries; Civil Engineering Education; Interdisciplinary Approach to Learning.

INTRODUCTION

Globalization is a topic frequently discussed by education experts in many countries. The trend of globalization is accelerating and making the world as a small village. The technological environment is constantly changing from one day to another. The advances in telecommunications, transportation and education tools have led to deep changes in the global environment. Modern telecommunications networks in some Arab countries provide the exchange of information on a global scale. Rapid technological progress leads to new construction materials, new construction methods, and new engineering knowledge. National boundaries between Arab countries are much less permeable to capital, goods, and skilled labor than European countries in which reduce the interaction between them. The economies of the world are becoming more interdependent. In this global corporate environment, technical professionals from Arab countries are required to work as part of international teams and devise solutions, which will be implemented across national boundaries of their countries. There is a need to effectively teach future civil engineers who will be involved with the development of new construction technologies in the 21st century. In recent years, there have been essential changes in

civil engineering education in terms of what is required in teaching (syllabus) and how to teach (knowledge delivery and education tools). The quality of engineering education today is one of the main issues for the education experts.

The impacts of globalization on the engineering profession consequently creates a challenge to understand what it means to be a civil engineer in the 21st century global economy and how best to prepare the engineers of the future. As Arab educators, we must prepare engineers with the skills needed to drive and benefit from these changes. In order to learn how best to prepare the engineers of tomorrow we must understand the future nature of the engineering profession. By understanding new skills that will be required of business and construction we can add to the knowledge base of engineering education and better prepare the engineers of tomorrow [1].

The knowledge-based society poses critical challenges to Arab educational institutes and universities in various aspects: expert engineering teaching staff, available technology and education tools. An integrated (interdisciplinary) approach toward a flexible education program is gaining popularity among educators in European countries, since it ensures the necessary evolution of engineering education to meet the modern society requirements [2]. Flexible education provides students with a wide variety of learning resources, and the opportunity to acquire a wide variety of skills.

The education process in some Arab countries needs to be improved. For example, the damages of the constructed buildings in some Arab countries and specially Iraq during wars and the reconstruction process that carried out through the last years had made the civil engineer in Iraq gain a lot of experience. The engineering process have faced many reconstruction problems and solved it. But, the engineering education which is exposed to these severe conditions needs to be improved to close the gap between engineering education in some Arab countries. Although, the education in Iraq have faced these severe conditions and used the simplest available education tools, the engineering students have gained a lot of practical information from their teaching staff through discussing the problems and solutions. The benefit of this process will help other Arab countries that may be exposed to similar conditions in facing problems and obtain solutions through the interaction of educational process between Arab countries and improving education tools. Some Arab universities that have a major development in their engineering education may help other Arab universities in improving their educational process. This paper addresses some critical challenges of civil engineering education in some Arab countries; it stresses the importance of creating a highly integrated, and learner-centered educational environment to provide multidisciplinary education.

GLOBALIZATION AND CIVIL ENGINEERING EDUCATION

The globalization of jobs is the final result of the knowledge-driven economic development. The mobility of technical professionals and engineering teaching staff between Arab countries is increasing; the job market is expanding and becoming global. Thus, the education experts today face a new set of challenges for education in civil engineering disciplines. With new technologies constantly being introduced across the world, there is an increasing need for scientific and engineering education. The global job market requires excellent technical skills, so we must educate engineering students for more sophisticated jobs and how to face major problems. On the other hand, the global job market needs interdisciplinary knowledge and multidisciplinary skills. Among valuable qualifiers for technical professionals are also constant self-development and intercultural teamwork. Experts assert that technical professionalism is not just about having technical competences, but it is also about mastering the principles of business, strategy, process and students [3]. They emphasize that construction companies want university to supply literate, educated, and technically competent individuals who, preferably, have some experience working in multidisciplinary, "team-based projects" [4]. The critical challenge for education experts is to provide students with the skills required for the new global economy, without sacrificing the deep foundational knowledge, to teach them how to think across disciplinary boundaries. Therefore, we have to adopt a new philosophy for knowledge delivery.

For teaching engineering students in the highly diverse and challenging global environment, Arab educators must take every advantage of both traditional methods and new approaches to engineering education. Some European experts offer a set of education strategies that could be applied by educational managers to enhance engineering education in Arab countries:

- Active/cooperative learning (educators use instructional activities, which engage students in doing and thinking instead of passive listening).
- Technology enhancement (computing resources are introduced into classroom to enhance learning by using software tools)
- Just-in-time learning (theoretical concepts are introduced when students experiences create a demand for them).
- Curriculum integration (learning activities are restructured to build contextual connections between topics) [5].

Let us summarize the benefits that educational managers can gain from using these strategies:

1. These new education strategies will support educators in their efforts to improve teaching and instruction so that each student may achieve at higher levels, which is the mission of all professional development [6].
2. The world is constantly changing; in this dynamic global environment only innovative companies will stay competitive. Innovation begins with creativity. Using these strategies we can develop a favorable educational environment, where students will have an opportunity to create, to innovate, and to enhance their creative thinking and their creative potential.
3. This new educational environment supports the development of engineering students personal identities as active and capable learners who believe that learning to the best of their ability is their main task.
4. For an engineer, it is very important to update his knowledge to keep step with fast technological progress. New education strategies pay special attention to developing life-long learning skills, which is vital for technical specialists today. These strategies are intended for providing students with an education so that they can develop themselves, to their intellectual and professional growth.
5. Computer technologies are changing the way students learn; they offer a great promise to both teachers and their students. Computer networks provide new alternatives for creating, storing, accessing, distributing, and sharing learning materials. They make available new channels for interaction between teachers and students, teachers and teachers, and students and students. Using modern computer technologies as a tool students can solve complicated problems and to acquire designing skills. Computer-based learning is gaining popularity spurred by a growing need for a life-long education, a demand for non-traditional learning environments, and the overall flexibility this learning provides for both the student and the teacher [6].

LEARNING STYLES

Students come with a wide variety of abilities, attitudes, interests, ambitions, and levels of motivation, and instructional methods that are effective for some students may be relatively ineffective for others. For example, one engineering student might be comfortable with relatively abstract theories and mathematical models and another might be much more receptive to concrete material such as lab experiments and industrial plant operations. A theoretical and math-intensive course would probably be much more effective for the first of these students, and a practical hands-on course would be a more positive experience for the second one.

A student's learning style is the way he or she characteristically takes in and processes information. Learning styles provide good clues to the instructional methods students are most and least comfortable with. If you know the range of styles that categorize the students in your class, you can design balanced instruction so that all students are taught sometimes in the manner they prefer, keeping them from becoming too uncomfortable to learn, and sometimes in their less preferred manner, forcing them to stretch and develop skills in areas that they might be inclined to avoid if given the choice[7] .

Active Learning

Active learning is anything that happens in a class that engages students with the material being presented. Students might be called on to work individually or in small groups for brief periods of time to answer questions, start problem solutions, fill in steps in a problem solution or derivation, brainstorm lists, troubleshoot processes, or think of questions about the material just lectured on. At the end of the allotted period, the instructor calls on several individuals or teams for their responses, then collects more responses from volunteers, and moves on when the correct answer has been obtained and it seems clear that the students understand it.

Good things happen in a class when active learning is used, even if it's only for a few minutes out of an hour-long class. Activity refocuses students who have drifted off into mental breaks and energizes the entire class. If the activity requires the students to do something they will later have to do on homework and tests (such as draw and label a flowchart or free body diagram, outline the solution of a problem, estimate the value of a process variable, do some computations or parts of derivations, or come up with a theoretical interpretation of an experimental observation or a data set), there will be a much better chance that they will be able to do it on their own when the time comes.

Collaborative/Cooperative Learning

Collaborative learning refers to two or more students working together on an assignment or project. There are several reasons for getting students to work collaboratively in lecture courses and not just in labs and the capstone design course, where collaboration is traditional. Engineering students will have to work in teams in their professional careers, and their performance evaluations could depend more on their ability to work well on those teams than on their technical skills. One of the mandated outcomes in some engineering criteria is the ability to work in multidisciplinary teams, and students are unlikely to acquire high-level teamwork skills if they only work on teams in one or two courses. Perhaps most importantly, hundreds of research studies have shown that compared to students working individually, students working on well-functioning teams

in a course learn more, learn at a deeper level, are less likely to drop out, and develop more positive attitudes toward the course subject and greater confidence in themselves.

The way to maximize the benefits of teamwork is to use cooperative learning, a subset of collaborative learning in which the teacher builds in measures to assure that five conditions are met:

1. Positive interdependence. The students have to rely on one another for the effort to be successful.
2. Individual accountability. Each team member is held accountable for everything in the assignment or project, and not just the part for which he or she may have had primary responsibility. If students don't understand what the team did, they do not get credit for the work.
3. Face-to-face interaction, at least part of the time. Much of the learning in team projects takes place when the team meets to discuss, debate, and reach consensus on solutions to problems. If the team simply divides the work and staples the individual parts together without discussion, it is not cooperative learning.
4. Facilitation of interpersonal skill development. Students are not born with the project management, time management, communication, leadership, and conflict resolution skills needed to work effectively on a team. For team assignments to qualify as cooperative learning, the teacher must take steps to help the students develop those skills.
5. Periodic self-assessment of team functioning. At regular intervals, the teams must be required to reflect on what they are doing well as a team, what they need to work on to improve the team functioning, and what if anything they will do differently in the future.

Problem-Based Learning/Project-Based Learning and other Inductive Approaches

The traditional approach to engineering teaching is deductive, proceeding from the general (principles and theories) to the specific (applications). In most courses, the teacher lectures on theories, principles, and mathematical methods and algorithms; gives assignments in which students practice the methods and algorithms; and later (sometimes much later) gets to applications. Engineering curricula work in much the same way. The students spend the first year learning basic science and math, then the next two learning mostly civil engineering science, and as seniors take the design courses in which they apply some of the fundamentals taught in the preceding three years to design a structure.

The main problem with the deductive approach is that it is not how students normally acquire and retain new knowledge and skills. Rather, they do so by confronting problems

that they need or want to solve; trying to accomplish their goal using what they already know and can do; discovering that more knowledge or skill is needed than they currently have and identifying what it is; gaining the required information (from books, classes, or observations of others solving similar problems) and adding it to their existing knowledge base; and practicing the required skills repeatedly and observing and reflecting on the outcomes of each attempt. In other words, people learn new material most effectively when they perceive a clear need to know it in order to solve a problem or meet a challenge. If they are simply presented with a body of new material and told that in a month or in two or five years they'll be shown why they need to know it, they are likely to learn it at best superficially [8].

An alternative and more effective instructional approach is to teach inductively, presenting students with problems before they have been taught everything they need to know to solve them and then teaching the required material once the students can clearly see why they need to know it. There are many variations of this approach with different names and somewhat different emphases, including problem-based learning, inquiry-based learning, discovery learning, need-to-know learning, and just-in-time learning. These methods are initially less comfortable for instructors than straightforward deductive presentation of material, and they can at first be distressing to students, who may not appreciate having to deal with problems they have not been taught to solve beforehand. Since induction is how people actually learn, however, the students taught this way are likely to end up with a much greater mastery of the knowledge and skills the instructor wishes to impart.

Formal problem-based learning calls for giving students significant problems whose solution requires the knowledge and skills normally taught in the course, and then having them work through the following steps, usually in teams:

1. Define the problem.
2. Build hypotheses to initiate the solution process.
3. Identify what is known, what must be determined, and what to do.
4. Generate possible solutions and decide on the best one.
5. Complete the best solution, test it, and either accept it or reject it and go back to Step 4.
6. Reflect on lessons learned.

The instructor serves primarily as a consultant, lecturing only when the need for new material arises in the context of the problem. A related but less formal instructional approach is project-based learning, which means that most of the learning in a course takes place in the context of projects, with lectures playing a subsidiary role or not taking place at all. The way the reinforced concrete design course is usually taught is project-

based learning, as is the engineering laboratory in which each experiment can be considered a project.

INTERDISCIPLINARY APPROACH TO LEARNING

Modern knowledge-based society needs professional civil engineers who can learn, create analyze and design. If we concentrate our efforts on creativity, we'll be able to succeed in knowledge-based development. Experts point out that interdisciplinary is a key to sustaining knowledge-based development, since "no single discipline can be capable of dealing adequately with the complex realities of the knowledge societies"

One efficient way to provide multi- and trans-disciplinary engineering education – an essential aspect of modern society development – is to incorporate interdisciplinary approach into academic programs. In other words, old-style teaching and rote learning must be replaced by more progressive methods. In order to become an integral part of the global environment an educational institutes and universities must revise its academic programs, and consider their relevance to the needs of the knowledge-based society. Educators recommend applying the so-called integrated approach to academic programs as a universal and common platform for studies [9].

This approach is aimed at intellectual fusion; the program must represent the convergence of disciplines and it must have stronger ties to the regional, national, and global communities, e.g. through program content, distance learning, and internship. The distance learning in Arab countries still have problems and the ministry of higher education in many countries does not recognize this way of learning. It is recommended to recognize distance learning and make the rules for this type of learning in the future of Arab countries. A defining characteristic of the program should be substantial breadth and significant depth across the technical and general subjects. Multidisciplinary programs are notable for their interdisciplinary model for content and integration of topics; general studies – humanities, social sciences, management, languages, other engineering fields – are integrated with professional studies of civil engineering. The benefit of such program is given below [10]:

1. Improving the quality of engineering education and training systems: developing the skills needed for a knowledge society, identifying new basic skills and ways of integrating them into the curricula, alongside the traditional basic skills.
2. Ensuring access to the internet for everyone and providing adequate equipment and educational software; encouraging the best use of teaching and learning techniques using computers.

3. Facilitating the access of all to education and training: creating an environment conducive to learning, making learning more attractive, and supporting active citizenship, equal opportunities and social cohesion.
4. Opening up education and training systems to the wider world: strengthening Arab countries cooperation, strengthening links with the world of work, research and society as a whole, developing the spirit of enterprise, improving foreign language learning, increasing mobility and exchanges.

MULTIDISCIPLINARY EDUCATION

The internal educational environment or learner-centered educational environment comprises the internal resources of an educational organization intended for instruction and learning [11]:

1. Non-human resources (physical and technological environment, financial resources).
2. Human resources; instructional environment – teaching materials, documents regulating the learning process.

The internal educational environment is not a collection of separate segments, but a complex system. A complexity of the system is due to a combination of its subsystems that function together to achieve a common purpose, though the nature of these components varies greatly through the system. It represents a phenomenon; i.e. the performance of the whole system is not equal to the total sum of its separate unit's performance. Such system allows the involvement of gradual growth, addition or modification to an existing environment structure. To be efficient it must work as a unitary whole. A change in one subsystem affects other subsystems as well, because they are interdependent.

The components (subsystems) of the internal educational environment must be interconnected and coordinated, the higher integration between the environment components, the more effective the performance of the educational organization. Thus, if we try to manage these components independently from each other, we will decrease our potential success. The interaction between the internal environment subsystems is essential to improve the educational organization's resources (human, non-human, and instructional) to the greatest benefit for all learners.

Only highly integrated educational environment is appropriate for advanced studies; it allows to cohere the knowledge among classes, and to offer students the opportunity to acquire a wide variety of skills. It points on the following:

- ensuring effective and coordinated learning opportunities for all students;
- providing efficient material base;
- ensuring effective and coordinated expert and instruction support;
- ensuring collaboration proficiency and effective communication.

Being a learner-centered medium, the highly integrated educational environment is characterized by the following teaching aspects: arranging for interactive learning and interactive material delivery, giving students the opportunity to solve different problems, offering students team work combined with individual work, generating the atmosphere for critical and creative thinking and problem-solving. As a result, the integrated educational environment provides the basis for the learning process that encourages continual progress through the improvement of the multidisciplinary skills, which students have to acquire.

Thus, the learner-centered educational environment is the necessary prerequisite for the implementation of the interdisciplinary approach to studies, for this approach presupposes interdisciplinary model for content and integration of various subjects, i.e. organized and coordinated learning activities. Multidisciplinary education can only be accomplished in the highly integrated and student-oriented educational environment.

The interdisciplinary approach to learning as the basis for the learning process organization involves a variety of teaching tools including the elements of teamwork-based learning, project-based learning, studies abroad, undergraduate work and research experiences, etc. Future engineers need opportunities to experience the workplace; the importance of context and practice for our students is really high [11].

DEVELOPING MULTIDISCIPLINARY SKILLS

In order to educate future civil engineers, Arab educators must find ways to integrate a multi-disciplinary approach into the learning process. For this purpose we may also make use of the so-called collaborative teaching: to organize multi-functional teams to work on the project. This process requires the integration of technical skills, as well as computer skills, communication skills, managerial skills, language skills (if the project involves the international aspect among Arab and other countries), etc. Teachers of special subjects help students prepare the project in cooperation with teachers of general subjects and the attending staff, and in the process use the

integrated resources (material, non-material, instructional) of the educational institutes and universities from any Arab country.

In that way, we prepare students for the changing workplace where cross-functional teams are common, simulate an environment where students with diverse backgrounds can work together to achieve common goals, and mature their presentation skills. In other words, we develop the whole set of multidisciplinary skills necessary for professionals today, so that future engineers will acquire the ability to integrate their knowledge, making connections between topics across different subjects and disciplines to solve multidisciplinary problems [11].

Multidisciplinary education engages civil engineering learners in performing a variety of roles, which associate to those that they may carry out in real life. In the highly integrated and learner-centered educational environment, we can provide our students with the opportunity to shape their own roles according to their learning goal orientation and the resources available to them. For this purpose, we use the interdisciplinary education model, which allows educators to use different learning techniques and various combinations of internal and external resources for developing multidisciplinary skills. This education model embraces diversity; it is suitable for a multidisciplinary engineering educational program realization.

In the learning process, each student is allocated a particular role/or roles, which help as follows [11]:

- enhance their self-capabilities (capacities);
- foster the acquisition of professional skills;
- encourage the acquisition of multidisciplinary skills;
- stimulate their creative potential;
- stimulate effective communication, exchange of knowledge and experience, etc.

SUMMARY AND CONCLUSIONS

The conclusion is obvious – the way we teach technical students in some Arab countries must change. The development of an educational environment must be sensitive to changes in technology, new developments in teaching, and the importance of life-long learning. Arab educators in these countries have to provide civil engineering students with a multidisciplinary engineering program that combines engineering theory, design and practice with some new non-science skills.

Educators in some Arab countries have to find the balance between the general subjects (languages, social sciences, humanities, other engineering field, etc.) and the civil engineering subjects. Just as the public must know more about science and technology, engineers must know more about social sciences, humanities, management, etc. In order to educate future engineers, who will be involved with the development of new construction and design methods in the 21st century, educational institutions must find ways to integrate an interdisciplinary approach into their academic programs, thus providing multi- and trans-disciplinary engineering education. Special subjects and general subjects must be kept in proportion to offer students a better preparation for life and work in the global environment, in which mobility is becoming increasingly more widespread and should be in reach of everyone.

Technical students and their teachers expect their educational experiences to involve the use of the whole suite of modern learning techniques, which engage the following aspects:

- active learning;
- integrative learning;
- cooperative learning;
- interactive learning;
- technology-enabled learning;
- just-in-time learning;
- project-based learning;
- internship;
- work and research experience.

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Use of Technology in Engineering Education

DESIGNING AND DEVELOPING A WEB ENHANCED PROJECT MANAGEMENT COURSE FOR ENGINEERING GRADUATING STUDENTS

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ABSTRACT: A web enhanced project management course in the final semester of curriculum can facilitate the teaching-learning process. Professors and lecturers faced with trying to cram in as much of lecture materials in a shorter semester can make use of the web to upload lectures that students can download and study beforehand, give assignments that use the internet, post discussion boards that will develop critical thinking among students and give on-line examinations to help students upgrade their scores. All these were facilitated through the use of a learning management system (LMS) called Whiteboard. This paper will discuss the design and development of a web-enhanced project management course, a capstone course for graduating Engineering students that integrates all the basic knowledge a student has learned in project management. The development and implementation of a web enhanced course in Project Management coupled with the use of classroom multimedia instruction, active and cooperative learning aimed to facilitate the teaching-learning process compared to the traditional whiteboard instruction.

KEYWORDS: Web Enhanced Project Management Course; Engineering Education; Higher Education; Technology in Engineering Education

INTRODUCTION

Project management involves planning, organizing and managing resources to bring about the successful completion of specific project goals and objectives. It is sometimes conflated with program management, however technically a program is actually a higher level construct: a group of related and somehow interdependent projects. Over the years, rapid changes in industry, technology and society has led to significant changes in the requirements for engineering graduating students. New fields such as construction project management, engineering management and energy management emerged to meet industrial and societal needs. New topics such as Integrated Project Planning, Resource Leveling Allocation, MS Project and Primavera Planning were added to the project management course. These did not only place considerable pressure on curriculum time allocation but also led to excessive workloads and increased education costs for students. Curricula that attempt to remain current with industrial practice by continually providing courses in the “new technology” are likely to be ineffective. By the time the need is identified, the courses developed, and the students trained, the new technology has changed. The education that succeeds will be the one that facilitates lifelong learning, equipping students with the skills they will need to adapt to change [1].

The truth is, no matter how many new topics were, it will never be possible to teach graduating engineering students everything they will be required to know when they go to work 2. The Internet has always been a widely accepted tool to supplement additional

knowledge. If student learning skills can be enhanced and instructor teaching can be facilitated by integrating the course with a learning management system delivered via the internet, then our graduates will be more ready to meet the demands of industry and society.

BACKGROUND

The BS degree course in Engineering (Civil, Mechanical, and Electrical) is a 4- year course consisting of 139 credit-hours(12 credit-hours University requirements, 54 credit-hours College Requirements, 68 credit-hours Program and/or Departmental Requirements and 5 credit-hours Free Courses) based on Educational System of Qassim University . At the University of Qassim, the educational system in the college is based on two main semesters per educational year. Each semester is fifteen(15) week length . In addition; an optional eight week summer semester may be offered. An engineering student may complete any of the engineering programs in eight semesters after the Preparatory Year Program (PYP). A successful engineering student may complete the full requirements of the selected program if he completed (after the PYP) a total of 139 credit-hours.

One of the general courses in Engineering is Project Management, a 3-unit subject offered this semester. Project Management is the capstone course in general engineering since it integrates almost all the knowledge a student has learned in 4 years of college education. This course has traditionally been delivered through classroom whiteboard instruction to engineering students. Often the one semester learning period is insufficient to fully discuss all the topics for this course.

Software Aided Calculations and Design

Problem solving was made easier by the use of software. Part 1 of the course which required spreadsheet calculation and graphical projections were easily delivered using Microsoft Excel. Optimization, material and energy balance problems were made a lot easier using MathCAD. Students were able to make use of GenCAD or Design II for Windows in the preparation of process flow diagrams and equipment design. The students were trained in all these software in a separate course (Computer Applications in CE, EE and ME).

Internet Classroom Assistant (ICA)

Students were asked to log in to a website called Internet Classroom Assistant (www.nicenet.net). ICA provides a free web-based learning environment for classrooms, distance learning programs and collaborative academic projects⁵. Lectures were uploaded and made available through a free web hosting site called Geocities (www.geocities.com/qassim_gen_engg) and web links were posted at ICA where students can easily access them. ICA also facilitated the discussion of ideas among students via email.

Table 1: The course outlines and course requirements of Project Management.

PART 1		PART 2	
Project Management 1	No of Hours	Project Management 2	No of Hours
Introduction/Orientation		Executing Process	
Basic Management Approach , Managing Project, Project Management Overview , Project Manager	2	Risk Management, Change Management, Conflict Management, Angry Management	3
Steps in Analyzing Case Study	1	Case Study: Batangas Polytechnic College	2
Individual Presentation-Planning	1	Project Control Process	
Initiating Process		Controlling Process, PM Responsibility	1
Linking the project to a product, Problem, Product & Project Scope,	2	Case Study: Good Morning Broadcasting Corporation	2
Balancing Competing Demand with the triple constraints, Project Success, Outputs	1	Video: Executing & Controlling Process	2
Group Oral Presentation-Defining the Planning Process	2	MIDTERM	4
Integrated Project Planning, Work Breakdown Structure	2	Project Closing Process	
Network Logic, Estimating Fundamentals, Scheduling(Gantt & PERT-CPM), Outputs	3	Closing Process, PM Responsibility, Post Implementation Review	2
Quiz 1	1	Case Study : Four ACES Construction and Hardware	2
Quality Plan, Communication Plan, Implementation Plan, Change Plan, Risk Plan Negotiating and Contracting	3	Hand's On MS Project and Primavera Planning	5
Case Study: Northern Container Project Organization	2	Video : Closing Process	2
Project Management Structure, Leadership Characteristics, Vision, Motivation , Team Building. Conflict. Engineering Ethics	3	Field Trips (Company Visiting)	2
Case Study: Bits and Pieces International Corporation	2	F inals	4
Total	25	Total	31
Course Requirements	Rating	Time Allocation	
Management Design Project	20%	Hours Needed for Lecture and Exams	56
Case Studies	10	Passing Grade: Between 59 and 60	
Reports	10		
Midterm Exam/Final Exam	75%		
Assessment of Professionalism by Instructor	5%		
Attendance	3%		
Teamwork	1%		
Seatwork/Recitation	1%		
T O T A L	100%		

WHITE BOARD LEARNING SYSTEM (WLS)

In November 17, 2009, the authors subscribed to Whiteboard (www.blackboard.com), a Learning System used in over 2000 universities and institutions worldwide. Blackboard provides a convenient platform where students and teachers can access a robust set of tools, functions, and features for teaching and learning. Figure 1 shows the different course features in the Course Menu. Among these features are:

- Upload and download easily all Course Documents, Announcements, Calendar schedules, Links and Assignments
- Develop simple Assessment using a variety of examination types or by choosing from a pool of questions
- Timed Online examinations with options for single or multiple access and automatically checked
- Improved grading and tracking of student quizzes where after taking the examination the student is provided with an immediate feedback and the results are automatically entered into a gradebook
- Submit take home examinations, assignments and projects via Assignments, digital dropbox, or groups file exchange
- Facilitate communications through Discussion Boards, Email, Lightweight Chat and Virtual Classroom
- Access to a Blackboard Manual (http://company.blackboard.com/docs/cp!learning_system!release6!instructor/) for web support

Managing a Project Management Course Using Whiteboard

The course on Project Management was one of 6 courses that test piloted the Whiteboard Learning System. One class of 36 graduating engineering students were individually enrolled as whiteboard users in Project Management. All the students were required to attend all classes since the course is a “web enhanced course” (WEC) and not a “fully online course” (FOC). As in the previous years, Cooperative Learning was fostered by dividing the students into groups of three. Twenty-one groups (teams) were created and group-enrolled in Whiteboard.

Using the Features of Whiteboard Learning System

Course Documents and Course Information:

The Course Information contains all necessary materials such as the course description, syllabus and course requirements. All the lecture notes were uploaded into the Course Documents before the scheduled class day. Lecture notes were prepared using PowerPoint or Word and converted to pdf format. Problem statements and exercises were available for download minus the solution. The solution of problems was done in class using MathCAD or Microsoft Excel and the files were uploaded in mcd or xls format. The easy access to all learning materials and class information provided a means for students to be reminded at all times of the course policies and deadlines. They had a complete set of lecture notes which they can study before the class and have available

even if they fail to attend the class. Downloading solutions as mathematical files afforded the students a means of going over the problem, solving similar problems or doing “what-if analysis” on a variety of problem cases that developed in them critical thinking.

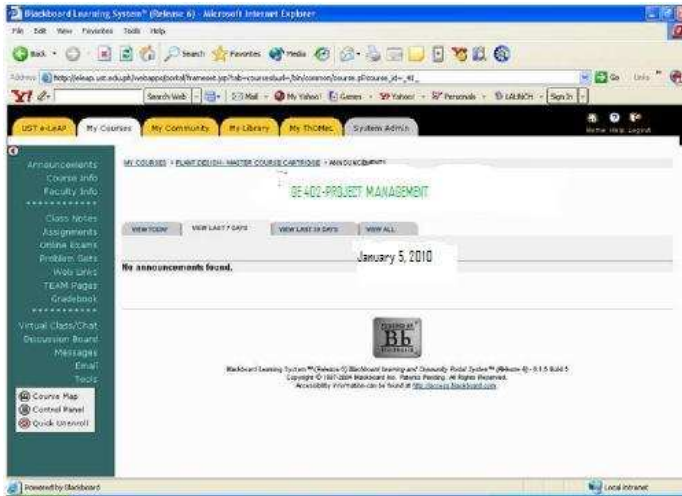


Figure 1: The course opening screen of Whiteboard Learning System showing the course menu for Project Management

The down side of this teaching strategy is that students were absent or late from their classes more often. This problem was solved by giving 10-question PowerPoint driven objective quizzes at the beginning of the class period and giving demerit points in Attendance to latecomers and absentees. Problem solving using mathematical software instead of calculators (most students are using a Casio FX880P Personal Computer with a Scientific Library) resulted in a noticeably slower problem-solving rate among students during classroom examinations. Students also complained that it took a while to download files with a lot of graphics. This was solved by dividing the lecture uploaded into BLS into smaller, more manageable files.

Assessment and Gradebook

One of the best features of the Whiteboard Learning system is the creation of online examinations using a variety of question type (fill in the blanks, multiple choice, true or false, matching type, essay etc.) which the students can take anywhere. The exam is automatically graded (except for Essay) and students receive an immediate feedback on their score; this grade is entered into a grading sheet called the gradebook.

Most of the online examinations given to the students were Fill in the Blanks, short objective questions (10 questions) and design problems where the students must write only the answers. Team Examinations were also given to teams where the score was the

same for all team members. These gave the students bonus grade points to be added to their classroom quizzes and major examinations.

One of the accepted problems in giving online examinations is cheating taking place. Among the methods used by students are: students sit in for other students; students “getting help” from others (classmates, other teachers, parents), students use a variety of materials to “aid” in the completion of a test or exam, students get around quiz time limits: they log on to a quiz, download it, log off then log on again with answers, students download papers from the Internet 6.

A survey on classroom cheating vs. online cheating was conducted among the graduating students to determine if online cheating was taking place. Figure 2 shows that 92% of the students did not cheat during classroom exams whereas 55% cheated once or twice during the Online exams.

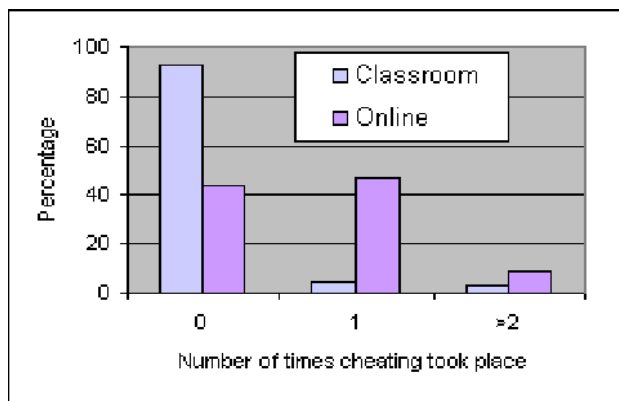


Figure 2: A comparison of students who cheated in online exams and those who cheated in classroom exams

To discourage cheating online, three approaches were employed: the Trust, Fence and Threat Method6. A comparison of these methods and the strategies employed to prevent online cheating are shown in Table 2.

At the beginning of the course and before any examination, the students were made to understand and sign an Honor Pledge indicating that they did not take part in any form of cheating and that any known violation of the honor code stated in their student manual will mean failure of the course.

Students were apt to abide by the Honor Pledge during classroom quizzes than during online quizzes. The most popular cause of cheating mentioned was peer pressure.

Table 2: Strategies employed to prevent online cheating communications.

Trust Method	Fence Method	Threat Method
Trust students not to cheat	Provide means to prevent cheating	Threaten them with punishment
Make tests easier by including lots of short self-study drills that give students a chance to practice	Create different sets of tests	Make students sign an Honor Pledge that indicates the consequences of cheating
Reduce the importance of grades	Randomly select questions from a list	Learners caught cheating will fail the subject
Use tests for only a small % of the final grade or give online tests as bonus points to be added to the final grade	Randomly order multiple choice questions	Those who help another cheat are treated as cheaters
Consider Group Exams	Give Essay questions	Those who fail to report cheating are cheaters themselves
Allow “open-web” tests	Show questions one at a time/no backtracking	Accusations of cheating are treated as confidential
Allow Multiple attempts. This lets students go back and practice or review while at the same time discouraging cheating; it also removes some of the pressure	Control access time Allow only single attempts Proctored On-line exams/ Video on-line exams	

Five ways of communicating with the students in Whiteboard Learning System are through Discussion Board and Email, Messages, Lightweight Chat and Virtual Classroom. The Discussion Board is an asynchronous communication medium for posting and responding to messages. Conversations are grouped in threads that contain a main posting and all related replies. The Virtual Classroom allows Instructors and Students to participate in real time lessons and discussions and also view archives of previous Collaboration sessions. The Lightweight Chat allows students to interact with each other and the Instructor via a text-based chat region. Email is asynchronous chat.

The following question was posted in the discussion board, “What is best type of Management Strategies to put up in the construction companies?”, and the students were encouraged to participate in the discussion thread. There were 204 messages posted but unfortunately some of these messages did not answer the discussion question and instead students used this medium to greet one another or ask questions not related to the course.

Virtual Classroom was not used in the Project Management Course although the same students participated in it in the course Construction Project Management . Students logged in at the same time from different parts of Buraidah. Unfortunately the system became very slow as more participants were present.

Digital Drop box

The Digital Drop box is a tool that the Instructor and Students can use to exchange files. Problem solving and writing assignments, plant design projects and a take home exam were submitted using the drop box. A variety of file types (doc, mcd, xls, bmp, jpeg, etc) were submitted by the students which filled up immediately my allotted course size quota of 5 megabytes. The files were difficult to manage because students submitted filenames that did not indicate what requirement was being passed and some students even submitted several versions of the exam solution.

STUDENT SURVEY ON THE USE OF WHITEBOARD LEARNING SYSTEM

The students were given a survey (Figure 3) that evaluated the Whiteboard System and the Project Management Course. Students were able to access whiteboard readily in campus as they were given free Internet accounts. However some students living in dormitories said that unlike their other classmates who can access Whiteboard at home and at Internet Cafes, they had curfews and could not access at night. They found the Whiteboard interface very user friendly and web support readily available. The students were more attentive when the delivery of the course was combined with multimedia lectures, active learning through games⁷ and web enhanced. They found it very different from traditional teaching-learning and were satisfied with the way the classes were conducted.

Overall they found the Whiteboard System, the course content, class integration of web materials and the Whiteboard delivery satisfactory. They said they were able to develop their learning skills from surfing the Internet and they had better grades because they were given more chances to increase their scores. The number of students who got 1.50 and 2.00 increased by 10% and student failure decreased by 20% compared with the previous semesters.

CONCLUSION AND RECOMMENDATIONS

A web enhanced course in the final semester of engineering curriculum can facilitate both the teaching and learning process. Teachers faced with trying to cram in as much of lecture materials in a shortened semester can make use of the web to upload their lectures, give reading assignments using subject links, provide discussion boards for individuals or groups to develop critical thinking and give on line examinations that are automatically checked by Whiteboard. Students on the other hand are able to learn more than what is given as lecture materials in the classroom and get additional points for solving online examinations.

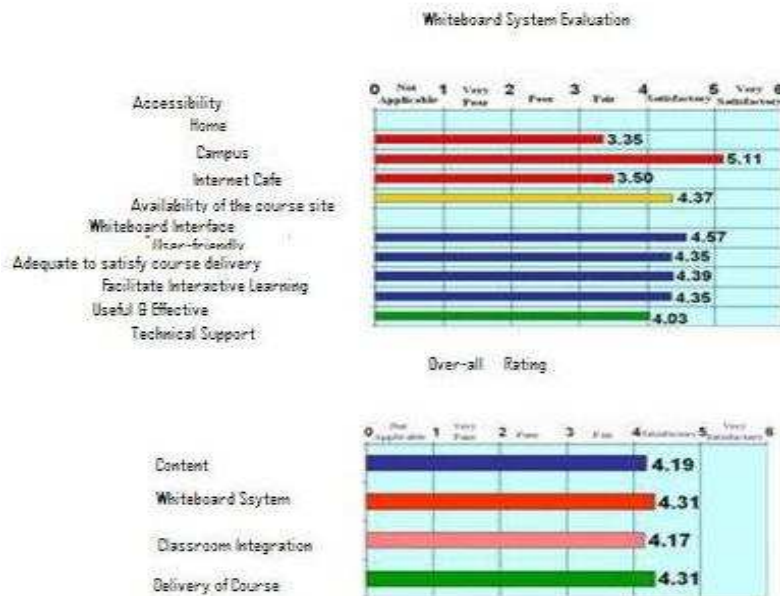


Figure 3: A survey on the effectiveness of Learning System and Classroom integration of a Web Enhanced Course

Some of the constraints of a web enhanced course are inequitable availability of the WLS to students and preventing cheating online. Online accessibility problems can be solved by proper WLS management such as providing free internet access to the students. Online cheating can be solved by techniques such as Trust, Fence and Threat Methods.

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E-LEARNING: AN EFFICIENT TOOL OF SUSTAINABLE HIGHER EDUCATION

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ABSTRACT: The key to achieve sustainable development is the awareness of how important is the way to provide, mobilize and optimize the necessary resources and imagine tools that enhance the efficiency of the actions undertaken. In pursuit of sustainable development, various actions can be taken, and a number of them is effectively underway worldwide. The role of education, among others, has long been recognized as decisive in this kind of particular battle. The concept of Education for Sustainable Development (ESD) was explicitly acknowledged in Chapter 36 of Agenda 21 and four major actions were identified to begin the work of ESD: improve basic education, reorient existing education to address sustainable development, develop public understanding, awareness, and training. This paper aims to focus on the innovative use of information and communications technologies - synchronous as well as asynchronous activities - to increase access to quality higher education and training opportunities through the various forms of *E-learning* and *Distance Learning Facilities*. The aim is to demonstrate how E-learning in higher education can be considered as one of the fundamental principles of Sustainable Development Education as well as an efficient tool in meeting the needs of the present and future.

KEYWORDS: E-learning; Information and Communications Technologies; Information Society; Sustainable Development; Sustainable Higher Education.

INTRODUCTION

At the beginning of this century (March 2001) Kofi Annan, former Secretary General of the United Nations, announced that *"the world biggest challenge is to take an idea that seems abstract - sustainable development - and turn it into a reality for all the world's people."* The idea goes back up to the 1970s when the notion of "sustainability" was employed to describe an economy "in equilibrium with basic ecological support systems". Ecologists have pointed the economic system as the main cause of the environmental imbalance and presented, therefore, the alternative of a "steady state economy" in order to address and tackle the thorny environmental issues. This approach was partially true but this necessary condition was insufficient to surmount the obstacles that came over the years. The limits of this purely economic conception of the issue led to the efforts that have been made to widen the concept of sustainable development to a comprehensive approach that break the field into three interdependent parts: *environmental sustainability, economic sustainability and sociopolitical sustainability*¹.

¹ The concept of "Sustainable Development" raises several critiques at different levels but this is not the object of this paper and will not be discussed.

Even though we are supposed to deal with the diversity of meanings that many people are using, the definition proposed by the 1987 Brundtland Commission, which is probably the most widely accepted, will guide us through this paper². The United Nations 2005 World Summit Outcome Document emphasized on the "interdependent and mutually reinforcing pillars" of sustainable development as *economic development*, *social development*, and *environmental protection* while various international forums such as the United Nations Permanent Forum on Indigenous Issues, the Convention on Biological Diversity and the Universal Declaration on Cultural Diversity (UNESCO, 2001), had enriched the concept by the fourth pillar and policy area, *Cultural diversity*, as a mean to achieve a more satisfactory intellectual, emotional, moral and spiritual existence. Since then, the concept could be considered as steady by regularly referring to, and tying together, the four aforementioned pillars.

Obviously, the key to achieve sustainable development is the awareness of how important is the way to provide and mobilize the necessary optimized resources, in addition to how we can imagine tools that enhance the efficiency of the actions undertaken. In pursuit of sustainable development, various actions are supposed to be taken and number of them is effectively underway worldwide. The role of education, among others, has long been recognized as decisive in this kind of particular struggle. The concept of Education for Sustainable Development (ESD) was explicitly acknowledged in Chapter 36 of Agenda 21 and four major actions were identified to begin the work of ESD: *improve basic education*, *reorient existing education to address sustainable development*, *develop public understanding, awareness*, and *training*. Moreover, in the recent decades widespread incorporation of *Information and Communications Technologies (ICTs)*³ into all life aspects has deeply impacted our daily activities through structuring the global economy and redefining the social and political processes. By increasing the speed of international communication, the international interconnectedness has been increased as well and, as a result, the process of globalization has been sped up. From some point of view, ICTs have positively impacted societies on many levels. They have extended the reach of public administration, leading to a centralization of regional management into urban centres. In business world, many deals can be made through emails and video conferencing, and mobile phone technology has made it possible for people to check and send messages on the go, allowing us to be connected "24-7".

² It makes clear the link between the concepts of environment and development and recognizes that development is essential to satisfy human needs and improve the quality of human life. Sustainable development is a pattern of resource use that aims to meet human needs while preserving the environment so that these needs can be met not only in the present, but also for future generations. The term was used by the Brundtland Commission which coined what has become the most often-quoted definition of sustainable development as development that "meets the needs of the present without compromising the ability of future generations to meet their own needs"

³ Also called information and communication technologies, or information and communications technology (ICT)

Despite this international spread of ICTs and the hope towards a more well-balanced distribution of the expected development and wealth worldwide, the economic and social impacts have been, unfortunately, geographically uneven. They have exacerbated pre-existing disparities, known as the *Global digital divide*, between developed countries, which can afford to produce and consume the latest technologies, and developing countries, which cannot. Nevertheless, ICTs have been identified by many international development institutions as a crucial element in developing countries, by integrating them into the global economy while making trades and exchanges in the global markets more accessible. The World Bank has collaborated with the International Finance Corporation and launched an initiative intended to promote access to ICTs and recently, in 2006, the United Nations launched a program called the *Global Alliance for Information and Communication Technologies and Development*. Greater collaboration between key entities, at the global as well as the local levels, is necessary to make a difference: by the commitment of the international community⁴, the assistance of the national governments and the active participation of the non-governmental organizations and the private sector, every effort has to be made to reduce the *digital poverty* and the gap between developed and developing countries. Change and success cannot be accomplished by any single organization, regardless of the resources available.

If we link the concept of Education for Sustainable Development to the ICTs we can probably explore one of the most interesting ways to achieve sustainable development using the wide range of potentialities offered by ICTs. The successful approach should involve education as a key element: more people at all levels must be empowered to develop the values, attitudes and skills necessary to change behavior in regard to environment management. The innovative use of information and communications technologies - synchronous as well as asynchronous activities - to increase access to quality higher education and training opportunities through the various forms of *E-learning* and *Distance Learning Facilities*⁵ is widely believed to be a smart and successful way to implement the concept of Education for Sustainable Development.

SCOPE, DEFINITIONS AND FORMS OF E-LEARNING

E-learning is defined as a computer-mediated instruction delivered via internet or CD-ROM (Clark & Mayer, 2007) and can be self cadenced or instructor led. Both forms are intended to build the user knowledge by a variety of means including media in the form of text, streaming video, and audio.

⁴ Through the specialized United Nations' organizations.

⁵ Virtual Learning Environment (Virtual Universities), Open Distance and E-Learning Institutions, etc.

Historically speaking, three generations of E-learning have to be considered: E-learning 1.0, E-Learning 1.3, and E-learning 2.0⁶, which represent an evolution of approaches that use the web to support learning and improve human performance.

E-learning 1.0

“*Conventional E-learning*” systems were based on instructional packets and commonly refer to training delivered electronically in an organizational setting⁷. These early E-Learning systems (Computer-Based Learning/Training) was assumed to be for transferring knowledge, as opposed to systems developed later based on *Computer Supported Collaborative Learning* (CSCL). E-Learning 1.0 is the first generation of learning (really training) delivered through the web: synchronous courses delivered using virtual classroom software, asynchronous courses built using an authoring tool, and course content design followed a traditional training model developed by an instructional designer [1]. The sector has quickly benefited from the potentialities offered by the technological development to start a new era.

E-learning 1.3

E-Learning 1.3 is the generation of e-learning in which learning is developed more quickly and delivered in smaller pieces. Learning is made available within the context of work and, thus, needs to be in a form that is easily retrieved. For that reason, learning is not always accessed via the LMS, but pushed to the learner through email or accessed via links on an organization's intranet. E-Learning 1.3 content is created typically by subject matter experts using templates developed with rapid e-learning tools or learning content management systems (LCMSs). In addition, virtual meetings might be dispersed occasionally as part of the over all learning experience.

E-Learning 2.0

The term *E-Learning 2.0* [1] is a neologism for CSCL (cf. supra) systems that came about during the emergence of Web 2.0⁸ [2]. While in the early conventional E-learning systems the instructional packets were delivered using Internet technologies and the student used to learn from the readings and prepare assignments evaluated by the teacher, in contrast, the new E-learning systems focuses on social learning and use of social software and networks such as blogs, wikis⁹, podcasts etc. The difference is about the philosophy of each system : by contrast to E-learning systems not based on CSCL, E-Learning 2.0 assumes that knowledge (as meaning and

⁶ E-Learning 2.0 refers to a second phase of e-learning based on Web 2.0 and emerging trends in e-learning technologies.

⁷ While Online Learning is used to differentiate courses delivered via the internet in educational settings.

⁸ Web 2.0 refers to a second-generation of Internet-based services - such as social networking sites, wikis, communication tools, - that let people collaborate and share information online in previously unavailable ways.

⁹ Wiki is a type of website that allows the visitors themselves to easily add, remove and otherwise edit and change some available content.

understanding) is socially constructed. Learning takes place through conversations about content and interaction about problems and actions. Other example of online learning platforms and classrooms is live online presentations in addition to social networks which are also part of E-learning 2.0¹⁰.

Meanwhile, changes in society, economy and culture led to a transition from an economy based on material goods to one based on knowledge. Knowledge has become the principle force of production over the last few decades and society has been transformed into a scientific civilization based on services, education, and creative activities as a result of a scientific/technological transformation based on technological progress and the increasing importance of computer technology. The development of the *Information Society* model has been identified as the marker of a new era in which E-learning gains new forms.

Information Society, Contemporary Mobilities and New Forms of E-learning

Indeed, the last decades of the twentieth century have witnessed a fundamental evolution which transformed the industrial society to the information/knowledge-based society of the twenty-first century. This dynamic process brought deep changes in all economic and social aspects, including knowledge dissemination, social interaction, new business practices, more political engagement, increased media involvement in all fields of everyday life, education, health, leisure and entertainment aspects, etc. In the recent years the concept of the *Networked society* has also gained importance in the information society theory.

In the information society, more opportunities are needed: unlimited and not censored access to information and expertise, free circulation of ideas and opinions, increasing correspondence with other learners and teachers. This need would be available through the wide use of internet-based tools such as *Virtual Learning Environments* (VLEs) or *Learning Management Systems* (LMSs), discussion boards or chat rooms; and may be designed as a "blended" approach: content available electronically and remotely, as well as the classic "face-to-face" classroom tutorials and lectures.

The information society is also characterized by greater mobilities and the increase in the processing power and attractiveness of mobile digital devices with, as a result, a considerable interest in *M-Learning* or mobile learning, related to E-learning and Distance education but distinct in its focus on learning across contexts, learning with mobile devices and the use of mobile devices such as mobile phones, iPods, and

¹⁰ Social networks have been used to foster online learning communities around a variety of subjects such as test preparation and language education [3].

Personal Digital Assistants (PDAs) to increase the mobility of learners and enhance their learning flexibility.

In the context of the information society, along with the terms *learning technology*, *Instructional technology*, and *Educational technology*, the term E-learning came to refer to the use of technology in learning in a much broader sense than the Computer-based Training or Computer Aided Instruction of the 1980s. It is also broader than the terms *Online Learning* or *Online Education* which generally refer to purely web-based learning. Where mobile technologies are used, the term M-learning has become more common (cf. supra). M-Learning, like other forms of E-learning, is collaborative. Sharing is almost instantaneous among everyone using the same content, which leads to the reception of instant feedback.

The implications of E-learning are also beyond just the technology and refer to the real learning that takes place using these systems. E-learning is naturally appropriate to *Distance learning* and *Flexible learning*, but can also be used in conjunction with face-to-face teaching, in which case the term *Blended learning* is commonly used cf. supra). E-learning is, and should be, a *Flexible Learning*¹¹ as modern learners need more choice, convenience, and personalization to suit their new lifestyle. The choice include where, when, and how learning occurs and frequently about personalized learning with new approaches, teaching and learning theories, philosophies and methods.

With the development of the Internet as a major means for communication and information, the context of the networked society has widened the concept of E-learning beyond its early limits and the above mentioned forms. The practice of *Networked learning* has tended to focus on the use of Web 2.0 since its emergence. The term is expanded to the term of *digitally networked learning* when referring to the use of this medium in networked learning. The definition of Networked Learning¹² can be found referenced in literature as: “*Learning in which Information and Communication Technology is used to promote connections: between one learner and other learners, between learners and tutors; between a learning community and its learning resources*”. Theoretical association of the term Networked Learning in an educational context has been made with Connectivism.

¹¹ As a component of Flexible learning, E-learning involves the application of electronic media in the delivery of flexible vocational education and training (VET) programs. It can include the use of web, CD-ROM or computer-based learning resources in the classroom, workplace or home, as well as online access to course activities such as group discussions and online assessment activities.

¹² This definition is used by Steeples and Jones (2002), Goodyear, Banks, Hodgson and McConnell (2004) and Dirckinck-Homfeld, Jones and Lindstrom (2009). The definition arose out of work at Lancaster University and it was used by the Networked Learning in Higher Education project and it is the definition used by the Networked Learning Conference Series that has run since 1998.

Virtual education, is another form of E-learning which refers to instruction in a learning environment where teacher and student are separated by time and/or space, and the teacher provides course content through course management applications, multimedia resources, the Internet, videoconferencing, etc. Students receive the content and communicate with the teacher via the same technologies.

The term *Virtual University* is used to describe any organization that provides higher education programs through electronic devices. Some of the universities are “real institutes” offering *Campus based teaching*, while others provide online courses only. Program delivery in a virtual university is administered through web pages, e-mails and other networked sources. Virtual universities aim to provide access to a part of the population who would not be able to attend a physical campus, for many reasons such as distance¹³ and need for flexibility¹⁴.

In higher education especially, the tendency is to create a *Virtual Learning Environment* (VLE)¹⁵ in which all aspects of a course are handled through a reliable user interface standard throughout the institution¹⁶. At a wide range of levels and disciplines, several physical universities and online-only colleges offer a selected set of academic degree and certificate programs delivered completely online. Nevertheless, especially in laboratory activities of engineering disciplines, some programs still require students to attend campus classes or orientations. In addition, the recent trend is to offer online student support services, such as online advising and registration, e-counseling, online textbook purchase, etc.

Communication Technologies used in E-learning

E-learning sector is particularly linked to communication technologies which are generally categorized as *asynchronous* or *synchronous* [4].

Asynchronous activities use technologies such as blogs, wikis, and discussion boards. Participants may engage in the exchange of ideas or information without the need of other participants' involvement at the same time. Electronic mail which can be sent or received without having both the participants' involvement at the same time is an example of asynchronous communication.

¹³ where students live too far from a physical campus to attend regular classes.

¹⁴ Some students need the flexibility to study at home whenever it is convenient for them to do so.

¹⁵ Which is sometimes combined with a *Management Information System* (MIS) to create a *Managed Learning Environment* (MLE).

¹⁶ The last technology used by e-Learning sector is screencasting with many tools which allow the users to create screencasts directly from their browser and make the video available online so that the viewers can stream the video directly. With the combination of video and audio, the expert can mimic the one on one experience of the classroom and deliver clear, complete instructions. From the learners point of view this provides the ability to pause and rewind and gives the learner the advantage to move at their own pace, something a classroom cannot always offer.

On the contrary, *Synchronous* activities involve the exchange of ideas and information with one or more participants during the same period of time. A face to face discussion is an example of synchronous communications. Synchronous activities occur with all participants joining in at once, as with an online chat session or a virtual classroom or meeting.

Different forms of E-learning systems have been identified and are being widely used in the particular context of the “*information/knowledge-based/networked society*”. It seems interesting to understand how E-learning in higher education can be considered as one of the fundamental principles of Sustainable Development Education as well as an efficient tool in meeting the needs of the present and future ?

E-LEARNING AS SUPPORT FOR SUSTAINABLE DEVELOPMENT

In the Millennium Declaration of the 8th plenary meeting of the UN General Assembly (8 September 2000), UN Member States agreed upon a number of key development goals. In addition to a commitment to eradicate poverty, improve health, ensure environmental sustainability and promote education, one Millennium Development Goal (MDG) is “*To ensure that the benefits of new technologies, especially information and communication technologies, (...), are available to all.*” ICTs have been therefore identified as a crucial element in support for the MDGs in developing countries, to achieve their integration into the global economy and to make global markets more accessible.

“How to proceed” to introduce E-learning in the developing countries, was the crucial question that had faced UN agencies: Starting with information technology (including E-learning) or addressing basic needs of citizens ?

E-learning to Address Poverty issues and Digital global divide

The answer was to proceed by a global approach and consider the problem as a system. Ensure the implementation of key programs and projects intended to address the most basic needs, such as building more classrooms and providing clean water, and, at the same time, consider ICTs as a part of the solution [5]. If education and capacity-building are critical steps for entering into the new global economy, E-learning should be considered as a critical facet of basic development¹⁷, an efficient alternative medium of capacity-building and a means to population's empowerment.

¹⁷ We should consider that Computer-literacy is a pre-requisite for learners to benefit from technology-based learning. E-learning requires a set of basic computer literacy skills. Generalize the fundamentals of E-learning which can then motivate individuals to pursue computer education, while serving as a vehicle for deepening literacy skills.

E-learning systems ignore distances, especially when blended systems are not necessary, and facilitate access to education when the lack of infrastructure is the main obstacle. As education on sustainable development is a major stake for the future of the planet, the increased access offered by E-learning facilities is likely to lead to better results. Instructors can share their knowledge across borders, allowing students to attend courses across physical, political, and economic barriers. As basic internet access, audio, and video capabilities are common infrastructure requirements for online courses, in addition to the fact that costly technology is not necessary, we have the opportunity to make information available worldwide at minimum costs.

Flexibility is another facet of these opportunities: many E-Learning systems are self-paced (cf. supra) and available “24-7”. Therefore, learners are not bound to a specific day/time to physically attend classes. Specific technology allow them to begin their courses while at work and finish them at home or at any other location. On the other hand, no doubt that poverty is the most common constraint encountered by developing countries preventing people from thinking of the environmental problems at stake, usually considered as an intellectual luxury. E-learning systems are able to overcome some of the issues related to the governments’ incapacity to build physical educational infrastructures and raise awareness of environmental issues. Large groups, initially unable to learn, can access education and develop the awareness of preserving their environment.

From a social point of view, how many handicapped individuals can we educate by offering them the opportunity to overcome their physical disability when they pursue distance courses. This will facilitate their access to education, their social integration, and their ability to communicate with others and participate in developing their communities. The social benefits in this case are really precious.

From an economic point of view, E-learning seems to be a promising industry. Developments in the basic enabler of E-learning, Internet and multimedia technologies, with the wide range of related activities (consulting, content, technologies, services, logistic, support, etc.) are source of employment and economic development. Investments in ICTs projects are less expensive, in terms of infrastructure, and of a high added value.

E-learning and Environmental Benefits

E-learning solutions are well-suited to high volume training needs across large and geographically dispersed organizations and individuals. E-learning benefits, over traditional on-campus learning systems, can be definitely analyzed and weighted from several points of view : the organization and its goals, the learner satisfaction and development needs and the community return on investment beyond the pure

economic interests. Some economic indicators, especially those related to time and energy saving, can be used as environmental arguments.

A practical example can explain this main idea. Train students on how to arrange equipment in a sterile environment like an operating room, using the real environment, would be expensive due to material and labor costs. By creating the environment online and giving the learner the opportunity to practice, the community avoid the costs associated with set up, use, maintenance, clean up, etc. This decreased material and labor costs can be quantified and counted on the scale of the community and on the long term.

But generally speaking, we have to keep in mind that, beyond this particular example, an accumulation of consumption of natural resources using any kind of material, say wood for furnishing your classrooms or laboratories, is a real environmental issue when considered at the global scale. E-learning systems simply give us the opportunity to avoid this environmental footprint. These considerations are obviously valid for all activities that operate a pressure on natural resources.

Also, producing learning content is time consuming whether it's online or not. But with E-learning, each time the course is accessed the return on investment improves as the fixed production costs are divided by the number of uses. Savings are also identified through decreased travel, reduced material use, and improved and more efficient performance. These improved training costs can also be quantified as well.

On a more specific environmental point of view, E-learning reduces the cost of transportation to physical classrooms: learners do not need to travel and remain in one location (home, office, airport, coffee shop, etc.). This should be understood as time and energy saving which reduces considerably the environmental footprint when considered, once again, at the global scale.

If we consider the direct environmental benefits as part of the sustainable development pillars, it's interesting to refer to the Britain's Open University's study which found that *"producing and providing distance learning courses consumes an average of 90% less energy and produces 85% fewer CO₂ emissions per student than conventional face-to-face courses."* [6].

In some countries, like Saudi Arabia, with no public transportation system and almost one car per student attending on-campus courses, thousands of daily round-trip travels can be avoided with the consequent quantity of fuel consumption, the amount of CO₂ emission and the number of lives saved. Over 4.6 million U.S. students were taking at least one online course during the fall 2008 term at institutions of higher education [7] is about 4.6 million car movements avoided.

In the gulf region, where the air conditioning systems work a minimum of 12 hours a day and 10 months a year, we can simply imagine the amount of energy the community can save and the major implications on the natural environment, when only 20% of the educational system switches to E-learning.

SUMMARY AND CONCLUSIONS

This paper reviewed the history of the concept of sustainable development and emphasized on its implications when analyzed within the context of higher education leading to the concept of Sustainable Higher Education.

The use of information and communications technologies to increase access to quality higher education through the various forms of E-learning and Distance Learning Facilities, was particularly interpreted as a successful way to implement the concept of Education for Sustainable Development (ESD).

Different forms of E-learning systems were analyzed within the framework of the information society with special interest to reveal E-learning as a tool to address poverty and global digital divide in addition of its environmental benefits. The changes and new trends in lifestyle, economy and culture have led to the transformation of the society into a scientific civilization based on services, education, and creative activities. Therefore it seems that the use of E-learning is in adequacy with the scientific/technological transformation based on ICTs and the increasing importance of Internet and computer based technology.

The contemporary society is henceforth definitely borderless thanks to the opportunities offered by ICTs. E-learning should be the "*weapon of mass development*" in the world battle to realize the Millennium Development Goals especially in the sphere of sustainable development. As a real heavy trend/tendency, the universities of the future seem no more face-to-face institutions¹⁸. Saving the globe will depend, also, on our capacity to believe in, and achieve this objective.

¹⁸ In the United states the 17 percent growth rate for online enrollments in 2009 far exceeds the 1.2 percent growth of the overall higher education student population and more than one in four higher education students now take at least one course online [8].

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USE OF LEARNING DESIGN METHODOLOGY AND KNOWLEDGE MANAGEMENT IN ONLINE GRADUATE COURSES

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ABSTRACT: Performance results of managers with an engineering background indicate higher failure rates in management than individuals from any other functional area. Previous studies suggest that educational programs do not promote social learning, instead focusing on a limited scope of knowledge transfer. Drawing upon education and training that promotes individual problem solving, engineers rarely performed well in management roles, where group skills such as teamwork, facilitation, supervising, organizing, and resolving conflict are critical to overall success. Additional challenges for educators can occur with online students. Feelings of isolation are an important stress factor, and students report confusion, anxiety, and frustration due to difficulties in communication with the instructor.

To address this issue, engineering management curriculum and courses should be adapted to improve skills that promote contextual learning and knowledge construction. This modification in engineering management courses should incorporate case studies, project based learning, and discovery learning. Using these tools, students investigate multiple issues and identify various solutions, rather than find a single, optimal solution. Research in the area of social constructivism, or learning within a social context, suggests that group knowledge construction, rather than knowledge transfer, provides ideal learning. These approaches to education create the new paradigm that teaches students to discover and construct knowledge for themselves.

At Eastern Michigan University (EMU), the Graduate Engineering Management online program has evolved from “content” to “context” based, using Learning Design methodology and Knowledge Management/ Utilization. Students learn best when their current view of knowledge is challenged, reformed, and synthesized through interaction with others. By applying the Classroom Community Scale results from studies on the effect of students’ learning style, gender, and acquaintance level, the EMU team created a methodology to develop effective online case studies.

KEYWORDS: Engineering Management; Contextual Learning; Knowledge Management; Learning Design; Online Teaching.

INTRODUCTION

With the current economic meltdown in USA with the highest unemployment rate in decades, a large portion of the population is looking for ways to improve their skill set and learn new ones. At Eastern Michigan University (EMU), USA, the Graduate Engineering Management online program is the fastest growing online program with student’s population coming from various parts of the world and from different engineering background. The program has gradually evolved into a contextual learning philosophy. In this paper we will describe a new methodology for the development and re-development of online courses. Concepts like Learning Design, Knowledge Management and Contextual learning are used to develop a framework for such methodology. It is our goal to use this methodology to develop online courses that will

reduce, if not eliminate, the social isolation and boredom in students by utilizing social network groups for cooperation/collaboration and by using projects related with students' personal experiences. This paper also studies the implementation of commonly used web based and mobile applications as learning tools. New teaching strategies including knowledge generation and utilization, experience sharing, and online discussion, are presented and a comparison is made to evaluate student progress.

ENGINEERS AS MANAGERS

The importance of decision making in a globalized business world has put more emphasis on engineers' understanding of the business side of management. Since the last decade, universities, professional bodies and employers have been acknowledging and recognizing this importance to Engineering Education and Engineering Management. [1]

Engineering Management is a discipline that acts as a bridge between traditional engineers and business managers. Most importantly, however, engineering managers lead people. Thus we can say that engineering management uses a systems engineering approach to oversee the team developing products and services. As with other disciplines, Engineering Management is evolving. Advances in materials, nanotechnology, computing, bioengineering, and energy systems will affect the practice of engineering, by developing complex products, thus increasing the need of Engineering Management. Future engineering managers will not only play the role of system integrator, but will also need to be aware of changes in technologies that can be used as tools to develop and design new products and services. [2]

Performance results of managers with an engineering background indicate higher failure rates in management than individuals from any other functional area. It is not at all surprising when we find engineers rarely performed well in management roles. Poor performance can be directly related to the engineering education and training that promotes individual problem solving and searching for optimal solutions, rather than management education where group skills such as teamwork, facilitation, supervising, organizing, and resolving conflict are critical to overall success. Robin [1], also identifies teaching of management courses by non-engineers as one of the many reasons for engineers failing in management positions. These management courses are deeply rooted in already established management programs meant for business students rather engineering students.

EASTERN MICHIGAN UNIVERSITY'S ENGINEERING MANAGEMENT PROGRAM

Eastern Michigan University was founded in 1849 by an act of the Michigan legislature. Ypsilanti was selected from among five cities as the location of the first school west of the Allegheny Mountains. Since then, the University has grown, and in 2006 there were a total 22,974 students enrolled, with 18,245 at the undergraduate level and 4,729 at the graduate level. Eastern Michigan University is committed to excellence in teaching

through traditional and innovative approaches, the extension of knowledge through basic and applied research, and creative and artistic expression. Eastern Michigan University strives to be a national model of best practice in student access, community engagement, and learning across all dimensions of the institution.

The College of Technology at Eastern Michigan University was established in 1980 and consists of two schools, the School of Technology and School of Technology Studies & Military Science. The College has 1,525 undergraduate and 452 graduate students, taught by over 50 tenure track faculty. In 2000, the School of Technology started the Master of Science in Engineering Management (EM) program. Since then it has been one of the fastest and most consistently growing programs at EMU. The program popularity can be linked to its value and effectiveness for students, and because of the benefits that its graduates provide for the companies they work for. The EM program follows a simple principle, “practice what we preach”. It is the approach we used when we initially designed the engineering management program and it is the approach that we continue to use for continuous improvement in our program and courses. For the past two years, Eastern Michigan University’s Engineering Management distance learning Master of Engineering Management program has been rated and ranked a “Best Buy” by the editorial review team of the Web site GetEducated.com [3].

The EMU EM Program has five major tracks (Figure 1). Each track is developed through research defining that specialization of engineering management and its related disciplines. This research is also used to identify key professional certification examinations related to engineering management. As a requirement for graduation, EMU students gain extra value from the program by preparing for one or more professional certification exams that are offered by engineering-related professional societies, in areas such as engineering management, project management, lean systems and manufacturing engineering. Providing this curriculum online brings new students to the university from major corporations, businesses, and government agencies when previously business schedule and travel conflicts prevented most of these engineers from pursuing graduate studies.

CHANGING ENVIRONMENT

The Global Leadership Forecast showed that confidence in leadership is at a 10 year low, and has declined steadily over the past 8 years [4]. Many people believe that the current economic crisis will produce great leaders and managers. They argue that all the economic misery, financial disasters, and millions of lost jobs will produce a new generation of leaders who are battle-tested in crisis and ready to move the global economy in a healthier, long-term direction. With the lessons learned through current challenges, new management will employ fresh strategies, ideas and tools to build better organizations [2]. Along with these fresh ideas, importance will also be placed on implementing new technologies and tools needed to run, manage and collaborate in businesses.

Engineering Management Program				
CORE COURSES				
EM 505 Managing Engineering and Technology				
EM 509 Engineering Project Management				
EM 520 Engineering Value and Economic Analysis				
EM 540 Engineering Resource Management				
EM 570 Patents and Engineering Law				
EM 580 Engineering and Enterprise Integration				
EM 695 Seminar in Ethics & Leadership (capstone)				
TRACK COURSES				
Project/ Program Management	Design and Manufacturing	Lean Enterprise System	R&D Development Project	Quality Certificate
EM 519 Applied Engineering Project Management	EM 511 Manufacturing Engineering Fundamentals	EM 556 Lean Systems Team Management	EM 547 Management of Tech and R&D	Through special Quality certificates offered through EMU
EM 547 Management of Technology and R&D	EM 558 Lean Production	EM 558 Lean Production	EM 620 Integrated Product and Process Design	
EM 556 Lean Systems	EM 620 Integrated Product and Process Design	EM 620 Integrated Product and Process Design	QUAL 647 Research Methods	
EM 609 Team Management	EM 636 Analysis of Manufacturing Processes	EM 649 Manufacturing Process Planning	EM 691 Development Project Research Proposal	
EM 620 Professional Engineering Project Management	EM 649 Manufacturing Process Planning	EM 659 Advanced Lean Systems	EM 690 Development Project Research Report	
EM 649 Integrated Product and Process Design	EM 670 Design for Manufacturing	EM 669 Professional Lean Certification	QUAL551 Design of Experiments	
EM 649 Manufacturing Process Planning			QUAL557 Customer Satisfaction	
			QUAL651 Advanced Design of Experiments	

Figure1: Various Tracks at EMU MS (EM).

With the current economic crises in the world, the need for higher education has increased. Several countries have made education their number one priority to address the challenges of the global economic crisis. The current financial difficulties, rapid increase in unemployment and impending social crisis demands immediate attention. Employment, particularly traditional employment, is diminishing and the country must put itself in a position to respond to changing needs of employers in terms of availability of skills. This demands re-skilling and up-skilling of workers, and concerted action must be taken to expand education and training opportunities, particularly further, adult education and third level education and training opportunities [5]. In USA, the State of Michigan was the first one to be hard hit by this crisis. Michigan relies heavily on the automotive industry, with the headquarters of General Motors, Ford Motor Company and Chrysler, Detroit was known to be the “Motor City”. With diminishing automotive sales along with the off-shoring of manufacturing jobs, the unemployment rate in Michigan is highest in the USA. Michigan has no option but to diversify its economy. In 2007, Michigan governor, Jennifer Granholm started the “The No Worker Left Behind”

initiative. No Worker Left Behind (NWLB) is Michigan Governor Granholm's vision for accelerating the transition of thousands of workers into good-paying jobs by providing up to two-year worth of free tuition at any community college, university, or other approved training provider to gain the skills and credentials for new careers in high-demand occupations, emerging industries, or to start a business. The program will expand on the job training and education services currently available to job seekers. According the governor, "As we work to diversify Michigan's economy, we also strive to help Michigan workers diversify their skills" Governor Jennifer Granholm [6].

EMU, viewed this as an opportunity to re-skill these displaced workers and our Engineering Management program seemed well-suited for such activity. In order to meet the demand and challenges of the future engineers, it is important that students can become good decision makers and effective leaders. Engineering Management program faculty at EMU decided to modify few courses so as to address these challenges. We will now define the teaching methodology that utilize learning design and knowledge management concepts to develop these courses. These modifications are ongoing. This paper will describe some of these activities and their outcomes.

LEARNING DESIGN

How can we teach effectively, efficiently, attractively and accessibly? This question has a long history and has no simple answer. A solution, under given circumstances might work well on a particular person but will not on any other person. However, it is generally acknowledged that we can improve learning considerably by making the condition for optimal learning explicit and then using that knowledge to design new learning events [7].

While definitions of Learning Design vary, the main elements tend to include greater focus on "context" dimensions of e-learning (rather than simply "content"), a more "activity" based view of e-learning (rather than "absorption"), and greater recognition of the role of "multi-learner" (rather than just single learner) environments [8].

Thus, the knowledge of Learning Design helps us to:

- Find out what people need to learn
- Determine methods for assessing and communicating learning process results [students learn in a class and that knowledge is passed to the new class as Problem Solving knowledge].

Simply stating a learning design rule is as follows:

If learning situation (S) then use learning design method (M)

Finding such rules are not always easy. According to Koper, learning situation (S), can be divided into learning outcomes and learning conditions. Learning outcomes are related to:

- effectiveness, that describe how well the learning objectives are met by the learning design method (M),
- efficiency; describing the effort and cost of the learning design method,
- attractiveness; that describes the learning activities appeal to learner and the instructor
- accessibility; that describes the easy by which staff and learner access the learning facility.

Learning conditions are divided as the characteristics of the learning objectives, the setting and media. Finally, the learning design method (M), is described as a teaching-learning process that a learner will follow by interacting with the learning situation. Applying learning design concepts to online education requires some modification in the definition of the terms learning situation and learning condition in learning design rules.

ONLINE LEARNING

What is E-Learning? At the start of the internet boom, it was defined as “Internet-enabled learning” and is the ascendant form of electronic learning [9]. More than a decade later this definition does not do justice to the term and the concepts. Scholars had always known that the potential of this type of learning. Even as early as in 2000, David Brightman in his editorial commented, [10], this simple description does not adequately address the tremendous potential of e-learning to transform training and education as we know them.

Going beyond the definition, the decade also saw debate on the type of learning theory that online learning follow. Some authors contend that design for computer based or online learning is rooted in behaviorist theories of knowledge acquisition [11], while others argue that the needs of different learning styles are better served by a constructivist approach [12], most particularly in "multimedia based lessons" [13]. The range of approaches based on behaviorist and/or cognitive theories is usefully summarized by Meyer [14]. Doolittle [15], graded the ability of online education to meet eight primary requirements of constructivist pedagogy and concluded that, "Overall, online education provides the resources necessary for students to engage in rich and effective construction of knowledge. The key to online education and constructivism is not whether or not the potential exists, but rather, whether or not the potential will be actualized."

Along with the various issues and challenges related to online learning [16], feelings of isolation are an important stress factor. Students report confusion, anxiety, and frustration due to difficulties in communication with the instructor and classmate and lack of active participation. McInnerney and Roberts [17] describe the sense of isolation that online study may engender among learners, a factor often ignored by many educators, but one that may make the difference between a successful and an unsuccessful online learning environment for many students.

One way to address this issue is to have active communication by creating web communities. Rovai [18] suggested that online learners who have a stronger sense of community and perceive greater cognitive learning should feel less isolated and have greater satisfaction with their academic programs. Rovai and Jorden [19] later suggested that the sense of community can be enhanced and the sense of isolation can be reduced by offering “Blended learning environments”, which is difficult to achieve when students are geographically distributed in a completely online environment.

McInnerney and Tim S. Roberts [17] describe the importance of a proper appreciation of the learners’ social context, as is the concept of the ‘virtual self’ that individual learners may choose to portray during online communication. They suggest three protocols that can be built into the fabric of online courses in order that a sense of community may be enabled to exist, and productive social interaction can occur. These are (1) the greater use of synchronous communication facilities (in addition to, rather than instead of, asynchronous ones), (2) the deliberate design and inclusion of a ‘forming’ stage, or ‘warm-up’ period, incorporated as an essential component into the course structure, and (3) a much greater emphasis on the provision of (and adherence to) guidelines for successful online communication.

Finally for evaluating online education, Bourne et.al. [20] outline a three part scale that will help in the widespread of online education in all fields of engineering education. Bourne argues that for online engineering education to be broadly accepted and utilized, (1) the quality of online courses must be comparable to or better than the traditional classroom, (2) courses should be available when needed and accessible from anywhere by any number of learners, and (3) topics across the broad spectrum of engineering disciplines should be available. The five pillars of quality online learning have been adopted by the Sloan Consortium [21] as a means for creating explicit metrics for online education and gauging progress in the field. Learning effectiveness, student satisfaction, faculty satisfaction, access, and cost effectiveness are the five metrics that drive investigations into online education.

CONTEXTUAL LEARNING

According to contextual learning theory, learning occurs only when students (learners) process new information or knowledge in such a way that it makes sense to them in their own frames of reference (their own inner worlds of memory, experience, and response). This approach to learning and teaching assumes that the mind naturally seeks meaning in context, that is, in relation to the person's current environment, and that it does so by searching for relationships that make sense and appear useful. Building upon this understanding, contextual learning theory focuses on the multiple aspects of any learning environment, whether a classroom, a laboratory, a computer lab, a worksite, or a wheat field. It encourages educators to choose and/or design learning environments that incorporate as many different forms of experience as possible (social, cultural, physical, and psychological) in working toward the desired learning outcomes.

Hulls [22] states learning occurs only when learners connect information to their own frame of reference:

"According to contextual learning theory, learning occurs only when students (learners) process new information or knowledge in such a way that it makes sense to them in their frame of reference (their own inner world of memory, experience, and response). This approach to learning and teaching assumes that the mind naturally seeks meaning in context--that is, in the environment where the person is located--and that it does so through searching for relationships that make sense and appear useful."

Karweit [23] defines contextual learning as learning that is designed so that students can carry out activities and solve problems in a way that reflects the nature of such tasks in the real world. Research supports the effectiveness of learning in meaningful contexts. Resnick [24] points out that schools emphasize symbol manipulation and abstraction instead of the contextualized learning that is used in the world outside of school. She said the problem is that the symbols are detached from their real-world referents and because they are decontextualized, and thus have no meaning for students.

METHODOLOGY

Using Learning Design as a guide and utilizing Gagne's Nine External Events of Instruction, concept of contextual learning and Greenfield Methodology as a guide [25], a framework for EMU Engineering Management Program "Online Learning Methodology" was created, as shown in Figure 2. The framework emphasizes the importance of Social Learning as per Bandura [26] and Vygotsky [27], Cognitive and Experiential Learning as per Rogers [27], and Saloman's [28] Media Focused Learning. With this focus, we were able to maximize the effectiveness of instruction by adding relevance to the content, and fostering an active learning atmosphere.

The use of a social network system and smart phone will play an important role in e-learning. The possibilities for mobile learning are endless, and the market is already primed for adoption of these learning capabilities. Cell phones, iPhone, Droid, handheld computers and Blackberry have the capabilities today to support learning. EMU e-learning methodology has mobile capabilities that will be described in a future paper.

Another aspect of this methodology is the utilization of Knowledge Management in eLearning. The objective of eLearning and Knowledge Management are same, "learning". However, eLearning by nature is static and is only good with is a time period, while Knowledge Management is dynamic in nature and changes with time. While we see lot of efforts by online courses to let students share their knowledge and by online content developers to let students transfer tacit knowledge into explicit knowledge, still there is no transfer of knowledge take place between students of various courses. For example; students taking a course in Fall will share their knowledge and will also create knowledge. Once the course is finish a new one starts in the next semester all that

knowledge gets wasted and is not been utilize by the next semester students. This waste of knowledge can be utilized to promote effective learning.

The new methodology uses technology to create and store knowledge from students in every course and lets other students use it on an anytime and anywhere basis. This will help students to learn from mistakes from past students, which will also create an environment where students can spend time to learn the depth of the subject rather wasting time to inquire about issues already solved/ answered by past students.

The new methodology will help in developing courses that will utilize:

- Experiential Learning/ Context to link
 - Students' prior knowledge
 - Students' current interest and environment
- Media Focus Learning, to
 - Create stimulating media, simulation models, video blogs etc to engage students
- Social Learning, to
 - Create active learning environment with the use of case studies, live discussions, debates etc
 - Create knowledge management portals to collect and disseminate knowledge
 - Provide virtual meeting environment and direct connectivity with social network groups, like MySpace, Facebook etc for effective communication and collaborations.

New methodology (Figure 2) seeks to create a:

- Highly interactive learning environment
- Meaningful discussion
 - Communication
 - Team work
 - Collaboration
- Knowledge Creation
- Knowledge sharing
- Knowledge Management

CASE

The methodology was use to re-develop EM619, “Applied Project Management”, course (Figure 3). This is a three hour course, and in one of the three Project Management courses that students in Project Management track has to take.

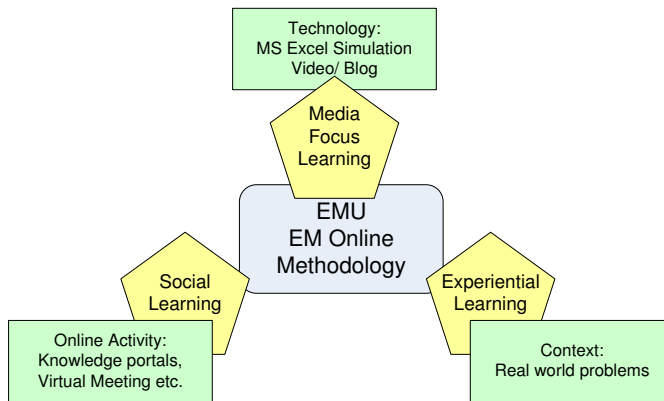


Figure 2: EMU Engineering Management Online Methodology.

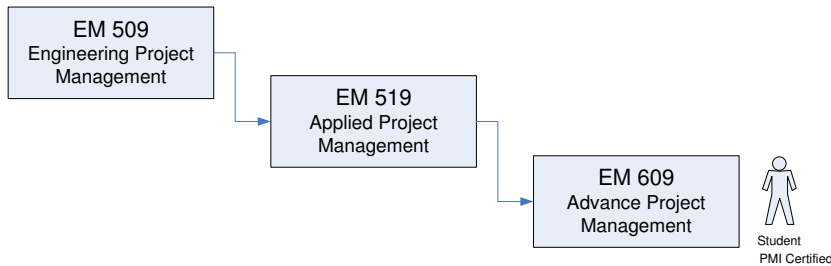


Figure 3: Engineering Project Management Courses and Prerequisites.

EM 519 Course Descriptions

This course includes advanced applications of software and theory for planning, implementation, management, and analysis of engineering projects. Students will use PMBOK as a guide to understanding the practical aspects of the engineering project life cycle, along with case study discussions and hands-on applications of project management tools and techniques.

Course Outline

The course is divided into 8 units. Each unit is 2 weeks long. Unit One is the introductory unit. In this unit students are given time to learn about the course. Unit includes documents/video/audio regarding:

- Course syllabus
- Course description and the way course is managed
- Students' expectations

- Important deadlines and milestones
- How to conduct a debate
- How to analyze case study
- Presentation format and guideline
- Report format and guideline
- Formulation of groups and selecting project manager
- Other items as needed

The main purpose of Unit One is to ensure that the online learning system or the course flow doesn't become a hindrance to learning process. At the end of the first unit, students are tested on their knowledge about the course. Students can attempt this test multiple times. Students have to score 100% before the points are counted toward the Unit One grade.

All other units are divided into:

- Lecture
 - Students are provided with a lecture on the topic. These lectures are in the form of videos, Power Point presentations, chapter and/or journal reading.
 - Several solved problems are provided to students so that they can understand how to formulate problems and attempt their solutions.
- Discussion (Figure 4)
 - Case Study Analysis:
 - The main idea of case studies is to invoke critical thinking among students. We use this opportunity to teach students that not always will they be able to find an optimal solution or make the best decision or that all decisions are correct. Students learn that decisions are based on several factors and one should be able to make decision under given circumstances based on the available data/ information.
 - In every unit, one or two case studies are provided. These case studies are either provided as text or in video format. In case of audio students can also download the MP3 version as well. These MP3 are created using text-voice software.
 - The case studies are directly related to the topics of the units. The main idea of these case studies is to motivate students to define problems in the case study and to discuss various solutions that can be implemented. Each student has to comment on at least three other students' comments/solutions. The discussion is evaluated based on the critical thinking, references used in the argument, data/information/facts used and the quality of discussion the comment has created.
 - Instructors participate in these discussions to motivate and to ensure that the discussions are on track. Strict communication etiquette, called "netiquette" is followed. The discussion also teaches communication skills and the art of creating alliances, a very

important part of business management. Twice during the semester, students working in teams will be in a web-meeting (audio and video) to discuss their strategy about the case study presentation. This helps them to learn the virtual meeting environment and the tools and the techniques needed to obtain best results for such an endeavor.

- Knowledge Capture (Figure 5):
 - For every unit, students are asked to write problems and issues that they faced during the unit, along with their solutions. These can be (tagged) problems related to MS Project, unit topics, problem examples, assignments or group projects. Students have to search the Knowledge database to ensure that the problems that they have outlined were never reported before, thus making sure that their problems are unique.
 - Students also utilize this Knowledge database to solve their own issues. The searchable database helps students to look for solutions for the problems that they are encountering. If they are unable to find the solution to any issue, they can report the issue to the discussion where other students can collaborate to help the student in finding a solution. Figure 4 shows one such collaborative discussion page.
- Assignments
- Group Projects
 - There are two types of group projects. One related to overall Project Management cycle, including planning, executing monitoring and closing of the project, and the second one is about monitoring an engineering project. In our EM program, we get students from every type of engineering field and background. It is important that we use the contextual learning concepts by assigning group projects where students can link their own personal and professional experiences in completing the projects. We have projects in the several areas and we either asks students to pick a project themselves or we assign them one based upon their experiences. Following are two examples of such areas.
 - Energy Project: The objective of this project is to design and select an integrated sustainable/renewable solution for an average house. Students are asked to develop an integrated wind and solar solution for an average size house using equipment and solutions readily available in the national and international markets. There are a few variations in the project based on the geographical location of students. Some of these variations are: location of the house, number of hybrid solutions sold, cost of the solution, etc.
 - Training Projects: Every big and small company in the world has to plan and invest in their workers and one way to achieve that is continuous training. The current economic crisis has had a very devastating effect on companies training budget. Companies are now using their own employees as trainers. Thus new engineers need to

know the art and science of training and teaching adults. In the training project, students work in groups to learn about the methodology of developing training and then develop a training program. They are evaluated based on the content and delivery of such training. Again there are variations in this project too; the area of the training, the number of days training has to be conducted, etc.

- The second type of project is an Engineering project. This project deals with monitoring and managing an engineering project where students in group have to make decisions about the project based on various scenarios. In real life, the project always experiences situations that are not planned. Political situations, war in a region, sickness, strike, natural disasters, etc. usually cannot be predicted, however, they are a part of life and business, and the project needs to address them when they occur. In the engineering project, students are placed in such arbitrary, but realistic situations. For example, they can be told that their shipment is arriving from South Africa and the container is being high-jacked by the Somali pirates. The group has to make a decision on how to reallocate resources and modify timelines to ensure successful completion of project.
- Students working in groups participate in online discussions and in a virtual meeting environment. At EMU, we have created a separate video conferencing software using Joomla along with Elluminate. Students can also use Dimdim, NetMeeting, GoToMeeting, etc. (Figure 6). The collaborative web page for the group has many options and students as group decide on what software they prefer using. In the same way, apart from EMU's own chat and discussion boards, students can use Skype, MySpace, Facebook and Twitter for communication and collaboration. EMU's learning system has provided an option where students can use one unique login ID to access their MySpace, Facebook and Twitter account. They can use these social networks for communicating, texting and instant messaging.

EASTERN MICHIGAN UNIVERSITY **Engineering Project Management**
 Instructor: Muhammad Ahmed
 Tools: Course Admin | Gradebook | Email | Live | Doc Sharing | Dropbox | Journal | Weblog | Help

Course Author
 Debate Case
Unit 1
 Lecture
 MS project
 Reading
 Outline Summary
 Assignment
 Threaded discussion
 Exam
 EPM course prep
 quiz
Unit 2
 Lecture
 Reading
 Assignment
 MS project
 Exam
 Threaded discussion
Unit 3
 Lecture
 Reading
 Assignment
 MS project
 Exam
 Threaded discussion

Problems and Solutions
 Please tell us about: (1) Any technical or procedural problems you had or still have with figuring out how to use the EMU online system, the course textbook or CD, MS Project 2007, or submitting assignments (begin entry with PROBLEM; then describe it). (1 pt.) (2) Solutions you came up with to solve that problem, or may offer to other students to help them solve their problems (begin response entry with SOLUTION; then describe it. (1 pt. extra credit each post, 2 pts. e.c. max.) Learning software is often a difficult task at first, and is a drain on productivity before it enhances productivity. It shouldn't be surprising to see some people having a few problems figuring out how to use MS Project 2007 throughout our course. Hopefully, this will be a good forum for overcoming some of these difficulties. Remember, when you provide a helpful tip to one person via the Threaded Discussion, you are probably helping a number of others at the same time. Check out the Threaded Discussion frequently. Feel free to extend the discussion for the mutual benefit of everyone in our class on any related topic that may be of help to you and others. Thanks.

[Respond](#)
[Expand All](#) [Print View](#) [Show Options](#)

Responses

Response	Author	Date/Time*
Assignment Feedback	Douglas Lund	2/3/2010 10:19:21 AM
RE: Assignment Feedback	Chalan Munasinghe	2/7/2010 11:01:56 PM
RE: Assignment Feedback	Megan Skelton	2/9/2010 7:50:32 PM
RE: Assignment Feedback	Chalan Munasinghe	2/12/2010 1:25:09 PM
RE: Assignment Feedback	Marikay Clancy	2/14/2010 5:42:47 PM
PROBLEM:MS Project 2007	Chalan Munasinghe	2/13/2010 2:37:09 PM
RE: PROBLEM:MS Project 2007	Chalan Munasinghe	2/13/2010 2:44:16 PM
RE: PROBLEM:MS Project 2007	Douglas Lund	2/14/2010 10:36:23 PM
RE: PROBLEM:MS Project 2007	Chalan Munasinghe	2/15/2010 12:48:02 AM
PROBLEM: Cost Roll-Up in MS Project.	Michael Ade	2/14/2010 1:20:00 PM
Problem MS Project	Kennith Tate III	2/14/2010 2:18:56 PM

Figure 4: Collaborative Issue Resolutions Using Issues and Solutions Web Discussion.

EASTERN MICHIGAN UNIVERSITY **ENGINEERING MANAGEMENT**
 About EMUEM | EMU | EMU Online | Software

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EM 519 Knowledge Management

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- EM519 Group Project (2 Articles)
- EM519 MS Project (1 Article)

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- Send Text
- Site Map

Courses

Resources

- Resource - Topics
- Social Collaboration

Knowledge Management

- EM509 Knowledge Management
- EM519 Knowledge Management

tom www.emuem.org...

Figure 5: Knowledge Management Portal for Issues and Solutions.



Figure 6: The Collaborate Web Page.

EVALUATION

At EMU, all Engineering Management courses have a “course evaluation” site where students have to evaluate all courses. To ensure 100% participation, the evaluation is graded. Instructor evaluations are not done on this site. The course we selected for re-design and development, Applied Project Management, has been taught at EMU for many years. We would like to investigate effectiveness of the new course based on the overall satisfaction of students from the course, number issues students encountered during the course, the effect of the knowledge management portal on learning and problem solving, and the effect of social networking on communication and collaboration. In Fall 2009 and Winter 2010 semesters, we taught this course using the newly redeveloped course. A total of 32 students were registered during these semesters. The sample size was small so we were not able to use the “Classroom Community Scale” [29]. Our plan is to re-evaluate the course once we have a sample size of 100 using this scale.

In order to get some insight about the new course, we compared this group of students and 28 students who took this course in Fall 2008 and Winter 2010. Results are presented in Tables 1 to 3.

Table 1: Student satisfaction from the course.

Fall 2008 – Winter 2009 (28)					Fall 2009 – Winter 2010 (32)				
Very	Above	Average	Below	Not	Very	Above	Average	Below	Not
7	9	10	2	0	24	6	2	0	0

Table 2: Course Activity Gauge for Fall 2008 and Winter 2009.

What is the best course activity?				
Discussion	Case	Project	Lecture	Nothing
5	7	5	4	7

Table 3: Course Activity Gauge for Fall 2009 and Winter 2010.

What is the best course activity				
Collaboration	Knowledge portal	Project	Web meeting	Nothing
6	8	10	8	0

The above comparisons indicate that the students' overall satisfaction has increased and the group projects have created the contextual learning link with students. Meanwhile, the use of web based technology, social networking, etc. have a higher approval rate, suggesting a higher acceptance of commonly used technology in a learning environment.

In order to obtain the effectiveness of the knowledge portal and knowledge management, we compared the number of problem and issues students posted rather than getting the solution from the knowledge portal. Table 4 shows the difference in the number of problems:

Table 4: Course Knowledge Portal Affectivity.

	Fall 2008 – Winter 2009 (28)	Fall 2009 – Winter 2010 (32)
Total Questions in Discussion	209	82
Total Questions through emails	523	114

The significant change in the number of questions asked by students and number of hits received by the knowledge portal web site suggests that the knowledge utilization module helped students solve their issues.

CONCLUSION

The paper described a new methodology for the development of online courses by employing the concepts of Learning Design, Knowledge Management and contextual learning. Linking web based activities with students' base knowledge and incorporating web based and mobile technologies, effective communication and collaboration can be achieved. Using these tools, students investigate multiple issues and identify various solutions, rather than finding a single, optimal solution. This is an unfinished work; more data is needed to investigate the effectiveness of such methodology. Work will be continued and other methods, like Sloan's quality pillars, and scales, like the Classroom Community Scale, will be used to validate our hypothesis. Hopefully these approaches to education create a new paradigm that teaches students to discover and construct knowledge for themselves in an online environment.

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MULTIMEDIA TEACHING METHODS

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ABSTRACT: The best philosophy of today's global education involves a combination of teaching styles, including both normal classroom instruction and also new IT multimedia tools. Students should also learn how to organize their time and balance school with the rest of their lives. The key to combining various teaching methods that use knowledge, skills and creativity in combination with computers, IT methods and multimedia graphics is to use new computer programs and software applications. To improve the standard education students are given today, multimedia educational tools are often used in combination with regular classes taught by teachers. Teachers can utilize the multimedia methods in the classroom to help provide additional learning instruction, as well as allowing students to access the school database to learn more on their own. Multimedia methods also are available for online courses in universities for global students who cannot attend college elsewhere. Multimedia educational teaching methods provide useful information using new IT teaching systems that will benefit all students in the future, whether in the classroom or from online courses available overseas.

Although there are many different kinds of teaching methods, a combination of various styles using regular classroom teaching with new IT multimedia tools may be the best education for students of all ages. Schools need to implement new multimedia teaching programs that allow for creative thinking mixed with a solid foundation of core knowledge and skills so will obtain the most effective overall education to prepare them for the competitive workforce. Researchers agree that the American education is starting to raise its learning standards using more IT multimedia teaching methods, which have been proven effective in both traditional classrooms and also for online university courses.

KEYWORDS: Multimedia Educational Tools; Multimedia Teaching Methods; Online Course; Multimedia Education; Multimedia Graphics; IT Educational Tools.

INTRODUCTION

The best philosophy of today's global education involves a combination of teaching styles, including both normal classroom instruction and also new IT multimedia tools. Students should also learn how to organize their time and balance school with the rest of their lives. The key to combining various teaching methods that use knowledge, skills and creativity in combination with computers, IT methods and multimedia graphics is to use new computer programs and software applications. To improve the standard education students are given today, multimedia educational tools are often used in combination with regular classes taught by teachers. Teachers can utilize the multimedia methods in the classroom to help provide additional learning instruction, as well as allowing students to access the school database to learn more on their own. Multimedia methods also are available for online courses in universities for global students who cannot attend college elsewhere. Multimedia educational teaching methods provide useful information using new IT teaching systems that will benefit all students in the future, whether in the classroom or from online courses available overseas.

PURPOSE OF MULTIMEDIA EDUCATION

The main purpose of multimedia educational tools is to provide extra help in the classroom for teachers who may be overwhelmed with so many students that they do not have the time to offer individual help. The multimedia IT tools allow students to access databases of information that help students learn at their own pace. Researcher Ho (1983) feels different kinds of education are important to keeping students interested in the material. As students get bored with regular classrooms, the multimedia IT tools help them to learn new skills, find out different information related to processes they previously did not know, and then use their brain to think more creatively, which will be good for them later on in college when computer skills are mandatory [1].

In E.D. Hirsch's article (1993), "Teach knowledge, not 'mental skills'", he explains how teachers usually focus on improving students' mental skills through computerization as a necessary part of learning. However, many teachers often cannot make the learning experience beneficial for students that are either smarter or slower because they must stick to the prepared teaching plans. Since many students progress at different levels during their education, it is difficult for teachers to have an overall teaching system that is effective for everyone. Multimedia courses can help students to progress at their own pace from home, whether it is advanced or slower, so they can learn without the competition of having to meet other students' pace [2].

Another purpose of multimedia educational tools is to provide online instruction over the Internet and World Wide Web so that students overseas can benefit from western education. Many universities are offering online courses using multimedia tools, such as Blackboard classrooms online that allow for students abroad to attend virtual classes taught by American or UK professors at western universities. Hirsch feels there is no consistency in what children were taught in previous grades, teachers have to make a compromise in how much time they can provide per pupil. Researchers think teachers have a very hard job and they really must have trouble getting all the students to learn at the same pace. Hirsch accepts that students must first have the proper IT and computer skills to use the multimedia learning tools, and then find ways to use them. Researchers also agree that if schools can upgrade their teaching and learning systems using IT multimedia methods, they will do a better job teaching student [2].

Some students learn more than others so they are at different levels during their education. This makes it hard for teachers to help students keep up with each other. Hirsch created the Core Knowledge Foundation multimedia program to help schools improve the content of learning and using IT tools, rather than just classroom learning skills. Many administrators in the US are now putting this Core Knowledge Foundation multimedia education program into their schools. One Bronx school even had major improvement in all their students' learning abilities: "Over 50% of classroom time is spent teaching each student a core of knowledge through multimedia methods that is the same material offered to every other child in regular classrooms. Researchers think this multimedia program is very interesting and that it will probably be very effective in helping students learn more [2].

OBJECTIVES OF MULTIMEDIA EDUCATION

The overall goal of multimedia education is to integrate hardware computers and accessories, with software applications and IT methods as essential components of providing instructional courses to achieve the following objectives:

- to provide global students with practical experience of using the multimedia methods.
- to enrich students' understanding of the multimedia methods.
- to enhance students' understanding of the underlying information and knowledge provided to them.
- to provide practical usage of computers, IT methods and multimedia tools in order for students to gain knowledge on various subjects [3-5].

INSTRUCTIONAL FEATURES OF MULTIMEDIA EDUCATION

There are many useful features of multimedia education, including using graphics, sound, music and images in combination with text words to help students better understand the course content. Multimedia education involves mixing IT methods of learning with instructional teaching in a classroom atmosphere. Multimedia imagery uses IT tools as guides to help students, even when they are at home using their own computers. Multimedia education can also be used in the classroom to help teachers provide useful examples of what they are teaching.

Some of the educational benefits of multimedia education include:

- Division of teacher and student (during most of the instructional process).
- The power of a strong IT educational tool (including the provision of student evaluation).
- The application of educational multimedia to unite teacher and learner (and explain course content).
- The provision of two-way communication (between teacher, educational organization and pupil).

Some of the positive features of multimedia education include: learner-paced, can be used anywhere, low cost, and works with any age, race or nationality of people, due to being available in all languages. Some of the negative features of multimedia education include: limited interactivity, students sometimes have difficulty keeping pace with the instructional guide, and students must have excellent IT and computer skills. Teachers need to realize that students learn at different paces and some need more attention than others. Teachers who use multimedia teaching methods like the Core Knowledge Foundation program will be better able to help those students who may fall behind others who learn at a faster pace. Even advantaged students are hurt by being left with huge knowledge gaps or by being bored with repetition. Hirsch's Core Knowledge Foundation

program has even been used in the Clinton Administration's new education bill, even though many educational reformers think skills are better than teaching mere facts [6].

APPLYING MULTIMEDIA TEACHING METHODS TO DISTANCE LEARNING

Besides applying the multimedia teaching methods to existing classroom curriculums, they can be used in distance learning programs. Distance learning has given students the higher learning they need to be effective in their positions in a competitive workplace environment. With the advancement of Internet technology, distance study and online courses have become very popular. Many foreign students want to earn their college degrees but need access to the materials. The technologies involved include using the World Wide Web and Internet to provide overseas access, desktop collaboration software, electronic mail, email discussion groups (listserver), bulletin board discussion groups, and in class technology. Internet downloads and wireless technologies like laptops and mobile telephones offer compatibility with global software and hardware so students all over the world will be able to participate in the online class discussions and attend the online virtual classrooms [4,7,8].

Colleges like The University of Minnesota use multimedia instructional systems to improve the communication level between teacher, students and classmates by allowing virtual classroom discussions, student input, teacher feedback, posted assignments with flexible time schedules for completion. The teacher and class can have all of their course interaction in a virtual cyber classroom 24 hours a day for obtaining homework assignments from the bulletin board, and then placed into the drop box. Desktop Collaboration Software, video software systems, email discussion groups or listservers, and virtual "Smart" classrooms allow for innovative interaction between students and teachers [4,7,8].

SUMMARY AND CONCLUSIONS

Although there are many different kinds of teaching methods, a combination of various styles using regular classroom teaching with new IT multimedia tools may be the best education for students of all ages. Schools need to implement new multimedia teaching programs that allow for creative thinking mixed with a solid foundation of core knowledge and skills so will obtain the most effective overall education to prepare them for the competitive workforce. Researchers agree that the American education is starting to raise its learning standards using more IT multimedia teaching methods, which have been proven effective in both traditional classrooms and also for online university courses.

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A TOOL FOR EFFICIENT PLANNING OF COURSE OFFERINGS AND EFFECTIVE ACADEMIC ADVISING IN A CUSTOMIZED CREDIT-HOUR SYSTEM

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ABSTRACT: In many universities and colleges in which the credit-hour system is adopted, planning of the courses to be offered every semester is neither a standard nor a straight forward task. This is particularly true for smaller colleges and departments, where academic advising is emphasized, and when the students' selection of courses is restricted due to factors such as prerequisite requirements and academic probation policies. In such a "customized credit-hour system", the planning of course offerings is not limited to ensuring efficiency in managing the academic program, but should also yield in offering courses that shall meet every student's needs based on his/her individual study plan, thereby assist in producing an effective academic advising system while enhancing the quality of the academic program. This paper explores key issues regarding the planning of course offerings as well as the expectations of an effective academic advising system and its impact on the quality of an academic program. The paper also details the rationale for and purpose of the development of tools to support these processes. It then presents a program management worksheet that was created and developed, over the past three years, for the Aeronautical Engineering program at Emirates Aviation College - Aerospace and Academic Studies. The worksheet has been used for the planning of the courses to be offered by the department every semester as well as to assist in providing students with quality academic advising. Analysis and results of deploying the program management worksheet are also presented.

KEYWORDS: Program Management Worksheet; Course Offerings; Course Planning; Academic Advising.

INTRODUCTION

Development of a comprehensive course plan is driven primarily by curriculum and student demand, but it is also affected by the appropriate size for different classes, and teaching load of instructors. Due to resource limitations in small colleges and departments, teaching resources should be fully utilized. Moreover, the cost of student-credit-hour demands that the number of students in any course should be greater than a certain minimum number, to be financially visible. Also, students' course load should be considered to help them, especially in the freshman year, to complete their degree in time while adhering to academic policies and regulations such as those related to academic warnings.

Effective academic advising includes, but is not limited to, helping students learn current academic information, progress toward their educational goals, develop strategies to avoid academic problems, be confident about the choices they have made, and select courses [1]. By guiding students toward appropriate course selections, the academic adviser encourages better student-course matches, fewer failures, less frustration, and more satisfied students and faculty. Improper advising may occur when delivering

inaccurate or misleading advice. Other symptoms may be lack of knowledge of the course offering, relationships, prerequisites, or inadequate understanding of the case at hand. This uninformed advising would eventually lead students to waste their time taking non-required course work, make wrong career choices, or create inappropriate study program [2].

The freshman course selection [3] and ability of students to handle certain course load [4] are another two important issues to be considered in course offering planning and academic advising. Some colleges assign academic advising to students on the basis of academic preference, while in other colleges, students are assigned to an advisor on the basis of residence area [5]. In small colleges in which the credit-hour system is adopted, following a standard study plan for the offered courses in each semester is not possible due to many restrictions. These restrictions include prerequisite requirements, cost of student-credit hour, availability of faculty member, and academic probation policies. In such cases, a customized-credit hour system should be employed. Also, the planning of course offerings is vital to ensure efficiency in managing the academic program, and to yield in offering courses that meet every student needs based on his/her individual study plan. Moreover, the academic advising will positively influence the student performance if it is based on the academic status of the student not on his ID number or other irrelevant criteria.

This paper explores key issues regarding the planning of course offerings as well as the expectations of an effective academic advising system and its impact on the quality of an academic program. It then presents a program management worksheet that was created and developed, over the past three years, for the Aeronautical Engineering program at Emirates Aviation College - Aerospace and Academic Studies. The worksheet has been used for the planning of the courses to be offered by the department every semester as well as to assist in providing students with quality academic advising. Analysis and results of deploying the program management worksheet are also presented.

PLANNING OF COURSE OFFERINGS

In colleges with large number of students enrolled each semester, the planning of course offerings is mostly a straight forward process. A schedule, for the courses that will be offered during the whole academic year, can be prepared and announced to the students. Then, students have to plan for themselves with the help of the academic adviser without expecting any change in the announced plan. Also, because many of the courses are offered only one time each year, the student has to plan his schedule accordingly. Moreover, all course offerings are contingent upon sufficient enrollment, which means that a student may choose a course and then is obliged to switch to another one because the chosen course will not be offered or is dropped, else he/she will have to wait until the course is offered again and the minimum required number of students is enrolled.

On the other hand, in colleges with small number of students enrolled, the planning must be flexible enough to meet each student's needs while enabling him/her to register for courses such that they can graduate in time. Moreover, the offered courses must include

some general courses, departmental courses, and major courses to distribute the study load over the whole period of study and to satisfy the course prerequisites requirements. In such circumstances, a standard deployment of the credit hour system shall not suffice to achieve the various desired outcomes, and a customized credit-hour system is required that is characterized by the following:

- a) Emphases on academic advising by universities in the region as well as the UAE ministry of higher education and scientific research.
- b) Immaturity of students (and inability) to handle credit-hour system on their own. Mainly due to lack of awareness and not being used to such a system.
- c) Prerequisite requirements and their role particularly in engineering programs.
- d) At Emirates Aviation College (EAC), the minimum fees covers up to 15 credit hours, and hence, it is required to provide every student with the opportunity to register for five courses according to his/her individual study plan.
- e) Academic warning policy, which has been adopted by a number of universities to provide students with a fair chance to improve their CGPA. According to this Academic warning policy, a student is placed on academic probation if at the end of a semester his/her cumulative GPA falls below 2.00. A student on academic probation for the first time is allowed to register four courses with a maximum load of 13 credit hours and must at least repeat one course.
- f) A student on academic probation for the second consecutive semester is allowed to register four courses with a maximum load of 13 credit hours and have to repeat at least two courses. A student on academic probation for the third consecutive semester will be dismissed from the college. It is highly recommended that students on academic probation consult regularly with their academic advisors. Probation will be removed at the end of any semester in which the student attains a minimum cumulative GPA of 2.00.

To successfully deploy the academic warning policy the courses to be repeated have to be offered. In a regular credit-hour system, courses are offered once per year and hence in many cases the student will not find the appropriate minimum number of courses to register in. The planning of course offerings during any semester should take into account the following rules:

- a) At least 5 courses will be available for each regular student and 4 courses will be available for a student on academic warning, one or two of them are repeating courses.
- b) The minimum number of students to register in a course should be above 16 students per course to run the program efficiently.
- c) Teaching load should be distributed on all major fields to equally load the faculty staff.
- d) The load on a student should be distributed over the major fields and general courses.
- e) The prerequisite for each course should be satisfied.
- f) For each student there should be a proposed plan for the coming two or three semesters assuming that the student will succeed in all courses. This represents

the severest situation that the college may encounter in planning for course offering.

- g) The above criterion should allow a graduating student (the student who has two semester to graduate) to finish the remaining courses in time.

ACADEMIC ADVISING AND THE PLANNING OF COURSE OFFERING

Academic advising can play an important role in helping students to find solutions to questions and concerns. In a recent study [6], recommendations for better performance and effective advising in small colleges were summarized as:

- a) Advisers and students should understand the purpose of the advising program.
- b) All advisers should receive training.
- c) Advisers should focus on developing personal relationships with their advisees.
- d) Students with specific needs should receive increased assistance.

The last recommendation requires academic advising to be based, mainly, on the student needs and it will be different from case to case specially in small colleges' environment. Distributing the advising load on the faculty members may be based on ID number or residence location of the students. However, this criterion is not recommended because of inconsistency of student's needs and situations. Alternatively, distributing the advising load according to number of completed credit hours results in a more consistent group and hence very close needs and concerns. Moreover, the advising group will, mostly, be taking the same set of courses and they will graduate in the same year. This helps in planning the courses they need and thus distribute the study load across their study period.

PROGRAM MANAGEMENT WORKSHEET

In Emirates Aviation College, a worksheet has been developed and implemented in planning of course offerings. This sheet has many capabilities. It makes the study plan for each student perceptible and thus the planning team can bring forward or delay course(s) for this student to match the needs of the majority of students without violating the prerequisites. This helps in increasing number of students that can register in each course without affecting the graduation plan of the student. Moreover, the sheet helps in distributing the study load by offering the student general course beside some department and major courses. Also, this helps in balancing the teaching load to be suitable for the available faculty staff.

Figure 1 illustrates part of this sheet using student ID as a sorting criterion. The second row of this sheet includes all the courses that comprise the program (some of them do not appear in the Fig.). The courses are grouped according to the field of specialization, i.e., all math courses appear in the first few columns, then structure courses followed by propulsion courses, and so forth. Also, the prerequisite for each course appears in the first row to help the planning team to satisfy the prerequisite while choosing a course for a student. The Excel sheet calculates, for each student, the number of finished credit hours,

number of offered credit hours, AGPA, number of offered course, and the number of remaining courses till graduation. Also, the sheet checks if the AGPA falls below 2.0 on a 4.0 scale and if so, the student gets an academic warning.

A selected course for the coming semester is given (1), while (N1) is given to a course, which is proposed for the next semester, (N2) for a course, which is proposed for the semester after the next semester, and (N3) for the semester after the next semester. Also, (S) is given to the course/student cell if the college has a plan to offer summer courses and this student is eligible to register in one of these courses. Also, according to policies and procedures in Emirates Aviation College, a student who needs three courses or less to graduate will be offered these courses in the summer. By vertical summation of cells with (1), the total number of students that can register for certain course in the coming semester can be estimated. Similarly, the number of students that may be eligible to register for certain course in the next three semesters can be estimated assuming that all students can pass the prerequisite for this course. This assumption causes an error in the estimation, and it was found that this error is in the order of 10 to 20%. Grouping courses according to field of major specialization helps in insuring that the student can finish all courses in time and that the selected courses will be distributed on all fields of major specialization. Also, there is a group (not appearing in the figure) for general courses (GE) such as English and IT courses. In any semester, the planning team tries to offer some GE courses beside department and major courses to help in balancing the study load the a student may have in one semester.

Student ID	Prerequisite																																
	Student Name	Courses																															
		Current Courses (1)->	Next Courses (N1)->	Next Courses (N2)->	Next Courses (N3)->	Summer Courses (S)->	Cr Hours per course->	Finished Credit Hours	Offered Credit Hours	GPA	Warning	Offered Courses (1)	Remaining Courses	Int to Math	Math I	Math II	Math III	Math IV	App Mech	Eng Mechanics	Mech of Material	Materials Eng	Struct Analysis	AC Structures	AC str Analysis	Eng Thermo	Fluid Mechanics	Heat Transfer	Thermo - Fluid	Heat Transfer + Intro to Aerodynamics	Prop Technology	Gas Turbine	
200521015	Abd El Rahman Hussien	107	107	2.52		5	4	B	D	B	B+	A	C	C+	D	C	D	N1	B+	A	D+	D	C										
200522051	Amir Hossein Faghghi	125	125	2.65		3	0	B+	B+	B+	A	A	A	D+	B	C	B+	1	D	D	D	B+	D	C									
200522052	Buraq Khalid Abdulrahim	119	119	2.73		5	0	A	D+	B	B+	C+	D	C	D+	A	B+	1	C+	C+	B	C	D	1									
200522053	Mohammed Al Rahma	119	119	2.59		5	0	A	D	D	A	C+	C	D	C+	B	D	1	C+	B	C	D											
200522056	Mohammad Ahmad Abdallah	91	91	2.03		5	9	C+	D+	D	B	C	D	D	1	D	N1	N2	D	D	C	C	N1	N2									
200522057	Hamad Sayed Al Musawi	100	100	1.89	W	4	7	B	D+	D	C	C+	D+	D+	1	C	N1	N2	D	C	B	D	D	1									
200522062	Abdulkarim Salah Salankli	113	113	2.15		6	1	B	C	D+	C	C+	D+	C+	D	D+	B+	1	D	B	B	D	1										
200522063	Galston Russ D' Souza	119	119	2.69		5	0	A	D+	D+	A	B+	D+	D	B+	A	D	1	C	C	C+	D	1										
200522067	Ali - Hamad	119	119	2.83		5	0	A	B	B+	C+	B	C+	B	C+	B	B+	1	D	D+	C	D+											

Figure 1: Program management worksheet sorted by student ID.

It was found that sorting the students according to the number of finished credit hours helps the planning team in selecting the most important courses to be offered in the coming semester to satisfy the needs of the graduating students in this semester and then build on this bases and try to fill these courses with the maximum number of eligible students. After finishing the planning for the courses needed for the graduating students,

the planning team considers the courses for the students who are going to graduate after two semesters and so on. Rationalization of course offering according to graduating students was very helpful in offering the minimum number of courses and thus increasing the number of students registering in each course without violating the course prerequisite. Also, it is worth to mention that there is a maximum limit on the number of students that can register in one class and if the number of students become above this limit, the planning team suggests opening two classes for this course and split the students in two groups. As it can be seen from Fig. 2, courses like Aircraft Structures and Gas Turbine Science are required for graduating students who have finished 119 credit hours out of 134 which means they need only one semester to graduate. Such courses have priority to be offered in the coming semester over any other course.

Prerequest																																																									
Student Name		Courses																																																							
Student ID	Current Courses (1)-->	Finished Credit Hours	Offered Credit Hours	GPA	Warning	Offered Courses (1)	Remaining Courses	Int to Math					Int to Mech					Mech of Material					Mech of Mat+Material Eng					AC str Analysis					Int to Math					Fluid Mechanics					Thermo + Fluid					Heat Transfer + Intro to					Prop Tech				
	Next Courses (N1)-->							Math I	Math II	Math III	Math IV	App Mech	Eng Mechanics	Mech of Material	Materials Eng	Struct Analysis	Material Eng	AC Structures	Eng Thermo	Heat Transfer	Thermo + Fluid	Heat Transfer + Intro to	Prop Tech																																		
	Next Courses (N2)-->							38	36	0	0	9	35	0	27	24	0	21	29	9	26	0	22																																		
	Next Courses (N3)-->							0	22	48	21	0	25	50	0	0	28	16	18	37	0	33	0																																		
	Summer Courses (S)-->							0	0	22	47	33	0	20	44	0	0	28	0	7	51	0	34																																		
	Cr Hours per course-->							0	0	0	22	35	0	0	25	41	0	0	0	0	0	0	0																																		
								1	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0																																		
								3	3	3	3	3	4	4	4	3	3	3	3	3	3	3	3																																		
200522051	Amir Hossein Faghihi	125	125	2.65	3	0	B+	B+	B+	A	D	D+	B	C	B+	1	D	D	B+	D	C																																				
200522052	Buraq Khalid Abdulrahim	119	119	2.73	5	0	A	D+	B	B+	C+	D	C	D+	A	B+	1	C+	C+	B+	D																																				
200522053	Mohammed Al Rahma	119	119	2.59	5	0	A	D	D	A	C+	C	D	C+	B	D	1	C+	B	C	D																																				
200522063	Galeston Russ D Souza	119	119	2.69	5	0	A	D+	A	D	A	B+	D+	D	B+	A	D	1	C	C	C+	D																																			
200522067	Ali . Hamad	119	119	2.83	5	0	A	B	D	B+	C+	B	D	C+	B	C+	B	B+	1	D	D+	C																																			
200621100	Abhishek Ajay Sood	119	119	2.12	5	0	A	D	D	D	D	C+	B	B	D	D	1	D	C	C+	C	B																																			
200621094	Mohammed Hassan Ayoub	116	116	2.65	6	0	C	B	B	B	B	A	D+	B	C	B+	1	C+	C	A	A	A																																			
200621099	Ankur Jayantilal Dobariya	119	119	2.34	5	0	C	D+	D	B+	D+	C	C	A	B	D+	B	1	D	C	C	C	B																																		

Figure 2: Program management worksheet sorted by number of finished credit hours.

Also, a student who has got warning will be assigned three (or two) new courses plus one (or two) repeating course(s), which will be selected from the courses with the minimum grade (F is better than D, and D is better than D+, and so on). This helps the student with academic warning to improve his AGPA in the coming semester to get out of the warning. In the next step, the planning team looks at the course with the minimum number of students and tries to select a different course for the students who were initially assigned to this course. This should be done without removing any of the courses needed by the graduating students. This process ends up with a plan for each student on the basis of student needs and with the maximum number of students in each course.

Also, this worksheet is employed to plan for the teaching load of faculty members. The selected courses are assigned to faculty members according to their field of specialization and within the maximum allowable load. The remaining courses will be covered by part time staff providing that the percentage of part time teaching load is less than or equal to 25% of the total teaching load in this semester. This percentage is set by the Ministry of Higher Education and Scientific Research in the UAE. If this percent becomes above this limit, this means the college needs to hire a new faculty member and the major field of

specialization can be obvious from the Program Management Sheet. Generally, in Aeronautical Engineering, there are main four fields of majors, namely; Structure, Aerodynamics, Propulsion, and Control.

Figure 3 shows part of the program management worksheet on which the conflicts between courses can be evaluated. All courses are inserted in a column and at the intersection between each two courses, one from vertical list and another from the horizontal list, the number of students who register in these two courses simultaneously is evaluated. For example, consider (Math I) from the horizontal list and (Mechanics of Flight) from the vertical list. There are 23 students register for both (Math I) and (Mechanics of Flight). Alternatively, (Mechanics of Flight) has no conflict with (Introduction to Math), (Math IV), (Aircraft Structures) and (Gas Turbine Science). The course (Mechanics of Flight) can be scheduled in the same time with (Introduction to Math) or (Math IV) or (Aircraft Design) or (Gas Turbine Science). On the other hand, the course (Mechanics of Flight) should not be scheduled on the same time with the course (Math I) or (Applied Mechanics).

Moreover, using some sorting techniques, a more compact and clear worksheet can be constructed as shown in Figure 4. All conflicting courses can be grouped on two corners, while the non-conflicting courses will appear on the other two corners. Using this configuration, three or four courses can be scheduled at a time without any conflict. For example, the course (Introduction to IT) has no conflict with the course (English II, sec 1), and both courses have no conflict with the course (Math IV). Thus, these three courses can be scheduled in a class time table and final exam time table in the same period without expecting to get any complain from students. Moreover, these courses are taught by different faculty members. This means again, there will be no conflict on the time table of the faculty member. This scheme results in reducing efforts spent in preparing time tables and during the last three years, no announced time table was changed due to students or faculty complains.

The advantages of this worksheet can be summarized in providing every student with the required number of courses those suites their study plan to graduate in the shortest time while maintaining efficiency and diversity in the courses to be offered. More recent advantages include the distribution of advising load based on academic status rather than batch ID, which improves the effectiveness of academic advising and make it straight forward process.

		Prerequisite																						
Student Name		Courses					Intro to Math	Math I	Math II	Math III	Math IV	Intro to Mech	Applied Mech	Eng. Mech	Math I	Mech of Mat+ Material Eng	AC str Analysis	Intro to Math	Math I	Thermo + Fluid	Heat Transfer + Intro to	Prop Tech		
Student ID	Current Courses (1)->	Finished Credit Hours	Offered Credit Hours	GPA	Warning	Offered Courses (1)	Remaining Courses	38	36	0	0	0	35	0	27	24	0	24	0	25	0	22		
	Next Courses (N1)->							0	22	48	21	0	25	50	0	0	28	16	37	0	33	0		
	Next Courses (N2)->							0	0	22	47	33	0	20	44	0	0	28	0	7	51	0	34	
	Next Courses (N3)->							0	0	0	22	35	0	0	25	41	0	0	0	0	0	0	0	
	Summer Courses (S)->							1	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	
	Ct Hours per course->							3	3	3	3	3	4	4	4	3	3	3	3	3	3	3	3	
	200522051							Amir Hossein Faghghi	125	125	2.65		3	0	B+	B+	B+	A	A	D+	B	C	B+	1
200522052	Buraq Khalid Abdulrahim	119	119	2.73		5	0	A	D+	B	C+	C	D	C+	A	B+	1	C+	C	B+	D	1		
200522053	Mohammed Al Rahma	119	119	2.59		5	0	A	D	D	A	C+	C	D	C	B	D	1	C+	B	C	D	1	
200522063	Gailston Russ D' Souza	119	119	2.69		5	0	A	D+	D+	A	B+	D+	B	C+	A	D	1	C	C	C+	D	1	
200522067	Ali . Hamad	119	119	2.83		5	0	A	B	B+	C+	B	C+	B	C	B	B+	1	D	D+	C	D+	1	
200621100	Abhishek Ajay Sood	119	119	2.12		5	0	A	D	D	D	D	D+	B	C	B	D	1	D	C+	C+	C	A	B
200621094	Mohammed Hassan Ayoub	116	116	2.65		6	0	C	B	B	B	B	A	D+	B	C	B+	1	C+	C	A	C	A	B
200621099	Ankur Jayantilal Dobariya	119	119	2.34		5	0	C	D+	D+	D+	D+	C	C	A	D	B+	1	D	C	C	C	B	
Mech of Flight								0	23	0	0	0	24	0	3	5	0	0	25	9	6	0	0	
AC System Principles								0	0	0	0	6	0	0	5	0	0	1	0	0	2	0	2	
Flight Control								0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
Stability and Control								0	0	0	0	2	0	0	1	1	0	8	0	0	0	0	14	
Intro to Aero								0	0	0	0	1	0	0	19	18	0	0	0	18	0	0	0	
Advanced Aero								0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
Exper Tech								0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
Aircraft Design								0	0	0	0	5	0	0	2	0	0	5	0	0	1	0	9	

Figure 3: Program Management Worksheet to schedule classes and final exams

	Intr to Math	Math I	Introduction to IT	English I	English II (sec 1)	Enviro Studies	Math IV	System Principles	Aircraft Design	App Mech	Mech of Material	Stability and Cont	Intr to Aero	Intr to Programming	Heat Transfer	Materials Eng	Gas Turbine	Wind turbine	AC Structures	Psychology	Eng Manag	Research Methods	Eng Thermo	Workshop Tech	English II (sec 2)	Electrical Principles	Fluid Mechanics	Mech of Flight	
English II (sec 1)	0	0	0	0	0	0	0	0	0	0	0	0	1	1	2	2	3	4	6	6	7	11	0	2	2	4	4	4	4
Research Methods	0	0	0	0	0	0	0	0	0	0	0	1	1	2	2	2	3	4	6	6	7	11	0	0	0	1	1	3	3
Materials Eng	0	0	0	0	0	0	0	0	0	0	21	1	18	0	23	24	0	0	0	1	1	2	0	0	0	21	2	5	0
Fluid Mechanics	0	0	0	0	0	0	0	0	0	1	0	0	0	1	3	2	0	0	0	0	3	2	3	3	4	6	9	9	0
AC Structures	0	0	0	0	0	1	1	1	5	0	0	8	0	0	0	0	11	9	21	12	17	6	0	0	0	0	0	0	0
Intr to Aero	0	0	0	0	0	0	1	2	0	0	20	0	21	1	18	18	0	0	0	1	1	1	0	0	0	19	0	0	0
WindTurbine	0	0	0	0	0	0	2	3	1	0	0	4	0	0	0	0	5	15	9	10	13	4	0	0	0	0	0	0	0
Stability and Cont	0	0	0	0	0	0	2	1	8	0	1	18	0	0	0	0	1	14	4	8	5	11	1	0	0	0	0	0	0
Heat Transfer	0	0	0	0	0	0	2	2	1	0	22	0	18	0	26	23	0	0	0	2	2	2	0	1	0	22	3	6	0
Mech of Material	0	0	0	0	1	0	3	6	2	0	28	1	20	0	22	21	2	0	0	3	3	0	0	0	0	21	0	3	0
Gas Turbine	0	0	0	0	0	0	4	2	9	0	2	14	0	0	0	0	22	5	11	8	15	3	0	0	0	0	0	0	0
Psychology	0	0	0	1	0	0	4	5	6	0	3	5	1	0	0	0	1	8	10	12	23	19	6	0	0	0	0	0	0
Aircraft Design	0	0	0	0	0	0	6	4	14	0	2	8	0	0	1	0	9	1	5	6	9	0	0	0	0	0	0	0	0
Eng Manag	0	0	0	0	0	1	6	7	9	0	3	11	1	0	2	1	15	13	17	19	32	7	0	0	0	0	0	0	0
System Principles	0	0	0	1	0	1	7	12	4	0	6	1	2	0	2	2	3	1	5	7	0	0	0	0	0	0	0	0	0
Math IV	0	0	0	0	0	1	10	7	6	0	3	2	1	0	2	0	4	2	1	4	6	0	0	0	0	0	0	0	0
Mech of Flight	0	24	0	0	7	1	0	0	0	25	3	0	0	0	17	6	5	0	0	0	0	0	3	26	3	4	9	9	36
Eng Thermo	0	28	0	0	10	2	0	0	0	28	0	0	0	18	0	0	0	0	0	0	0	0	30	0	2	3	2	26	0
App Mech	0	34	3	2	14	2	0	0	0	36	0	0	0	19	0	0	0	0	0	0	0	0	28	3	0	4	1	25	0
Math I	3	37	3	2	17	2	0	0	0	34	0	0	0	21	0	0	0	0	0	0	0	0	28	2	0	2	0	24	0
Intr to Programming	7	21	0	0	9	2	0	0	0	19	0	0	1	28	0	0	0	0	0	0	0	2	18	1	0	6	1	17	0
Electrical Principles	8	2	2	4	5	5	0	0	0	4	21	0	19	6	22	21	0	0	0	0	0	1	3	5	4	39	6	9	0
Introduction to IT	13	3	16	14	2	13	0	0	0	3	0	0	0	0	0	0	0	0	0	0	0	0	0	13	0	0	0	0	0
Workshop Tech	15	2	13	15	2	14	0	0	0	3	0	0	0	1	1	0	0	0	0	0	0	0	0	21	2	5	3	3	0
English I	17	2	14	20	0	16	0	1	0	2	1	0	0	0	0	0	0	0	1	0	0	0	0	15	0	10	4	0	0
Enviro Studies	19	2	13	16	4	22	1	1	0	2	0	0	0	2	2	0	0	0	1	0	1	0	2	14	0	5	0	1	0
IntrJo Math	25	3	13	17	8	19	0	0	0	0	0	0	0	7	0	0	0	0	0	0	0	0	0	15	0	10	8	0	0

Figure 4: Conflicts between courses

The results from this program management worksheet are very promising. During last two semesters, the college offered 4 courses (12 credit hours) in each field of major specialization in Aeronautical Engineering. This causes a balance on the teaching load on faculty members. Also, the minimum number of students in any course was above 16 with overall average of about 22 students per course. There was about 34 students having academic warning out of about 150 students, however, all of them have registered on the proper courses to help them improve their AGPA and progress in their study as possible.

During the academic year 2009-2010, there are 32 graduating students. Only one of them has spent 10 semesters in the college to graduate, while 9 students graduate after 9 semesters, and the remaining 22 students graduate after 8 semesters (4 years), which is the normal period for a student to graduate according the standard study plan. This indicates that about 70% of the students graduate in time, 28% graduate after one semester delay, and only 2% graduate after two semesters delay. It is worth to mention that this delay in graduation was not due to non-availability of courses to be offered for these students but it was because of their weakness and academic capabilities.

SUMMARY AND CONCLUSIONS

Management of academic programs in universities and colleges incorporates planning of efficient processes that yields optimum operation. This is a legitimate international practice in almost all organizations including private universities as well as ones supported by governments. In most universities and colleges, the main cost driver is that resulting from human resources and particularly that of faculty members. Therefore, ensuring that the teaching load of faculty members is efficiently utilized remains to be a prime goal. On the other hand, an emphasis on effective academic advising remains to be another important strategic goal. The effective academic advising allows students to be provided with quality guidance and practical means of achieving their academic goals. This leads to the historical managerial dilemma of striving to operate effectively and efficiently.

This paper presented a tool that can aid in managing academic programs in small colleges and university departments. The program management sheet presented provides the planning team with all the required data in a systematic order, which simplifies decision making and facilitates effective planning. Since the implementation of this tool, each student in the aeronautical engineering program at EAC, and every semester, was able to register for courses according to his/her individual study plan and while adhering to the academic rules and regulations. Furthermore, the timetable was not changed after the initial plan nor was there any courses added or dropped. Also, academic advising during the registration period was a straight forward process.

This paper does not aim to suggest that the program management worksheet presented here is the only tool that can aid in the planning of course offerings, but rather to highlight the need for understanding the constrains involved in managing academic programs in various colleges and universities and to strive for providing means for

achieving efficiency while maintain quality of academic programs in which students' interest remain to be a priority

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Training and Project-Based Engineering Education

ASSESSMENT OF THE PRACTICAL TRAINING REQUIREMENT IN ENGINEERING EDUCATION IN PALESTINIAN UNIVERSITIES

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ABSTRACT: Practical internship is a mandatory course requirement in all Engineering undergraduate programs in all Engineering disciplines and in all Palestinian universities and is congruent with international norms. In such courses, students are expected to spend a period of eight to ten weeks in a recognized engineering firm in order to achieve essential hands-on skills in their respective fields of study. Upon completion of this requirement students are required to present a comprehensive report detailing the extent of the practical experience attained in design work or in the field. Vernacular reasons dictate that the bulk of Palestinian students implement this requirement in local engineering firms. The following study is conducted to scrutinize the relevance of this requirement in fulfilling the objective of the requirement under the prevailing conditions of limited adequate engineering facilities taking into serious consideration the perpetually growing student demand. The following study shows that, despite the importance of this course as a key requirement for producing well qualified and trained engineering graduates, the actual practice of implementation needs to be constantly scrutinized. The hurdles facing better reinforcement of this obligatory requirement are discussed and suggested solutions are subsequently recommended. The study concludes that unless the training period is invested at a venue providing trainees with adequate exposure to the cutting edge of technology and to state of the art engineering then the entire exercise would be one of futility as it would be counterproductive. The present experience of the ubiquitous students exchange program for the purpose of training through the Union Arab Universities or through the International Association for the Exchange of Students for Technical Experience (IAESTE) is thoroughly discussed. In the Palestinian context transfer of knowledge is a well desired prerogative in the long overdue state building endeavor.

KEYWORDS: Engineering Education; Internship; Palestinian Universities; Practical Training; Assessment.

INTRODUCTION

Engineering education in Palestinian universities is playing a substantial role in fulfilling the dire need for skilled and well-trained engineers highly required to meet the intensified development and reconstruction efforts especially in infrastructure, construction and industry sectors which are corner stone's in the state building enterprise.

The initiation of engineering education in the Palestinian Territories happened in 1978 by the simultaneous establishment of 5 engineering departments in the West Bank; two of which are at An-Najah National University and the other three at BirZeit University. Presently there are 33 engineering undergraduate programs in 7 universities among the 13 universities that are spread in the West Bank and the Gaza Strip. The Ministry of Education and Higher Education regulates and monitors the quality of education in these universities through the newly established Accreditation and Quality Assurance Council (AQAC).

The total area of the Palestinian Territories (the West Bank and Gaza Strip combined) is 5,950 square kilometers, with a population that exceed four million in 2010. The number of registered engineers in the Palestinian Territories climbed to a whopping 14,000 in the year 2010. The number of engineering graduates from Palestinian universities increased from around 250 graduates in 1999 to more than 1500 graduates in 2009. The colleges of engineering in Palestinian universities award a B.Sc. degree in 12 different disciplines. All local universities follow the semester model, where the students in general are required to complete 160 to 175 credit hours for graduation, which extend over a five year period. Practical internship is a mandatory course requirement in any engineering undergraduate program in all Palestinian universities. This course is a zero credit course in most of these programs. However in some of the programs the course carries 3 to 6 credit hours. In such courses students are expected to spend a period of 6 to 8 weeks in a recognized engineering firm in order to achieve essential hands-on skills in their respective fields of study in order to meet ABET requirements. The Engineering Accreditation Commission, ABET, requires that engineering programs must demonstrate that their students have attained the following outcome:

1. A recognition of the need for, and an ability to engage in lifelong learning
2. An ability to use the techniques, skills, and modern engineering tools necessary for engineering practice.

RESEARCH METHODOLOGY

For the assessment of the effect of the practical training internship course in the engineering programs in the Palestinian universities, a special questionnaire was designed to explore the opinions of a sample of students at the fourth or the fifth year level and who completed the internship course requirement.

The questionnaire was designed to include a general information section, followed by a section in which the student was requested to mark a grade on a scale of 1 to 10 expressing the extent to which the internship course met expectations regarding the following aspects:

1. Supplementary knowledge.
2. Preparation for the first job.
3. Technical writing.
4. Administrative skills.
5. Detailed drawing.
6. Motivation for starting a private entrepreneurship.
7. Computer skills.
8. Familiarity with used codes .
9. Development of interpersonal skills
10. Building analytical capacity.

A sample of 250 students covered the universities in West Bank only, because students in the Islamic University in Gaza did not have the chance to be practically trained as required for the last three years because of the siege of Gaza Strip and due to the lack of training opportunities. The internship course was implemented in an extra ordinary form. The sample covered all engineering disciplines in the Palestinian universities. The supervisors who administer the implementation of the internship course in the schools of engineering were interviewed in order to examine their position regarding the current practice and their evaluation of the obstacles limiting the reaping of the potential benefits of the internship course.

STATUS OF PRACTICAL TRAINING IN THE PALESTINIAN UNIVERSITIES

The Engineering study programs in the Palestinian universities are essentially not diverse. They generally tend to prepare their students for local engineering vernacular practice which magnanimously speaking leaves a lot to be desired. Although the programs are not identical, they emanate from the same guiding principles. Research versatilities are absent due to obvious reasons that include but are not limited to lack of resources, financial and otherwise. Attracting seasoned faculty members is a futile exercise under the prevailing faculty benefit packages. Most serving faculty members are a product of a self-sustaining faculty creation program which is self-limiting when the objective is to create a remarkable academic climate conducive to being at the cutting edge and able to match other regional academic institutions of excellence.

BirZeit University has five undergraduate programs which essentially require 160 credit hours for graduation. The six-week internship, although obligatory, does not carry any credit hours. At Al-Quds University this graduation requirement is nearly the same save for the duration which is quoted in work hours rather than in weeks. At An-Najah University which has the largest engineering student population with 10 undergraduate engineering programs, students are required to complete 165 credit hours for graduation. The internship requirement carries three credit hours and spans an eight week period in a recognized engineering firm.

In the Islamic University of Gaza the total credit requirement for the first engineering degree stands at about 170. Internship is obligatory but carries no credit hours save for the Architectural study program where the credit number for the internship is two. The rest of the Palestinian Universities follow an almost identical course in defining the internship requirement. Table 1 provides a summary of the internship requirement in the various Palestinian universities.

Table 1: The Internship Course Requirements in the Palestinian Universities.

University	Department	Total credit hours	Internship course	Credit hours	Period
An -Najah National University	Civil Eng	166	61391	3	8 wks
	Architectural Eng	170	62400	3	8 wks
	Electrical Eng	165	63460	3	8 wks
	Chemical Eng	164	64390	3	8 wks
	Industrial Eng	163	65590	3	8 wks
	Computer Eng	173	66304	3	8 wks
	Mechanical Eng	160	67400	3	8 wks
	Building Eng	166	68400	3	8 wks
	Mechatronics Eng	163	67484	3	8 wks
	Communication Eng	165	69404	3	8 wks
BirZeit University	Mechatronics Eng	160	ENMC 401	0	6 wks
	Electrical Eng	160	ENEE 401	0	6 wks
	Civil Eng	160	ENCE 401	0	6 wks
	Architectural Eng	164	ENAR 401	0	6 wks
	Mechanical Eng	160	ENME 401	0	6 wks
The Arab American University/ Jenin	Telecom Eng	163	11071431	6	3 months
Islamic University Gaza	Civil Eng	172	ECIV 4000	0	8 wks
	Architectural Eng	174	EARC 4216	2	
	Electrical Eng	170	EELE 4000	0	60 hrs
	Computer Eng	170	ECOM 5000	0	60 hrs
	Industrial Eng	172	EIND 4000	0	60 hrs
Palestine Polytechnic University / Hebron	Mechanical Eng	163	ME391+ME491 3913391+ME491	0	180+180 hrs
Polytechnic University	Civil & Building	163	CE 391+CE 491	0	180+180 hrs
	Architectural Eng				180+180 hrs
	Electrical Computer	163	EE391+EE491	0	180+180 hrs
Palestine Technical University (Khadoorie)	Electrical Eng	170	No Course	0	400 hrs
	Industrial Eng Automation	163	No Course	0	8 wks
	Computer Eng	164	No Course	0	8 wks
	Mechatronics Eng	163	No Course		8 wks
	Communication Eng & Technology	164	No Course	0	8 wks
AL-Quds University	Electronic Eng	162	No Course	0	120 hrs
	Computer Eng	166	No Course	0	120 hrs
	Materials Eng	163	No Course	0	120 hrs

Analysis of Results

The student responses are presented in bar charts shown in the figures below. The graphs represent the degree of student satisfaction in regard to the training experience they had while striving to satisfy an important university graduation requirement.

Before in depth scrutiny of the results portrayed in the bar charts it is worth keeping in perspective the fact that students by and large have no established datum to compare their training exercise with. The choices made in the questionnaire were perhaps whimsical par excellence and based on little or no solid rational. Figure 1 indicates that trainees by and large expressed satisfaction. In Figure 2 the degree of satisfaction in the various disciplines is presented. While most disciplines hover around the 5.5 mark, the development of interpersonal skills stood out on the positive side while drafting engineering details stood out on the negative side. This is quite understandable; students are having their initial exposure to the business world with whatever degree of excitement this entails while on the other hand they do not get much exposure to hands-on production experience. At An-Najah University students, Figure 4, point negatively to technical writing. This is perhaps linked to the prevalent moderate English language skills. Furthermore, this may point towards the general abilities of the training venues in the general vicinity of the Palestinian Territories. This conclusion gets yet further reinforced when compared to the similar results of BirZeit University and Palestine Technical University (Khadoury). At the Palestine Polytechnic University in Hebron, students were clearly dissatisfied with the computer skills they expected to acquire during their training exercise, Figure 6. Regarding the types of firms that provided training opportunities, Figure 9 shows that such opportunities were uniformly distributed among all potential training providers; nongovernment organizations having a slight edge. On the other hand Figure 8 shows that a small fraction of engineering students invested time in a factory setting. This is expected as the Palestinian Territories are not known for their industrial capabilities. This area is best described as a market for the region. For obvious reasons the Israeli products overwhelm the Palestinian market.

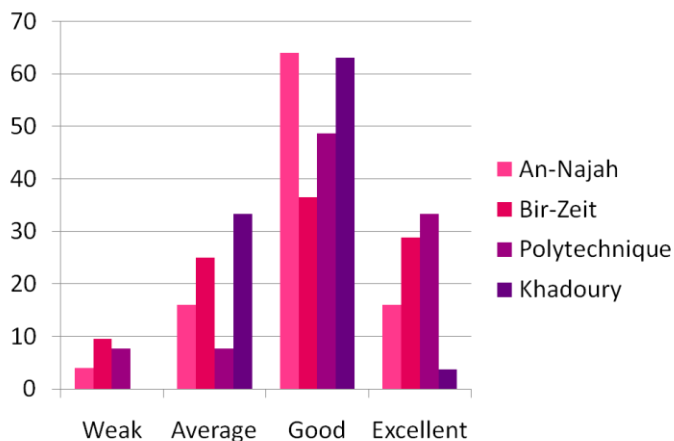


Figure 1: General Evaluation of Students in Palestinian Universities for Internship Course.

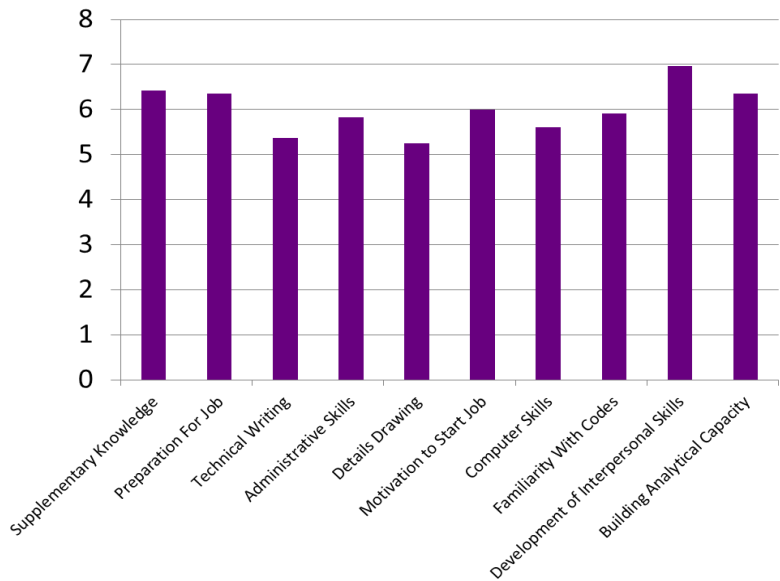


Figure 2: Degree of Satisfaction of Students on various indicators at Palestinian universities.

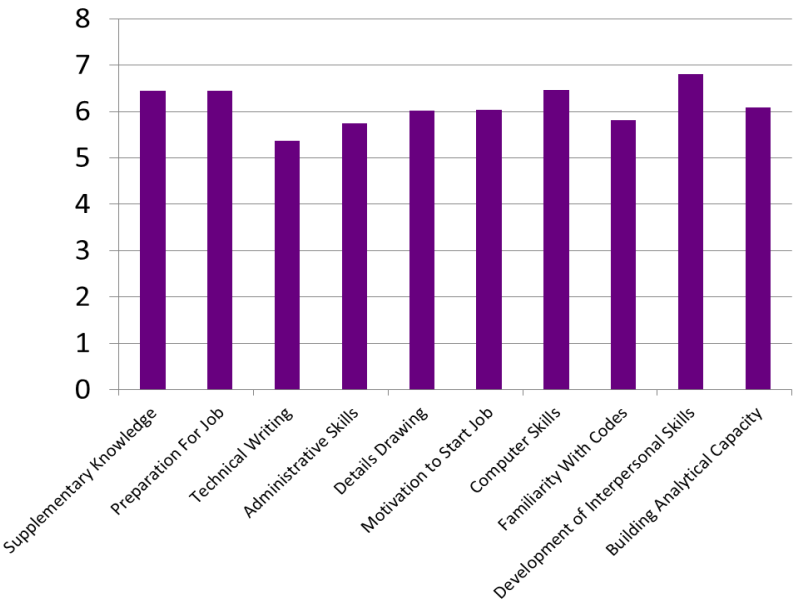


Figure 3: Degree of satisfaction of students on various indicators at BirZeit University.

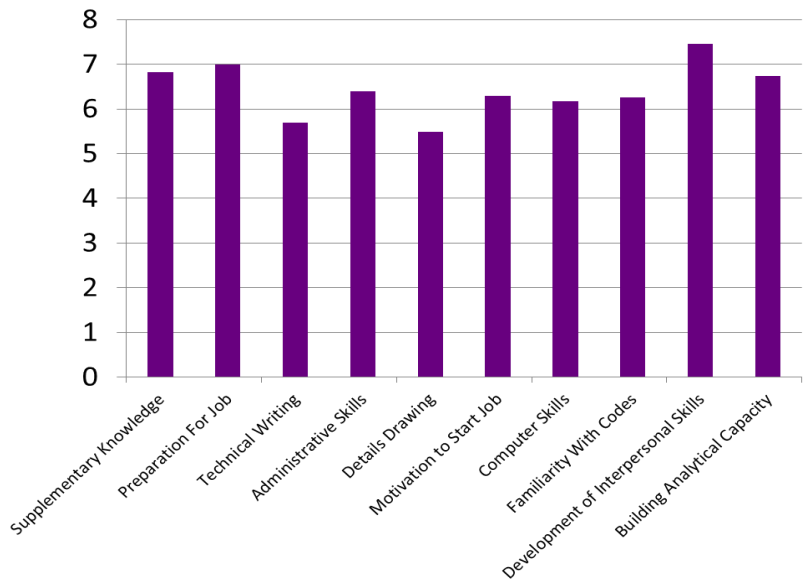


Figure 4: Degree of satisfaction of students on various indicators at An-Najah University.

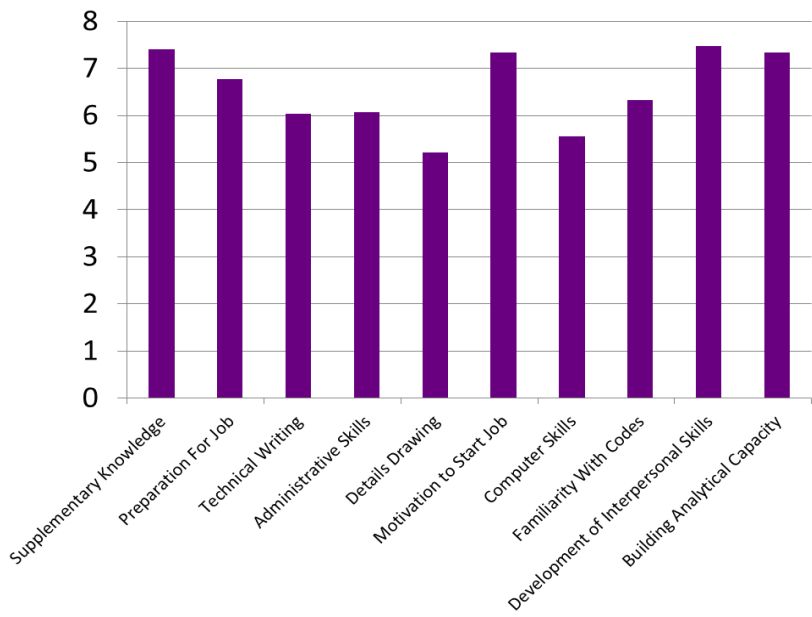


Figure 5: Degree of satisfaction of students on various indicators at Palestine Technical University (Khadoury).

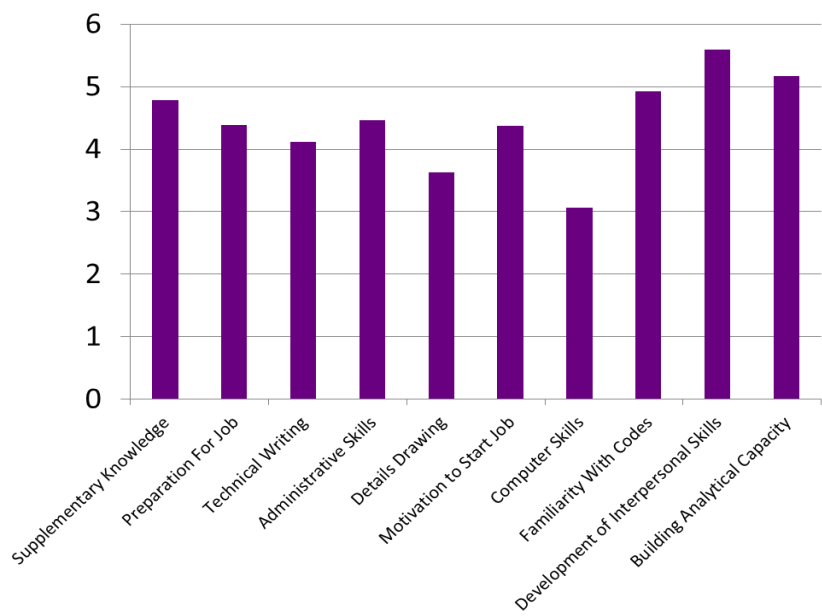


Figure 6: Degree of satisfaction of students on various indicators at Palestine Polytechnic University (Hebron).

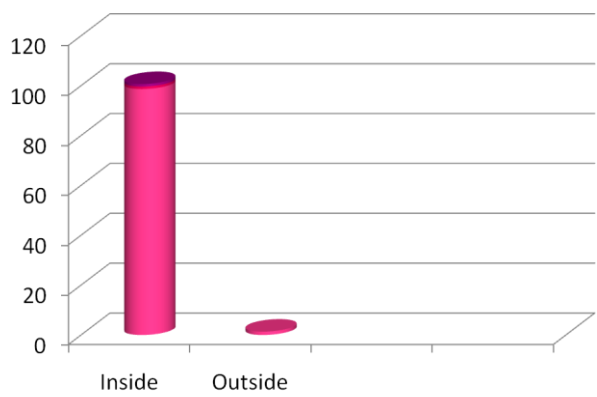


Figure 7: Percentage of Students Trained Outside Palestine in Comparison with Students Trained Inside Palestine.

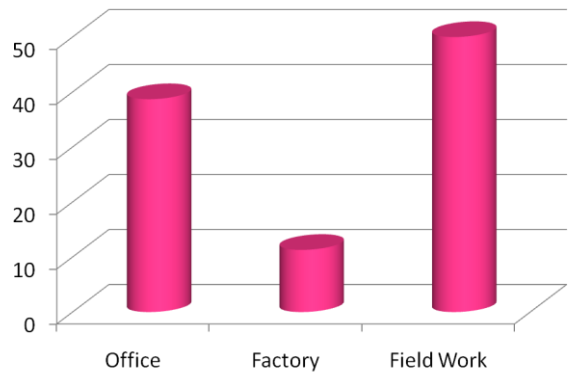


Figure 8: Percentage of Distribution of Training Period among Different Fields.

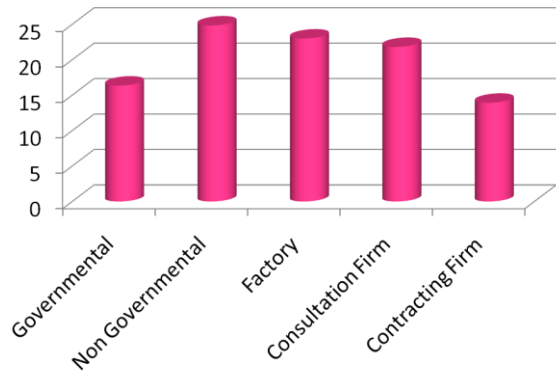


Figure 9: Percentage of Distribution of Internship in Different Types of Business.

CONCLUSION

The Palestinian Territories are on the path of becoming an independent state and under such conditions technical expertise that matches international standards is the order of the day. The extremely rapid development of technology is an added dimension that must be kept in perspective. Local technical training is no more than a rehash of an already expired technology. It fails to bring into the country a seriously needed added knowledge. The local market is just a reflection of the prevailing technical experience. Beyond any shadow of doubt, local training does not contribute effectively towards widening the horizon of the young university graduates and, as such, it does not help expand the local industry sector capabilities. In this direction the local industry needs to import and indigenize state –of-the-art technical knowledge. Student training is one effective mechanism in the dynamics of technical experience exchange. In the discourse one

should not fail to clearly note that future leadership is what is at stake. The results of the questionnaire by and large show a seemingly satisfying outcome. However it is not to be taken for granted as none of the students marked his or her choice according to any established criteria. The measured student satisfaction in this case is more of a concern than a comforting outcome.

International training possibilities through IAESTE are up for grabs. The onus for directing senior students towards such potential training venues rests squarely upon the local administrative body of the Palestinian universities at all levels with particular emphasis on the local engineering schools' administration. Perhaps an ad hoc financial aid program for student support may be solicited. It is of paramount importance to accept the fact that study programs remain self-limiting unless they bring the student populace towards exposure to the real world of technology. To perpetually rely on text book type problems and solutions is self-defeating; it is a recipe for losing a sense of direction.

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DEVELOPMENT OF A CONTROL AND EVALUATION STRATEGY FOR THE COOP TRAINING PROGRAM AT THE COLLEGE OF ENGINEERING IN QASSIM UNIVERSITY

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ABSTRACT: The course GE405 Cooperative Training Program must be completed one semester prior to the graduation from any program offered by the College Of Engineering at Qassim University. Many challenges face the application, control and evaluation of the program. The importance of this research stems from the real need to meet the different challenges by establishing control and evaluation strategy for the entire program with suitable and applicable mechanisms. A proposed strategy was established taking into consideration the ABET engineering education outcomes. These outcomes reflect the knowledge, skills, abilities and behavior that should be achieved by each engineering graduate. The proposed strategy was built in the continual improvement approach “Plan-Do-Check-Act”. The proposed strategy was implemented on one batch of cooperative students. Results and feedbacks out of this implementation were monitored and verified against the planned coop-program objectives and outcomes. Satisfactory results were obtained.

KEYWORDS: Qassim University; COOP Training; Engineering Education.

INTRODUCTION

ABET's outcomes-based assessment and evaluation requirements for engineering school accreditation has been a catalyst for curricular reform for engineering programs all around the world [1-4].

Cooperative Education is designed to give the student work experience related to their major field of study while earning college credit. Students are expected to learn skills related to their degree or major field of study in a work setting. Placements are normally off-campus with business, industry or governmental agencies, though, on occasion, placements may be on campus. Co-op work experience can be a paid or non-paid opportunity [5,6].

Assessment of program outcomes is an important, but time-consuming, part of the ABET accreditation process for faculty [7]. The difference between exam grading and assessment of program outcomes is always a matter of discussion. The problem with using grades as assessment tools is that grades often cover material that represents more than one programmatic outcome [8-13]. In addition, there may be a great deal of variability in assignment of grades, depending on which faculty member does the grading.

In QU, the Cooperative Training Program is a joint effort between the College of Engineering (QEC) in Qassim University (QU) and both the public and the private sectors in the area of specialization to allow students to practice the skills and knowledge

they have learned. A similar program was launched by KFUPM where an embedded-assessment program to insure continuous improvement toward the desired learning outcomes was initiated [14].

In 2006, new curriculums, in agreement with the ABET criteria, have been adopted by QEC in which, the cooperative training was introduced as a basic course (GE 405, 9 credit hours). The COOP program must be completed before the last semester precedes the student's graduation. A minimum of 100 credit hours must be completed prior to student admission for the COOP program. Moreover, a student has to satisfy the department special requirements, if any and he is not permitted to register for any other courses during the COOP program. The first batch of COOP-students have finished their COOP-program while the second batch started their program spring 2010/2011.

Objectives of the COOP Training Program

The objectives of the COOP training have been stated in the course syllabi as follows:

1. Allow students to relate the classroom learning outcomes to the actual engineering field experiences in either governmental or private sectors.
2. To build up the student's disciplinary, ability and personality to communicate effectively through teams with the most updated various industries and technologies.
3. Introducing students for first time to their expecting careers.
4. Build up the relation between the college and the various industrial fields as well as knowing the needs and expectations of these fields for the graduated students.
5. Enable the private and public organizations to identify the skills of the trainee, and polarizing him for jobs.

Learning outcomes of the COOP Training Program

The COOP training is one of the most useful areas for students to achieve the program outcomes for the different disciplinarians in the college. It is expected that these outcomes are to be achieved with different levels as shown in Table 1.

Problem Definition and Objectives

1. Many challenges face the planning, application, control and evaluation of the coop-program. The most important challenges arise from the duration of seven months of the program without on-site college supervision (administration restriction) while the program weights of 9 credits out of the required 139 credits for graduation. The problem stems from the real need to meet the different challenges by planning for and establishing control and evaluation strategy for the entire program with suitable and applicable mechanisms.
2. In this work a strategy was established taking into consideration the previous stated restriction besides the ABET engineering education outcomes. The ABET outcomes reflect the knowledge, skills, abilities and behavior that should be

achieved by each engineering graduate. The strategy was built in the continual improvement approach “Plan-Do-Check-Act”. This includes planning a procedure for carrying out the coop-program, assigning responsibilities, establishing implementation criteria, addressing checklists and getting feedbacks. Afterwards assessments and evaluations processes are to be carried out and consequence improvement actions are to be applied.

3. The rest of this paper includes an explanation of the coop program planning and structure. The roles and responsibilities of the different constituents are briefly explained. The evaluation strategy and the improvement of the coop program are discussed as well. Evaluation of the first batch of coop at QEC is given also. Most of the forms and checklist are designed to measure the level of achievement of the ABET outcomes by the trainee at the COOP training period. This method will utilize the Rubric system depending on Bloom Taxonomy [10].

Table 1: Expected level of achievement of the program outcomes.

Program Outcomes (ABET 2007)	Achievement Level
(a) An ability to apply knowledge of mathematics, science, and engineering	N/A
(b) An ability to design and conduct experiments, as well as to analyze and interpret data	N/A
(c) An ability to design a system, component, or process to meet desired needs within realistic constraints	N/A
(d) An ability to function on teams	MUST
(e) An ability to identify, formulate, and solve engineering problems	MAY
(f) An understanding of professional and ethical responsibility	MUST
(g) An ability to communicate effectively	MUST
(h) The broad education necessary to understand the impact of engineering solutions in a global, economic, environmental, and societal context	MUST
(i) Recognition of the need for, and an ability to engage in, life-long learning	MAY
(j) A knowledge of contemporary issues	MUST
(k) An ability to use the techniques, skills, and modern engineering tools necessary for engineering practice.	MUST

N/A not applicable MAY: may be achieved based on the training nature MUST: must be achieved

COOP PROGRAM PLANNING AND STRUCTURE

The coop-program is planned to elapse seven months (28 weeks). The structure of the COOP Training Program is given in Figure 1, while the planning of the major and the regular activities is given in Table 2. Moreover, the student tasks during the COOP training are shown in Figure 2. It is noticeable that these figures and table are self-explanatory. Thirteen different forms were established for the control and evaluation of the COOP process.

ROLES AND RESPONSIBILITIES

There are three constituents in the COOP training program; college/department, the organization offering the COOP training and the coop-student. Each of these constituents has an effective role to get the most outcomes from the COOP program. This section focuses on stating the role of each constituent. In addition, the interaction between all of constituents is addressed.

College/Department Responsibilities

Within the college, the role of the following parties will be of pivotal importance to the professional development of the student and to the successful completion of the COOP program:

- a) Academic Departments,
- b) COOP Coordinator,
- c) COOP Steering and Improvement Committee,
- d) COOP Academic Advisor, and
- e) COOP Examination Committee.

Table 2: Planning of the COOP program.

Time	Major Activity	Regular Activity
Before Beginning	Orientation meeting	Student weekly report Field advisor monthly
Week 1	Training start	report
Week 3	Last week to submit the training schedule	Portfolio's Preparation
At the 12 th and the 20 th weeks	First and second meetings with the academic advisor	
The Two weeks after returning back to the college	Meeting the academic advisor Prepare the report, the portfolio and the presentation Get ready for the celebration day (will be announced by the program coordinator)	

The details of their responsibilities are stated elsewhere [15]. Moreover, the college has general responsibilities towards:

1. Making orientation seminars for coop-students and giving information packages contain copies of the progress reports to be submitted along with their specific dates and meetings' schedule.
2. Nominate and communicate the public and private organizations offering COOP training.
3. Collect, statistically analyze and summarize results of COOP-student surveys and the COOP-Instructor Evaluation Reports.
4. Guide and follow up the COOP students through the entire training program.

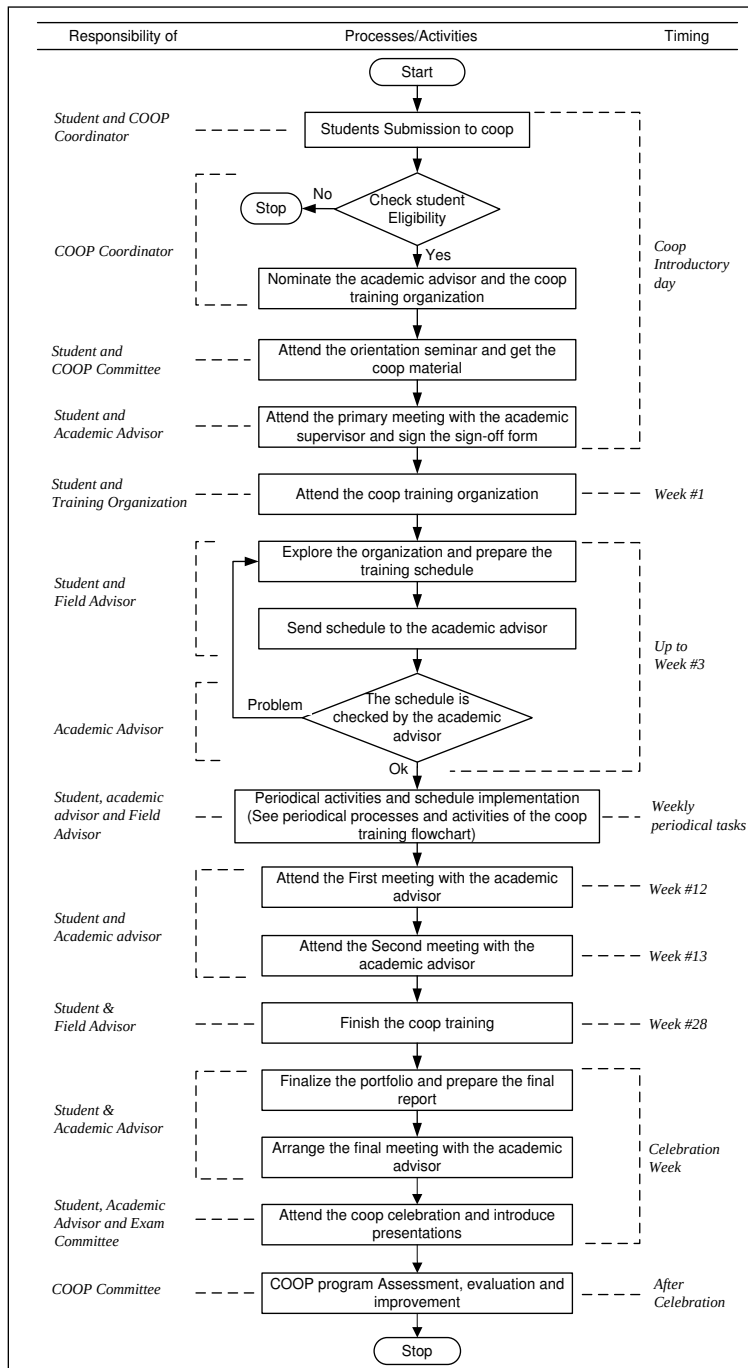


Figure 1: Flowchart for COOP program event sequences.

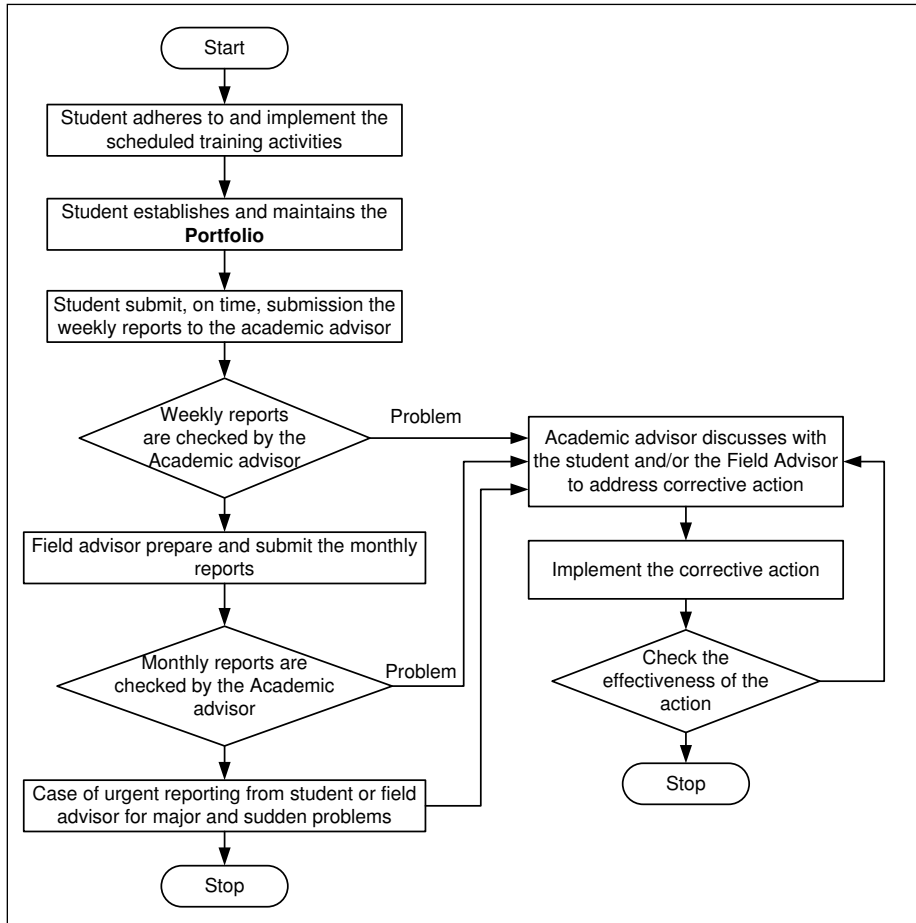


Figure 2: Periodical student tasks and activities during the COOP training.

Responsibilities of the Training Organization

The training organization is the place where the student will spend his COOP training period. It is expected that the training organization will supply the students by adequate practical information and training. It is expected also that the organization assign a COOP Field Advisor for each student or group of students. The COOP Field Advisor is asked by the college to keep track of the students and submit individual electronic-report for each student every month. The report may be accessed electronically through the college website. For more details one may review [15].

Student Roles and Responsibilities

The students' responsibilities are detailed elsewhere [15] and broadly may be categorized into three main groups:

Before leaving for COOP

This include that a student should familiarize himself with the regulations and planning of the COOP program, attending the orientation seminar and having all the required materials For more details one may review [15].

During the COOP

- (1) This include that a student should try to learn as much about the training activities he is involved in.
- (2) Student should establish a COOP Training Portfolio in which all documents, photos, catalogues, data and reports related to the COOP will be maintained. This Portfolio will be evaluated by the COOP Exam Committee.
- (3) By the end of each training week, student should prepare **two weekly reports**. The first is fixed electronic-format report which must be submitted weekly and includes brief addressing for the training activities through the week. The second report, however, is a free format report which details the training activities and learning outcomes through the week. This report is to be kept in the training portfolio.
- (4) Student should meet his COOP academic advisor personally two times through the training program. Within these meetings; student is expected to bring his portfolio, review his progress, and other related topics with his advisor. Extra meeting(s) may be arranged for specific concerns.
- (5) A student should keep records of his daily activities, such as specific jobs performed, field trips made, meetings attended, seminars attended, and any relevant data for his COOP-progress, portfolio and final reports.

Upon Return to the Qassim College of Engineering

In this stage, a student shall prepare his final coop-report, finalize his coop-portfolio and prepare himself for a presentation during the final exam day. The final exam of the COOP training program is called The Celebration. On the celebration day all the professors, advisors, trainee students and representatives from the training organizations (if possible) are invited. Three examiners (including the academic advisor) are to be assigned to each student. Forms COOP-04 up to COOP-10 will be finalized by the academic advisor and the examiners on this day.

It may be necessary at this point to state that in case of major problems that may face either the student or the field advisor; a quick report must be submitted immediately to the academic advisor. The later; upon his turn; must study the problem and try to solve it. If not he has to report the problem to the COOP coordinator. COOP-13 form is the

associated electronic form to report major problems. This form will be available through the college website and will be accessible to both the student and the field advisor.

EVALUATION STRATEGY

The evaluation strategy is based on evaluating three different categories. Each category is divided into some dimensions. The categories, the dimensions and their share in the total mark evaluation are given in Figure 3. Each evolution or mark distribution is based on a specific checklist. Moving between the different forms may be guided by the flowchart given in Figure 4.

COOP PROGRAM IMPROVEMENT

Upon completing the program for a specific student; feedback information are required. This information may be obtained by completing the COOP-11 and COOP-12 forms. COOP-11 is a Student COOP training Survey. COOP-12, however, is the Field advisor COOP training Survey. These surveys allow the COOP Steering and Improvement Committee to make changes for improving the program. Electronic copies of these forms will be available by the end of the program through the college website. Copy of COOP-11 must be included in the student portfolio.

a) Responsibilities of the departmental COOP-Training Subject Committee

- Collect the entire set of forms and documentations from the academic advisors.
- Direct forms COOP-11 to the analysis committee and receives the output of their analysis.
- Meets two weeks after the celebration to review and analyze the COOP-process completed in the previous semester.
- Suggest any required changes and/or improvements to the steering committee.

b) Responsibilities of the departmental COOP-Training Subject Committee .The COOP Steering and Improvement Committee has to meet four weeks after the celebration day. The objective of this meeting is to review the suggestions by the COOP-subject committees. Upon this review, the committee may issue necessary recommendations for changes and improvements and reports that to the dean.

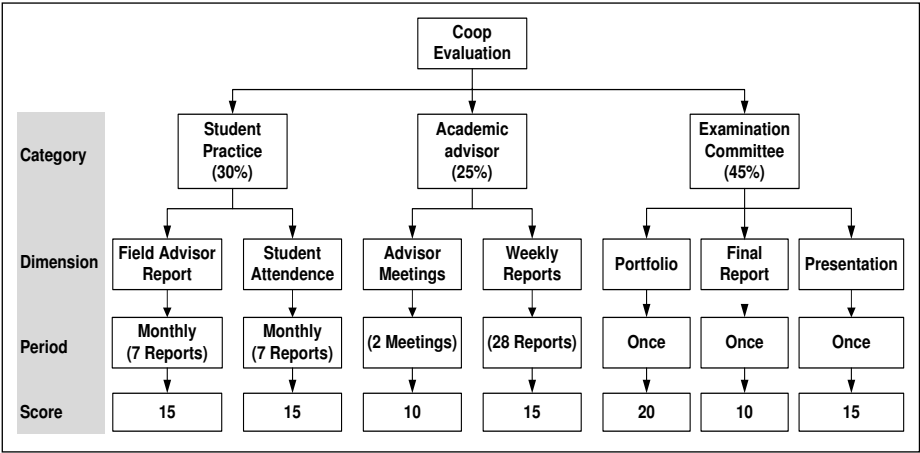


Figure 3: Mark distribution over the main dimensions of the evaluation categories.

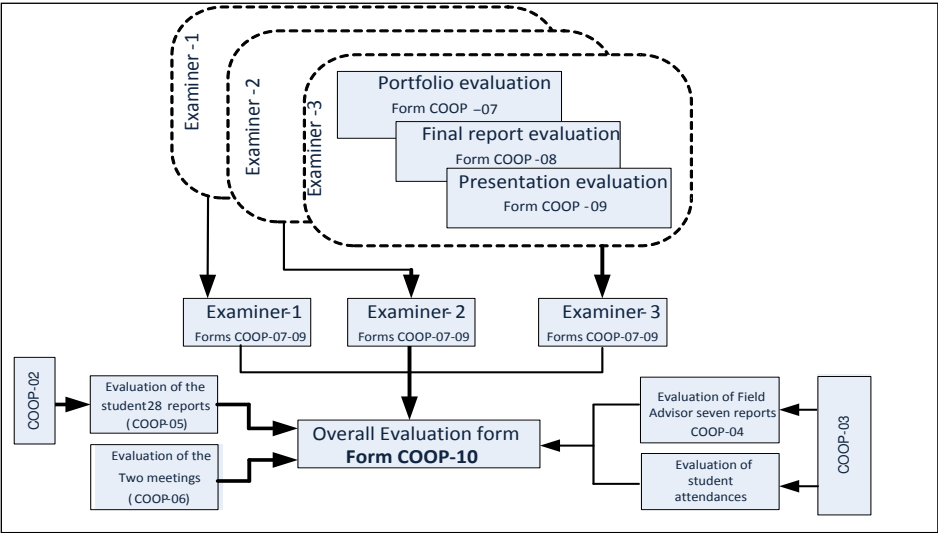


Figure 4: Managing different examiner evaluation forms.

EVALUATION OF THE FIRST BATCH OF COOP AT QEC

After completing a full cycle of COOP training program by the first batch of QEC students, assessment and evaluation process was carried out. This process led to several comments, among them are the followings:

- By the end of the first COOP program implementation, most of the faculties and coop-students appreciated the planning and implemented strategy for control and evaluate the COOP program, despite of their initial resistance to the system.
- The present control and evaluation strategies were reviewed by the NCAAA and ABET teams during their visits to the engineering college in Fall 2009. Both teams highly appreciated this system.
- Involving several parties in evaluating the student efforts and achieved outcomes during the coop reflects realistic measure.
- Based on general comment stemmed from faculties and coop-students, the length of the COOP training period (seven months) still a big issue for discussion.

CONCLUSIONS AND RECOMMENDATIONS FOR FUTURE WORK

In the present work strategies for control and evaluation of a COOP training program were proposed. The proposal was based on seven months period, equivalent to 9 credit hours and according to specific constraints. The proposed system was implemented through on the first batch of QEC. The implementation demonstrates quite satisfaction regarding the achievement of the COOP outcomes and evaluation of the students. However, some comments were raised which needs for more discussions after evaluating the implementation on the subsequent batches.

It is recommended for the future to build up an excel model for automatic implementation for the applied forms and checklists.

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A PROJECT-BASED ACTIVE/COOPERATIVE ENGINEERING DESIGN COURSE FOR FRESHMAN LEVEL STUDENTS

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ABSTRACT: An active/cooperative, problem-based, introductory modeling course was redesigned using the project-based learning approach to allow freshman level students to gain professional hands-on engineering design experience through well planned active/cooperative learning activities. The students function on effective design teams to practice guided conceptual design, project planning, and manufacturing of the designed artifact. The course introduces engineering design practices through guided design phases and provides the students with an opportunity to practice team work, quality principals, communication skills, life-long learning, realistic constraints, and global awareness of current domestic and global challenges. Each semester a new project is introduced in the form of a real-life project proposal prepared by an assumed customer to address one contemporary issue. The course is designed as an active/cooperative learning course with a suitable class layout and a small workshop to insure an effective learning environment. In addition to several successive design reports and two in-class assignments, the students are required by the end of the semester to communicate, clearly and concisely, the details of their design both orally and in writing through a functional artifact/prototype, a design notebook, an A0 project poster, and a final oral presentation. In addition to these direct assessment tools several indirect measures are used to insure triangulation including class feedback forms, process checks, entry and exit surveys and course evaluation questionnaire. Students are asked to peer assess the work of their classmates and to self-assess their own work before submission. Quality principles are enforced in each learning activity. Assignments are based on customer expectations and are assessed using a detailed checklist as: Exceeds expectations, Meets expectations, Acceptable, Needs Improvement, or represents No Credible Effort. Engineering professionalism is enforced and lapses are used to punish any unprofessional behavior. Bonus points are used, on the other hand, to encourage top performance. End of semester course evaluation is based on satisfying both course learning outcomes and course-supported program outcomes. The course was implemented for the first time in fall 2009. The students were asked to design a small wind turbine suitable for home use in Jeddah city. Direct and indirect assessment tools indicated high level of achievement of course learning outcomes together with a high level of student satisfaction.

KEYWORDS: Project-Based Learning; Engineering Design; Outcome-Based Courses; Active/Cooperative Learning.

INTRODUCTION

The Faculty of Engineering at King Abdul-Aziz University carried out, starting from the year 2004, fundamental curriculum modifications in order to meet the requirements of the ABET accreditation criteria EC2000. One aspect of these modifications was to follow the example of several institutions in introducing engineering design and problem solving skills at the freshmen level. Based on the experience of Arizona State University, two introductory freshmen engineering design courses, Introduction to Engineering Design I & II (IE 201 & IE 202) [1-3], were introduced at that time. Both courses used the Active/cooperative learning approach. The motion continued later-on to transform several

freshmen and sophomore courses, including engineering economy [4], fluid mechanics [5], construction management, and mass transfer, into active/cooperative learning. Al-Bahi [6] also developed a generalized checklist for the design phase of outcome-based active/cooperative learning courses as part of the work carried out in the problem-based fluid mechanics course.

Following the ABET visit in 2008, which was successfully concluded by the full accreditation of all of the 12 Engineering Programs of KAU Faculty of Engineering, the authors started revising the active/cooperative IE 202 course. Project-based learning was identified as an effective learning approach. The aim was to develop IE-202 from just a modeling course into a project based active and cooperative learning introductory design course. The course was redesigned to allow freshman level students to gain professional hands-on engineering design experience through well planned active/ cooperative learning activities. The developed course introduces engineering design practices through guided design phases and provides the students with an opportunity to practice team work, quality principals, communication skills, life-long learning, realistic constraints, and global awareness of current domestic and global challenges.

The course was implemented for the first time in fall 2009. The students were asked to design and manufacture a small wooden-bladed wind turbine suitable for home use in Jeddah city. In spring 2010, the students were asked to design and manufacture a low speed permanent magnet alternator to be coupled with the designed wind turbine.

In the present work the project-based learning approach in engineering education is reviewed and the developed project-based active/cooperative introductory design course is described.

PROJECT-BASED LEARNING IN ENGINEERING EDUCATION

The term “project” is universally used in engineering practice as a “unit of work”, usually defined on the basis of the client [7]. Almost every task undertaken in professional practice by an engineer will be in relation to a project. Projects will have varying time scales. A project such as the construction of a large dam or power station may take several years, whilst other engineers may be involved on numerous small projects for various clients at any given time. Projects will have varying complexity, but all will relate in some way to the fundamental theories and techniques of an engineer’s discipline specialization. Small projects may only involve one area of engineering specialization, but larger projects will be multidisciplinary, not only involving engineers from different specializations, but other professional and non-professional personnel and teams. Successful completion of projects in practice requires the integration of all areas of an engineer’s undergraduate training [7].

Project based learning is a teaching and learning model (curriculum development and instructional approach) that emphasizes student- centered instruction by assigning

projects. It allows students to work more autonomously to construct their own learning, and culminates in realistic, student-generated products [8].

Project-Based Learning, as well as Problem-Based Learning, has its roots in constructionism learning theory [8]. Constructionism posits that individuals learn best when they are constructing an artifact that can be shared with others [9]. Dewey [10], Piaget [11], Brunner [12], and others have contributed to the foundation of these methods as an outgrowth of cognitive and later constructivist, theory of learning [13].

Thomas [14] in his review of research on project-based learning considers that all of the research on Project-Based Learning has taken place in the past 20 years and most of it in just the last few years [14]. This goes in line with his definition of Project-Based Learning:

“Project-based learning (PBL) is a model that organizes learning around projects. Projects are complex tasks, based on challenging questions or problems, that involve students in design, problem-solving, decision making, or investigative activities; give students the opportunity to work relatively autonomously over extended periods of time; and culminate in realistic products or presentations” [14].

This research on project-based learning is highly attributed to recent reforms in Engineering Education. The significant changes that accompanied the appearance of ABET 2000 document in 1998 [15] reflected the observation by academia and industry that engineering education needed to change to better prepare engineering graduates for the current work environment [16, 17].

Modern engineering profession deals constantly with uncertainty, with incomplete data and competing (often conflicting) demands from clients, governments, environmental groups and the general public. It requires skills in human relations as well as technical competence. Whilst trying to incorporate more “human” skills into their knowledge base and professional practice, today’s engineers must also cope with continual technological and organizational change in the workplace.

In addition they must cope with the commercial realities of industrial practice in the modern world, as well as the legal consequences of every professional decision they make [7].

Despite these challenges, Mills and Treagust noticed that the predominant model of engineering education remains similar to that practiced in the 1950’s - “chalk and talk”, with large classes and single-discipline, lecture-based delivery the norm, particularly in the early years of study [7]. They consider that developments in student-centered learning such as problem-based and project-based learning have so far had relatively little impact on mainstream engineering education.

On the other hand, Mills and Treagust were able to find several examples of project-based learning being used in individual or a few courses in engineering programs that have been reported in the literature [7]. They noticed that some of these examples use the

term project-based, others use the term “problem-based learning”, but are actually project-based learning. Still others use the terms interchangeably, which points to the grey area that exists in engineering between these terms. The courses reported cover a range of discipline areas and program levels and include:

- Final semester undergraduate industry projects in all disciplines at the Engineering College at Hogskolen i Telemark, Norway [18].
- Projects in the EPICS courses in first and second year at the Colorado School of Mines, USA [19].
- Several US examples cited in Rosenbaum [20] including Rose-Hulman Institute of Technology, Carnegie Mellon and Worcester Polytechnic Institute.

Heitmann differentiates between “project-oriented studies” and “project-organized curriculum” [21]. According to Heitmann, project-oriented study involves the use of small projects within individual courses, progressing to a final year project course. The projects will usually be combined with traditional teaching methods within the same course. They focus on the application, and possibly the integration of previously acquired knowledge. Projects may be carried out as individuals or in small groups. Project-organized curricula use projects as the structuring principle of the entire curriculum, with subject-oriented courses eliminated or reduced to a minimum and related to a certain project. Students work in small groups with a project team of instructors who are advisers and consultants. Projects are undertaken throughout the length of the course and vary in duration from a few weeks up to a whole year. Mills and Treagust [7] notice that a completely project-organized curriculum does not yet exist, and the closest are programs where projects and project-related courses make up 75% of the program, as at Aalborg University in Denmark.

Perrenet et al [22] compare problem-based and project-based learning. They noted that the similarities between the two strategies are that they are both based on self-direction and collaboration, and that they both have a multidisciplinary orientation. The differences that they noted included:

- a. Project tasks are closer to professional reality and therefore take a longer period of time than problem-based learning problems (which may extend over only a single session, a week or a few weeks).
- b. Project work is more directed to the application of knowledge, whereas problem-based learning is more directed to the acquisition of knowledge.
- c. Management of time and resources by the students as well as task and role differentiation is very important in project-based learning.

One result of the changes introduced by the new outcome-based ABET EC200 criteria is that design, communication skills, managerial skills, working in multidisciplinary teams, and life-long learning have been given increasingly important treatment in undergraduate engineering curriculum. Project-based courses have been gaining acceptance as a means to introduce design, managerial skills, and teamwork experiences into the curriculum

prior to the senior capstone design course [23-25]. In many cases, communication skills are integrated into the engineering content of these project-based courses. [26] In 2001 the University of Sherbrook, Québec, Canada, used a combination of Project-Based and Problem-Based learning to develop the students' life-long learning skills in a freshman engineering course where the students are required to develop and reflect on their learning strategies [27].

A review of project based learning courses in engineering education indicates that these courses are not limited to introductory design courses. One can easily find several examples of project-based courses in statics [28], structures [29], vehicle engineering [30, 31], architecture [8], computer sciences [32], energy conservation [33], energy conversion [34], and industrial engineering [35].

In the late 1990, MIT's Department of Aeronautics and Astronautics engaged in a rigorous process to determine the knowledge, skills and attitudes that graduating engineers should possess. This resulted in a framework known as CDIO, short for Conceive, Design, Implement, and Operate [36]. CDIO initiative aimed at introducing Curriculum reform to ensure that students have opportunities to develop the knowledge, skills and attitudes to conceive and design complex systems and products [37]. The Approach uses both Project-Based and Problem-Based learning and provides a flexible, open architecture, along with enabling tools and resources that can be applied to any engineering discipline at any school. CDIO approach is based on two main elements, namely: the CDIO Syllabus and CDIO Standards. The CDIO Syllabus is an organized list of the areas of knowledge, skills and attributes that an engineering graduate could reasonably be expected to possess. The CDIO Standards focus primarily on the delivery of an engineering program, rather than its content and include 12 main elements [38]. In the context of the present work, 3 of these 12 elements are of particular interest namely; Introduction to Engineering, Design-Build Experiences, and Active learning.

Very recently "The First Bell" news briefings published by the American Society of Engineering Education (ASEE) briefed a report by R. Callahan, the Associated Press Writer [39]. The report indicated that "Youngsters taught science in classes where the goal was to design and build a device to perform a specific task scored significantly higher on a final test than students who got traditional classroom instruction, according to a study from Purdue University. The findings suggest that hands-on, problem-solving learning may have advantages over traditional lecture- and textbook-based methods of teaching students about engineering and technology. The study focused on students who learned about the principles of water purification and water quality in science classes. Those who learned mostly through hands-on instruction, working to design and build a water-purification device to make water taken from the Wabash River suitable for drinking, had an average score on the following test that was 20 points higher than those that learned through traditional instruction." Samantha A. Murray, the American Society for Engineering Education's K-12 coordinator, called the findings "timely and relevant," adding, "It hopefully will spur additional research efforts focused on the use of hands-on projects to successfully engage students in engineering concepts at an early age."

INITIAL STRUCTURE OF THE MODELING IE 202 COURSE

The course is compulsory for all engineering majors and enrolls more than 250 students per semester. This two credit hours course consists of two active/cooperative weekly class meetings, or modeling sessions, of 110 minutes each. The class size is limited to 21 students divided into 3-member teams that are heterogeneous in ability level (based on GPA and prerequisite score). The instructor, known as class facilitator, selects the heads of the teams from the top students and gives them the responsibility to form their teams out of the remaining students. This will guarantee that team members can integrate and meet easily while ensuring heterogeneity in ability level.

Modeling sessions take place in multimedia classes with a desktop computer for each student. A constructivist approach, suggested and supported by the course textbook [40], is used where the students are given an open-ended problem and asked to start developing models that could be useful in solving the problem. The modeling session concentrates on encouraging the students to think about how they created their models, and why they created them. The final work product (model) is not as important as the process the students used to develop that work product. Each modeling session has an agenda consisting of the following tasks:

1. Today's learning outcomes (5 minutes at the beginning of the session) in which the facilitator sets, before starting, the learning goals to be achieved by the students.
2. Class activities (85 minutes of the session time divided into 2 periods). During this time, the students are expected to work in teams on the assigned problem, to develop and test the computational model (usually using MS EXCEL), to prepare and deliver oral presentations (using MS PowerPoint) and to participate in the class discussions.
3. Break (10 minutes at the middle of the session) to help the students to be ready for their next assigned class activity.
4. In-Class Process Check (10 minutes at the end of the session) where each team (and in some cases each student) has to comment on one aspect they found valuable and would keep for future sessions and suggest how to improve one aspect for future sessions. This is known as $+\Delta$ technique.

Over the semester, 6 to 7 open ended unstructured problems are treated. Each problem addresses one of the following:

- | | |
|---------------------------|-----------------------|
| 1. Deterministic models | 2. Time driven models |
| 3. Stochastic models | 4. Linear Programming |
| 5. Risk analysis | 6. Simulation |
| 7. Critical Path Analysis | 8. Expert systems |

Each problem is treated in an active manner over two successive sessions. In the third session a new problem, in the same line of thoughts, is given to the students as an assignment and they are asked to work on it either individually or in teams. Although the students are encouraged to finish a large part of the assignment in class, they are given a week to complete the work, submit a complete written design report, and prepare an oral professional presentation [41]. Table 1 represents the schedule of the assignments during the spring 2009 semester where M_4_1, for example, indicates session #1 of week #4.

Table 1: Assignments schedule for IE 202 Modeling Course (spring 2009).

Assignment	Submission Due Date	Returned to the Student	Resubmission Due Date
Excel Modeling Assignment	M_4_1	M_5_1	M_6_1
Assignment on Chapter 1	M_5_2	M_6_2	M_7_2
Course Portfolio 	M_6_1	M_6_2	
Assignment on Chapter 2	M_7_1	M_8_1	M_9_1
In-Class Assignment #1	M_8_1		
Assignment on Chapter 4	M_8_2	M_9_2	M_10_2
Course Portfolio 	M_10_1	M_10_2	
Assignment on Chapter 9	M_11_2	M_12_2	M_13_2
Assignment on Chapter 7	M_13_1	M_14_1	No Resubmission
In-Class Assignment #2	M_13_1		
Non Mandatory Defect Removal (In-Class)	M_13_2		
Submission of Course Portfolio	M_14_1		
Project Poster and Presentation	M_14_1		
Celebration/Final Oral Presentation	M_14_2		

EVALUATION OF THE MODELING COURSE

The modeling course was taught and continuously improved over 12 successive semesters. Course evaluation was carried out and documented each semester - as a part of the systematic ABET documentation system - to address both course validation and course verification [39]. Validation is required to test if the course design goals are met and is carried out by measuring the students' level of confidence in attaining the learning outcomes specified for the course. Verification, on the other hand, is used to make sure that the course functions as planned by measuring the students' perceptions of the efficacy of the pedagogical tools to facilitate attaining the course learning outcomes. The opinion of the students, the end users of the course, indicated in course surveys, the $+\Delta$ feedback, and the course portfolio is discussed by the course instructors in weekly and end of semester meetings. Investigation of these meeting minutes indicates that the course is valid and functions as planned. In spite of the continuous improvement of the course over successive semester, the students and the course instructors - who are normally between seven and nine instructors per semester - pinpoint continuously the following drawbacks:

1. The number of the equally weighed graded assignments is excessive for a 2-credit course with 6 team assignments, each in the form of up to 20-page report, five resubmissions, two individual in class assignments, one project, one oral presentation, and one course portfolio.
2. The students find it difficult to complete the design project in two weeks' time, with limited in-class activities.
3. The work load increases near the end of the semester with lot of activities in the last two weeks.
4. Each assignment deals with different chapter and different concepts and deal with different real world problems that sometimes deviate from the design concept.
5. The course instructors make enormous effort in assessing and putting new assignments at each semester.

OUTLINES OF THE DEVELOPED PROJECT-BASED COURSE

Intended Learning Outcomes of the Course

IE-202 is a required introductory engineering active learning project based course, which should be taken by all engineering students. The course description, as it will appear in the Faculty of Engineering bulletin (2010), is as follows:

“Engineering design process. Computer modeling and heuristics for problem solving. Hands-on real life and team-based engineering design project: customer requirements, conceptual design, prototyping, functional testing, preparation of operational manual. Communicating design outcomes.”

The course has conserved its time structure by dividing the course content and the classroom activities into two Sessions per week. The student spends 2 hours per week in Session-1 and another 2 hours per week in Session-2.

The developed IE-202 course allows freshmen students to gain professional hands-on engineering design experience through a well-planned active learning course. The student will practice conceptual design, procedures of mock-up tests, detailed design, final planning, manufacturing, inspection and testing. This will give the students a solid background of practical engineering design through a cornerstone design project before joining their selected engineering programs. Although IE 202 course is considered as a key course for ABET outcomes c and d, it partially addresses another four outcomes of the study programs of KAU Faculty of Engineering:

1. ABET outcome c: an ability to design a system, component, or process to meet desired needs within realistic constraints such as economic, environmental, social, political, ethical, health and safety, manufacturability, and sustainability,
2. ABET outcome (d): an ability to function on multi-disciplinary teams,
3. ABET outcome (e): an ability to identify, formulate, and solve engineering problems,
4. ABET outcome (g): an ability to communicate effectively,
5. ABET outcome (i): a recognition of the need for, and an ability to engage in life-long learning, and
6. ABET outcome (k): an ability to use the techniques, skills, and modern engineering tools necessary for engineering practice.

These six ABET outcomes are addressed through the intended course learning outcomes which are stated as follows:

By the completion of IE-202 course the students should be able to:

1. Define the problem, identify customer needs, and transform the needs into design requirements.
2. Access information from a variety of sources, and critically evaluate their quality, validity and accuracy.
3. Plan an effective design strategy with manageable subtasks and timelines.
4. Develop and compare alternative solutions to select a baseline design
5. Consider realistic constraints such as economic, environmental, social, manufacturability, and sustainability.
6. Integrate prior knowledge of science and mathematics with engineering principles, heuristics and modeling techniques to formulate unstructured engineering problems.
7. Effectively use modern engineering tools to carry on design and performance calculations.
8. Evaluate the baseline design and argue suitable improvements and changes.
9. Work in a student team to Build, test, and evaluate a working prototype of the designed artifact.
10. Document the design procedure, communicate design details and express thoughts clearly and concisely, both orally and in writing.
Demonstrate ability to achieve objectives using independent, well organized, and regularly reported multidisciplinary team management techniques.

The Structure of the Course

The new course structure allows minimum effort in achieving the course goals. Also, it allows the student to practice a real design project from the beginning of the semester to

its end. The teams receive the project statement, which includes the customer needs from the beginning of the semester. The project is divided into five assignments or five modules jointed together to form the whole project. In each assignment the students update the previous one after gaining more knowledge about the project problem and join the current assignment with the previous in the same report and so on. So the resubmission is just an update that increases the sense of continuous improvement. After five assignments the project will be ready. Figure1 shows the course calendar. Note that the first five assignments formulate the whole project and the rest of the assignments measure the communications skills through the design notebook, oral presentation and poster. The course structure allows for a different project every semester/year using the same materials and assessment instruments. The instructor's materials and student's materials are just containing the design concepts. The new course checklist is applicable for all the assignments and has a serial number to indicate updating versions. The course checklist is shown in Figures 2 and 3.

Class Topic	Week	Presentation	Class Work	HTMI Task	Due	Checklists	Mark	Team	Individuals	Surveys	Hard Copies
Registration	M0	0				Evaluation Forms					
FDM	M1	1									FDM
Introduction to Project	M1	2									Project
Introduction to Excel	M2	1									Introduction to Excel
Introduction to Excel	M2	2									Introduction to Excel
Assignment 1	M3	1								Entry Survey	
Chapter 1 - HTMI	M3	2									HTMI
Chapter 1 - HTMI	M4	1									HTMI
Assignment 2	M4	2			Assignment 1	Checklist 1	5	5			
Chapter 2- HTMI	M5	1									HTMI
Chapter 2- HTMI	M5	2									HTMI
Assignment 3	M6	1			Assignment 2	Checklist 2	10	10			
Chapter 4 -HTMI	M6	2									HTMI
Chapter 4- HTMI	M7	1									HTMI
Assignment 4	M7	2			Assignment 3	Checklist 3	10	10			
In class Assignment 1	M8	1			In class Assignment I	InClass Ass. Checklist	10	10			
Introduction to Project- Phase 3	M8	2									Project
Chapter 5 - HTMI	M9	1			Assignment 4	Checklist 4	10	10			HTMI
Chapter 5 - HTMI	M9	2									HTMI
Chapter 5 - HTMI	M10	1									
Assignment 5	M10	2									
Workshop - Session I	M11	1								Exit Survey	Workshop Guide
Workshop - Session II	M11	2			Assignment 5	Checklist 5	10	10		Outcome Survey	Workshop Guide
Workshop - Session III	M12	1									Workshop Guide
In class Assignment II	M12	2			In class Assignment II	InClass Ass. Checklist	10	10			
Poster & Prototype	M13	1			Prototype & Poster	Prototype & Poster EF's	15	10	5		
Celebration	M13	2			Project Presentation	Presentation EF	10	5	5	Course Evaluation	
Defect Removal	M14	1			Design Notebook	Design Notebook EF	10	10			
							100	70	30		

Figure 1: Calendar for the project-based course (Fall 2009).



King Abdulaziz University
Faculty of Engineering
IE 202 – INTRODUCTION TO ENGINEERING DESIGN II (FALL_2009)

IE-202-FALL-2009-SEC()-Team- ()PRO- O

Work Self Assessed by _____ Assessment Symbol/Color ____ Date (/ /)

Work Assessed & Evaluated by _____ Assessment Symbol/Color ____ Date (/ /)

Self Assessment		Checklist Items	Instructor Assessment		
YES	NO		Acceptable 1	Unacceptable 0	Resubmission Mark
Report Requirements					
		1	Is the the work assembled in the correct order (Checklist, Cover page, Table of contents, Introduction, literature review, Main Body, Conclusion, Appendices, and References)?	1	
		2	Is the work self assessed and the checklist completely filled?	1	
		3	Is the cover page informative and well formatted?	1	
		4	Is there a well formatted table of contents ?	1	
		5	Is there an INTRODUCTION at the beginning of the report?	1	
		6	Is there a Conclusion after the main body?	1	
		7	Is the MAIN BODY of the report divided into sections with appropriate titles and subtitles using appropriate font for each?	1	
		8	Does a references section appear as the last item of the main report?	1	
		9	Is there an attached, deemedly filled, Process Check?	1	
		10	Is there an informative footer (Assignment#, pag# / no. of pages, and team # and members)?	1	
		11	Does each table have a number and a title , and is it mentioned in the text before it is placed?	1	
		12	Does each figure have a number and a caption , and is it mentioned in the text before it is placed?	1	
Graph Requirements					
		13	Does the graph have a reasonable size and format ?	1	
		14	Is there an appropriate, descriptive title or caption ?	1	
		15	Do both axes have descriptive titles (N.B. not a single letter) which include units ?	1	
		16	Are there labeled divisions (text or numbers) on the axes ?	1	
		17	If there is more than one chart line, is there a legend ?	1	
Spreadsheet Requirements					
		18	Are the work title , students' names and team number mentioned in the spreadsheet?	1	
		19	Are the data or " design constants or parameters " grouped in a single area which is separated from the calculation area?	1	
		20	Have the numerical values of the "design constants or parameters" been labeled in neighboring cells and have units ?	1	
		21	Are all calculation columns or rows labeled and have units ?	1	
		22	Has cell formatting been used to improve the appearance and presentation of the model?	1	
		23	Is the number of significant figures displayed appropriate for all the numerical values ?	1	
		24	Is a soft copy of the Excell Sheet attached with the report?	1	
		25	Are cell references used rather than numerical values for " design constants or parameters " in the formulae ?	1	
Total of Page 1 out of 25					

Figure 2: Page 1 of the general checklist for the assessment of project reports.

Self Assessment		Modeling Requirements (Work is assessed as Excelent, Good, Average, Marginal, Poor, or null)	Instructor Assessment								
YES	NO		Ex.	G.	Av.	Acc	Pr.	Nul	Resubmission		
			5	4	3	2	1	0	Max Mark	Mark	
		26	Introduction: The introduction provides background, forecasts the document and define the problem to orient the reader.							5	
		27	Problem Definition: The problem to be solved is clearly stated. Customer needs are correctly identified and transformed into project requirements. Potential customers are identified and their needs are taken into consideration.							5	
		28	Literature Review: All pertaining information are identified and collected from a variety of credible sources. Information are reviewed and assessed with respect to their quality, validity and accuracy and presented using a standard and ethically referenced literature review format.							10	
		29	Problem Formulation: The problem to be solved is logically formulated. Collected information are successfully integrated. Applicable realistic constraints are discussed. Objectives and constraints are design oriented, measurable and clearly presented. Evaluation criteria are quantitative, specific, and address customer needs.							5	
		30	Modelling and Design Calculations: Design parameters are correctly identified as well as their ranges based on acceptable arguments such as prior knowledge, data from existing similar products, theoretical modeling, and operational experience. Assumptions are reasonable, logic, and clearly stated. Mathematical equations are clearly written with their symbols explained. Appropriate engineering resources and computer tools are efficiently used to carry on accurate design calculations.							15	
		31	Results and Discussions: Qualitative and quantitative results are presented. Reference is made to supporting charts, figures, tables, and drawings that stand on their own with clear legends. Performance of the final design compares favorably to customer requirements, design criteria, operational constraints ,and existing products if any.							15	
		32	Conclusion: the conclusion remind the reader of the project requirements and the result obtained, and discuss why the results are conclusive and interesting. Relevance of the findings to other published work and real organisms in the real world is described. Future work and further studies are mentioned.							5	
		33	References: References used to credit work from other sources and appear in a standard reference list in the same order as they are referred to in the main body							10	
		34	Are the language and style of the report adequate?							5	
Total of items 26 to 34 (How many Ex, G., Av, Acc., Pr. and Nul.)											
Self Assessment		Team Work Requirements If the work is a team work assignment, is each of the following items included? (1 laps will be given for each missing item)	Instructor Assessment								
YES	NO		O.K.	Missing							
			No lapses	1 Laps							
		41	a. Well written Team Meetings' Minutes								
		42	b. Deemly filled Team Work Peer-to-Peer Assessment								
		43	c. Soft copy of the Power Point Presentation and Excell Sheet								
Total Lapses (sum of all poor or null in items 26 to 34 + lapses on items 41 & 43)											
Final Grade											
Assessment Results			Grade	Resubm.	Lapses	Grade After Resubmission					
1. Exceeds Expectations: Final Grade ≥ 85			E	R							
2. Meets Expectations: $85 > \text{Final Grade} \geq 70$			M	R		E					
3. Acceptable: $70 > \text{Final Grade} \geq 60$			AC	R		M					
4. Needs Improvement: $60 > \text{Final Grade} \geq 50$; the work has to be resubmitted within one week. The maximum grade after resubmission is AC.			NI	R		AC					
5. No Credible Effort: Final Grade < 50 , 1 laps; the work has to be resubmitted within one week. The maximum grade after resubmission is AC.			NCE	R		NI					
6. Resubmission within one week is required for any Poor or Null in the checklist items from 26 to 34, no matter what the final grade is. One lapse is given for each unsatisfactory item and R is circled beside the grade. The grade remains as is after successful resubmission, otherwise it becomes one grade lower (e.g. E becomes M, M becomes AC, and so on). Late resubmission results in one lapse. No more than 1 week of lateness is allowed, otherwise an NS is given.						NCE					
						NS					

Figure 3: Page 2 of the general checklist for the assessment of project reports.

Direct Assessment Tools

Course assignments are used as the primary direct assessment tool in the cognitive domain. The student's work is evaluated as Exceeds Expectations (E), Meets Expectations (M), Acceptable (AC), Needs Improvement (NI), or represents No Credible Effort (NCE). The checklist is mapped into the course learning outcomes they are used to assess and into the corresponding course supported program outcomes. The work evaluated as NI or NCE will be updated in the next project report. The maximum grade after resubmission is AC in the previous report version. On the other hand the major checklist items that receive Null or Poor are to be corrected and resubmitted, no matter what the final grade is. The grade remains as is after successful resubmission; otherwise it becomes one grade lower. This approach clearly enforces customer-based quality principles and continuous improvement philosophy. Work is accepted only if it Meets or Exceeds customer's expectations. Unsatisfactory work is considered to Need Improvement (NI) and the students are given one week to improve and resubmit. The total mark is calculated using the following equation.

$$\text{Final Grade} = \frac{\text{No. of E's} * 100 + \text{No. of M's} * 84 + \text{No. of AC's} * 69}{\text{Total No. of Assignments} - \text{No. of Lapses} + \text{No. of Bonuses}}$$

A smart checklist is developed to convert the grades of each assignment such that they map course learning outcomes in the main grading sheet. The checklist is intended to help the instructor to grade the assignment and periodically monitor the achievement of the course learning outcomes.

Design Phases of the Project

The course starts with a project manual that includes the project statement, required communications and step by step learning and instructional guide. The project statement describes the customer needs and the sponsor of the project. The required communications are as follows:

1. Final comprehensive, well organized design notebook, which includes parametric design, recommendations, rationale and plans for implementing changes, prototype drawings, and the project Gantt chart and deployment chart.
2. Comprehensive oral team presentation for a general audience.
3. A poster for exhibition.
4. Built, tested and analyzed project artifact or prototype.

The project is divided into three phases as shown in Figure 4. The parametric design phase will map some selected modeling chapters from the "How to model it" book [40]. After finishing this phase it is expected that the student teams had modeled the artifact, calculated all design variables and performed parametric studies. This phase is covered

by five team assignments. The second phase is the drawing phase in which the teams draw the artifact to scale as a starting point before implementation. The third phase is the prototype phase in which the teams implement their designs and manufacture their prototype following the flowchart of Figure 5.

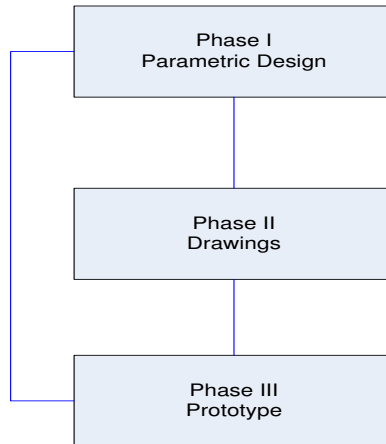


Figure 4: Project phases.

Evaluation of the Course Design

In order to compare the developed project-based course to the modeling one, the method of “exposure matrix” proposed by Al-Bahi [41] and systematically used by the majority of Engineering Programs in KAU is utilized. The method uses course-level measures of achievement of intended program outcomes to evaluate the achievement of ABET outcomes on the program level. This approach is based on the fact that simple averaging is not suitable since each course addresses one or more program outcome at a certain level of learning (which may be defined as learning height). Also the students in different courses could be exposed lightly, moderately or extensively to the same program outcome (i.e. learning coverage or breadth). The approach is used to obtain a weighted average of achievement of program outcomes by a combination of learning height and learning breadth or coverage in different courses. A modified measure of Bloom's levels of learning, in which 1 is assigned to knowledge and comprehension, 2 to application and analysis and 3 to synthesis and evaluation, is used to quantify the learning height while contact hours allocated to each program outcome in the course are used to quantify the learning coverage or breadth. Students' exposure to certain outcome in a course is then measured by multiplying its intended attainable level of learning by the contact hours allocated to that outcome.

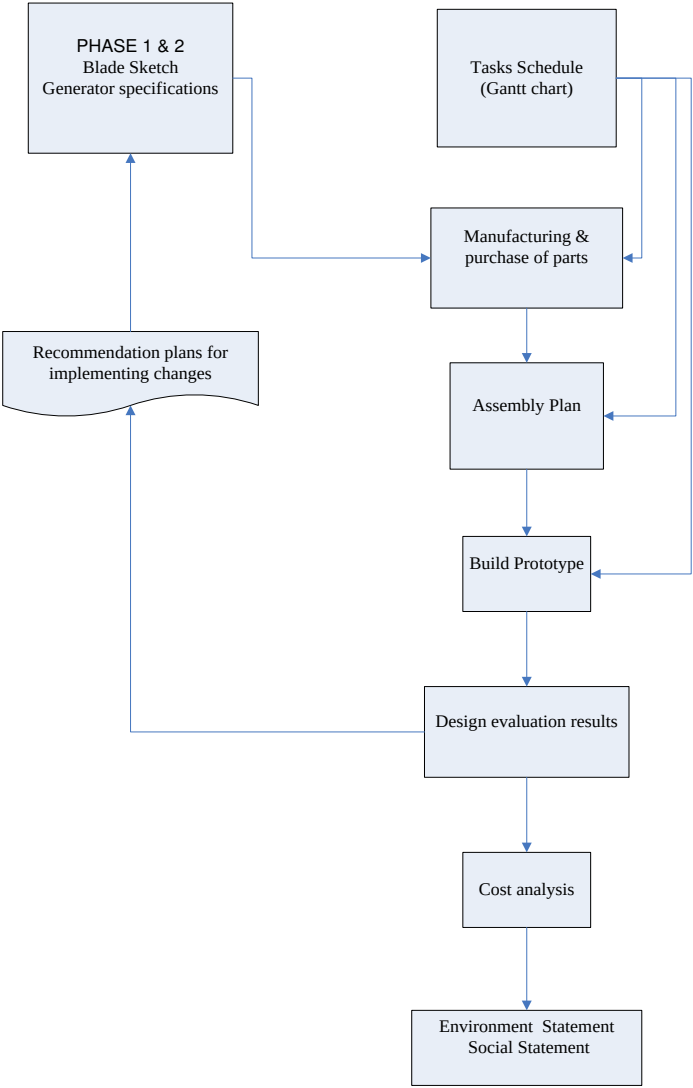


Figure 5: Flowchart of the prototype phase.

Evaluation of the project-based course indicates that (see Figure 6) the exposure of the key outcome 3c is almost 6 times as large as it was in the modeling course. In the project based course the exposure of outcome 3c contributes to 40 % of the total course outcome exposure, while it contributed to only 11% for the modeling course due to the addition of more design attributes to the course. The structure of the assignments and their resubmission let the student more experienced in identifying, solving and evaluating engineering problems, and resulted in an increase in the exposure of outcome 3e. The

long life learning attributes (outcome 3i) also increased because of dealing with open ended design problem that requires intensive literature review in each assignment.

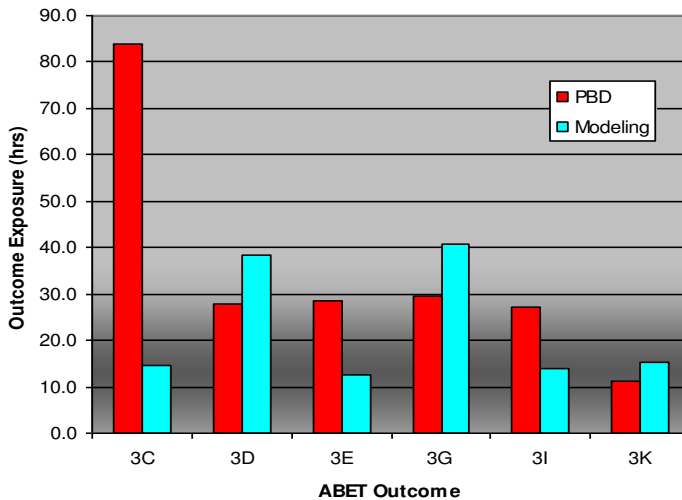


Figure 6: Students' exposure to ABET outcomes in both courses.

On the other hand the total outcomes exposure in the course increased from 136 hrs to 208 hrs, an increase of 53 % while maintaining the course credit hours, as a result of increasing the level of learning for certain key outcomes.

The overall contribution of the course to the design outcome (3c), in particular, increased from 2% to 5 % by developing the new project-based design course.

COURSE IMPLEMENTATION

The course was implemented starting from fall 2009. Two main facilities were constructed before the start of the course offering. The first is an active learning laboratory equipped with 12 round tables and 48 computers to accommodate twelve teams of four students each. The second facility is the workshop equipped with the essential tools needed for the artifact manufacturing. The course accommodates six sections for 288 students. In the first week course materials were delivered to the students including the first day materials, project assignments and students' guide, surveys, checklists and forms. The course calendar plays an important role to alert the students when they should deliver assignments and surveys. The instructors meet regularly once a week to insure the sustainability of the course and to decide on minor continuous improvement actions. The course instructors had to implement by themselves the artifact

in the workshop before the beginning of the workshop activities to assure that the work is feasible for the students within allocated time constraints.

At the end of the semester students had delivered the course design notebook, artifact and poster. The project was to design a wind turbine for home use in Jeddah city. Figure 7 shows sample pictures of the students' products and activities.

COURSE ASSESSMENT AND EVALUATION

The student performance target is that, at least 70% of passing students must achieve at least 65% score in each outcome. This criterion is applied to both direct and indirect assessment methods.

Entry survey is used as an indirect assessment tool that measures the students confidence level in their abilities to achieve course addressed ABET outcomes and is usually distributed in the second week of the course. The same survey is redistributed in the last week of the course and is called exit survey. Differences between the two surveys are used as measure of gain caused by the course.

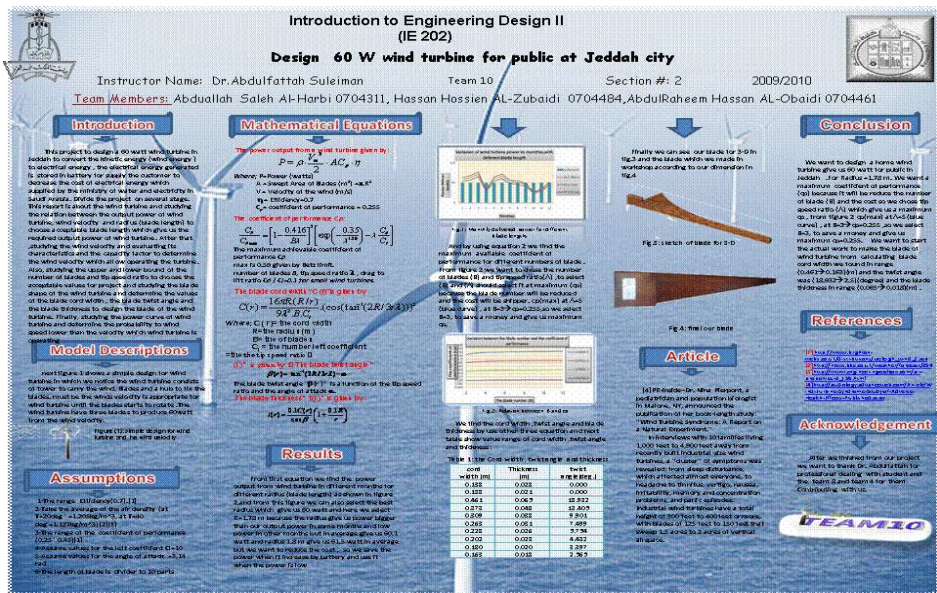


Figure 7a: An example of the project poster delivered by one team of students.



Figure 7b: Sample workshop activity of graving wood to manufacture the blades.



Figure 7c: Sample wind turbine blade manufactured by a team of students.

Figure 8 indicates the results of these 2 surveys for the fall 2009 offering of the project-based course. It deserves attention to notice that the confidence level of the students indicated in the exit survey are in good agreement with the results of the direct assessment tools as depicted in Figure 9. This indicates that the project-based offering not only increased the level of achievement of ABET outcomes; it also increased the confidence of the students in their abilities.

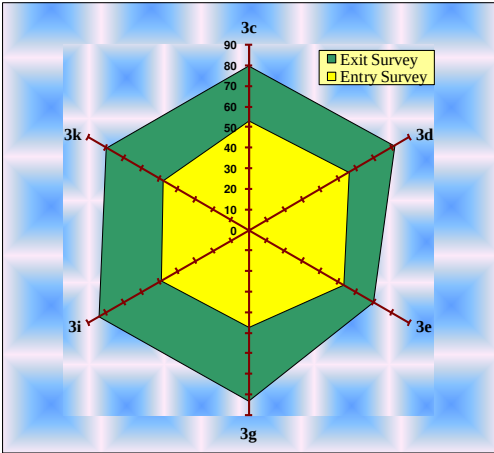


Figure 8: Students' confidence level in their abilities.

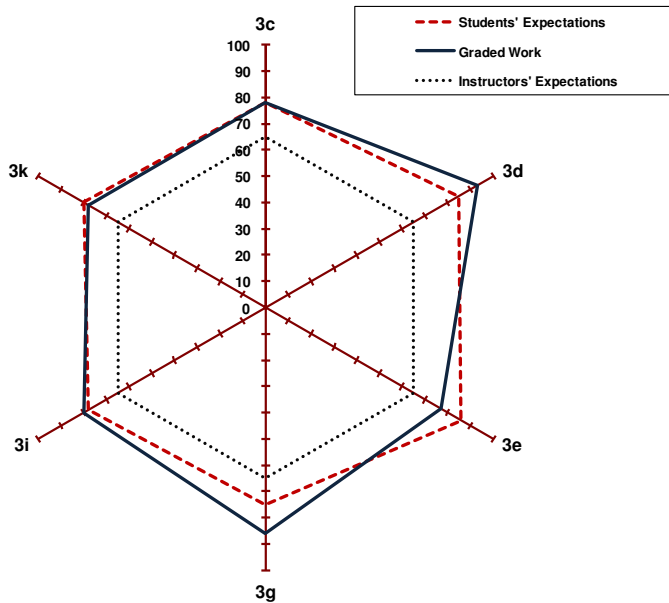


Figure 9: Results of direct and indirect assessment of ABET outcomes

SUMMARY AND CONCLUSIONS

An active/cooperative, problem-based, introductory modeling course was redesigned using project-based learning to allow freshman level students to gain professional hands-on engineering design experience through well-planned active/cooperative learning activities. The developed course introduces engineering design practices through guided design phases and provides the students with an opportunity to practice team work, quality principals, communication skills, life-long learning, realistic constraints, and global awareness of current domestic and global challenges. Course implementation for two successive semesters gave rise to the following conclusions:

- Project-based learning is an efficient learning and teaching model suitable for engineering education. It provides the students with an opportunity to practice team work, quality principals, communication skills, life-long learning, realistic constraints, and global awareness of current domestic and global challenges.
- Project-based courses increases the students exposure to engineering design attributes and permit the attainment of higher levels of learning even for freshman level students
- In hands-on project-based learning the student's achievement of intended course learning outcomes is higher than that of the students enrolled in problem-based cooperative learning classrooms.

- d. Project-based learning courses require commitment and sincere work from the part of the course instructors, as well as leadership, motivation and support from the college management, to insure sustainability.

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ASSESSMENT OF CAPSTONE GRADUATION PROJECT IN RELATION TO ABET ACCREDITED PROGRAM OUTCOMES

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ABSTRACT: Earning the B.Sc. degree in Biomedical Engineering (BME) at Jordan University of Science and Technology (JUST) requires the successful completion of a minimum of 159 credit hours. Four of these credit hours are devoted to the senior graduation (capstone) projects required as a two-semester course, namely, graduation project I and II. The importance of the senior graduation projects stems from the fact that they are conducted in a fashion that mimics, to the largest extent possible, real world industrial practice. Students, during graduation project I, must identify and formulate problem statements, perform a thorough review of literature in order to gain expert knowledge in the area chosen, and formulate the conceptual design for the proposed solution. Subsequently, during graduation project II, students use modern engineering tools to assess the proposed designs and implement the design that represents the best solution to that engineering problem. This paper discusses how graduation projects that are built based on the knowledge and skills acquired in earlier course work can be an excellent means to provide students not only with professional skills; such as communication, teamwork, and understanding of professional and ethical responsibility; but also with skills related to engineering within a global and societal context, lifelong learning, and knowledge of contemporary issues. Assessment tools directed at evaluating the extent to which graduation projects fulfill the BME department program outcomes are also presented. The paper concludes with the assessment results, lessons learned, observations and recommendations that should be of value to engineering educators.

KEYWORDS: ABET; Accreditation; Design; Capstone Projects; Undergraduate Engineering; Engineering Education.

INTRODUCTION

The engineering profession requires design abilities that are of crucial importance in most of the activities conducted by engineers. Because of this, educators in all engineering fields of study tend to incorporate engineering design courses within the curricula they develop [1]. The teaching of such courses aims at fulfilling demands put by professional bodies responsible for accreditation of engineering programs. The accreditation board for engineering and technology (ABET) as a leading and internationally respected organization has set the higher-educational standards in its fields [2, 3]. Accordingly, to be ABET accredited, engineering programs must meet quality standards set by engineering profession. These standards in context with engineering design dictate that students must acquire during their course of study three types of knowledge. These include knowledge to generate ideas, knowledge to evaluate ideas, and knowledge to structure a design process. All of these three types of knowledge are sought to equip the students with skills related to the following issues [4, 5]: Development and use of design methodology, Formulation of design problem statements and specifications, Consideration of alternative solutions, Feasibility study, Detailed system description, Economic factors, Safety, Aesthetics, Ethics, and Social impact.

The BME Department at JUST offers Bachelor of Science in Biomedical Engineering degree. To earn this degree, the student must successfully complete 159 credit hours. The design component available in the BME at JUST curriculum demonstrates the strength of the program and at the same time the commitment of JUST to produce graduates that are able to compete at both national and international levels. The design tasks have to follow engineering standards and meet realistic engineering constraints. These standards and constraints are highlighted more clearly during the capstone projects to which four credit hours of BME program at JUST are devoted. During these projects students are required, at a minimum, to provide sections on economic analysis including costing of component, system, or process, and the health/safety/and environmental impact of their designs, including any relevant discussion on other implications. Senior graduation projects are given to the student as a two-semester course. Namely, graduation project I and graduation project II. The utmost importance of senior graduation projects stems from the fact that they are conducted in a fashion that mimics, to the largest extent possible, the real industrial practice. Students, during the graduation project I, must perform a thorough review of literature in order to gain expert knowledge in the area. This knowledge allows students to identify and formulate problem statements. After having built such knowledge and a problem statement, students during the graduation project II use modern engineering tools to design a system that represents a solution to that engineering problem. Projects during this two-semester activity are conducted in groups of two to four students, with each group supervised by one or more faculty members.

CAPSTONE PROJECTS: COURSE CATALOGUE, OBJECTIVES, STRUCTURE, MECHANISM, AND EVALUATION

Capstone projects, described in the BME department course catalogue list, are as follows:

Senior Capstone Project I

Provides students the opportunity to individually explore a BME problem or issue within their field of study and apply their education to solving the problem for the benefit of the local community and society as a whole. Students produce a short report that documents the application of previous learning, experience and knowledge to the problem at hand, and evaluates the results.

Senior Capstone Project II

Students perform the experimental and practical phases associated with solving the BME problem addressed in Senior Capstone Project I. Students produce a full technical report that documents the research, design, results, analysis, and recommendations of the study, followed by a final presentation and defense. The objectives of these capstone courses are:

- Applying the methodology of design, addressing issues central to biomedical engineering, by utilizing the knowledge gained from past fundamental courses.
- Understanding of professional and ethical responsibility

- Practicing skills related to engineering within a global and societal context, lifelong learning, and knowledge of contemporary issues.
- Applying time management fundamentals and cost effectiveness.
- Implementing effective communication both orally and in writing.
- Practicing effective team work management.

Consequently, typical projects in Biomedical Engineering involve a review of state-of-the-art designs for biomedical engineering practice, and combine engineering analysis and design with experimental and/or simulation work to provide needed information relevant to the specific constraints of equipment operation. During the capstone project I each group of students are required to complete a literature review, perform the necessary engineering analysis, and provide an initial design for their project. In capstone project II, they are expected to optimize their designs and perform the economic, health/safety/and environmental impact, and other implications of their design. The mechanism according to which the BME department at JUST suggests and assigns project proposals to students is as shown below:

1. The department forms Graduation Project (GP) committees each semester.
2. Each faculty member, offering GP I, submits a proposal to the GP committee during the first week of the semester.
3. GP committee evaluates the submitted proposals and lists all approved projects.
4. Students communicate with each other to form project teams.
5. Students select their project preferences on a Team Assembly Form which is submitted to the GP committee.
6. The GP committee assign a project to each team according to their preference. If more than one team show an interest in one project, the faculty member offering that project chooses among the teams.

Capstone projects are evaluated based on specific assessment information that can be divided into three criteria:

- *Advisor(s) Grading (25%):* The advisor(s) grading is conducted based on two items: Technical ability, data analysis, professional responsibility, ability to work independently, use of modern engineering tools (17.5%) and Team Work (7.5%).
- *Final Report (35%):* The guidelines used to assess the final report are:
 1. General Format (1%): this includes number of pages, font, margins, title page and chapter numbering.
 2. Report Sections (6%): Executive summary, nomenclature, table of contents, list of tables, list of figures and team member contributions.

3. Technical Contents (17%): Introduction, background theory, methodology and techniques, results and discussions, conclusions and recommendations, references and appendices
 4. Ethics, Impacts and Quality (11%): Ethics, citation, language (grammar and spelling), general looks and quality and economical environmental, safety and social impacts.
- *Final Presentation (40%)*: This criterion is evaluated based on three items: Ability to formulate a problem, select an optimal approach and design a process or a system by applying math/science/engineering principles, analyze and interpret results for a system/experiment to meet desired needs (20%), ability to answer technical questions (12%) and oral presentation (8%).

The selection of these three criteria is strongly defensible especially when mapping the used criteria to the BME program at JUST outcomes.

CAPSTONE PROJECTS IN RELATION TO PROGRAM OUTCOMES

The BME program at JUST after extensive meetings, discussions, and consultations adopted the a-m criteria in ABET. Course outcomes are defined for each course in the program, based on the material in each course, and these are linked to the program (a-m) outcomes. The success of the program is evaluated through the achievement of program outcomes. One of the direct tools the BME at JUST uses to assess the attainment of curriculum outcomes is capstone projects. The use of this tool is apparently justified by the fact that capstone projects' objectives are related to all program outcomes. Faculty members are also defined to be a program constituency exploited to provide valuable feedback for the development, evaluating how the program outcomes are met. Figure 1 gives the results of how the faculty members in the BME at JUST evaluated the achievements of program outcomes using the capstone projects as a direct tool. This assessment was done for projects conducted by students in four successive semesters starting with the first semester of the academic year 2007/2008.

The success criteria for each program outcome are indicated as follows:

- Suggested Improvement: Above 3 on a scale of 5, the program outcome has been met, but recommendations for some improvement may be suggested.
- Needs Improvement: Between 2.5 and 3.0 on a scale of 5, the program outcomes have been marginally met. Improvement should be suggested and implemented.
- Major Improvement: Less than 2.5 on a scale of 5, the program outcome has not been met. Major improvement should be suggested and implemented.

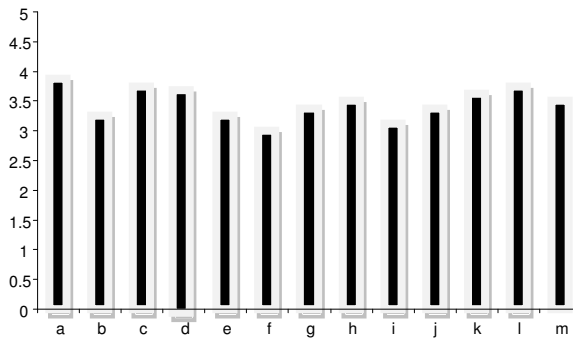


Figure 1: The results of achievement program outcomes using capstone projects as a direct assessment tool.

SUMMARY AND CONCLUSION

Capstone design projects can be used as an assessment tool to judge the students comprehension of the different courses within the curriculum, this in turn serves as feedback when restructuring course content and material. Instructors' observations with regard to the capstone projects can be summarized as follows:

- Students perform very well when they have an opportunity to choose the topic of the projects themselves.
- Including design component in other courses has a great impact on improving the student performance during the conduct of the capstone project.
- The inclusion of communication course within the curriculum has also improved student writing and organizational abilities.
- Applying acquired theoretical knowledge to the solution of the practical biomedical problems infer a sense of self-confidence and social responsibilities within the students.
- The practical training requirement in the fourth year of study gives the students exposure to a wider array of biomedical related issues and problems.
- Efforts to conduct joint capstone projects with industry and other governmental institutions were not very successful due to bureaucratic limitations.

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Development and Review of Engineering Education

INTRODUCTION TO BALANCE BETWEEN THE CREATION OF ALLAH AND HUMAN INDUSTRY - THE GREATEST CHALLENGE OF EDUCATION FOR THE 21st CENTURY

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ABSTRACT: God's creation of heavens and Earth is characterized by creator's knowledge which covers everything, his soul tying him with the creatures and his wisdom achieving enhanced balance with time. Current science is characterized by innovation and imitation of God's creation. However, it evolved independently of a universal reference resulting in problems in balance seen through environmental corruption and manners' collapse. Since current science represents the best valid materialistic civilization, the requested challenge is both legislative and methodological in how to restore balance. This research presents a vision through which we make use of what we first read from materialistic science to develop another reading in the Godly Universal Reference. This will help man first absorb materialistic sciences and then direct and enhance it. Such interaction between the two readings is essential to preserve and improve balance. Unfortunately such interaction is absent in current civilization which discovered how much important it is to provide the user with a manufacturer manual but did not find out how much a human is in need for his own reference book to reveal the purpose of his creation and the way to achieve it! Researcher finds the greatest challenge in how to provide students with qualified co-chairs: one in science to improve efficiency of digesting art beneficial to the world, the other in manners which adjusts its behavioral work according to scientific knowledge. The complete universal reference of God "Qur-an" is the best reference to achieve both co-chairs. The research also provides an understanding from Qur-an and science of how to cure the most important issues concerning scientific institutions (to be based on science and faith), education institutions (to simplify and facilitate learning skills through exciting hard thinking, identifying variables and providing evidence and proof) and industrial institutions (to provide evidence as an output).

KEYWORDS: Balance; creation; industry; education manual; universal reference.

INTRODUCTION

In modern times, man has discovered by trial that humanities (just like science) are two types. One is theoretical facts, characterized by constancy. These are scientific, humanistic legislative laws. Another is practical applications that are renewable and are characterized by change according to changing situation. On this basis, specialists are classified as scientists (possessing theoretical knowledge) and applied scientists, like engineers. Scientists learn theoretical science (pure science) while engineers learn how to apply this science and benefit from it in changing situations.

With increasing scientific knowledge and discovery of new means of observance and measurement, what scientists think to be constant (stable) turns to serve only under specific conditions. So the laws turn to be a wise wisdom that works under specific circumstances. For example, Newton's laws which were thought to be the discovery of laws of universe motion, are not valid when speed becomes equal to the speed of light. Thus, they are replaced by the laws of Einstein [1]. Also, Newton's laws are not valid in Nano-sciences and are thus replaced by quantum physics. Quantum physics is also in

contradiction with physics of Newton and Einstein forcing scientists to try to resolve these inconsistencies through a new theory, superstring theory, which assumes eleven world dimensions [2]. Thus, we can say that human discoveries are always in continuous increase and change with increasing human knowledge and improved means of observance and measurements. Such discoveries are either scientific representing human laws bounded by place, time and means of observance and measurement, or the corresponding applied sciences showing how to understand and use such human laws in balanced form for all creatures.

On the other hand, one studying book of God finds out another source for accurate information sent from the creator. The facts of the universe are either discovered from reading the universe or from reading the book sent from the creator to the creature. The term, The Book, refers first to a constant script (whose understanding is dynamic: changes with place, time and development of means of observance and measurement) which represents theoretical legislation and, second is the platform necessary to understand these facts and apply them (called balance) as revealed by Ash-Shura chapter:

اللَّهُ الَّذِي أَنْزَلَ الْكِتَابَ بِالْحَقِّ وَالْمِيزَانَ وَمَا يُدْرِيكَ لَعَلَّ السَّاعَةَ قَرِيبٌ (17).
الشورى/42

17-It is Allah Who has sent down the Book in truth, and the Balance. And what will make thee realize that perhaps the Hour (of punishment) is close at hand. Sura Ash-Shura\Number 42.

Balance is the tool that is used to judge the implementation concepts of The Book on different worlds, i.e. it is the wisdom necessary to achieve balance in the universe.

Ibrahim (Abraham) (peace be upon him) emphasizes the importance of integration in education between established constant facts, concepts, (named book) and practices (named judgment) as the basis for development of education, considering those who did not abide by such platform a fool as revealed in Al-Baqarah chapter:

رَبَّنَا وَابْعَثْ فِيهِمْ رَسُولًا مِنْهُمْ يَتْلُو عَلَيْهِمْ آيَاتِكَ وَيُعَلِّمُهُمُ الْكِتَابَ وَالْحِكْمَةَ وَيُزَكِّيهِمْ إِنَّكَ أَنْتَ الْعَزِيزُ الْحَكِيمُ (129) وَمَنْ يَرْغَبْ عَنْ مِلَّةِ إِبْرَاهِيمَ إِنْ مَنِ سَفِهَ نَفْسَهُ وَلَقَدْ اصْطَفَيْنَاهُ فِي الدُّنْيَا وَإِنَّهُ فِي الْآخِرَةِ لَمِنَ الصَّالِحِينَ (130) البقرة/2

129-130"Our Lord! Send amongst them a Messenger of their own, who shall rehearse Thy Signs to them and instruct them in Scripture and Wisdom, and sanctify them: for Thou art the Exalted in Might, the Wise.". And who turns away from the religion of Abraham but such as debase their souls with folly? Him We chose and rendered pure in this world: and he will be in the Hereafter in the ranks of the Righteous. Sura Al-Baqarah\Number 2.

Knowledge of science facts represents strength for sponsorship learner. And abiding by the requirements of this science instead of following the Hui represents stability in sponsorship learner. Stability is a change of thought and sponsorship behavior for the benefit of people and contributes to the architecture of the Earth. However, science alone without guidance from The Book of God is unable to discover all universal facts due to

human limitations (human ideas are developed through means of observance and measurement; and assumptions bounded by place and time) which bounds his abilities to achieve balance. Whereas the creator abilities are thorough as describes in Ta-ha chapter:

قَالَ فَمَنْ رَبُّكُمَا يُمُوسَى (49) قَالَ رَبُّنَا الَّذِي أَعْطَى كُلَّ شَيْءٍ خَلْقَهُ ثُمَّ هَدَى (50)
طه/20

49-50 (When this message was delivered), (Pharaoh) said: Who, then, O Moses, is the Lord of you two?" . He said: "Our Lord is He Who gave to each (created) thing its form and nature, and further, gave guidance." Sura Ta-ha\Number 20.

Thus Our Lord has designed everything and has given it its form and nature. Allah's saying: "gave guidance" means that Allah has programmed the designed thing to perform its role easily and with the least cost and effort. He has also programmed other things that are interrelated with each other to carry out tasks that are fully integrated to make things do their roles easily. Allah has never designed a thing in isolation from others. Therefore, He said "gave guidance" and didn't say "gave it guidance". For example, the human body organs and systems are programmed to do their roles automatically and in an easy fashion. The same is true for thousands or even millions of fish in the sea, and birds in the sky: they move quickly and continuously without one fish or bird colliding with another. In contrast, many planes have collided in the vast space and many ships have also collided head on in oceans and seas, let alone the numerous collisions of cars on roads.

Thus it is logical to find out that many of human beings' inventions and industries, that had characterized the 20th century, have been a human imitation, however imperfect, of some of Allah's creatures: planes are a weak copy of birds; the submarines a costly copy of fish; the cameras a copy of eyes, calculators a copy of human brain; satellites a transformed simple copy of planets and moons, keeping in mind the huge difference between the copy and the original. Although such a difference is admitted by intellectuals, yet it is strange that they imitate God's creation, yet they don't ask earnestly for the universal reference book from Allah, the creator. Whereas they do produce a manual for every machine they produce to show its operation instructions, its purposes and function.

Although the Christian West belongs to People of the Book in its first script (the Torah and the Bible) and because the book is not complete, the People of the Book couldn't find in it what might cure their burning desire and quench thirst for knowledge after deciding to start their reformation and consider the Torah and the Bible the only source of revelation and religion. And because the Christian West had not known the Lordly Universal Complete Reference, they saw things with one eye (eye of materialism) bounded by available physical means of measurements, lots of assumptions and limitations of human mind to produce the available civilization. This one-eyed civilization, since it is read from universe alone without reference to the book of Allah, produced corruption which will finally lead people to return to the final complete Lordly universal script as stated in Ar-Rum chapter:

ظَهَرَ الْفَسَادُ فِي الْبَرِّ وَالْبَحْرِ بِمَا كَسَبَتْ أَيْدِي النَّاسِ لِيُذِيقَهُمْ بَعْضَ الَّذِي عَمِلُوا لَعَلَّهُمْ
يَرْجِعُونَ (41) الروم/30.

41 -Mischief has appeared on land and sea because of (the deed) that the hands of men have earned. That (Allah) may give them a taste of some of their deeds: in order that they may turn back (from Evil).Sura Ar-Rum\Number 30.

Once we return, Allah has stated qualifications needed to understand details of his Book at the beginning of Fussilat chapter

كِتَابٌ فُصِّلَتْ آيَاتُهُ قُرْءَانًا عَرَبِيًّا لِقَوْمٍ يَعْلَمُونَ (3) فصلت/41.

3-A Book, whereof the verses are explained in detail; a Qur-an in Arabic, for scientific people; Sura Fussilat\Number 41.

Those who want to understand details of Quranic verses need to be knowledgeable with Arabic, in Terms of expression, comprehension and thought and must have scientific knowledge that helps them understand signs and recommendations which Allah has embedded in His verses. This is the science which Allah has promised to be the index to prove the authenticity and truthfulness of the Holy Book verses. To this end, Allah said at the end of Fussilat chapter [3]:

سَنُرِيهِمْ آيَاتِنَا فِي الْآفَاقِ وَفِي أَنْفُسِهِمْ حَتَّى يَتَبَيَّنَ لَهُمْ أَنَّهُ الْحَقُّ أَوَلَمْ يَكْفِ بِرَبِّكَ أَنَّهُ
عَلَى كُلِّ شَيْءٍ شَهِيدٌ (53) فصلت/41.

53-Soon will We show them Our Signs in the (furthest) regions, and in their own souls, until it becomes manifest to them that this is the Truth. Is it not enough that thy Lord doth witness all things. Sura Fussilat\Number 41.

UNIVERSAL CREATION REFERENCE: THE BOOK OF GOD (ALLAH)

The most important advice in the universal creation reference is stated in Saba chapter:

قُلْ إِنَّمَا أَعِظُكُمْ بِوَاحِدَةٍ أَنْ تَقُومُوا لِلَّهِ مِثْلَيْ خَافِضَةٍ يُؤْفِكْ أَذَى تُمْ وَتَنْفَكُوا مَا بِصَاحِبِكُمْ مِنْ جِنَّةٍ
إِنْ هُوَ إِلَّا نَذِيرٌ لَكُمْ بَيْنَ يَدَيْ عَذَابٍ شَدِيدٍ (46) سبأ/34.

46-Say: "I do admonish you on one point: that ye do stand up before Allah, - in pairs, or singly - and reflect (within yourselves): your Companion is not possessed: he is no less than a Warner to you, in face of a terrible Penalty" . Sura Saba\Number 34.

To do anything as learning or education, it must be done in pairs at start, then individually. So we understand several pairs like the importance of studying two truth references: reading the book sent from God as stated in Az-Zumar chapter:

إِنَّا أَنْزَلْنَا عَلَيْكَ الْكِتَابَ بِالْحَقِّ... (41) الزمر/39

41- Verily We have revealed the Book to thee in Truth, for (instructing) mankind... Az-Zumar\Number 39.

And reading the truth seen in the universe as emphasized in Al-Tagabun chapter:

خَلَقَ السَّمَوَاتِ وَالْأَرْضَ بِالْحَقِّ وَصَوَّرَكُمْ فَأَحْسَنَ صُورَكُمْ وَإِلَيْهِ الْمَصِيرُ
التغابن/64

3-He has created the heavens and the earth in Truth, and has given you shape, and made your shapes beautiful: and to Him is the final Goal. Sura Al-Tagabun\Number 64.

The terms book and truth were repeated equally (227 times) in the book of Allah "Qur-an" [4,5]. This reveals that the truth is the same in both the words of God and his creation seen in the universe. Thus, reading the truth from any reference of the two helps reading it in the other. And since both references belong to a unified source, their readings cannot contradict each other. If contradiction appears, it must be in human understanding of one of the two sources. Since human understanding is not complete nor perfect, contrary to God's laws that govern the universe: they do not change or turn off as said in Fatir chapter:

... فَلَنْ تَجِدَ لِسُنَّةِ اللَّهِ تَبْدِيلًا وَلَنْ تَجِدَ لِسُنَّةِ اللَّهِ تَحْوِيلًا (43) فاطر/35
43-...But no change wilt thou find in Allah's way (of dealing): no turning off wilt thou find in Allah's way (of dealing). Sura Fatir\Number 35.

Thus, such approach provides the learner with two-eyes, each one helps the other. However superiority, as in human eyes, must be given to the eye reading the book of Allah as stated in Al-Maida chapter:

وَأَنْزَلْنَا إِلَيْكَ الْكِتَابَ بِالْحَقِّ مُصَدِّقًا لِمَا بَيْنَ يَدَيْهِ مِنَ الْكِتَابِ وَمُهَيْمِنًا عَلَيْهِ... (48) المائدة/5
48- To thee We sent the Scripture in truth, confirming the Scripture that came before it, and guarding it in safety: ...; Al-Maida\Number 5.

And in God's script at the end of Fussilat chapter:

سَنُرِيهِمْ آيَاتِنَا فِي الْآفَاقِ وَفِي أَنْفُسِهِمْ حَتَّى يَتَبَيَّنَ لَهُمْ أَنَّهُ الْحَقُّ أَوَلَمْ يَكْفِ بِرَبِّكَ أَنْ عَلَى كُلِّ شَيْءٍ شَهِيدٌ (53) فصلت/41
53-Soon will We show them Our Signs in the (furthest) regions (of the universe), and in their own souls, until it becomes manifest to them that this is the Truth. Is it not enough that thy Lord doth witness all things. Sura Fussilat\Number 41.

A promise that his verses (signs) will be revealed in both the regions of universe and in their own souls, such a promise implies the unity of science and faith. Science area is materialistic, while faith area is the soul. The book of Allah unify both in verses, thus any scientific discovery will reflect faith, also any faith verse reflects materialistic scientific discovery. To affirm such declaration, the Lord who created the universe and the souls reminds us in Gafir and Fatir chapters respectively:

لَخَلْقُ السَّمَوَاتِ وَالْأَرْضِ أَكْبَرُ مِنْ خَلْقِ النَّاسِ وَلَكِنَّ أَكْثَرَ النَّاسِ لَا يَعْلَمُونَ
 (57) غافر/40

57-Assuredly the creation of the heavens and the earth is a greater (matter) than the creation of men: yet most men understand not.
 Sura Gafir\Number 40

فَلَنْ تَجِدَ لِسُنَّتِ اللَّهِ تَبْدِيلًا وَلَنْ تَجِدَ لِسُنَّتِ اللَّهِ تَحْوِيلًا (43) فاطر/35.
 43-...But no change wilt thou find in Allah's way (of dealing): no turning off wilt thou find in Allah's way (of dealing). Sura
 Fatir\Number 35.

And in affirming unity, God says in As-Shura chapter:

وَمَا اخْتَلَفْتُمْ فِيهِ مِنْ شَيْءٍ فَحُكْمُهُ إِلَى اللَّهِ ذَلِكُمُ اللَّهُ رَبِّي عَلَيْهِ تَوَكَّلْتُ وَإِلَيْهِ أُنِيبُ
 (10) الشورى/42

10-Whatever it be wherein ye differ, the decision thereof is with Allah: such is Allah my Lord: in Him I trust, and to Him I turn. Sura
 Al-shura\Number 42.

Importance of providing students with two qualifications: strength (efficiency) and stability (trusty) completely in agreement of what God says in Al-Qasas chapter:

...إِنَّ خَيْرَ مَنْ اسْتَأْجَرْتَ الْقَوِيُّ الْأَمِينُ (26) القصص.

26-Said one of the (damsels): "O my (dear) father! engage him on wages: truly the best of men for thee to employ is the (man) who is strong and trusty. Sura Al-Qasas\Number 28.

Being specialized only by strength or by stability alone, or by both strength and stability in aspects not beneficial to the entire nation is tyranny in education. The current education in the Islamic world is divided into two sections. The first section is concerned with building societies scientifically in medicine, pharmacy, engineering, science and others. These are taught how to read the universe without reference to the book of Allah leading to strength buildup independently of the stability. This is the ethical problem of Western societies.

The other section is concerned in the stability building in the fields of education, humanity and social sciences without strength buildup. Believe in feasibility of such approach contradicts with what distinguishes human from angels is that humans have superior strength while angels are superior in stability. The result is misunderstanding the objective of creation and separation of religion from life and this is the major problem in our Islamic societies.

CENTRALIZATION OF EDUCATION IN ACHIEVING BALANCE BETWEEN COMMUNITY INSTITUTIONS

Development of any society is based on three institutions whose role is inter-related such that the objective of education (which is to benefit society and establish earth architecture) cannot be achieved unless their role integrates together: these are scientific, technical education and industrial institutions.

The objective of scientific institutions is to discover the laws governing the universe and the way to achieve architectural development, thus they represent the base of civilization. The objective of technical educational institutions, the central role, is to prepare the technical staff needed to read the laws and know the way to implement them to achieve development, thus they represent the foundation of civilization (the link between scientific and industrial institutions).

The objective of industrial institutions is to set the environment and capital needed to translate scientific research through technical staff into earth architecture, thus they represent the civilization structure of a nation (the fruit). The centralized role of education to achieve balance can be analogized through the computer example [6]. To solve any problem using the computer, three steps are needed:

- 1) *Input*: provide system determinants needed to define the problem;
- 2) *Processing*: implement theoretical ideas and methodology of solutions in a flow chart that read the input determinants and suggest a solution;
- 3) *Output*: the suggested solution either solves the problem indicating correctness of both input data and processing, or the problem stays indicating false in input or processing or both.

The script of the book of Allah (Qur-an) together with scientific institutions act as inputs, the technical education institutions and reading Qur-an (understanding the meaning of its verses) act as processing. Industrial institutions and their products represent civilization output. Such an output is the image of level and correctness of research and education. This mechanism is clearly stated in Al-Israa chapter:

وَقُلْ رَبِّ أَدْخِلْنِي مُدْخَلَ صِدْقٍ وَأَخْرِجْنِي مُخْرَجَ صِدْقٍ وَاجْعَلْ لِي مِنْ أَلَدْنِكَ سُلْطٰنًا
تَصِيْرًا (80) الإسراء/17

80-Say: "O my Lord! Let my entry be by the Gate of Truth and Honour, and likewise my exit by the Gate of Truth and Honour; and grant me from Thy Presence an authority to aid (me)." Sura Al-Israa\Number 17.

Obviously, renaissance civilization cannot take place unless integrated action and coordination exist among the three institutions. The following present details of such an argument.

Scientific Research Institutions (Input)

Aim of scientific research is to identify and apply the laws governing the universe and souls through two approaches:

- 1) Extrapolation of creation by collecting items that share the physical characteristics and uniform laws (specification) in what is known as the extrapolation method: induction.
- 2) Application of customary laws in the community including legislative acts as the practical examples in the so-called interpolation method: deduction.

If research prospects aim to detect laws that govern creation, research education aims to adjust the behavior so that the laws of ethics are in agreement with laws of creation. God defines three classes of verses in his book: verses attributed to Allah, and verses attributed to Lord and once attributed the verses to Rahman (most gracious) in the mechanism of application of the verses of Allah and Lord in Maryam chapter:

أُولَئِكَ الَّذِينَ أَنْعَمَ اللَّهُ عَلَيْهِمْ مِنَ النَّبِيِّينَ مِنْ ذُرِّيَةِ آدَمَ وَمِمَّنْ حَمَلْنَا مَعَ نُوحٍ وَمِنْ ذُرِّيَةِ إِبْرَاهِيمَ وَإِسْرَائِيلَ وَمِمَّنْ هَدَيْنَا وَاجْتَبَيْنَا إِذَا تُتْلَى عَلَيْهِمْ آيَاتُ الرَّحْمَنِ خَرُّوا سُجَّدًا وَبُكِيًّا (58) مريم/19.

58-Those were some of the prophets on whom Allah did bestow His Grace, of the posterity of Adam, and of those whom We carried (in the Ark) with Noah, and of the posterity of Abraham and Israel, of those whom We guided and chose. Whenever the Signs of (Allah) Most Gracious were rehearsed to them, they would fall down in prostrate adoration and in tears. Sura Maryam\Number 19.

Allah's saying "of those whom We guided and chose" includes anyone who seeks to be blessed. The name of God: Rahman (most gracious) refers to pair of mercies: creational mercy attributed to Allah (God) the creator and ethical mercy attributed to Lord mastermind command:

أَلَا لَهُ الْخَلْقُ وَالْأَمْرُ تَبَارَكَ اللَّهُ رَبُّ الْعَالَمِينَ (54) الأعراف/7
54-... Is it not His to create and to govern? Blessed be Allah, the Cherisher and Sustainer of the Worlds. Sura Al-Araf\Number 7.

Thus, Rahman verses are collections of God (Allah) verses and Lord verses collecting creation and ethics: theory and practice. Thus standing for God is done either through pairs of Allah and Lord verses (Qur-an: Al-Rahman verses) or individual verses of Allah or Lord: "I do admonish you on one point: that ye do stand up before Allah, - in pairs, or singly..."

In addition to clarity in script, Qur-an provides the same meaning in statistics. As an example: the number of occasions where "Allah verses الله" is used equal the number of occasions where "the Lord of the world's رب العالمين" is used and is equal to 42. This equity in number declares how to achieve balance between creation (Allah verses) and

ethics (the Lord of the worlds). Every creation verse provides strength necessary to architect the world, and every ethical verse provides stability needed to direct strength towards building and not demolition. All this clearly indicates the importance to provide balance between scientific research (seeking truth) and its translation into acts of conduct. Focusing only on one of them is tyranny in balance.

Manuals produced by manufacturers are a small example of previous ideas. A manual of personal computer for example provides detail description of the components of the computer, the hardware. Computer software's start by examining the computer hardware first, and then controls and directs its outcome [7]. A computer without compatibility between hardware and software is tyranny in balance: imagine playing cards on a super giant computer or trying to analyze a high rise building on a hand calculator.

Such combination between creation and ethic verses provides an additional advantage making it easier to learn and remember as said in Al-Qamar chapter:

وَلَقَدْ يَسَّرْنَا الْقُرْآنَ لِلذِّكْرِ فَهَلْ مِنْ مُدَكِّرٍ (17) القمر/54.

17-And We have indeed made the Qur-an easy to understand and remember: then is there any that will receive admonition. Sura Al-Qamar\Number 54.

Achieving enhanced balance between creation and ethics was the most important demand (might be the only one) in Al-Rahman chapter which speaks in its start about teaching Qur-an:

الرَّحْمَنُ (1) عَلَّمَ الْقُرْآنَ (2) خَلَقَ الْإِنْسَانَ (3) عَلَّمَهُ الْبَيَانَ (4) الشَّمْسُ وَالْقَمَرُ
يَحْسِبَانِ (5) وَالنَّجْمُ وَالشَّجَرُ يَسْجُدَانِ (6) وَالسَّمَاءَ رَفَعَهَا وَوَضَعَ الْمِيزَانَ (7) أَلَّا
تَطْغَوْا فِي الْمِيزَانِ (8) وَأَقِيمُوا الْوَزْنَ بِالْقِسْطِ وَلَا تُخْسِرُوا الْمِيزَانَ (9)
الرحمن/55

1-(Allah) Most Gracious! 2-It is He Who has taught the Qur-an. 3-He has created man: 4-He has taught him speech (and Intelligence). 5-The sun and the moon follow courses (exactly) computed; 6-And the herbs and the trees both (alike) bow in adoration. 7-And the Firmament has He raised high, and He has set up the Balance, 8-In order that ye may not transgress (due) balance. 9-So establish weight with justice and fall not short in the balance. Sura Al-Rahman\Number 55.

Allah considers the most losers are those ignoring ethic verses in his messages as declared in Al-Kahf chapter:

قُلْ هَلْ نُنَبِّئُكُمْ بِالْأَخْسَرِينَ أَعْمَالًا (103) الَّذِينَ ضَلَّ سَعِيَّهُمْ فِي الْحَيَاةِ الدُّنْيَا وَهُمْ
يَحْسِبُونَ أَنَّهُمْ يُحْسِنُونَ صُنْعًا (104) أُولَئِكَ الَّذِينَ كَفَرُوا بِآيَاتِ رَبِّهِمْ وَلِقَائِهِ فَحَبِطَتْ
أَعْمَالُهُمْ فَلَا نُقِيمُ لَهُمْ يَوْمَ الْقِيَمَةِ وَزَنًا (105) الكهف/18.

103-Say: "Shall we tell you of those who lose most in respect of their deeds? 104-"Those whose efforts have been wasted in this life.

*While they thought that they were acquiring good by their works?
105-They are those who deny the Signs of their Lord and the fact of
their having to meet Him (in the Hereafter): vain will be their
works, nor shall We, on the Day of Judgment, give them any Weight.
Sura Al-Kahf\Number 55.*

Technical Education Institutions (Treatment/Balance)

Technical education institutions aim to provide the learner with qualifications necessary for earth architecture. They do so through two key roles:

- 1) linking research to actuality updated variables. Thus, they simplify and facilitate laws to be easily connected to the largest possible audience, and
- 2) finding qualified staff to understand human achievements of scientific research and translate them into reality by providing them with two essential co-chairs:

a. Strength/(efficiency): teaching human staff technology; i.e. latest advanced ways of dealing with the problem to be solved. Or teaching human staff how to do a good job by understanding the achievements of scientific research in the specified domain, learns the mechanism of combining this understanding to reality to come up with a new product and learn mechanism of implementation of this product on the ground.

b. Stability/(trusty): teaching technical staff to play their role effectively (abide to laws: a basic principle of ethics). Contrary to what is expected that increasing materialistic scientific knowledge is the best way to reduce failures, practically the largest percentages of failures are due to human ethics.

This means that the human does not abide by science discoveries and laws in implementation. For example: it is true that failure of structures subjected to earthquakes are larger in weak old structures as compared to modern strong structures, but statistical study of both types of old versus modernized structural collapses showed that the larger number of collapses in both are due to ethics: lower quality of materials used as compared to specifications [8]. This emphasizes importance of strength to produce modernized structures, and stability for quality control.

For technical education institutions to play their role effectively, they should be careful of methodology of providing students with the necessary co-chairs of strength and stability. Globalization of education makes it necessary to achieve four w's: know what (the amount of information), know why (understanding the information), know when and know where (establish importance of proof in all areas of learning and education). Here are some important details for the previous items:

(1) know what (amount of information) and Know how (education methodologies): As reading materials present the previous information necessary to understand and grasp reality, it looks like raw materials that if it fits, it will provide a good fuel for thought; and

if rotted, negated any progress to reality. Thus, Allah declares in Al-Nahl and Al-kahf chapters that his words do not run out of fuel while human words quickly run out:

مَا عِنْدَكُمْ يَنْفَدُ وَمَا عِنْدَ اللَّهِ بَاقٍ... (96) النحل/16
96-What is with you must vanish:. Al-Nahl\16

قُلْ لَوْ كَانَ الْبَحْرُ مِدَادًا لِكَلِمَاتِ رَبِّي لَنَفَذَ الْبَحْرُ قَبْلَ أَنْ تَنْفَذَ كَلِمَاتُ رَبِّي وَلَوْ جِئْنَا بِمِثْلِهِ مَدَدًا (109) الكهف/18
109-Say: "If the ocean were ink (wherewith to write out) the words of my Lord. Sooner would the ocean be exhausted than would the words of my Lord, even if we added another ocean like it, for its aid." Sura Al-Kahf\Number 18.

Since the book of Allah, the Qur-an (a universal reference) is 77407 words, the amount of information to be given must be short like a rule of thumb. This is emphasized in Al-Maida chapter:

قُلْ لَا يَسْتَوِي الْخَبِيثُ وَالطَّيِّبُ وَلَوْ أَعْجَبَكَ كَثْرَةُ الْخَبِيثِ فَاتَّقُوا اللَّهَ يَا أُولِي الْأَلْبَابِ لَعَلَّكُمْ تُفْلِحُونَ (100) المائدة/5.
100-Say: "Not equal are things that are bad and things that are good, even though the abundance of the bad may dazzle thee; so fear Allah, O ye that understand; that (so) ye may prosper." Al-Maida\5.

To interpret the foregoing, Allah provides an example for human to remember in Ibrahim (Abraham) chapter:

أَلَمْ نَرِ كَيْفَ ضَرَبَ اللَّهُ مَثَلًا كَلِمَةً طَيِّبَةً كَشَجَرَةٍ طَيِّبَةٍ أَصْلُهَا ثَابِتٌ وَفَرْعُهَا فِي السَّمَاءِ (24) تُؤْتِي أُكْلَهَا كُلَّ حِينٍ بِإِذْنِ رَبِّهَا وَيَضْرِبُ اللَّهُ الْأَمْثَالَ لِلنَّاسِ لَعَلَّهُمْ يَتَذَكَّرُونَ (25) إبراهيم/14.
24-Seest thou not how Allah sets forth a parable? A goodly Word like a goodly tree, whose root is firmly fixed, and its branches (reach) to the heavens, 25-It brings forth its fruit at all times, by the leave of its Lord. So Allah sets forth parables for men, in order that they may receive admonition. Sura Ibrahim\Number 14.

The goodly word is the Lord verses in Qur-an text. This text is stable like the parent tree. Its fruits grow on renewed understanding like the tree fruits that grows on the new branch. The old branch either can be utilized for building renewed branch or it has become firewood. This indicates the need to update all information.

To prune the tree is to remove dead branches, which have become a burden on the tree to grow and live; much like what the human needs of prune old understandings today to book of Allah to grow instead new understandings suitable for present times.

There are two main methodologies of education (know how): indoctrination method based on memorization of knowledge and thinking method based on several hierarchy

steps starting from understanding of the knowledge and its applications, to analysis and synthesis.

Indoctrination method produces copy designs without developments or innovations, thus unsuited for continued improvements needed for earth architecture which changes with place and time due to different design determinants. Not a single word in the whole Qur-an asks for memorization of information.

The thinking method produces development and innovation designs which are a characteristic of human for qualification of ruling the earth. This is why such a job (earth architecture) is given to humans with lower mark in stability, instead of angels who have lower mark in scientific strength qualifications as evident by their talking in Al-Baqara chapter (which is similar to an introduction as it comes at the start of Qur-an):

قَالُوا سُبْحَانَكَ لَا عِلْمَ لَنَا إِلَّا مَا عَلَّمْتَنَا إِنَّكَ أَنْتَ الْعَلِيمُ الْحَكِيمُ (32) البقرة/2
 32-They said: "Glory to Thee: of knowledge we have none, save what Thou hast taught us: in truth it is Thou Who art perfect in knowledge and wisdom." Sura Al-Baqara\Number 2.

Therefore, it is unworthy to educate humans with minds (the binding strength and development) by indoctrination method. Instead, the human must first learn to understand the Godly script that doesn't change, and then to develop his understanding by the methodology of thinking to address the problems of the constantly changing earth architecture. God warned human beings not to disable the quality of thinking because of ignorance or imitating parents, as stated in Al-A'raf chapter:

وَإِذْ أَخَذَ رَبُّكَ مِنْ بَنِي آدَمَ مِنْ ظُهُورِهِمْ ذُرِّيَّتَهُمْ وَأَشْهَدَهُمْ عَلَى أَنْفُسِهِمْ أَلَسْتُ بِرَبِّكُمْ قَالُوا بَلَى شَهِدْنَا أَنْ تَقُولُوا يَوْمَ الْقِيَمَةِ إِنَّا كُنَّا عَنْ هَذَا غَافِلِينَ (172) أَوْ تَقُولُوا إِنَّمَا أَشْرَكَ آبَاؤُنَا مِنْ قَبْلُ وَكُنَّا ذُرِّيَّةً مِنْ بَعْدِهِمْ أَفَتُهْلِكُنَا بِمَا فَعَلَ الْمُبْطِلُونَ (173) الأعراف/7
 172-When thy Lord drew forth from the Children of Adam from their loins, their descendants, and made them testify concerning themselves, (saying): "Am I not your Lord (Who cherishes and sustains you)?" They said: "Yea! we do testify!" (this), lest ye should say on the Day of Judgment: "Of this we were never mindful." 173-Or lest ye should say: "Our fathers before us may have taken false gods, but we are (their) descendants after them: wilt Thou then destroy us because of the deeds of men who were futile?". Sura Al-Araf\Number 7.

Ignorance is a product of not being knowledgeable of Allah's verses, and the great injustice is in heroes concepts that do not fit reality which leads to a failure in developments and innovations.

(2) *Know when and know where (Evidence/verification)*: the universe is ruled by a single system perspective, this system has global way of functioning with similar laws. However, we cannot study (analyze) it as a unit. Thus, we need to discretize it first and study the laws governing its parts, and then try to establish a common system that

combines all these laws into a unified theory. This approach faces researchers with growing disabilities in both methodologies of scientific research:

- a) Difficulty to discover an analytical law to the issue under discussion in more than one dimension, leading to many hypotheses or resorting to extrapolate statistical solutions. The problem in both cases is that we through hypotheses deviate from reality, and in statistics we face increasing difficulty to discover the governing law comparable to difficulty in accuracy and truthiness of collected data.
- b) Collecting previous information prior to accessing one analogical system (that governs all) became extremely difficult for the huge amount of available information, especially when easily accessed through the Internet .

Consequently, sorting the information and trying to develop a comprehensive system mounts increasing difficulty with time. The more anthropology the human understood, the more incapacity and needs for help is recognized. Especially when larger issues need solution so that the price of any additional experiences ranks extremely high. At the end of the twentieth century and the beginning of this century, emerged difficulties in digesting this vast human discoveries and revised experiments are well recognized. Thus a need for a universal reference to help the world to see his/her discoveries from a global angle is essential.

This implies the need to refer to the God book which is complete in script and oriented to all worlds to configure humanitarian vision to help us digest information and repair construction. The name Allah has chosen for this universal book is (Qur-an). The name implies the thinking methods needed by the learner to resolve problems of this growing deficit. From Al-Furqan chapter:

وَقَالَ الَّذِينَ كَفَرُوا لَوْلَا نُزِّلَ عَلَيْهِ الْفُرْقَانُ جُمْلَةً وَاحِدَةً كَذَلِكَ لِنُثَبِّتَ بِهِ فُؤَادَكَ وَرَتَّلْنَاهُ تَرْتِيلًا (32) الفرقان/25

32-Those who reject Faith say: "Why is not the Qur-a revealed to him all at once? Thus (is it revealed), that We may strengthen thy heart thereby, and We have rehearsed it to thee in slow, well-arranged stages, gradually. Sura Al-Furqan\Number 25.

It is clear that the possibility to study Qur-an as one unit is not possible. The word (Qar') means read in Arabic script, this implies understanding parts of Qur-an according to subject and to extrapolate laws for every part to be read (induction). The word (Qaran) in Arabic means combining parts read to form a global vision from which we analogize behavior of everything (deduction).

Thus, Qur-an is a combined word for methods of scientific research compiling with methods of studying the universe. The name carries the objective of messages of Allah, is to help the human to perform his duties by enhancing his ways of thinking, said clearly in Al-Nahl chapter:

... وَأَنْزَلْنَا إِلَيْكَ الذِّكْرَ لِتُبَيِّنَ لِلنَّاسِ مَا نُزِّلَ إِلَيْهِمْ وَلَعَلَّهُمْ يَتَفَكَّرُونَ (44) النحل/16.

44-(We sent them) with Clear Signs and Scriptures and We have sent down unto thee (also) the Message; that thou mayest explain clearly to men what is sent for them, and that they may give thought. Sura Al-Nahl\Number 16.

This means that Qur-an is provoking thought. Qur-an -as defined by the sender- is a book of pairs and analogy as defined in Az-Zumar chapter:

اللَّهُ نَزَّلَ أَحْسَنَ الْحَدِيثِ كِتَابًا مُتَشَابِهًا مَّثَانِي (23) الزمر/39

23-Allah has revealed (from time to time) the most beautiful Message in the form of a Book, consistent with itself (analogical), repeating (pairs). Sura Az-umar\Number 39.

The meanings of book and pairs were explained previously. By analogy it is understood that Allah provides a global explanation that applies to everything proving that there is only one God. By analogy, physical science horizons (science) are explained in psychological science (humanities) and psychological science are written in physical science horizons.

Thus it is a universal book that can be applied to human and all creatures that constitute the universe. This means that the achievement in any field in science raises the reader to understand verses in the book of Allah, which then can be downloaded on other scientific areas, making all areas posted each other a common reference represents the Charter which links all sciences together.

This will reduce the effort of researchers and activate solving any problem and deal with recent problems in best developed modern style, rather than wasted in many experiences that some result in tragic outcomes and some cost a lot disabling development and prolonging fruitful outcomes.

Humans reached through experiments that unified laws govern this universe. Doctors perform experiences first on animals to benefit from the results of their research to treat human diseases. This was revealed in the book of God in Al-An'am chapter:

وَمَا مِنْ دَابَّةٍ فِي الْأَرْضِ وَلَا طَائِرٍ يَطِيرُ بِجَنَاحَيْهِ إِلَّا أُمَمٌ أَمْثَالُكُمْ مَا فَرَّطْنَا فِي الْكِتَابِ مِنْ شَيْءٍ ثُمَّ إِلَىٰ رَبِّهِمْ يُحْشَرُونَ (38) الأنعام/6

38-There is not an animal (that lives) on the earth, nor a being that flies on its wings, but (forms part of) communities like you. Nothing have We omitted from the Book, and they (all) shall be gathered to their Lord in the end. Sura Al-An'am\Number 6.

Earth scientists and engineers combine- their findings of research on ground and in sky with humanitarian concepts as also revealed by the book of God in Ghafir chapter:

لَخَلْقُ السَّمَوَاتِ وَالْأَرْضِ أَكْبَرُ مِنْ خَلْقِ النَّاسِ وَلَكِنَّ أَكْثَرَ النَّاسِ لَا يَعْلَمُونَ (57)
غافر/40

*57-Assuredly the creation of the heavens and the earth is a greater (matter) than the creation of men: yet most men understand not.
Sura Ghafir\Number 40.*

Industrial Institutions (Outputs: Fruit)

Industrial institutions aim to develop or provide earner demanding co-chairs: local and comprehensive validity of subjective material. Local material validity means that the product's function for the time period specified by the manufacturer. Comprehensive validity makes product achieve goal if used properly without being spoiled and thus impairing things around it. If both validities are satisfied, improved balanced development on Earth is accomplished.

Thus similarities of manufacturing and material specifications versus human qualifications exist. Poor manufacturing material on local scale reflects lower strength on a human strength level, and on comprehensive scale reflects lower level of stability. The product of industrial institutions for any nation is the picture of health inputs (scientific research) and processing (technical education institutions).

Modern civilization led by the West produced high level local materialistic science because of its efficiency in reading the creation book, but failed to provide a comprehensive civilization because it did not use a universal reference book of God. This results in tyranny in balance which led to corruption in environment and collapse in ethics.

The indoctrination civilization is in deficit to achieve the required level of materialistic and comprehensive civilization which led to a decrease in balance. Scientific research institutions headed for subjective benefits like promoting researchers independently of seeking to benefit the nation and solve their problems.

Technical education institutions, especially humanitarian, are based on indoctrination to reduce costs or to gain a quick low sum rather than raise thinking and quality that requires a great effort in learning and a lot of money in spending for Renaissance. This yielded traditional architectural institutions incapable of creativity and continuous loss in balance indicating bugs in their scientific or educational institutions or most probably both [9].

SUMMARY AND CONCLUSIONS

The manuals provided by industry providers (emphasizing importance of reading them before use to make sure that the handmade works efficiently and to minimize glitches ...) presents a modern example of the importance of the universal Book of God, the Almighty Creator, for humans to provide guidelines and safeguards and warnings (if understood) that promote and improve human performance. The book of Allah combines verses of

creation with verses of ethics in single scripts, thus offering in each materialistic (physical) science an ethical code of practice. This provides learner with qualified efficiency and stability in improved balanced development almost absent in present education.

The scientific research institutions provide the base for Renaissance where you extrapolate laws, facilitate them to humans and define mechanism of architecture. They must balance between truth discovery and translating discoveries into practical ethical applications. The technical education institutions provide the foundation connecting Renaissance rules (product of scientific research institutions) with industrial institutions by providing graduate with qualified co-chairs: qualified efficiency and qualified stability (integrity). Industrial institutions are structural products of research and educational institutions. Their level is a mirror image of scientific and educational institutions. Their grade depends on level of achieving and enhancing balance without loss or tyranny in it.

Present materialistic science is inadequate to establish renaissance because of corruption and environmental collapse. This results from one-eye civilization based on trial and error, lack of commitment and letting personal interests supersedes the moral values (which yielded tyranny in balance: increased efficiency compared to decrease in stability).

Turning away from reading the book of God in the Middle East produce loss in balance; in both the efficiency/strength and in the stability. To correct our mission on Earth we must do two readings; first readings from the universe (creation) and the other from verses of the book (verses of Allah and Lord: creation and ethics) without overriding one reading over the other.

This century calls first: searching for rightness to be the fuel for thought. And calls second: the realization that the script of the book of Allah provides holistic and detail of all reality, giving us a valued neutral reference to resort any disagreement. This dual reading promises, if read and implemented correctly, to establish enhanced balance without tyranny nor loss, indicating the possibility of advancement and resolving differences and problems of all kinds to all worlds. This dual reading is called Qur-an, making its reference easy to memorize and a mercy to all the worlds.

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FIVE DECADES OF ENGINEERING EDUCATION A NOSTALGIC LOOK BACK, A BOLD LOOK FORWARD

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ABSTRACT: Up to about 1960, Engineering Education had not changed significantly from the previous five decades. Problem solutions were accomplished by using CRC Handbooks and the slide rule. The invention of the transistor in 1947, and the subsequent invention of integrated circuits would change Engineering Education forever. Main frame computers started appearing on college campuses and a high level language called Fortran made it possible to solve Engineering problems that were too daunting for students to solve in the past. Then in the early seventies the hand held calculator made its appearance. In 1972 the H-P 35calculator, using reverse polish notation, was \$395 and even though that cost was prohibitive it was the beginning of the end for the slide rule. It was only five years later that at the West Coast Computer Fair AppleII, the first real usable personal computer, made its appearance. Software manufacturers now created powerful programs that could make life so much easier for students and faculty and gave them the ability to solve complex problems within a few minutes. Super Calc, Excel, MatLab and others, were programs that provided not before seen capabilities and programs like Word Perfect and MS-Word made the type writer obsolete.

In 1962 an agency called Advanced Research Projects Agency (ARPA) was created. It was the forerunner of what culminated in 1993 into the World Wide Web. In 1968 ARPA had four Host computers, now there are millions. Information that used to be obtained through painstaking research at the library is now available with a few keystrokes. As we move into the teen years of the 21st century we see new developments that will affect Engineering curriculums. Alternate Energy sources and Nanotechnology will have a dramatic impact on course materials and will lead to completely new Engineering disciplines. What a ride it has been for those last 50 years and the excitement and impact of new devices and technologies will continue for the next half century.

KEYWORDS: The Main Frame Computer; The Slide Rule, Women in Engineering, The Internet, Nanotechnology; Energy Programs.

INTRODUCTION

When the transistor was invented in 1947 and Sputnik was launched in 1957, the impact of these milestones would be felt in the Engineering Community most dramatically from the 1960's, through the 1990's. When in 1958 Nobel Laureate Richard P. Feynman gave his now famous speech "There's plenty of room at the Bottom" to the American Physical Society at Cal Tech, he predicted one of the most revolutionary changes we are experiencing today. Nano technology is what he was talking about, and how it will affect Engineering Education is at this point even unpredictable [1].

The author, who has experienced the events over the five decades personally, starting as an Engineering student in 1958 and having been an Engineering Educator since 1968 has used the information from a paper published in 2004 about the 1960 to 1990 timeline, but has shown the changes since 2000 that will or have influenced Engineering Education. In addition to Nanotechnology, a rapid change in how we look at obtaining energy from

sources other than fossil fuels, will have an impact on courses in Engineering curriculums, or will spawn completely new programs. We have come from the slide rule as a computational tool to the point where the cell phone has the capability of a main frame computer in the 1960's. Where in five years the phenomena of Facebook has gone from zero subscribers to 400,000,000. Where the number of host computers of the Internet has gone from 4 in 1968 to over 700,000,000 now. We, as Engineering Educators, have a responsibility to decide where we are headed, how we can cope, and how we can use the new tools to our greatest advantage.

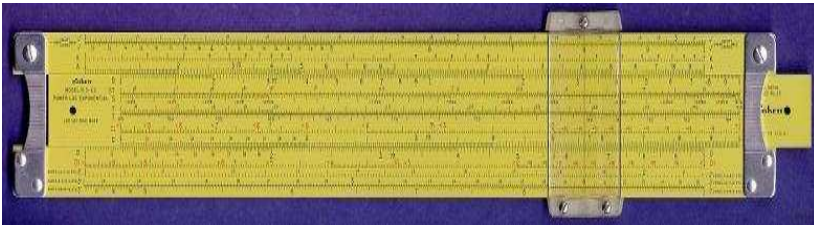


Figure 1: Example of a slide rule: This one is a Pickett [2].

What a change from the simple device shown. Yes, one could multiply, divide, use Log functions, trig functions and LogLog scales on this device, it was our computer, our calculator. Slide rules did not have decimal points so it was essential that one knew the approximate magnitude of the answer before it was put down on paper.

THE 1960's

The space race was on and so was the Vietnam war. Many engineers ended up in the service and many ended up in defense industries. As technology in the defense industries and the space race leapfrogged this filtered down into the university community and computers used for mainly administrative purposes were now engaged to be used for student problem solving. Here were computers like the IBM 360 series and the DEC pdp series (The first ones that were not built for just special applications) that took up large rooms which were air conditioned and could support various programming languages. The Fortran language was very popular for solving many problems that previously had taken hours and hours of manual calculations. Now a complex fourth order Mesh could be solved, where previously it was nearly impossible.

Although the use of mainframes as shown above increased the calculation ability greatly, it was still a batch process with turnaround times of as much as 24 hours. Punch cards would have to be keyboarded and if one mistake was made, one had to start all over again.



Figure 2: IBM 360 series computer [10].

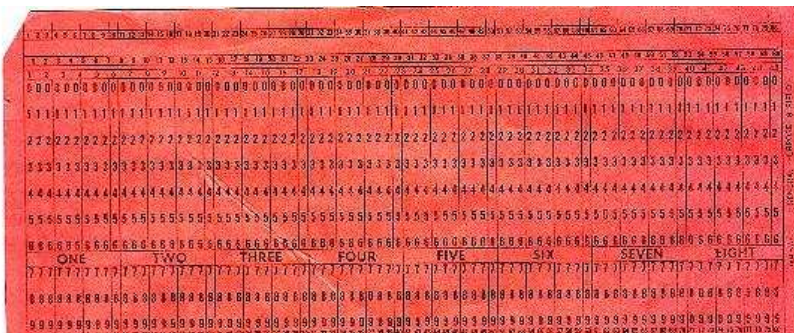


Figure 3: Punchcard as used with batch processing.

As the end of the decade approached and large scale integration became common, the minicomputer made its debut and many Engineering departments acquired units like the HP-2100 series. Large desktop calculators made their entrance, but the expense and their size made it prohibitive for students to own. Another computational language was introduced. It was called BASIC and it made inroads into the exclusiveness of FORTRAN, mainly because of being much more user friendly [10].

THE 1970's

The Vietnam war was coming to an end , long hair was in , gas lines were long during the oil embargoes, students in colleges and universities were introduced en masse to all kind of drugs brought back by the Vietnam vets. More and more of the baby boomers were attending college and numerous new schools were built and especially the Community

College boom was initiated. What was happening in the Engineering areas? In 1972, Hewlett Packard introduced the HP-35 [9], which was followed very quickly by the very successful HP-45. Both of them were touted as “Slide Rule Pocket Calculators”(Figure 5), and even though initially over \$200 (Equivalent to about \$1000 in today’s money) they spelled the doom of the instrument Engineers and Scientists had used for centuries, the Slide Rule. Other manufacturers like Texas Instrument quickly followed suit and in 1980 Keuffel & Esser (Known as K&E) quit making Slide Rules.

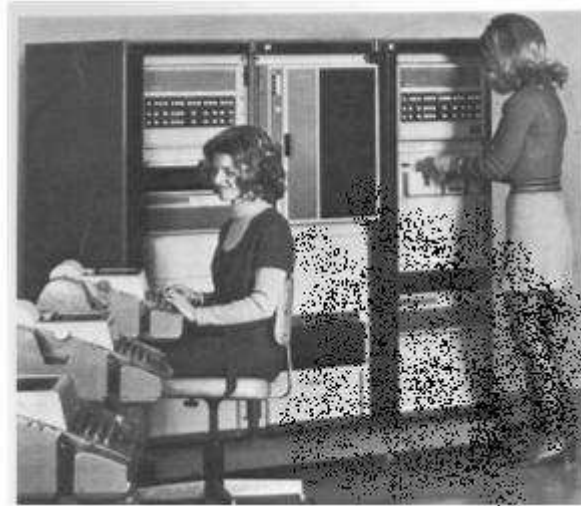


Figure 4: Example of a HP-Computer.



Figure 5: Hewlett Packard’s Slide Rule Pocket Calculator [9].

HP calculators used reverse Polish Notation and employed LED displays initially, which was quite hard on battery life and they had to be recharged very frequently. Not only did revolutionary changes occur in the area of personal calculation but Intel put in succession

several single chip microprocessor chips on the market. Starting with the 4004, the 8008 and the 8080 the path to more and more powerful devices and computers was laid down. The dizzying speed of innovation challenged Engineering departments across the board to rise to these challenges. New courses had to be created and others discarded and especially in the Electrical Engineering curriculums some tough choices had to be made. Power and machinery courses were the first ones to go and Communication courses were curtailed in favor of Digital Logic and Microprocessor and Thick and Thin film courses. So much new and interesting design was happening in the Electrical Engineering areas that all of this new material just would not fit into the normal curriculum areas and the Computer Engineering curriculum was born. In 1972 PONG was introduced, and was an instant success. The dawn of the computer game had arrived and generations of new students would sit in front of their various game designs and play these games for hours.

For decades most prospective Engineers had taken Mechanical Drawing or Drafting. Borne in the early sixties, a process called CAD (Computer Aided Design), was starting to make another tradition obsolete. Using software that could draw most intricate shapes quickly and accurately and eventually in 3-D, would now replace the drawing board, the protractor and the mechanical pencil. CAD and CAM (Computer Aided Manufacturing) would be the operational mode of all manufacturing companies. Software courses and instructions to learn about PLC's (Programmable Logic Controllers) were integrated into various curriculums. It was not just Fortran anymore, but a new language called C had made its debut, initiated by programmers at Bell Labs.

The cost of a slide rule was about \$20, the cost of a good calculator over \$100 and the cost of the next device would be from about \$1000 to several thousand Dollars. More and more powerful microprocessors, IBM's development of the Winchester Hard Drive and innovations in display technology resulted in the first useful Personal Computer, the APPLE II. Displayed at the West Coast Computer Fair in 1977, it would lead to a boom in personal computers which has not stopped.



Figure 6: Apple Ii Personal Computer Shown In 1977 [4].

Changes did not occur in just the computing field and the technological advantages for faculty and students, but the makeup of the student population was changing as well. In 1966 the number of females receiving BS Engineering degrees was 146 out of a total of

nearly 36000. In 1979 that figure had risen to 4881 out of a total of over 53000. Even though this was a phenomenal rise in 13 years, percentage wise it was still under 10%. If one looks at the statistics of Ph.D. degrees the numbers are much lower. 8 females out of a total of 2301 in 1966 and 62 out of a total of 2494 in 1979. Since an influx of foreign students has contributed to the totals above, some of the results would have been skewed somewhat. This would be especially true at the Master's and Doctoral levels [5].

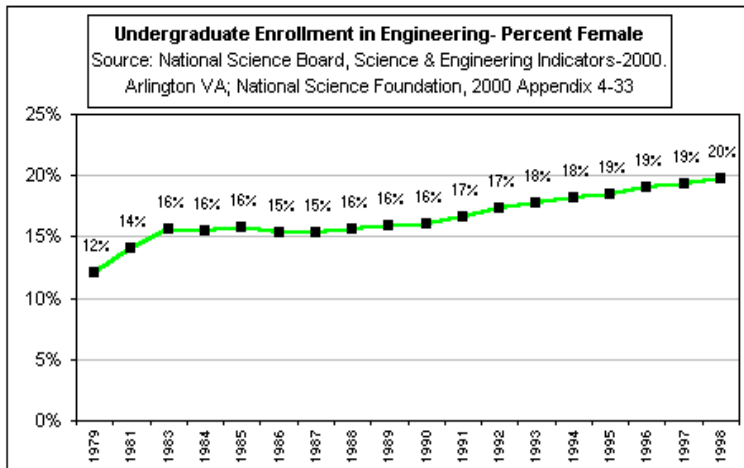


Figure 7: Women in Engineering Disciplines 1979-1999 [6].

The total number of females enrolled in Engineering programs has stayed fairly constant from the mid 1980's. What has changed is this, the total enrollment has decreased and therefore the % of female enrollment is higher. The number of females enrolled in Engineering reached a peak around 2001 but then declined drastically to about 16.4% before recovering slightly to 17.2% in 2008.

Other more mundane changes brought about by again technological advances were the use of copy machines that did not require carbon paper. Even though Xerox Corporation had their first copier on the market in 1959, they did not appear in most schools until the 1970's. It certainly improved the quality of preparing handouts and tests. At the end of the decade Spreadsheet programs like VisiCalc, Lotus 1-2-3, Excel, and Supercalc came on the market [3]. Each one initially targeting different types of personal computers and operating systems. Oh what a great labor saving device these application programs were for faculty and students alike. Many problems could be solved using the built in functions and one did not have to resort to writing programs to get a quick answer. Keeping track of grades was now so much simpler and getting final grade results at the end of a semester was a snap.

The continuous advances in all areas of technology gave rise to the establishment of night school programs. To keep up and to possibly better themselves many employees of small

and large companies would attend courses in all areas of Engineering. To get a degree this way would normally take as much as 8 years, and even though it was a hard road to travel, thousands would be engaged in the pursuit of this. The term of lifelong learning was coined and in order to stay abreast of a continually changing world, employees in especially high tech companies would have to continually upgrade themselves. [10]

THE 1980's

The innovations and progress in the 1970's resulted in an explosion of products in the 1980's. If one would categorize this decade from a technology perspective it would have to be the decade of the rise of the personal computer. At least a dozen companies got into the fray to sell computers to the masses and even IBM who was considered a main frame supplier got into the act in 1981 with its IBM PC, which was followed by the XT and AT. Clock speeds were headed toward 20MHz and RAM was 512Kb. Just looking back at the APPLE II, it had a clock speed of 1MHz and a RAM of 4Kb. Many Engineering students got their introduction into personal computing from the Commodore 64. Approximately 20 million units were sold and the best part of it was its price of around \$400. Engineering departments around the country were scrambling to keep up with this frenzy and computer labs sprung up for student and faculty use. Many of them were open for 24 hours and usually 1 or 2 proctors were assigned to each lab.

To keep up with the advances and the spiraling costs, tuitions increased at record rates and some Engineering schools required their incoming Freshmen to buy their own computers. Along with computer sophistication came advances in all areas of electronics and instrumentation. Up to date Laboratories were equipped with networked instruments and results of experiments could be printed out, could be stored and could generate graphs and diagrams. In order to keep up, faculty would spend much time to generate equipment grants from private industry and from the National Science Foundation. Some schools would employ professional grant writers to make sure that they got part of their equipment grant pie. Enrollment in Engineering schools was at an all-time high but as shown before, female enrollments still lagged far behind. In the mid 80's NSF sponsored aggressive programs to remedy this situation. Women in Engineering programs boosted the total number to above 11000 enrolled. However since then this number has been fairly constant and in some cases has decreased.

Storm clouds were gathering at the end of the decade in the Engineering enrollment area. The baby boom birthrate bubble was about to burst. Lower birthrates in the late sixties and early seventies diminished the number of high school graduates in the late 80's and Engineering enrollments plummeted from a high of about 78000 in 1985 to 62000 in 1991. Schools were scrambling to attract students with incentives of various kinds which of course usually meant good scholarships. All of a sudden the sellers' market had turned into a buyers' market. Programs were developed to make sure that once a student enrolled they were kept in school, preferably in the department they enrolled in. Prep programs sprouted and Administrators looked unkindly at Engineering faculty that had a high failure rate in their classes.

To list all of the advances in technology during this decade would take too much space. However there are a couple advances that should be mentioned. In 1984 a powerful Word Processing program was introduced. It was called Word Perfect. It not only changed the life of thousands of secretaries but it had great impact on faculty and students as well. At about the same time another very powerful program was introduced. It was called MatLab and with its Toolboxes and practical approach to programming, was soon a staple in many departments and industries.

One aspect of technology development will be left to the discussion of the next decade. The influence of these developments did not just affect the Engineering community but they have changed the world and its impacts will be recorded in history as one of the major milestones [10].

THE 1990's

It is the decade identified by Internet and World Wide Web. They are the milestones previously mentioned. Who could have perceived about 30 years earlier when the Advanced Research Projects Agency, also known as ARPA was created, that from those humble beginnings a system would develop that has affected nearly all of humanity. When one follows the development through the years from 1962 through 1993 the following developments should be recorded. Packet switched network, TCP/IP, INTERNET, ETHERNET, BITNET, USENET, CSNET, T1line, and the culmination of it all in 1993 as the World Wide Web (www) [1]. Thousands of Engineers and hundreds of Engineering Departments around the country and the world contributed to get to this point. In 1968, four Host computers were available, in 1993 there were 2,026,000 and this was just the beginning. Figure 8 shows the exponential growth of Host computers from 1968 through 2010.

In the archives of Engineering and Science dozens of names and organizations would be mentioned that were masterminding the development of the Internet. One name stands out above the rest, known to millions around the world. In the archives of Engineering and Science dozens of names and organizations would be mentioned that were masterminding the development of the Internet. One name stands out above the rest, known to millions around the world. It is of course Bill Gates. Just a couple of highlights on the life of one of the major architects of the Internet. In 1973 he brags to one of his friends in prep school that he will make his first million by the time he is 25. Along with a friend they develop BASIC programs for the Altair computer company during 1975 and at the same time start the TRAF-O-DATA company. In 1976 Bill Gates drops out of Harvard to devote himself full time to a company that was incorporated in November of 1976 as MICROSOFT. The rest of course is the meteoric rise of that company and its founder and whoever turns on a computer today will most certainly see that well known logo of Microsoft.

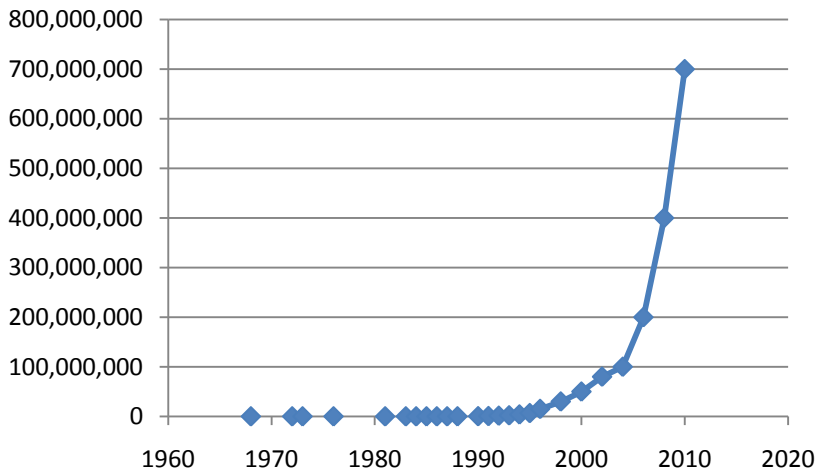


Figure 8: Number of host computers over 40 years [].

The development of faster computers with more memory in both RAM and hard drives continued. In 1993 Intel put the Pentium processor on the market and the mid 90's PC's were now running at speeds of up to 120MHz and RAM was up to 16Mb. Disk space was up to 200Mb. Windows 95 was followed by Windows 98, which was then upgraded to Windows 2000. Every time a new Pentium chip came on the market clock rates doubled or tripled from the previous design and we are now at about 3 GHz. A similar statement could be made about RAM and Diskspace.

What were the effects on Engineering and Engineering Education? Well it was not just the accessibility to all kinds of information at the click of a button but the development of ever faster processors and the development of newer and better and easier software that affected not just Engineering Education but the whole University and College community. Access to the most sophisticated databases was now possible and presentations to large groups of students in networked computer labs became common. Simulation of intricate designs was enabled by powerful software and information obtained through the Internet. Laptops are as common as calculators used to be and preparation of lectures and presentation could be done on the run. Distance education started flourishing and E-Mail interaction was as common as telephoning. 3-D graphics for animation and CAD were introduced and Virtual Labs could be used in many Engineering applications. Asking what the effects were and are, is still being sorted out and as we march forward into the first decade of the 21st century we will be surprised by the next innovation around the corner [10].

FROM 2000 TO NOW

If one were to put a general stamp on the 1st decade of the new century it would be one of cell phone overload and mass expression masquerading as individualized expression.

How else would it have been possible to have a worldwide network like Facebook (Which did not exist before 2004), to go from nothing to 400,000,000 subscribers in six years. With Wireless available throughout the world, with very few exceptions, one can be as close to home and E-Mail information as is possible. The same thing can be said about the cell phone, which has changed from a phone to a sophisticated small computer. Can your student's text someone on the outside for the answers to your exam? Do we have to put a Faraday cage around each classroom? Zip drives have storage capabilities of 6 Gigabits and approach the DVD as a storage medium.

Even though some of the above developments overshadow some of the other technological developments, one wonders about Richard P. Feynman's famous speech about all of the room at the bottom. It was the Scanning Tunneling Microscope developed in 1981, which was followed by the Atomic Force Microscope in 1985 that would make it possible to do extensive research into the world of Nanotechnology. At 10⁻⁹ meter, one now is looking at atomic structures and once it was possible to look at these structures a flurry of activity commenced in the 1990's but the real impact of Nanotechnology has not been felt until a couple of years ago and it will change the way we look at many areas in Engineering. Just about every major university now has a Nanotechnology department and every week on ASEE's First Bell, announcements of new products, using nano-particles, is given. In 2001, the Federal Government created the National Nanotechnology Initiative (Recognizing the Importance of this Technology) and in 2008 the NNI budget was 1.5 billion.



Figure 9: The Author working with an Atomic Force Microscope at Penn-State.

It is not only Nanotechnology that is making news, changing engineering curriculums is demanding attention. Alternate energy sources, their development and their viability are at the forefront of serious discussions in Engineering departments around the world. How can one fit all of this new information into present curriculums? Impossible! Even though alternate energy is only about 7% of the total energy spectrum, it will certainly command a larger portion of the total energy pie in the near future. It is not just Petroleum

Engineering or Nuclear Engineering any more, but Biomass, Biodiesel, Ethanol, Solar Power, Wind Power, Geothermal are pieces of the total energy mix. Curriculums in Energy Engineering seem to be the answer. If based on the same rigorous math and science background as any other Engineering program they should be successful.

CONCLUSIONS

It has been over 52 years since a young man (the Author) trudged to the campus of a Midwestern University and enrolled as an Electrical Engineering student. He is an old man now but has had one of the most exciting rides life has to offer and the ride continues. From the day buying his first slide rule to now being deeply involved with the study of Nanotechnology and alternate Energy sources, life has been a love affair with technology and innovation. It has been and still is an honor to be an Engineering Educator and to try to instill in future generations the drive to make the world a better place through Engineering. We have always been the ones that have invented, improved, eliminated drudgery, made all advances in transportation, medicine, entertainment, communications, household chores, construction and many other areas. Life without Engineers and Engineering Educators would not be possible.

What exciting things does the future hold? For sure we will see more powerful computers. Will clock speeds be at 10 or 20GHz? Will robots take over in many areas? Will we still teach in classrooms or will it be cyber education? Whatever the technological future holds it will be Engineers and the ones that prepare them to be Engineers that will determine that future.

ACKNOWLEDGEMENT

I would like to acknowledge the role the computer played in the preparation of this paper. It would have been extremely difficult to do some of the research, the preparation and the execution of the document without it. Numerous workshops on Nanotechnology, Biodiesel, Biomass and Ethanol provided by the University of Buffalo and Penn State with sponsorship of NSF gave me the background to talk about these topics.

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DEVELOPMENT OF HIGHER EDUCATION IN JORDAN

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ABSTRACT: Higher education in Jordan has grown drastically in the last decade. The number of students, teaching staff and universities has been duplicated many folds. This study will focus on the development of higher education components in general and the development of engineering education in particular between the years 2000-2010. The study will show statistics about the government and private universities indicating number of students, specializations, and course programs given. The development models of higher education components will be formulated. The annual growth rates of higher education components will be compared with population growth rate. The relationships between number of students and teaching staff will be graphically presented.

KEYWORDS: Higher Education; Engineering Education; Jordanian Universities; Development Models; Accreditation.

INTRODUCTION

Higher education in Jordan falls into two categories: universities and community colleges. There are public and private institutions of both. Enrollment rates to higher education have risen dramatically over the last 10 years, today just over 3.65% of Jordan's total population is enrolled at university, a proportion comparable to the United Kingdom [1].

Jordanian universities largely follow the Bachelor and Master system. A Bachelor is 4 years in most fields; Dentistry, Pharmacy and Engineering are 5 years, Medicine 6 years. A Master study follows the completion of a Bachelor's and takes 2-3 years. Teacher education is part of the university system. All teachers must obtain a Bachelor; secondary teachers must in addition pass one more year of study to obtain the Higher Diploma in Education.

According to the World Bank report no. 46824-JO [1], Jordan spends 0.4 percent of his GDP on higher education. This amount counts for 14% of total education expenditures. The country has many universities compared to the size of the population, one per 250,000 inhabitants, which is no. 3 in Middle East and North Africa (MENA) region. These rates are low when compared to other middle income countries and to the Organization of Economic Cooperation and Development (OECD) average of 1.6 percent of GDP. Government transfers to universities have declined from JD 60.4 million in 2004 to JD 52.6 million in 2007 and JD 45 million in 2008 [1].

HIGHER EDUCATION IN JORDAN

Evolution of Higher Education

The higher education in Jordan has started since the middle of the past century. Before that the students used to continue their higher education in other Arabic and World Wide universities. Higher education in Jordan started in 1951 with a one year postsecondary teacher training class [2]. The first Jordanian governmental; so called state or public; university was established in 1962 in Amman and was named "Jordan University". Followed by Yarmouk university in Irbid in 1976, Mu'tah university in 1981, Jordan University of Science and Technology in 1986, Al-Albait University in Mafrq in 1994, The Hashemite University in Zarka in 1995, Balqa Applied University in Salt in 1997, Al-Hussein University in Ma'an in 1999, Tafila Technical University in 2004 and the last state university was the German–Jordanian University which was established in 2004. The first 4 state universities (Jordan, Yarmouk, Science and Technology and Mu'tah) are considered relatively old, the rest which were established after the year 1986 are considered new.

The idea of establishing private universities came into existence since 1990, after which about 16 universities were granted licenses and accreditations. Private universities are all in the northern and central regions of the country where the population is dense. They are Amman Private University, Philadelphia University, Al-Isra University, Applied Sciences University, Petra University, Al-Zeitunah University, Jerash Private University, Al Zarqa Private University, Irbid Private University, Educational Sciences College, Princess Sumayya University, Jadara University, Middle East University, Amman Arabic University and Jordanian Academy for Music.

Article 3 of the University Law of 2009 summarizes the formal functions of the universities as follows: to offer university study opportunities; to encourage scientific progress and serve the society; to provide the country with specialties in different fields; to pay special attention to the Arab-Islamic civilization and spread its heritage; to participate positively in international thought; and to strengthen cultural and scientific ties with other Arab and foreign universities and scientific organizations.

Fields of Study

In order to fulfill their functions, Jordanian universities teach different aspects of knowledge. In the year 2009, a total of 219227 Students at B.Sc level are distributed among 20 fields of study [3] as shown in Figure 1. The figure shows that 12.1% of the students study engineering.

Non-university higher education is offered at Community Colleges, which were created in 1981 by converting and expanding the existent Teacher Colleges. These institutions are meant to offer specialized, career-oriented training. All community colleges are supervised by and affiliated to Al- Balqa Applied University, a Jordanian public university [4]. About 30061 students are enrolled in community colleges. Students in

these colleges study 2 years before they awarded the Diploma degree. Their fields of study are shown in Figure 2.

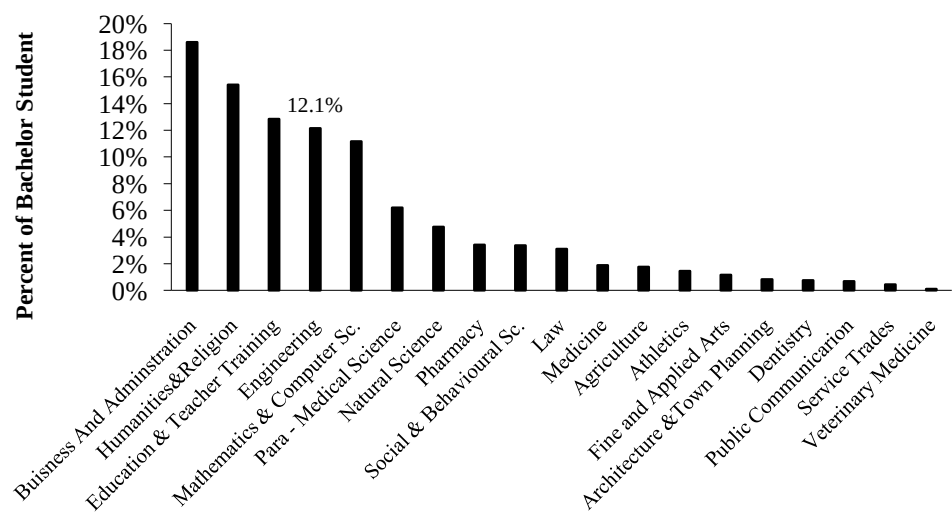


Figure 1: Distribution of Bachelor Students According to their Field of Study.

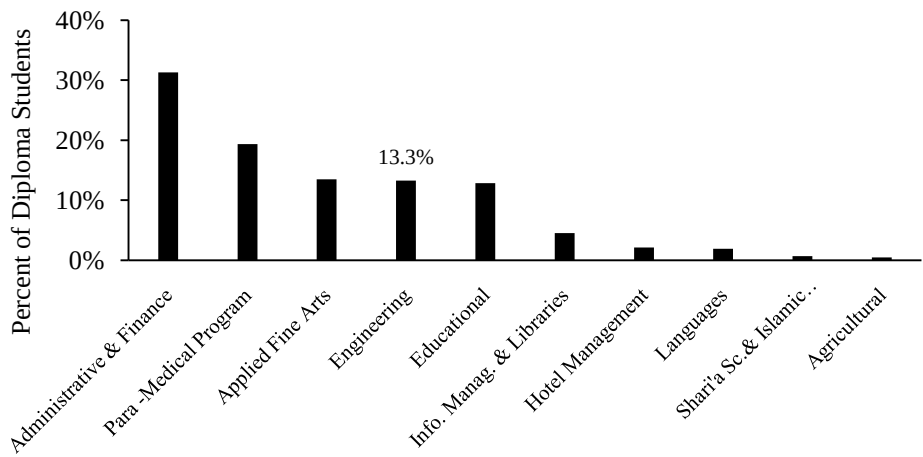


Figure 2: Distribution of Community College Students According to their Field of Study.

Governance

The Ministry of Higher Education was established in 1985 with a mandate that included controlling the process of random pursuit of specializations by students and, rather, coordinating specializations with the development needs of the country. Public and

private universities are governed now by the Law of Higher Education. Accordingly, each university should have a university council, deans council, faculty councils, and departmental councils. The current administrative organization is as follows:

Higher Education Council (HEC): Legislation governing higher education in Jordan was first passed 6 April 1980. This marked the formation of a council that plans and coordinates higher education in Jordan and lays down its general policies. This Council is chaired by the Minister of Higher Education.

University Board of Trustees: Jordan Universities law (2009) state that each university should have a Board of Trustees consists of 13 members for each public university and 15 members for each private university.

The objectives of higher education are to graduate students for the needed manpower in the various fields of knowledge, including sending students for study outside Jordan.

University Council: Jordan Universities law (2009) states that each university should have a university council, chaired by the university president. Its members are: all vice presidents; all deans; a member from each faculty elected by the faculty to serve for one year subject to renewal; the directors of two administrative units at the university, appointed by the president for one year; three members of different backgrounds from the local community, recommended by the president and appointed by the Board of Trustees for one year; one student, selected by the president, for one year; and one member from the university alumni, selected by the president, for one year. The university council is responsible for developing general policy for the university; evaluating university activities and examining the president's annual reports; strengthening the relationship between the university and the public and private sectors; looking into university regulations and plans; and preparing the budget for approval by the Higher Education Council.

Deans Council: The deans' council is chaired by the university president. Its members include all vice presidents and deans. It is responsible for appointing and promoting faculty members; approving faculty sabbaticals and other leaves of absence; and approving the curricula of the various faculties.

Faculty Council: The faculty council is chaired by the dean of the faculty. Its members are all vice deans; heads of all departments of the faculty; a representative from each department, elected by its faculty members for one year; and two experienced members of relevant experience to the functions of faculty from local society appointed by the president upon the recommendation of the dean, for one year and subject to renewal.

Department Council: Every academic staff member is a member of one of the department councils, which form the basic unit in the academic structure of the university. In the department council, decisions are made with the participation of all members.

University Density

Jordan presently has 10 state universities, 16 private universities, and about 6 million inhabitants, corresponding to a university density of 250,000 inhabitants per university

[5], placing Jordan as no. 3 of 22 in the Middle East and North Africa (MENA) region as shown in Figure 3.

The information in Figure 3 is provided to illustrate the size and development stage of infrastructure for higher education. The information is only valuable if used together with other information, simply because the quality of institutions and size of institutions are not reflected. For comparison, Sweden has one university per 580,000 inhabitants; and Canada one per 410,000 inhabitants. Overall, the countries doing best in modern development average at around half a million inhabitants per university.

As a general rule, high density can be just as negative as low density. High university density can suggest overstretch of resources, both human and financial. It can also cause each institution to become too small to provide enough force for its scientific communities and research.

Low density is, naturally, a negative indicator to the extent that it reflects insufficient capacity compared to the population. For developing countries, a low density may be positive to the extent that not too many candidates are graduated for a work life with limited number of relevant jobs.

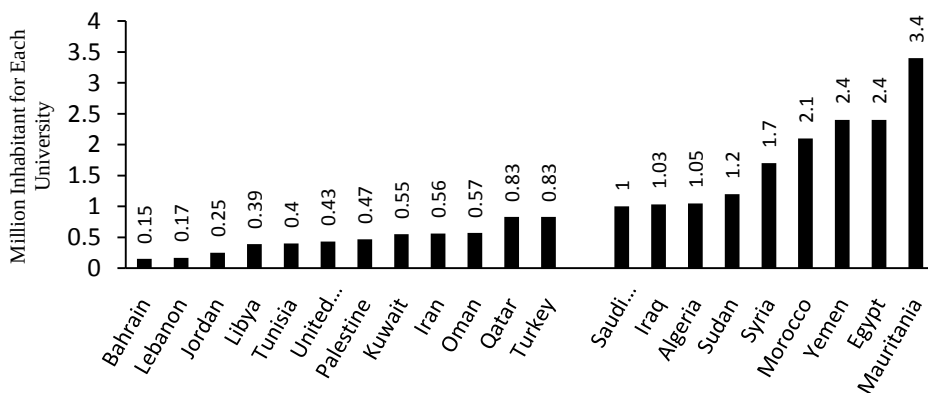


Figure 3: University Density for Middle East and North Africa Countries (Source: <http://looklex.com/e.o/index.education.universities.density.htm>).

DEVELOPMENT OF HIGHER EDUCATION COMPONENTS

Development of Universities

Universities are considered as indicators of the greatness and advancement of nations. They are looked at as centers of enlightenment and research and the incarnation of culture in its broad meaning: thought, literature, science and technology. The first Jordanian state (public) university was founded in 1962. The last one was in 2004. Private universities

were granted permission in 1990. Since then; 16 private university or university colleges were established. The period between 1990-2005 has experienced a noticeable growth in number of universities. During this period, public universities in Jordan could not accept all applicants and because of this shortage a number of private universities run and financed by companies have emerged. Figure 4 shows the development in number of universities (public and private). It can be seen from the figure that the number has jumped from 6 to 13 in one year (1991). That is because six private universities were licensed in that year.

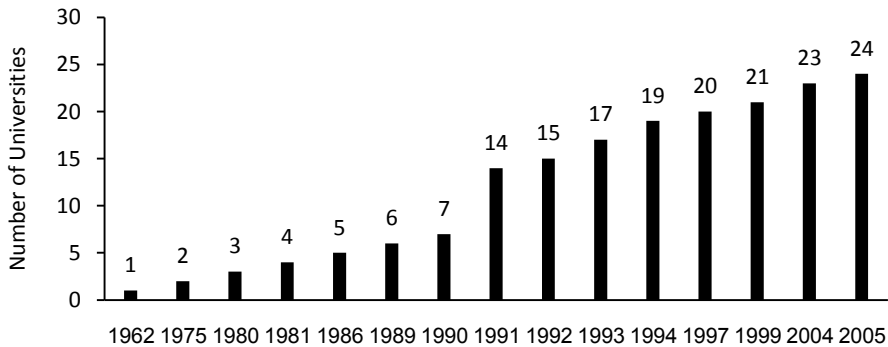


Figure 4: Development of Jordanian Universities.

DEVELOPMENT OF ENROLLMENT

Bachelor Level

During the last decade the number of B.Sc student enrollment in the Jordanian universities has increased from 105813 in 1999 to 219277 in 2009. This counts for an annual increase rate of about 7.5%. The annual rate of increase in population according to the Department of Statistics [7] is 2.52%. Interpreting these results indicates that the annual increase in enrolment is three times the annual increase in population. The estimated population of Jordan in 2009 is 5932130 inhabitants. The percent of enrollment to population is 3.7%. Figure 5 below shows the growth histogram during the study period. The trend model is shown on the figure. The model helps to predict the number of students for future.

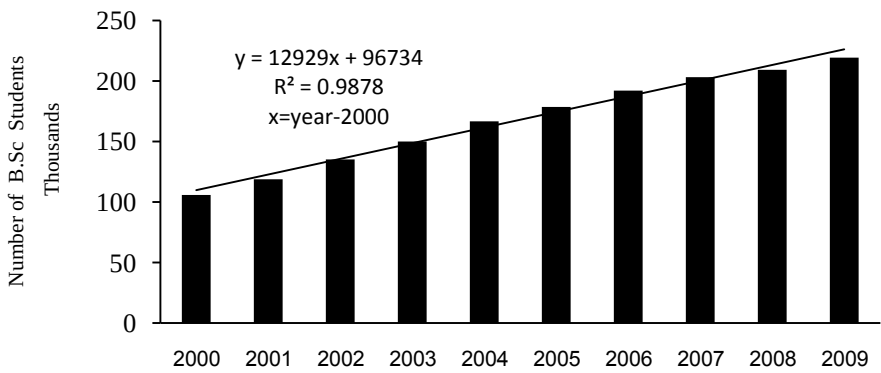


Figure 5: Development of Bachelor Student Enrollment 2000-2009.

Graduate Level

The number of graduate student enrollment has increased from 6670 in 1999 to 17543 in 2009. The years 2004, 2005 and 2006 faced a jump in graduate studies due to the opening of 3 graduate studies universities and licensing for M.Sc programs in other universities. Figure 6 shows the growth trend of graduate enrolment during the study period. The development model is shown on the figure. The annual rate of increase is 10.15% which equals 4 times the annual rate of population increase.

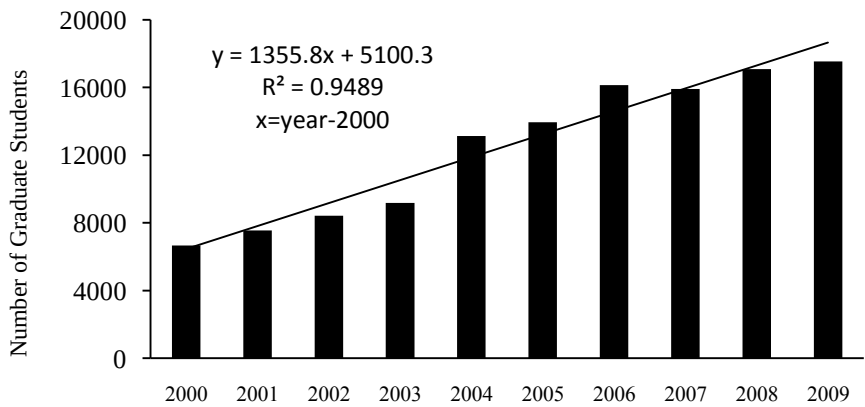


Figure 6: Development of Graduate Students 2000-2009.

DEVELOPMENT OF TEACHING STAFF

Figure 7 below shows the growth of teaching staff in higher education institutes during the study period. The development model is shown in the figure. The annual growth rate is 5.1%. This rate is not compatible with that of student (7.5%). These results indicate that there is a shortage in staff members in Jordanian universities.

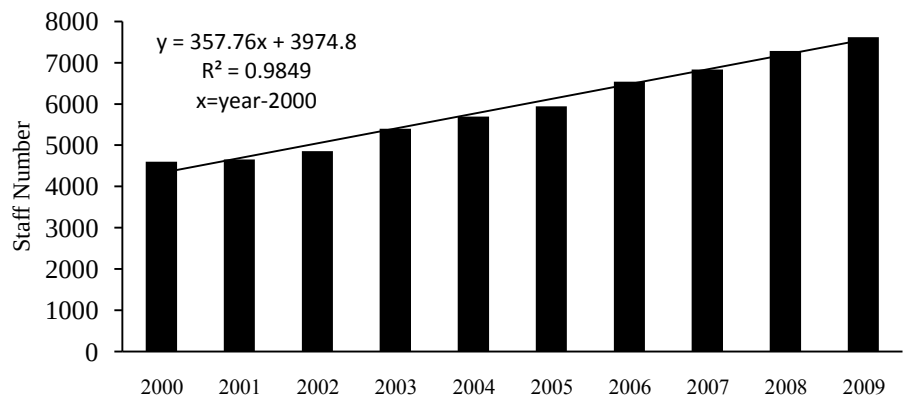


Figure 7: Development of Teaching Staff 2000-2009.

The student - staff ratio increased from 24 students/staff in the year 2000 to 31 in the year 2009 as shown in figure 8 below. This increase is attributed to the uncompetitive rates of increase in the number of students and instructors. The ratio is different between humanities and science faculties. The Jordanian Higher Education Accreditation Commission specifies 30 student/staff for humanity faculties and 20 students for engineering faculties.

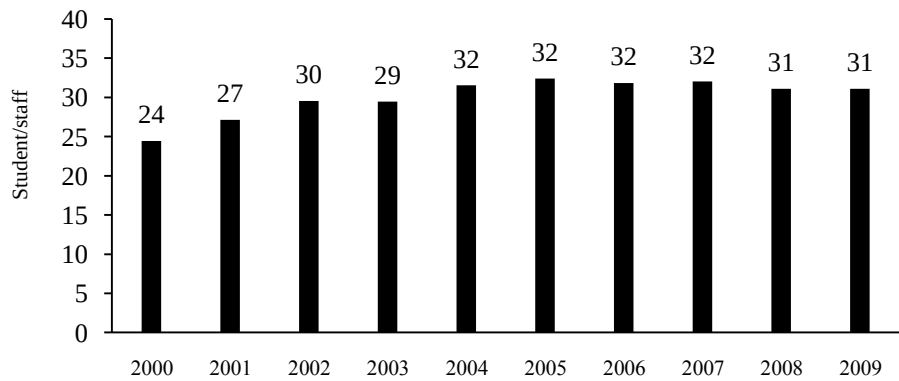


Figure 8: Development of student- staff Ratio.

DEVELOPMENT OF FOREIGN STUDENTS

Jordanian institutes accept on the average about 11% of their total enrollment as foreign students, mostly from Middle East and Gulf countries. The average annual growth rate of foreign students is about 8.5% which is higher than the total annual enrollment rate (7.5%). This development is due to the higher level of education environment offered in Jordan. Foreign students are attracted to private universities where tuition fees are lower than that in neighboring countries. Some private universities have about 50% of their student as foreigners. Figure 9 illustrates the growth in number of foreign students in Jordanian universities during the study period. The development model is shown on the figure.

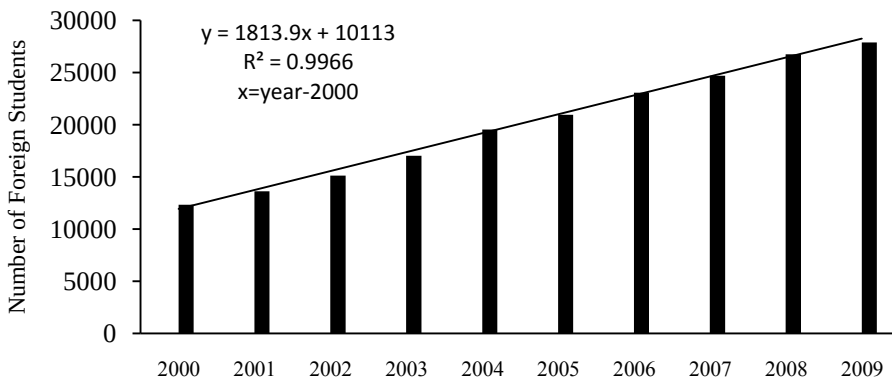


Figure 9: Development of Foreign Students in Jordan 2000-2009.

HIGHER EDUCATION IN ENGINEERING

All of the state universities include engineering faculties teaching different specializations of engineering. Most of private universities do so. The first faculty of engineering was established in Jordan University in 1975.

Engineering faculties employ academic staff members which have a strong engineering knowledge and significant experience that is constantly improved by their research efforts. The Faculties are committed to excellence in teaching to achieve their aim in bringing forth highly trained and active graduates, with strong engineering and science background and understanding through the progress of key skills, innovation, and ambition.

DEVELOPMENT OF ENGINEERING EDUCATION

As shown in Figure 1, engineering study is ranked number 4 among fields of study with about 12% of the total enrolled student. Figure 10 shows the growth in engineering

student during the study period. The model that describes this growth is shown on the figure. The annual growth rate is 10.4%. Such a rate is higher than the total rate of enrollment (7.5%). The prosperous development in construction in Jordan and in Gulf countries during the last decade is the reason for this high rate. The rise of oil prices lead to a great investments and thus for high demand for engineers.

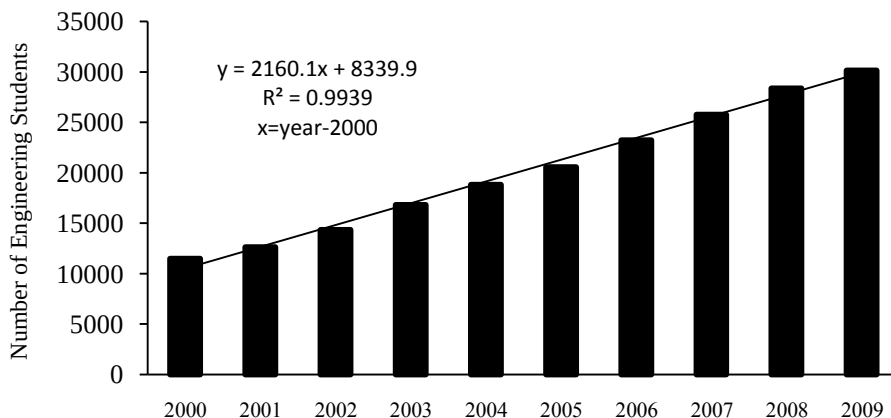


Figure 10: Development of Engineering Students 2009-2010

ENGINEERING DEPARTMENTS

The engineering departments within the faculties provide wide spectra of different engineering programs. These programs satisfy social, regional, and industrial needs in Jordan as well as Middle East countries. Most universities have the four conventional specializations like civil, mechanical, chemical and electrical engineering. The new universities have more specializations related to the latest technology and to compete with industry needs. Such specializations can be found in the German-Jordanian and Balqa universities. To fulfill the needs of the south part of the country, where natural resources exist, special departments; such as mining engineering; were established in Mu'tah, Tafila and Al-Hussein universities. It should be noted that due to its specialization in Islamic heritage; the University of Al-Albayt has only one engineering department called Islamic Architecture. Private universities have also established some engineering departments to complete the shortage in accepting students that cannot find places in state universities.

ENGINEERING CURRICULUM AND TUITION FEES

A range between 141 to 166 credit hours is required from the student in order to obtain the Bachelor of Science in Engineering in Jordan. A period of five years is normally enough to finish the requirements. The requirements are divided into three categories:

university requirements (about 16%-18%), faculty requirements (about 15%-20%) and department requirements (60%-70%). University requirements cover topics related to general knowledge including a variety of humanity courses and other courses offered by different faculties in the university. Faculty requirements imply courses needed to prepare the student for engineering such as mathematics, physics, chemistry and computer programming. Department requirements cover the core engineering design courses.

Study costs comprises of two parts: a) cost of living b) tuition fees. Cost of living depends on the regional location of the university and the standard of living required. As everywhere in the world; cost of living increases as the university gets closer to the capital. University fees implies mainly fees for credit hours and fees for insurance, computer use, library, services and other fees payable per each semester or year. Fees per credit hours consists the major part of tuition fees. These fees depend on the type of university (state or private) as well as the type of specialization. For example the cost of credit hour of engineering ranges between 20-40 JD in state universities, while it is higher than 100 JD in most of private universities. Not all branches of engineering are alike in credit hour fees. The cost of credit hour in one engineering faculty can differ according to specialization. For example the cost of credit hour of civil engineering in Jordan University of science and technology is 29 JD while the cost of nuclear engineering in the same university is 60 JD.

GRADUATE STUDIES IN ENGINEERING

Pursuing higher education in engineering is available in state universities only. Private universities are not accredited nationally to offer graduate degrees in engineering.

A score of 500 in written Test of English as a Foreign Language (TOEFL) and a GPA of GOOD or higher are two conditions for admission in graduate study at any university. Conditional GPA of PASS may be accepted. Graduate studies at the Master level exist in state universities. Higher degrees at the Ph.D level can only be offered in the Jordan University of Science and Technology in Irbid and Jordan University in Amman.

Table 1 shows summary of higher education elements development and the trend models.

SUMMARY AND CONCLUSIONS

The paper contains information about higher education in Jordan. It present comparison of higher education in Jordan with other countries in the region. It presents also information about fields of study, higher education governance, components and growth rates. Engineering education statistics and trends were given special attention.

The following conclusions can be withdrawn from this study:

1. Jordan has a high University Density among the Middle East and North Africa region; ranked no. 3 after Lebanon and Bahrain.
2. Higher Education components are growing faster than the population rates.
3. Teaching staff growth is not compatible with number of students.
4. The demand for engineers is very high compared to other fields of study.

Table 1: Summary of higher education development

Higher education component	No. in year 2000	No. in year 2009	Annual growth rate	Trend model*
Jordan Population	4687500	6000049	2.5%	
B.Sc students	105813	219277	7.5%	$y=12929x+06734$
Graduate students	6670	17534	10.15%	$y=1355.8x+5100.3$
Staff	4602	7613	5.1%	$y=357.7x+3974.8$
Foreign students	12328	27871	8.5%	$y=1813.9=10113$
Engineering students	11494	30163	10.4%	$y=2160x+8339.9$

* x = year-2000

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MULTI-SPECIALIZATION: THE FUTURE REQUIREMENT

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ABSTRACT: It is clear that advancements in science and technology give rise to develop specializations and change their types. It also causes these specializations to interfere with each other. By focusing on large scale projects, it can be realised that interference of specializations become an important condition and not a temporary case that may vanish by ending the multifarious project. In fact, matters become more complicated once a technical or scientific project is planned whether they are limited in their involvedness or boundless. From this point of view, the need arises to provide persons who are specialized with more than one field of specialization as well as computing abilities and foreign languages as well. According to the personal experience of the authors in collecting more than one specialization and making use of these specializations equally, in addition to the large number of other persons having equal abilities, it was found that it is necessary to focus on this issue of multi-specialization and show its advantages and suggest or design the proper educational and scientific procedures to achieve this aim. One way of achieving a practical procedure to provide a multi-specialized engineer, for instance, is to create new scientific departments or develop traditional ones to acquire the required specializations. This solution have been well established in famous universities such as Michigan University and Wellington Institute of Technology as well as normal level ones, such as Nahrain University and University of Technology where new departments were established and the students were graduated from these departments; (e.g. : Laser and Optoelectronics Engineering, Mechatronics, Biomedical Engineering, Engineering physics, and others). Our main theme here is to focus in depth on these important experiences in order to expand it to include most of our universities within the Arab countries and give reasons of the importance of adding or collecting some specializations to one person to be a multi-specialist in certain fields. Also the research will focus on the necessity of the society, represented by industrial projects or firms, scientific research centres, and even universities to this kind of multi-specialists.

KEYWORDS: Contemporary Issues and Engineering Education; Sustainable Development Education; Emerging New Trends; Knowledge Tacit Dimension; Multi-Agent Systems; Multitalented Engineering.

INTRODUCTION

As an overview to the Arab academic society, until recently, when a new form of department is suggested, it may face some opposition from University Board; (e.g.: Computer related departments including IT). What matters here is not the title of any department but rather the contents of its courses and the directions of researches that it will lead to. If we consider Engineering Faculties, in specific, it may be noticed that number of departments that have more than a specialization have been constructed successfully in number of Foreign as well as Arab Universities. In this respect, case studies presented here will enhance the importance of multi-specialization on personal level and in general. Focus will be on practical experiences in this respect. This paper will discuss multi-specialization as a future requirement using a broader look that projects become multifarious and requires interference of specializations. Case studies explored

will show how Academia is investing this multi-specialization issue optimally. Examples from Germany, USA, New Zealand and Japan [1-4] were given.

Personal experience of the authors inspires the idea of producing this research. One of the authors holds two higher degrees in two fields [5,6]. The other author holds a higher degree in two fields also [7,8]. In addition, both authors form a teamwork based on their background experiences [9,10].

The roll of a multi-specialist engineer arises when establishing a multifarious project and does not end by the end of the project. Also systems based on computer control and robotic applications require large number of specialists to provide such tools. In fact, examples of nowadays technology are endless in this respect, which makes decision-makers to think seriously about providing such multi-specialists, in particular, if it will lead to increase the opportunity of job finding.

PROSPECTS ON DEVELOPMENT OF EUROPEAN AND GERMAN UNIVERSITY EDUCATION

In the global world of today, the development of whole regions and countries depends on some crucial factors. Accordingly, European countries, and especially in Germany, are focusing their efforts on developing their educational systems. They want to provide excellent education for their students giving them better qualification and new job opportunities.

Challenges for Multi-Specialization of Engineering Education

Due to the growth of the global population up to 10 billion during this century, several socio-economic challenges arise. The worldwide energy consumption will increase, while the environmental conditions deteriorate because of climate changes. The future society will need more renewable technologies such as for food production, transport and exchange of goods and information. Urbanization will increase, as well as the percentage of people living in mega-cities.

This will require different technological solutions. To handle these problems, a higher number of multi-disciplinary scientists and engineers will be necessary. The requirements and competition in global education will get stronger. Since international companies need multi-specialist and internationally educated engineers, cooperation in worldwide education will be more important. Thus, engineering education of the future requires not only the best knowledge of facts and methods in natural sciences and engineering, but also a broad expertise in social and language skills, team-working in international groups, and understanding of other cultures.

ACTIVITIES OF THE FEDERAL GOVERNMENT IN GERMANY

Partners for Innovations

The German government has launched a number of initiatives in order to promote a culture of innovation and education. One initiative is called "Partners for innovations". More than 400 experts from German blue chip companies and institutions like acatech (German Academy of Science and Engineering, Germany) or the Fraunhofer-Gesellschaft worked in 15 initialization groups on concepts for a new innovation culture. This initiative included a foundation to support technical startups with a volume of 260 million Euros. In total, more than 100 single projects in nanotechnology, renewable energy, health care, transport and other fields have been supported and recommendations for actions will be given to the Federal Government, industry, and universities.

Another initiative is the so called "High-Tech Strategy", which aims at expanding cooperation's between universities and industry. It supports 17 future fields of high relevance or with high development potential (e. g. logistics, optics, laser, security and healthcare). The funding is 15 billion Euros for top level technology and service infrastructure until 2009.

The Roll of German Universities

The most prominent development in the German academic landscape is the "Exzellenz-Initiative". It was found in 2005 with the aim of increasing the competition among universities, and thus to achieve a higher competitiveness on the global level. An extra funding of 1.9 billion Euros until 2011 will be provided. This funding is divided into three fields. One field consists of the elite universities, which currently are only 3, but will be 9 or 10 by the end of 2010.

Another field consists of the 40 graduate schools, situated at different institutes. The last field consists of 30 clusters of excellence, which means the fusion of institutes working on bigger projects.

DEVELOPMENT AND INTEGRATION OF MULTI-SPECIALIZATION SYLLABUS FOR ENGINEERING PROGRAMS

In this section, a study of the multi-specialization syllabus is introduced. It will depend on Conceive-Design-Implement-Operate complex (CDIO) [1] model with accreditation standards in Europe country. As an independent check on the comprehensiveness of the CDIO Syllabus, it was compared with generic skills needed by engineers in five different career tracks. The generic skills applicable to all tracks include:

- Engineering Reasoning and Problem Solving,
- Personal Skills and Attitudes,
- Professional Skills and Attitudes,
- Multidisciplinary Teamwork,

- Communications,
- Communications in a Foreign Language, and
- External and Societal Context.

There are at least five professional tracks that engineers can and must follow, according to their individual talents and interests.

The tracks, and sections of the Syllabus that support them, are shown in Figure 1. Of course, no graduating engineer will be expert in all of these potential tracks, and in fact, may not be expert in any. However, the paradigm of modern engineering practice is that an individual's role will change and evolve. The graduating engineer must be able to interact in an informed way with individuals in each of these tracks, and must be educated as a generalist, prepared to follow a career that leads to any one or any combination of these tracks.

It can be said that this syllabus was followed partially by number of nowadays experts, way before the creation of it, when they join team works or participate in specialized training courses or follow any individual tracks presented in this syllabus. But, as a procedure to be followed, it seems to be systematic and well organized to be a plan for creating a multi-specialist engineer.

In this context, new departments at universities have been created and developed during the last two decades. These include, and not limited to, Mechatronics, Biomedical Engineering, Laser and Optoelectronics Engineering [11]. They were built according to the academic requirements and have their own syllabuses. Large number of students graduated from these departments; giving the proof that multi-specialist engineer does exist, in addition to that they do exist in Arab Universities. Appendix (A) in reference [2] provides a good example of the kind of knowledge provided by such multi-specialized departments at Michigan University.

CASE STUDIES

Based on this background, it becomes possible to discuss some case studies in depth to examine the idea of multi-specialization on the ground.

Computational Intelligence

A Coordination Perspective addresses and comprehensively answers commonly asked questions about coordination in agent-oriented distributed systems. Characterizing the state-of-the-art research in the field of coordination with regard to the development of distributed agent-oriented systems is a particularly complex endeavor, as the space of available approaches is indeed considerable, and research is independently conducted in a great number of domains.

A professor in *Computational Intelligence* said in his book about students attending his course on *Intelligent Multi-Agent Hybrid Systems* at Wellington Institute of Technology [3]: “They were really pleased to become familiar with the Intelligent Technologies and with some typical competitive software, such as Neural Network Professional II Plus and Soft Computing Genetic Tool”.

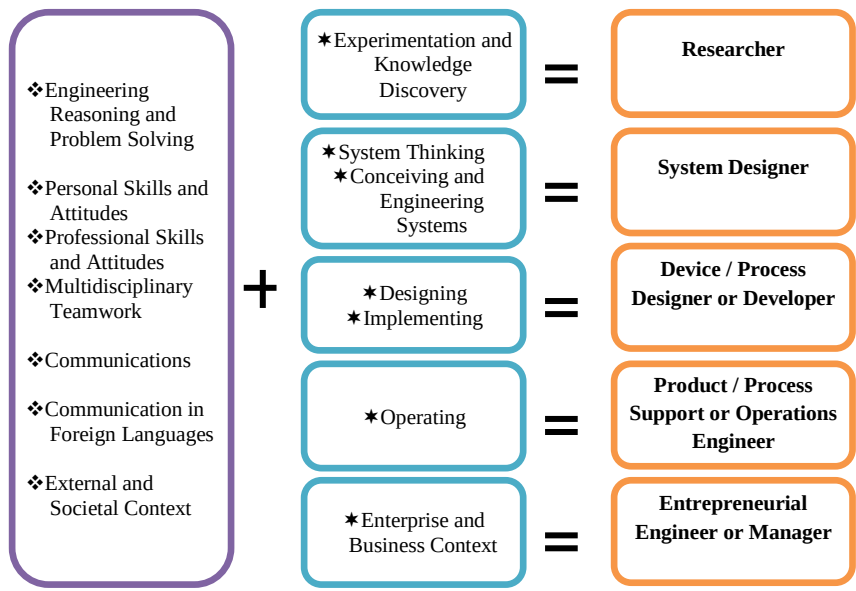


Figure 1: Professional engineering career tracks implicitly identified in the multi-specialization syllabus.

Smart Grid

The US Department of Energy gives a definition to Smart Grid that it integrates advanced sensing technologies, control methods and integrated communications into the existing electricity grid [12]. Taking the Smart Grid as an example is due to the need for the power engineer who works within this system is to have multi-abilities and talents in addition to the solid technical information. Smart grid includes, in addition to power engineering, enough knowledge in control, communications, sensors and information technology. It is prospected that the future grid is a smart grid. This implies that the future power engineer should raise his knowledge level with these multi-branch subjects through advanced training courses for optimal operation. Here, it can be suggested that two types of multi-specialized engineers, one in power, control and power electronics and the other in electronics, communications and information technology, are the types of engineers required to run the smart grid.

Organizational Receptivity

This example is to discuss which factors can be seen essentially affecting a company’s learning ability through its organizational receptivity in inter-organizational knowledge transfer [13]. This will be done by developing a typology of the factors affecting company’s organizational receptivity (and absorptive capacity) of new knowledge in inter-organizational knowledge transfer. Yet, only after the pre-conditions for the cooperation are created, it is the individuals’ abilities and the organizational culture that can essentially affect the outcome.

Before exploring the concept of organizational receptivity further, one must understand the web of interdependencies affecting an organization’s ability to learn as shown in Figure 2.

Next a typology based on a literature review about the antecedents of organizational receptivity will be presented (Hamel 1991 [16] among other references). The essential factors are presented in Figure 3.

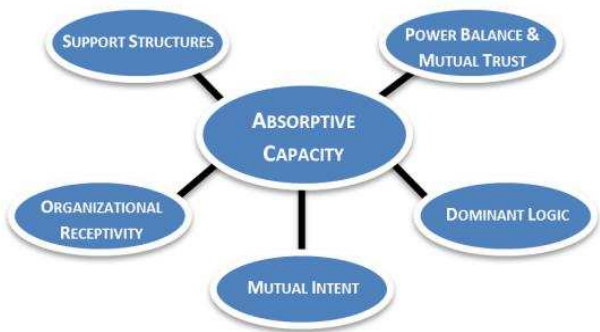


Figure 2: Determinants of absorptive capacity in an inter-organizational knowledge transfer context (Based on Minbaeva et al. 2003 [14]; Lane et al. 2001 [15] among other references)



Figure 3: Typology of organizational receptivity

Managing Knowledge Work

In this work, the exploratory nature of knowledge creation and sharing practice in high-technology industry is investigated [4]. Traditional approaches in knowledge management focus on the storage and retrieval of knowledge, but they do not address the tacit dimension of knowledge process. Using data gathered at three semiconductor manufacturers in Japan and Korea, we examine the social processes by which expert teams cooperate across team boundaries despite differing points of view resulting from increasing team specialization. Three engineering teams are studied: design, process, and process integration. They are responsible for trouble management in the production of dynamic random access memory (DRAM), a class of integrated circuit semiconductor devices. Trouble management is the handling of problems that require exploratory, yet routine problem-solving practice. The findings suggest that the crucial challenge in achieving effective control of the knowledge management process rests not in strategies for collecting and classifying relevant problem/solution information. Rather, it is in the management of “problemization”, a political process involving the articulation behaviors of different teams of engineers.

SUMMARY AND CONCLUSIONS

Advancements in science and technology cause interference of specializations in large scale projects which seems to be assorted. After a meticulous study of inter-dependent specializations, number of suggestions arises. According to the available trends some universities were keen to build-up new departments that contain multi-specialization in their programs, which idea is encouraged by the authors. Also there is the CDIO model for development of multi-specialization syllabus for engineering programs. This is also encouraged and wishes that it may be certified by Arab officials. Number of case studies is given to prove the proposal of providing multi-specialized engineers for future vision.

Due to the global changes, education has gained strategic importance. It is the responsibility of the academic society to attract young generation to technical and natural sciences. Competition and cooperation in worldwide education is considered necessary. Innovation plays a dominant role in all current activities of all countries. Engineers can play a leading function in the future if they are not only technical experts but also have:

- International education,
- Interdisciplinary and multi-disciplinary edification, and
- Open minded perceptions with the capability to understand other cultures and society's needs.

The National Academies can be the key players in consulting governments and universities for the successful transition to a knowledge-based economy and society.

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PROGRAM REVIEW: COMPUTER ENGINEERING AT THE UNIVERSITY OF SHARJAH CASE STUDY

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ABSTRACT: This paper discusses a procedure for performing a detailed review of the strengths and weaknesses of a modern academic program. The review leads to identification of points of concern and produces a set of corrective actions to improve the quality of the program. The paper will use the review of the Computer Engineering program at the University of Sharjah as a case study to highlight the success of the review procedure. The paper will summarize the review procedure, as well as the findings and recommendations of the case study.

KEYWORDS: Academic Program Review; Computer Engineering; Program Strengths and Weaknesses; Curriculum.

INTRODUCTION

It is well-known that modern academic programs need to be continuously reviewed and adapted to dynamically changing job markets, economic situations and competing disciplines. Therefore, this paper presents a procedure for performing a detailed review of the strengths and weaknesses of a modern academic program. The procedure consisted of the following steps: a detailed internal review by the program's faculty, a set of current student surveys, and a set of alumni surveys. The review and survey results were analyzed and a set of preliminary findings and recommendations were obtained. A preliminary report was drafted and sent for review by external topic experts. Their input was used to guide the drafting of a final comprehensive report which was then reviewed by the required internal committees and boards before going into implementation.

The paper uses the Computer Engineering (CPE) program at the University of Sharjah as a case study. The triggering point for conducting this review can be summarized as follows. Since its inception in 1997/1998, the CPE program witnessed a steady and swift increase in student enrolment until 2002/2003. In fact, the CPE program was perceived as the most attractive program offered by the University of Sharjah. Starting 2003/2004, however, there was a continuous decline in the number of incoming students into the program over a number of years. Typical of the MENA (Middle East and North Africa) region, top-ranked students tend to favor medical studies. Therefore, the decline in student enrollment was initially attributed to the inauguration of a group of medical colleges at the university in 2002/2003. This coincided with the effect of the Internet burst which started in the West around 2000, but had a delayed effect on the MENA region that materialized starting in 2002. Another significant development that affected the size of the incoming Computer Engineering class was the 2005-2006 inauguration of the Architectural Engineering program at the university. Yet again, another seemingly more attractive program was on offer and newly graduating high school students

migrated towards it. All these factors motivated the CPE faculty to conduct a detailed review of the program with the objective of reviving the CPE program, keeping it attractive, and improving its student enrolment.

The findings of this review can be summarized as follows. The program enjoyed strengths relative to the quality of its faculty, the support of the administration, modern infrastructure, a solid technical core, and desirability amongst the students. On the other hand it suffered from weaknesses relative to program identity, some curriculum deficiencies, and global market effects. The review produced recommendations to highlight the program's identity through a clear definition of focus areas related directly to career prospects, realign the curriculum with the internationally agreed upon Computer Engineering Body Of Knowledge, and define the desirable characteristics of future hires into the program. Most of these recommendations have been put into implementation according to a timed action plan.

Research papers that discuss academic program review procedures do exist, see, e.g., [1-4]. This paper describes an alternative procedure, which has proven to be suitable for implementation at the University of Sharjah. The main contribution of this paper is the use of the CPE review at the University of Sharjah as an illustrating case study.

The following section describes the details of the procedure used to conduct the CPE program review at the University of Sharjah.

PROGRAM REVIEW PROCEDURE

The CPE program faculty went through a detailed comprehensive review of their program. The objectives of the program review were to improve the program in the following areas:

- Student enrolment
- Teaching and learning
- Research and scholarship
- Community service initiatives

The review process was conducted in a phased manner; it went through several major phases (and iterations through some of the phases).

1) Phase I – Data Gathering:

The committee supervising this phase was comprised of faculty members from the Computer Engineering program and a faculty member with expertise in processes as an external advisor. This phase concentrated on collecting evaluative input regarding the program. Input was sought from:

- all faculty members in the Electrical and Computer Engineering Department through a formal questionnaire and a set of interviews;
- representatives of the undergraduate student population through an informal survey;
- the alumni of the program through an email survey; and
- investigating the global trends in Computer Engineering student enrolment, and the Computer Engineering job market through resources available on the Internet.

2) Phase II – Data Analysis and Preliminary Recommendations:

This phase concentrated on evaluating the results gathered in phase one, identifying areas of concern and drafting a set of recommendations to address these concerns.

3) Phase III – External Review:

This phase started with soliciting external input on the report of phase two. Domain experts from several leading universities representing different higher education styles were retained to render their input on the program review process, findings, and recommendations. Experts were solicited representing American, Canadian, British, French, and Australian higher education institutions. Each reviewer was requested to prepare a short report appraising the overall process and its outcomes as well as contribute his/her own recommendations. The outcomes and recommendations of the review were also presented to the Program Advisory Committee (PAC), which provided useful and constructive feedback.

4) Phase IV – Detailed Action Plan:

An internal committee was convened to appraise the external reviews and determine how to incorporate them into the overall review. The findings of the previous phases were compiled into a plan for implementation. The plan was drafted to be implemented while the program was in operation. Some changes were planned for immediate implementation on students currently in the program. These changes necessitated drafting contingency plans for students progressing out-of-sync with the main student body. Some of these outliers were ahead of their mates while others were lagging behind. Specific plans were drawn to ensure minimum adverse effects. Major curriculum changes were planned for implementation only on newly incoming students.

5) Phase V – Approvals:

Once the review was completed and the plans were drawn, the entire package was sent through the appropriate academic approval process. The coordination within the department was quite strong throughout the process. This translated into a fast paced approval process within the department. The coordination outside the department

was slightly less which necessitated a slightly lengthier approval cycle at the college and university levels.

FINDINGS

In what follows, we summarize the findings of our CPE program review.

Strengths

The strengths of the program can be summarized in the following points:

1) Quality of the faculty:

One of the main assets of the program has been its faculty. The faculty members of the computer engineering program are all very well qualified, western educated at reputable institutions, and most have significant relevant industrial experience. The faculty's dedication to the success of the program was actually the triggering point for the entire review process. Students have always indicated their strong satisfaction with the teaching effort and some have indicated that the reputation of the faculty was amongst their points of attraction to the program.

2) Support of the administration

The administration of the university had always recognized the significance and desirability of the computer engineering program amongst the student population. They have provided the necessary means of support for the program and had indicated strong willingness to back the program with required resources.

3) Modern infrastructure:

The University of Sharjah as a whole enjoys the benefits of a very short history. The facilities are built following the latest modern designs, the infrastructure is state-of-the-art, and the equipment is up-to-date and offers excellent educational opportunities. In addition, adequate information technology (IT) resources are prevalent allowing the students access to the latest information both locally and internationally.

4) A solid technical core:

The existing computer engineering program is quite rigorous and is based on a solid technical core that covers all of the required aspects of the computer engineering body of knowledge as identified by the IEEE (Institute of Electrical and Electronics Engineers) and ACM (Association for Computing Machinery) societies. The program is well grounded culturally and scientifically and offers the student a thorough introduction to the Computer Engineering field of study.

5) Desirability amongst the students:

While the size of the student body was reducing, the program was still quite desirable amongst students. The program was still attracting a reasonable incoming class for sustainable operation. The program was attracting top-ranked students at a

rate similar to the rest of University of Sharjah (with the exception of the medical colleges).

Weaknesses

Although the CPE program enjoys some strengths (as discussed in the previous subsection), the review indicated that the program suffers also from weaknesses, which can be summarized as follows.

1) Self-identity problem:

Through formal and informal interaction with current and past CPE students, it became quite clear that a leading concern is the vague self-identity of the CPE program. CPE students could not identify a specific factor that differentiates them entirely from Computer Science (CS) and Electrical and Electronics Engineering (EEE) students. The weakness in self-identity manifested itself in additional issues related to the focus areas and career prospects of the CPE program. In particular, students did not understand clearly what the focus areas and career prospects of the CPE program were. In fact, the EEE program attracted more students because it was perceived as being more diverse, rich and with wider career prospects.

2) Curriculum deficiencies:

Some important market-relevant courses that would be beneficial to the CPE graduates in their future careers were lacking. Some basic CPE topics were not covered by the curriculum. That further weakened the self-identity of students going through the CPE program. Some of the courses needed to be modified to become more suitable for CPE students.

3) Global market effects

It is well-known that the job market goes through cycles of peaks and valleys. In fact, Computer Engineering and Computer Science programs, both regionally and globally, are experiencing the problem of declining student enrolment [5]. This fact, however, does not imply in any way that there is nothing we can do. Essentially, this review was conducted to determine the appropriate corrective actions that can be enacted.

RECOMMENDATIONS

In light of the above-mentioned analysis, the program review led to a set of recommendations (corrective actions) that can be summarized as follows:

1) Focus Areas and Career Prospects:

The conducted review indicated that, typically, students did not have a clear understanding of the focus areas and career prospects of the CPE program. In fact, it is crucial to clearly identify the diverse and rich CPE focus areas and job prospects. Otherwise, we would not be able to convince students to join the CPE program. Towards this end, the following focus areas have been identified.

1. Communications and Networking
2. Information Security
3. Computer Systems Architecture
4. Embedded Systems
5. Integrated Circuit Design
6. Software Engineering

In fact, most of these focus areas appear in the existing course description. Students, however, are not educated enough on these focus areas, and their relevant job prospects. Therefore, the review strongly recommended communicating the CPE focus areas and career prospects to prospective students, current students and the community at large. This can be achieved through presentations, brochures and targeted school visits. In addition to identifying the program's focus areas, it is vital that these focus areas are clearly linked to their respective career prospects. In particular, Table 1 shows the linking of CPE focus areas to their respective career prospects:

Following the recommendations of the review, an article that clearly identifies the job prospects of the CPE program was published in the "University Forum" magazine to educate existing students who tend to pass information through word-of-mouth to their siblings and relatives [6].

Table 1: Linking of CPE focus areas to career prospects

CPE Focus Areas	Corresponding Career Prospects
Communications and Networking	Computer engineers design and build faster and more secure communication networks, network protocols and network applications.
Information Security	Computer engineers design and implement cryptography mechanisms, protocols, software and hardware systems to protect the Internet and information systems from hostile attacks and security threats.
Computer Systems Architecture	Computer engineers design and implement modern computer systems and their various components, e.g., processors and memory.
Embedded Systems	Computer engineers design and build embedded hardware and software systems for airplanes, robots, smart appliances, mobile phones, media players, ...etc.
Integrated Circuit Design	Computer engineers design smaller and faster chips for computers and mobile devices.
Software Engineering	Computer engineers design and implement software for Internet search engines, gaming, mobile devices, multimedia applications, and medical imaging.

2) Curriculum Change:

The review helped CPE faculty realize that the current program is missing some important courses. These courses can be summarized as follows.

- Technical elective in Communications and Networks
 - Computer and Communication Networks II
 - Wireless and Mobile Network Architectures
- Technical electives in Information Security
 - Computer and Network Security II
- Technical electives in Computer and Embedded Systems
 - Human-Computer Interaction
 - FPGA Design
 - Robotics
- Technical electives in Software Engineering
 - Mobile Computing
 - Artificial Intelligence
- Elective courses of general interest
 - Entrepreneurship
- Basic CPE courses
 - Algorithms
 - Database Systems
 - Computer Systems Laboratory

In addition to the above-mentioned courses, the review recommends modifying some of the existing courses as to become suitable for CPE students. For example, the review recommends dividing the course “Introduction to Electrical and Computer Engineering” into two courses:

- Introduction to Electrical Engineering; and
- Introduction to Computer Engineering

Furthermore, it was recommended that “Introduction to Computer Engineering” be taught mostly in the laboratory as opposed to the classroom. In particular, it is envisioned that, through this course, students will gain hands-on experience in:

- assembling a computer (which was demanded by many of our alumni in the College of Engineering Alumni Day in May 2007);
- building a computer network; and
- writing a software program.

Finally, the review noticed that the CPE graduate lacks some software skills (e.g., programming in a certain language) that cannot be taught through a formal course. To close this gap, the review recommended reinforcing the students’ programming skills through:

- summer training provided on-campus;
- course projects; and
- senior design projects.

3) Program Structure Change:

The most important recommendation of the CPE review was to add tracks/concentration areas to the CPE program. Note that a CPE program with different track options is adopted by, e.g., the Royal Institute of Technology in Sweden (KTH) [7]. Our CPE review recommended offering the following four CPE tracks.

1. Computer Engineering – Communication Networks
2. Computer Engineering – Information Security
3. Computer Engineering – Computer and Embedded Systems, and VLSI
4. Computer Engineering – Software Engineering

Notice that the above tracks are strongly linked to the CPE focus areas and career prospects. The CPE program with different track options can be implemented as follows:

- A “basket of electives” is to be identified for each track option.
- To complete the CPE degree in one of the above-mentioned tracks, the student needs to take at least a required number of electives from the relevant “basket”.
- Students may choose to complete a CPE degree without a specific track (similar to the current format). In this case the student can take electives from different “baskets” without necessarily completing the majority of electives from the same “basket”. This can be considered as the general track that complements the four above-mentioned tracks.

We believe that the CPE program with different track options as described above has the following advantages:

- Strengthening the students' depth.
- Maximizing the program flexibility.
- Clearly identifying the CPE focus areas. Thereby, students would realize that the CPE program is diverse, rich and offering many cutting-edge career prospects.

The committee recommended mentioning the track (completed by the student) on the student's transcript, but not on the degree certificate. The degree name should remain Bachelor of Science in Computer Engineering. In fact, this is the standard brand name used in the vast majority of institutions (with a few exceptions) world-wide. Our recommended CPE program with different track options will allow us to maintain the standard degree name, and still highlight the attractiveness of the program and its diverse job prospects through the track names.

4) Faculty Recruitment:

Our review recommends recruiting top faculty members with teaching and research experience in the new tracks and focus areas; and/or industrial experience (to communicate to our students the CPE job prospects and job experience); and/or excellent research record (or potential, to nurture the program's research activities).

SUMMARY AND CONCLUSIONS

This paper presented a procedure for performing a detailed review of the strengths and weaknesses of a modern academic program. We used the review of the Computer Engineering (CPE) program at the University of Sharjah as a case study. The paper summarized the review procedure as well as the findings of the case study.

The main recommendations of the case study focused on issues related to teaching and learning, as well as marketing/student welfare. We believe that these areas will have an immediate and tangible impact on improving the student enrolment – the ultimate goal of the case study. Note that some recommendations, e.g., identifying and advertising the focus areas and career prospects, some curriculum changes and faculty recruitment, were already implemented. Some other recommendations, e.g., introducing the track options, need more time to be implemented. To gain better visibility, the CPE program needs also to initiate some community service activities, e.g., establish links with the local industry, deliver training courses for the industry and community, and organize international conferences.

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THE JOINED RESPONSIBILITY OF THE SCIENCE & ENGINEERING FACULTIES IN THE PROCESSING OF ENGINEERING STUDENTS

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ABSTRACT: Four phases in the processing of the professional engineer are mentioned in terms of renewability. The first phase which covers the undergraduate study period, is considered as a non-renewable phase. The latest ABET outcome criteria are discussed with respect to the latest engineering design requirements. Knowledge of basic ecology as a natural science is emphasized as necessary for the understanding of environmental issues and sustainability. The macroscopic approach in raising student environmental awareness and learning about global issues such as economics and other human needs is strongly recommended. It is concluded that such goals could only be achieved with a close cooperation and sharing of responsibility between the faculty of engineering and the faculty of sciences. If this could be achieved, graduate students will be better equipped with the ability to contribute synergistically in a competitive environment, and tackle problems with a holistic multi-disciplinary approach.

KEYWORDS: Engineering Curriculum; Ecology; Sustainability; Macroscopic; Professional Engineer; Lifelong Learning.

INTRODUCTION

It is common knowledge that engineering is a well appreciated profession among societies of the developing countries (considered prestigious), and that high school graduates have to compete to enroll in an engineering program. What is less known and/or acknowledged in such societies, is that becoming a professional engineer [1] requires a long and tedious apprenticeship period after graduation (with a bachelor degree). This usually takes 3-6 years of apprenticeship and leads to recognition by a peer society; that the graduate has attained sufficient field experience to take responsibility in public engineering projects. However, becoming a licensed engineer that can take responsibility in engineering projects is not a sustainable status unless it is periodically fed by ‘on the job training’ and/or courses in new developments in the science and technologies relevant to the field of the profession (continued education).

To become a professional engineer and stay as one, would involve the following four phases:

Phase I: The undergraduate phase (a non-renewable phase)

Phase II: The apprenticeship phase (possibly renewable)

Phase III: The updating in new academic developments phase (renewable)

Phase VI: The Lifelong self-learning phase (continuously renewable)

Responsibilities of phases I and III belong to faculties of engineering and the “continued education” organization of the university, respectively. Responsibilities of phase II belong to the professional engineering societies such as the IEEE [2,3], and responsibilities of phase VI relate to the professional engineer’s attitude.

In this work we shall concentrate on phase I which we indicate as the non-renewable phase as far as the engineering student is concerned [4]. We point out that this phase must be implemented by joint efforts and fostering of the faculty of engineering and the faculty of science (Mathematics & the Natural Sciences). This phase forms the basis upon which the other phases will be effective in educating engineers as expected by society and required by the market.

ABET and the Undergraduate Curriculum

ABET, when formed in 1980 by joining various engineering accreditation committees into one, put the following definition for the engineering profession [5] (repeated below for convenience), to guide faculties in designing the course curriculum.

“Engineering is the profession in which knowledge of the mathematical and natural sciences gained by study, experience, and practice, is applied with judgment to develop ways to utilize, economically, the materials and forces of nature for the benefit of mankind.”

A possible implementation of this definition has been laid out in block diagram format (as a guide for course design) in [5], also shown in Fig.1 below (repeated for convenience). This diagram shows how the natural sciences could possibly be related to engineering science courses at various levels and to the senior engineering design courses (one 3 credit course each semester). The block diagram also shows that while evaluating engineering design, knowledge from ecological principles should be taken into consideration to ensure contributions towards the benefit of human kind. The basis of this knowledge, which will be recalled upon later, is largely discussed in [6]. It is encouraging to see that ABET has also considered this very important topic when it modified criteria 3c (also mentioned as “outcome c” in some literature) to be effective with the 2006-2007 evaluations [7]. The modified criteria 3c is repeated below for convenience.

“an ability to design a system, component, or process to meet desired needs within realistic constraints such as economic, environmental, social, political, ethical, health and safety, manufacturability, and sustainability.”

In this renewed criteria, we see that the engineering design project the engineering student would need to include considerable knowledge outside that learned traditionally in engineering science courses.

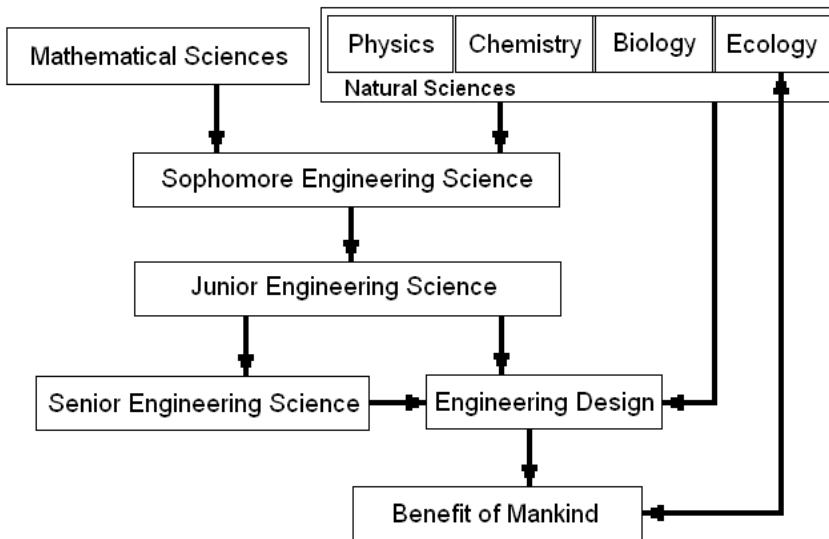


Figure 1: Hierarchy of Scientific/Technical Courses (Reprinted from [4] with permission)

The modification includes two wordings that specifically point to comprehension in basic ecology (as a natural science). Those two words are “environmental” and “sustainability”. In addition it could be argued that the words “social”, “ethical”, “health and safety” could also be related to ecological basis [8]. This modification also implies that the engineering design evaluation teams should include people with background in ecology, supporting the statement regarding the need of cooperation between the engineering and science faculties.

On the Cooperation between the Engineering and Science Faculties

Cooperation between the engineering and science faculties has always existed as evidenced by engineering course programs worldwide. Emphasis of the dependence of the engineering science courses on basic science courses, such as physics, chemistry and mathematics, have recently been pointed out by some authors [9-11]. Courses in biomedical engineering require detailed knowledge in biology. The latest “outcome” based criteria issued by ABET, include the modification made to criteria 3c starting in the 2006-2007 evaluation period. It is this aspect of the new requirements that point to the need for more cooperation among faculties in fostering engineering students. Since this phase in the students’ life is non-renewable, it should be covered thoroughly where each engineering student should be made aware, of the fundamental laws of nature. In this respect members of staff from the science faculty, teaching engineering students, should be as aware of the ABET requirements as the staff of the engineering faculty are. This

can be made possible by the full cooperation of the relevant staff and administration of the two faculties. Time should be allocated for scheduled joint meetings and/or seminars. The cooperation should also lead to the mutual understanding of the two faculties on the minimal course requirements for graduation, paying utmost attention to the time limitations that the students have, to implement their weekly study program. ABET requirements also touch upon economics and manufacturability. These matters could also be discussed within the engineering design courses.

The Macroscopic View Approach

Students need to develop a “macroscopic” view of the world and relate to the ecosystem(s) of which they are a consuming participant. They need to understand the global ecosystem in which all biota have to co-exist. They must be taught how the earth and all biota related cycles within the ecosphere work as a system [12-14]. They need to approach world matters with a holistic view, learn how to work in multidisciplinary teams, hence must have guidance from cooperating staff members. Further, To satisfy the engineering design requirement set by ABET (3c) these aspects should be discussed within the two 3-credit engineering design courses at the senior level.

SUMMARY AND CONCLUSIONS

World population has more than tripled in one century [15]. The daily net increase of the human species is about 220000. This means that many more mouths have to be fed every day. It is clear that this increase with no signs of slowing down in the near future will be putting a considerable amount of pressure on global natural resources such as land, potable water, and quality of air. The overcrowding of people in cities is weakening their resilience against natural disasters worldwide. Engineers of the 21st century should have capabilities to help humankind to overcome the shortages imposed by overpopulation and at the same time maintain a healthy environment throughout the ecosphere. It is clear that the four phases in the making of an engineer, pointed out earlier also need the cooperation of the Chambers of engineers, the faculties of engineering and the sections that deal with “continued” education in universities.

In this work, we have focused mainly on the nonrenewable phase in the engineer’s educational life. We have shown how ABET requirements lead to the development of curricula requiring the cooperation of the engineering staff with the ones from the natural sciences faculties. It is clear that when the engineering students go through the recommendations above, they will be:

- b) equipped with basic ecological knowledge with the “systems” approach,
- c) will have developed a macroscopic view of the ecosphere,
- d) will be able to contribute synergistically in a competitive environment, and
- e) will be able to tackle problems with a holistic multidisciplinary approach.

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GENDER-BASED STATISTICAL ANALYSIS OF STUDENTS IN ENGINEERING PROGRAMS OVER TEN YEARS

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ABSTRACT: Several reports and data suggest that women in the UAE are outperforming men at various educational levels and that the UAE is among the most developed nations in educating women. We are presenting here a comparative study between women and men to analyze trends for five baccalaureate programs in the college of engineering at Ajman University of Science and Technology (AUST), UAE. Normalized statistical data is used to analyze fresh admissions, program completion, duration of completion, academic performance and student attrition. For all fresh admissions, during the academic years 2000-01 to 2009-10, overall there were 86 women for every 100 men admitted. Women to men ratio in the year 2000-01 was about 1:2, which significantly improved to about 1:1 in 2009-10. In the recent five years, cumulative fresh intake for women has somewhat exceeded that of the men. For program completion, during the ten year period overall 110 women graduated for every 100 men. From the group of graduating women about 80% completed their program in ten semesters, while only 63% of the men completed in as many semesters. For academic performance till graduation, more women scored higher grades than men. 19% graduating women compared to 12% men scored high grades, while 32% women and 48% men scored low grades in their respective groups. For attrition, the number of women aborting their programs was about half that of men. More than 50% of the ten-year cumulative attrition in each group occurred in the first two semesters of admission. In nearly all comparisons, women outperformed men. The study calls for investigations into the factors that would support and motivate more men to take up the engineering challenge.

KEYWORDS: Women in Engineering; Women Education in Middle East; Gender Statistics in Engineering.

INTRODUCTION

Gender disparities in academic programs are quite common around the world [1-3]. This is more so in engineering related programs. Such disparities can lead to inequalities in professions with related social effects. Only limited gender-based statistics or studies from the UAE or the neighboring countries are available in the literature. The present study is an attempt to analyze gender-based students statistics in engineering programs at AUST.

According to a report prepared by the Ministry of State for Federal National Council Affairs, UAE, women in the UAE are outperforming men at various educational levels and that the United Nations recognizes the UAE to be among the most developed nations in educating women [4]. Also, in the University of Sharjah, women represented nearly 65% of the entire student population for the fall semester of the academic year 2008-09 [5]. Similarly, in the UAE University, women represented 77% of the entire student population for the spring semester of the academic year 2008-09 [6].

The present study concentrates on various aspects of women students in engineering education as compared to men. Statistical data collected over ten years for the academic years 2000-01 to 2009-10 is used for analysis of students from five baccalaureate programs in the college of engineering at AUST. The programs are offered separately for women and men in the fields of Electronics (EE), Communication (COMM) and Biomedical (BME) engineering as well as in Architecture (Arch) and Interior Design (ID).

STATISTICAL DATA AND ANALYSIS

At AUST, the academic year consists of Spring, Fall and Summer semesters. As the Summer is not a regular semester, it is not included for analysis. Thus, each academic year analyzed consisted of two semesters. Until 2005-06, the recommended duration of completion for each program was 5-years (or ten semesters) except for 4-years for ID. From 2006-07 modified 4-years programs are offered for EE, COMM and BME. For the present study we analyzed overall data for program completion in ten semesters, irrespective of the program. The students who are expected to complete by the end of the current academic year (2009-10) are also included.

Normalized statistical data is used for women and men to analyze the trends for fresh admissions, program completion, duration of completion, academic performance of the graduates and student attrition. The analysis is carried out for separate groups of women and men.

Fresh Admissions (Figure 1): This section gives a comparison of group size for women for every 100 men admitted to the college of engineering. During the ten year period, overall there were 86 women for each 100 men admitted. Figure 1 shows the group size for each academic year. The smallest group was 56 in the year 2000-01 and the biggest group was 118 in the year 2006-07. Only in the three early years, the group was 72 or less as compared to 80 or more in the recent seven years. In the recent five years, cumulative fresh intake for women has somewhat exceeded that of the men.

Program Completion: It is defined as successful completion of all requirements for the program in which the student was admitted. During the ten year period, there were 110 graduating women for every 100 men.

Duration of Completion: About 80% of all the graduating women completed their respective program within ten semesters. In comparison, about 63% of all the graduating men completed their program within ten semesters. It is worth mentioning in this context here that nearly all the remaining graduating women completed in up to three additional semesters, while the remaining men took even longer.

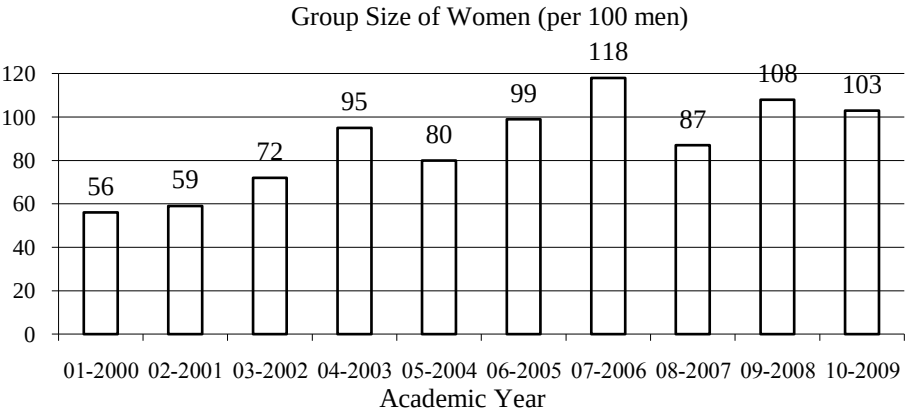


Figure 1: Fresh admissions–normalized *group size* of women for each 100 men admitted during the academic years 2000-01 to 2009-10 taken as total of all programs in the college of engineering.

Academic Performance of the Graduates (Figure 2): It is taken here as the overall performance till graduation evaluated on a 4.5 scale from cumulative grade point average (or CGPA) in terms of three levels in the increasing order of merit as: Low (CGPA from 2 to <2.75), Medium (CGPA from 2.75 to <3.75) and High (from 3.75 to 4.5). Figure 2 shows a comparison of performance from the Low to High levels. 32% women and 48% men in their respective groups graduated with Low level grades. This gap in the percentages narrowed significantly for higher level performance, as 19% women and 12% men graduated with High level grades.

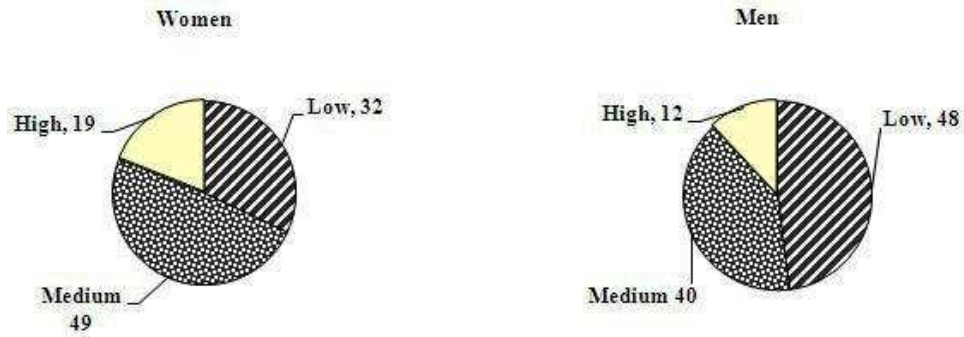


Figure 2: A comparison of academic performance of the graduating women on the left and men on the right is shown as percentages for the different levels.

Student Attrition: It is defined here as the number of students who aborted their program without completion. Much less women aborted their program during the ten year period.

There were 57 women for every 100 men who aborted. More than 50% of the total attrition from each group of students occurred in the first two semesters of admission, perhaps because during the first year of university education the students explore and determine their career interests.

SUMMARY AND CONCLUSIONS

The analysis suggests that there is a significant increase in the percentage of women studying engineering programs at AUST. More women than men graduated within the specified duration of their programs. In nearly all the comparisons for academic performance, women outperformed men.

As the students analyzed in this study come mostly from the UAE and neighboring countries, this study may, to a limited extent, suggest that a lot more women in this region are now ready to accept challenges in various fields of engineering.

Perhaps one of the reasons for relatively lower academic performance shown by the men may be their involvements and responsibilities of non-academic nature. From our personal experiences, we have noticed that significantly more men have to generate funds to support their studies financially. The present study, therefore, calls for further investigations into the factors that would support and motivate more men to take up the engineering challenge.

Though excellence in academic performance is a definite requirement for higher studies, the field or market performance of the excellent as well as the not so excellent graduates remains to be investigated.

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Enhancing Students' Learning

IDENTIFYING REASONS FOR STUDENTS' NON-UNIFORM LEARNING OUTCOMES

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ABSTRACT: This paper presents results of an investigation into identifying reasons for students' non-uniform assignment outcomes in a first year subject in the Civil Engineering discipline and proposes some effective measures to overcome this issue. The subject has been taught for three years since it was introduced in 2007. The assessment of the subject includes three assignments contributing 40% of the final result. In 2007 and 2008 the author observed that students performed well in the first and third assignment, however student performance in Assignment 2 was poor. This observation was confirmed through statistical analysis of the students marks from these two years. In an attempt to rectify the less than satisfactory student results in assignment 2 a change was made to the amount of teaching and tutorial time allocated to preparing for this assignment in 2009. It was found that this increase in teaching time allocated to mathematical calculations produced significant positive outcomes. While student results in Assignment 2 improved to a satisfactory level, assignment 2' remained the least performing assignment compared to other assignments in the subject. To gain a deeper understanding students were surveyed. The initial hypothesis of this study was that the mathematical calculation focus of Assignment 2 might be the reason for lower student performance, however results of the survey show that the majority of students did not agree with this hypothesis. Students reported that they found Assignment 2 interesting and they understood the concepts and theory that it was testing. It would appear that other factors, perhaps the timing of the assignment mid-semester competing with other subject assessment, may account for the dip in student results. The outcomes from this investigation inform a set of recommendations for future teaching of the subject.

KEYWORDS: Non-Uniform Learning; Assignment; Statistical Analysis; Problem Based Learning; Mathematical Calculations.

INTRODUCTION

The subject named 'Sustainable Design' was introduced in 2007 in the Civil Engineering discipline as a first year compulsory subject at an Australian university. The strategic approach employed in the teaching of the subject is 'problem based learning'. The assignments in the subject contribute 40% to the students' final result. Assignments include a degree of choice and are on the topics require students to work concept designs for infrastructure and utility services with sustainability as the prime objective. Project topics are sourced from Engineers Without Borders (a non-profit organization) and the final product is submitted to nation-wide competition. Project work is carried out in small groups and problems relate to real-life issues. During the semester course content informs the group project and is delivered concurrently through lectures, tutorials and consultations. This duration of semester allocated to Assignment 1 six weeks while it requires conceptual knowledge on sustainability and innovative thinking, it is introductory in nature. The objectives are to enhance students' ability to apply knowledge of basic science and engineering fundamentals; enhance students' ability to communicate

effectively, not only with engineers but also with the wider community; develop an understanding of the social, cultural, global and environmental responsibilities of the professional engineer and to improve the understanding of the principles of sustainable design and development. The objectives of Assignment 2 are more focused and aim to enhance students' ability to undertake problem identification, formulation and solution as well as demonstrate an ability to utilize a systems approach to design and operational performance. Assignment 2 also requires students' to perform a set of mathematical calculations to calculate heat gains and losses from a typical house, eventually to minimise cooling load required by the traditional air-conditioning system. It requires accurate calculations using provided mathematical equations and steps. The objectives of the third and final assignment in the subject are to increase student knowledge about sustainability features, increase their understanding of professional and ethical responsibilities as well as their ability to function effectively as an individual in a multi-disciplinary team. The third assignment requires students to demonstrate their knowledge of life cycle analysis of the building or house selected by each group. This assignment also requires detailed calculation of energy and water uses, as well as waste generation for the building's whole life cycle. Finally, students prepare a comprehensive life cycle assessment for the building at its different phases. The pattern of variable assessment observed over the first two years of the subject showed that most students did well in the 1st assignment, not as well in the 2nd assignment and yet their marks improved again in the 3rd assignment. The objective of this research was to investigate the reason(s) for this fluctuation in student results using a survey as well as an analysis of assignment tasks and content. The final goal was to propose measure(s) to overcome this pattern of variable results to enable more effective and uniform learning of the students.

SELF-EFFICACY AND STUDENT PERFORMANCE

The literature shows that self-efficacy is important in student outcomes and is task related. Researchers have been exploring these concepts for over 40 years. For example, Marton and Saljo [1] conducted an experiment with two groups of 20 first year students and studied outcome differences as a function of the learner's conception of the task. Marton and Saljo [2] described functional differences in the process of learning which gave rise to the qualitative differences in outcome. Svensson [3] studied outcome skills in different situations and related study activity to levels of understanding and academic performance.

Twenty years on, Bandura [4] defined self-efficacy as "one's belief that he/she is able to organize and apply plans in order to achieve a certain task" and described affective variables which were found to play an essential role that influences behavior and learning. Bandura and Locke [5] commented that construct self-efficacy is tightly connected to motivation and plays a prominent role in human development since it directly influences behavior. They further mentioned that among the various mechanisms of human agency, none is more central or pervasive than self-efficacy beliefs. According to Bandura's social cognitive theory, every individual possess a system that exerts control on his/her thoughts, emotions and actions.

Pajares and Schunk [6] examined the contribution made by the self-efficacy component of Bandura's [4] social cognitive theory to the study of self-regulation and motivation in academic settings. He explained the difference between self-efficacy beliefs and other expectancy constructs, followed by a brief overview of problems in self-efficacy research.

Klassen [7] reported that self-efficacy is a task-specific construct and there is a correspondence between self-efficacy beliefs and the criterial task being assessed; in contrast, self-concept is the sense of ability with respect to more global goals, while self-esteem is a measure of feeling proud about a certain trait, in comparison with others. Nicolaou and Philippou [8] found that self-efficacy belief is a strong predictor of mathematical performance while problem posing is considered fundamental in mathematical learning. They examined the relationship that efficacy has in problem posing, problem-posing ability, and mathematics achievement. They reported that a students' perceived efficacy to construct problems is a strong predictor of the respective performance as well as of their general mathematics achievement. A strong correlation was also found between ability in problem posing and general mathematics performance.

In similar studies Pajares [9] posited that children self-beliefs are inextricably tied to their thinking and functioning. These researchers identified reasons why students select some activities and avoid others, why they succeed in some academic pursuits and fail at others, or why they are filled with either anticipation or panic at the thought of doing this or that task. Furthermore, Schunk and Pajares [10] described the development of one type of motivational process: perceived self-efficacy. They concluded that poor perceptions of self-efficacy reduces academic motivation, learning, and achievement. Self-efficacy is grounded in a larger theoretical framework known as social cognitive theory, which postulates that human achievement depends on interactions between one's behaviors, personal factors (e.g., thoughts, beliefs), and environmental conditions.

This body of literature demonstrates that self-efficacy is an important variable and corresponds to the criterial tasks. It influences the global measures of student achievement and can inform prediction of related outcomes. These earlier studies informed the hypothesis that underpinned the investigation reported in this paper:

The strong mathematical content of Assignment 2 is related to self-efficacy around the task and self-efficacy in mathematics affects student outcome.

RESEARCH METHODOLOGY

As the main focus of this investigation was to determine if students had a particular with the Assignment 2 a survey was constructed with to obtain student feedback on assignments. The survey questions were prepared to extract information on students' level of understanding, their efforts in terms of total hours spent on the tasks, their self-reported interest related to creative thinking, mathematics and learning new concepts. The survey was conducted at the end of the teaching period in 2009 when students had completed and submitted all of their assignments for the semester.

As noted in the introduction, the observation that students performed poorer on Assignment 2 was verified by two years of data. However, to improve students' learning outcome related to Assignment 2, a strategic change was made in 2009 in the teaching process and the amount of time devoted to teaching concepts and content applicable to Assignment 2. In brief the changes are outlined below:

- An increase in teaching hours (from 1 hour to 2 hours) on explaining the basic theory to strengthen students understanding on basic concepts related to the assignment.
- More tutorials on hands-on calculations (from 2 hours to 4 hours) for the same assignment components to facilitate more practice and to build efficacy as suggested by Nicolaou and Philippou [8].

RESULTS ANALYSIS

This study was initiated with two years (2007 and 2008) of students' assignments results. With the two years of data, a brief statistical analysis was performed to quantify the students' results anomaly. Table 1 shows the comparison of statistical analysis performed on 2007 and 2008 data. Note that the sample number was not same for both years. It is evident that there are significant differences between student performance on Assignment 1 and 2. Similar differences of performances between Assignment 2 and Assignment 3 are also evident (see Table 1).

In summary the mean values of assignment marks are 83 to 86.3, 60.2 to 62.7 and 83.3 to 84.7 for assignment 1, assignment 2 and assignment 3 respectively. The median values of assignment marks are 80~90, 60~65 and 88~90 for assignment 1, assignment 2 and assignment 3 respectively. Figures 1 and 2 graphically show the 'Mean Mark' and '10th Percentile Mark' respectively for all the assignments in 2007 and 2008. It is shown that the 'Mean mark' for 'Assignment 2' was around 60, whereas the 'Mean mark' for other assignments were above 80. Again, '10th Percentile Mark' for 'Assignment 2' was about 45, whereas '10th Percentile Mark' for other assignments was above 65. This statistical analysis proves that there are significant differences in the student results of Assignment 2 compared to other assignments.

Table 1: Summary and Comparison of Statistical Analysis.

Statistical Function	Assignment 1		Assignment 2		Assignment 3	
	2007	2008	2007	2008	2007	2008
Mean	86.3	83	60.2	62.7	84.7	83.25
Sample No.	103	126	103	126	103	126
Median	90.0	80.0	60.0	65.0	88.0	90.0
10 th Percentile	65.0	70.0	45.0	45.0	65.0	70.0
90 th Percentile	100.0	95.0	75.0	80.0	100.0	95.0
Minimum	50.00	20.00	30.00	0.00	40.00	0.00
Maximum	100.0	100.0	100.0	85.0	100.0	100.0

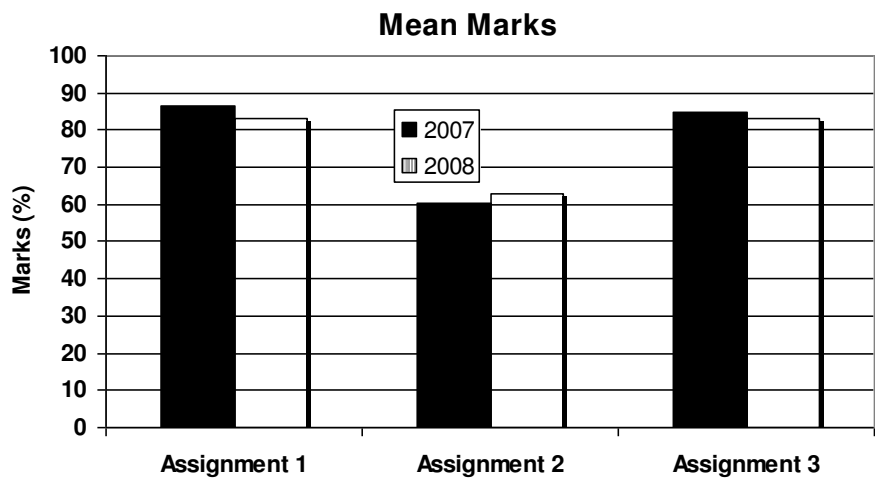


Figure 1: Comparison of ‘Mean marks’ among all assignments in 2007 and 2008

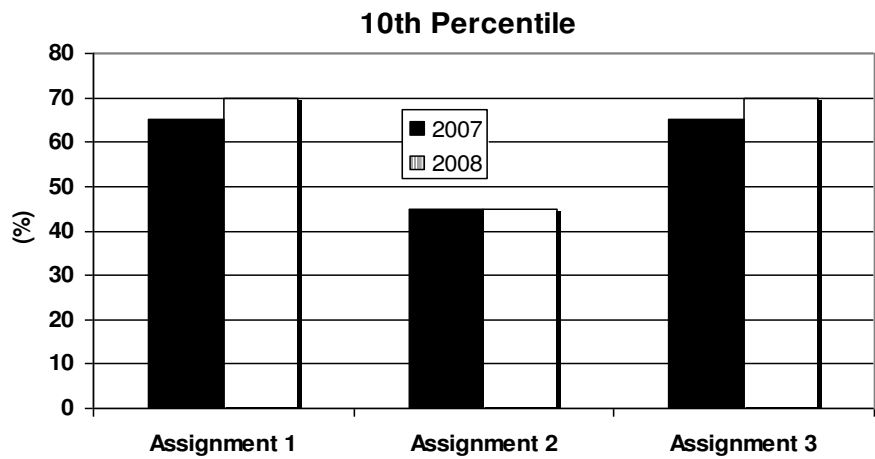


Figure 2: Comparison of ‘10th Percentile’ among all assignments in 2007 and 2008

EFFECTS OF STRATEGIC CHANGE

A further statistical analysis was carried out using the assignment marks for 2009. Keeping in mind that in 2009, there was a strategic change in the teaching of the subject. Table 2 shows the statistical analysis summary for the 2009 assignment marks compared to the average of 2007 and 2008 marks.

Table 2: Comparison of Statistical Analysis between 2009 and Previous years.

Statistical Function	Assignment 1		Assignment 2		Assignment 3	
	2007-8	2009	2007-8	2009	2007-8	2009
Mean	84.6	91	61.5	85.5	84	92.3
Sample No.	114.5	166	114.5	166	114.5	166
Median	85.0	95.0	62.5	90.0	89.0	95.0
10th Percentile	67.5	80.0	45.0	60.0	67.5	80.0
90th Percentile	97.5	100.0	77.5	100.0	97.5	100.0
Minimum	35.0	25.0	15.0	50.0	20.0	50.0
Maximum	100.0	100.0	92.5	100.0	100.0	100.0

It would appear that the effect of the strategic change in teaching and tutorial timing produced significantly positive outcomes. The effects of the strategic change are presented graphically in the Figures 3 to 6. From these figures it is shown that student results in all the assignments increased in 2009 compared to 2007-8. Due to increased teaching and tutorial hours, ‘Mean mark’ for ‘Assignment 2’ increased by 39% in 2009. Moreover the ‘Mean mark’ for Assignment 1 and 3 also increased by 7.5% and 10% respectively.

Figures 4 to 6, graphically show that the ‘10th Percentile’ and ‘90th Percentile’ values for 2009 were increased by 33% (45 → 60) and 29% (77.5 → 100) respectively. The ‘10th Percentile’ values for Assignments 1 and 3 were also increased by 18.5%. There was significant increase (233%) in ‘Minimum mark’ for ‘Assignment 2’, which may be attributed to the increased teaching and tutoring on mathematical calculations, ‘Minimum mark’ for ‘Assignment 3’ also increased significantly (150%). However, ‘Minimum mark’ for ‘Assignment 1’ decreased, this may be considered as an outlier.

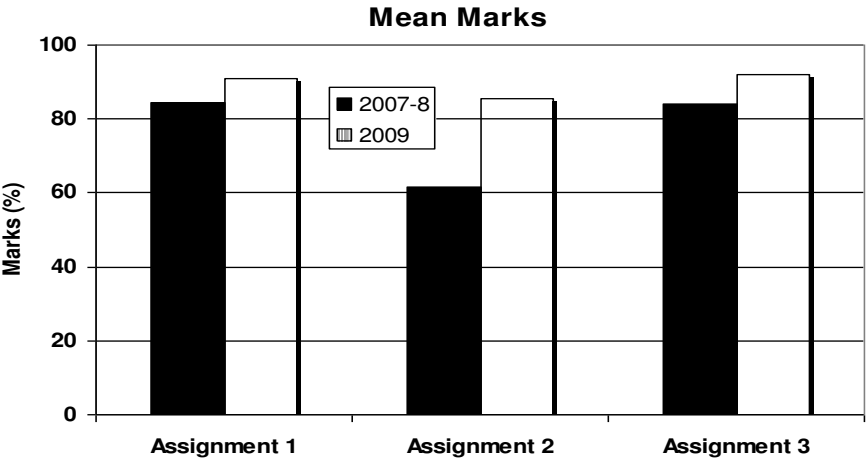


Figure 3: Comparison of ‘Mean Marks’ between 2007-8 and 2009.

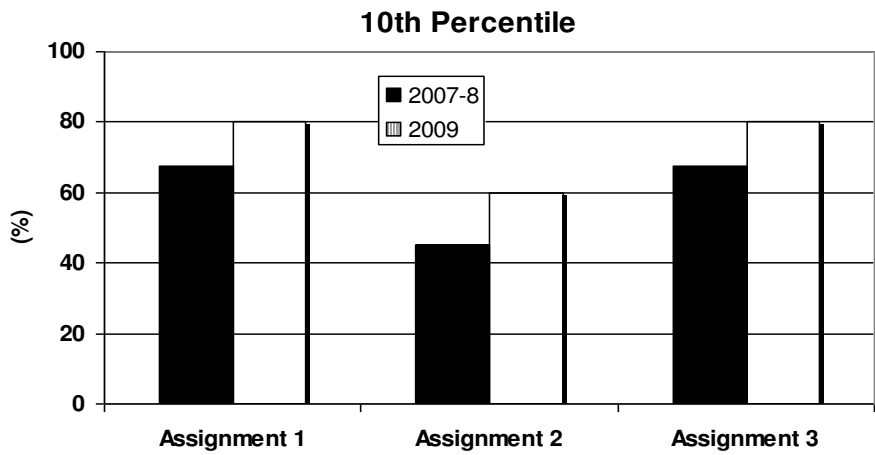


Figure 4: Comparison of ‘10th Percentile’ between 2007-8 and 2009.

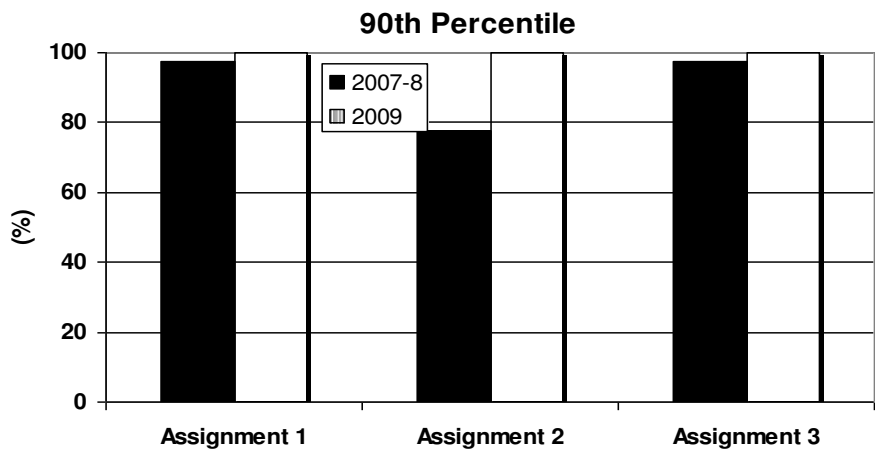


Figure 5: Comparison of ‘90th Percentile’ between 2007-8 and 2009.

In summary, it may be concluded that strategic changes (more teaching and tutoring hours for basic theory and hands-on practice on mathematical calculations) have produced significantly positive outcomes for Assignment 2. It may also be concluded that because Assignment 3 also has some mathematical calculations, the strategic changes also had a positive effect on students assignment 3 results. This finding is in line with the findings of Marton and Saljo [2], which mentioned that functional difference in the process of learning gives rise in the outcomes. Figure 7 shows the temporal patterns of different statistical patterns for Assignment 2.

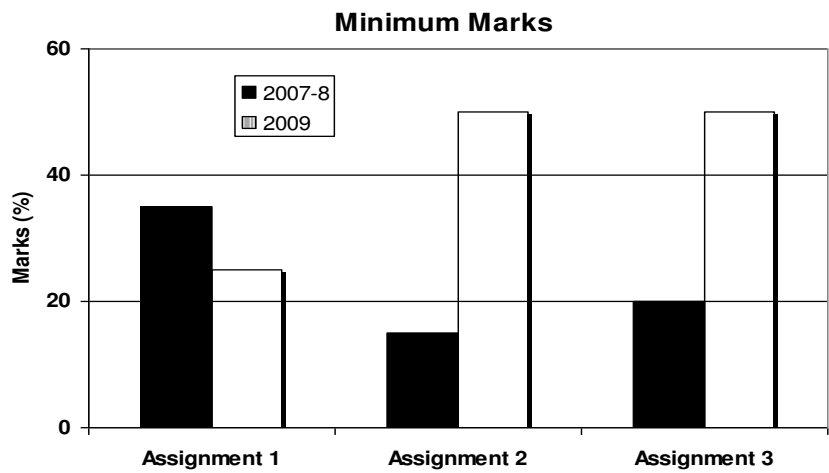


Figure 6: Comparison of ‘Minimum Marks’ between 2007-8 and 2009.

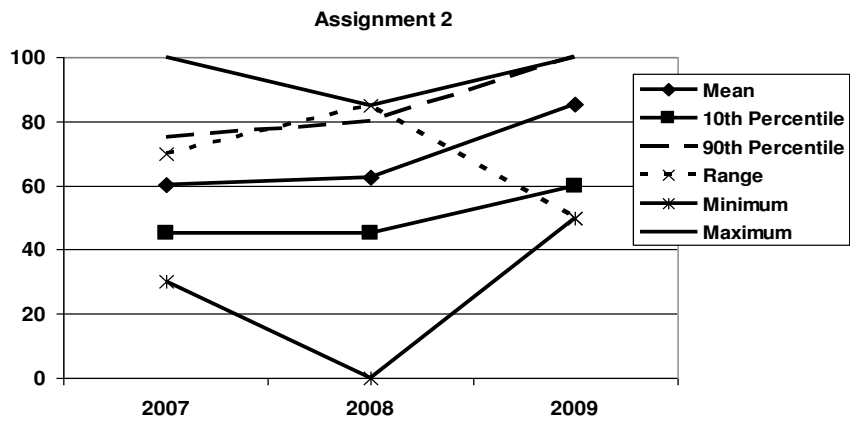


Figure 7: Temporal patterns of different statistical parameters for Assignment 2.

SURVEY RESULTS

A set of survey questions was prepared and were given to the students towards the end of the semester in 2009. Of the 170 students enrolled in the unit, 122 participated in the survey, a response rate of 72%. The survey questions were prepared to elicit information about the level of student engagement in each assignment; their perception of the level of creativity, interest, and improvement of knowledge applied to Assignment 1; their

perceived reasons for lower performance in Assignment 2 and perceptions about excitement, interest and difficulties associated with Assignment 3. Figure 8 shows the percentage of students who spent less than 5 hours on each assignment. It was found that more than 40% of students spent less than 5 hours on Assignment 2; however for Assignment 1 less than 20% students spent less than 5 hours. This finding supports the conclusion made by Schunk and Pajares [10], that self-efficacy reduces academic motivation, learning and achievement.

It may be concluded from these survey results that Assignment 1 enhanced students learning and knowledge; they reported that they found it both interesting and inspiring. Approximately 75% students agreed that the 'problem based learning' style of Assignment 1 enhanced their knowledge and skills, whereas only 3% students disagreed with this. Approximately 80% students agreed that the incorporation of 'sustainability features' and the real-life application of the problem made Assignment 1 interesting, whereas only 4% students disagreed with this. Approximately 66% students agreed that Assignment 1 was inspiring because it encouraged creative thinking and had the potential to lead into a national competition, however approximately 12% students disagreed with this. In summary, Assignment 1 appeared to be effective in satisfying the learning objects moreover students' results were very good.

The initial hypothesis of this study was that the mathematical calculation aspect of Assignment 2 might be the reason behind lower student performance. However, only 22% students agreed with this hypothesis and approximately 58% students disagreed. In general many students did not realize the magnitude of deeper mathematics required for this assignment. This supports finding by Nicolaou and Philippou [8], which says strong correlation exists between ability in problem posing and mathematics performance.

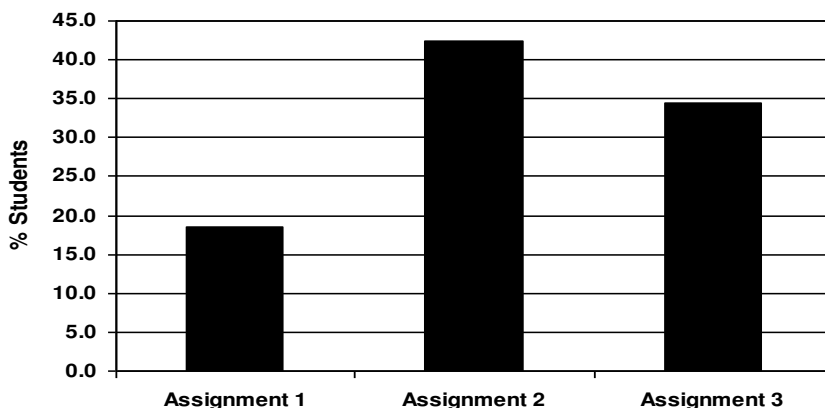


Figure 8: Percentages of students spent less than 5 hours for the assignments.

CONCLUSIONS AND RECOMMENDATIONS

The following conclusions are proposed as a result of this investigation:

- Increased teaching and tutorial time on Assignment 2 contributed to improving student results in this task. The lowest mark of Assignment 1 was increased by 230%.
- Even with the strategic changes, the least performance was still observed in Assignment 2, although most of the students agreed that they understood the theory (concept) and reported that they found the task interesting.
- Mathematical calculation was thought to be the reason for lower performance in Assignment 2, however most of the students did not agree with this reason. Only 22% students reported that they had difficulties with mathematical calculations. It should be noted that in the survey year (2009), approximately 20% students were from non-engineering disciplines, and may therefore have had weaker knowledge and skill related to mathematics.
- Most of the students reported that they understood the theory and concepts of Assignment 2 and that mathematical calculations were not a critical issue for this assignment. However students spent the least amount of hours on this assignment compared to other assignments. Could this mean that a degree of over-confidence (due to good performance in Assignment 1) might have led them to apply less effort to this assignment and be the reason for the poorer performance in Assignment 2

Through the observation of the effect of the strategic change and feedback from the students, the following recommendations are proposed to be implemented:

- More hands-on tutorial time on applied to Assignment 2 because in 2009 there was a significant improvement on students' outcome for this assignment.
- If a significant number of students are from non-engineering disciplines, it is recommended that the subject to be reorganized in a way that results that in one semester it is offered for engineering students and in the other semester it is offered for non-engineering students.
- During tutorials, a performance summary of previous years student results could be presented to current students to alert them not to become over confident and to regulate student self-efficacy.
- Assignment 2 needs to be modified to make it more feasible for non-engineering students.

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DEVELOPMENT OF DESIGN, IMPLEMENTATION, AND TROUBLESHOOTING SKILLS OF EE STUDENTS

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ABSTRACT: This paper describes the experience of a project-based course “Design with ICs” and its educational effectiveness in developing the design, implementation, and troubleshooting skills of junior-level Electrical Engineering students. In contrast to traditional approach of conducting experiments using laboratory handouts, students are assigned specific projects to design, simulate, implement, and test their projects in the laboratory. The course aims at gradually and systematically developing the design and practical skills of students in analog and digital electronics. Course projects are outlined and some of the designed projects are presented. Students’ feedback on their first exposure to projects-based approach for developing the desired skills has been analyzed and presented in the paper. It is shown that the projects-based course, though more demanding in time and effort, has significantly contributed in developing the design, implementation, and troubleshooting skills of students. In addition, by requiring the students to carry out all stages of the project, starting from the design specifications and ending with complete project testing, students have gained confidence in their acquired skills that might not have been achieved by following the traditional approach of conducting experiments in the laboratory.

KEYWORDS: Projects-Based Course; Design Skills; Practical Skills; Engineering Education.

INTRODUCTION

In Electrical Engineering education, design, implementation, and troubleshooting skills have always been considered as important skills to be acquired by EE students. Their importance has been further emphasized during the past decade or so with the introduction of EC2000 Criteria adopted by ABET [1]. As a result, students are now introduced to design concepts at an earlier stage and their design, implementation, and troubleshooting skills are gradually developed throughout their undergraduate studies [2-5]. This is in contrast to the earlier approach where most of the design work was done at the senior level, primarily related to the capstone project. The usefulness of projects-based courses in enhancing the technical as well as generic skills of engineering students has been demonstrated in a number of case studies [6-8]. An interesting case representing the new trend is that of Olin Curriculum [9] that follows the concept of design throughout – from the day the students arrive on campus to the day they graduate.

In line with the recent trend on the development of design, implementation, and troubleshooting skills, the EE Department at AUST has adopted a systematic approach to develop these skills from an earlier stage. In a number of EE courses with associated labs, students are required to design, implement, and test one or two course-related projects near the end of the semester when they have gained reasonable experience through traditional laboratory experiments during most part of the semester. Subsequently, in their junior year, students take a course “Design with ICs” that emphasizes design throughout the semester. In contrast to traditional laboratory sessions, students

implement, troubleshoot, and test their own design work in each laboratory session. This paper explains the approach adopted by the EE Department for developing such skills through “Design with ICs” course. It also presents an analysis of the students’ feedback regarding the effectiveness of the presented approach in developing their skills in design, implementation, and troubleshooting. It is shown that the projects-based course has not only enhanced the desired skills but has contributed in developing students’ self-confidence in their acquired skills. As such, they are well-prepared for their capstone project in the final year.

COURSE PROJECTS

A total of six projects are given throughout the semester covering many of the topics discussed in the class. Four such projects are described below. In addition to the common goal of developing design and practical skills, each project has additional goals related to the course material.

Design Project 1

Design, implement, and test a circuit that will work as follows:

- a) If the room temperature is less than 25 °C, a green LED shall become ON.
- b) If the room temperature is between 25 °C and 30 °C, a 12V fan will become ON.
- c) If the room temperature is more than 30 °C, a red LED shall flash at a frequency of 2 Hz with a duty-cycle of 60 %.

For this project, you will use the temperature sensor LM35, the timer IC 555, open-collector comparator ICs (LM311 or LM339), a relay, LEDs, a fan and other components, as needed.

Design Project 2

You are working in an engineering company and for their next product the manager has decided to develop a digital temperature meter that can measure and display room temperature. He has asked you to complete this project in two phases. In the first phase you will design, implement, and test a circuit that will interface your temperature sensor (LM35) to the input of an 8-bit A/D converter. In the second phase you will convert the analog input at A/D converter into digital form, process it using a microcontroller and then display the temperature. The second phase will be completed later in this course. For the first phase, the design specifications are as follows:

- a) The room temperature is in the range of 15 °C to 40 °C.
- b) The supply and reference voltages of the 8-bit A/D converter are both 5 V.
- c) If the temperature exceeds 40 °C, a beeper/buzzer shall sound for 10 seconds.

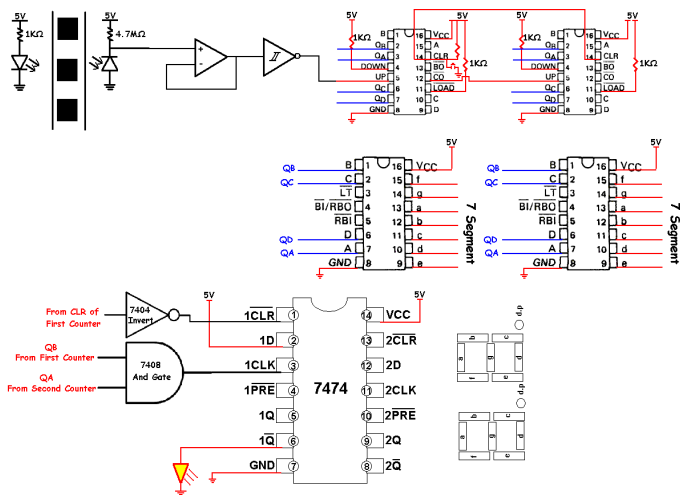


Figure 2: Design of Project 3 by a student team.

IMPLEMENTATION AND TROUBLESHOOTING SKILLS

After the design had been completed and tested by simulation, where applicable, students had two laboratory sessions (in two weeks) to implement their design on breadboard, test it, and carry out troubleshooting as needed. They were required to demonstrate the working of the complete project satisfying all design specifications. A laboratory engineer was always available to guide the students in troubleshooting and checking complete working of the project as per specifications. During their work in the laboratory, students were also asked related questions to further develop their understanding of the project and, in particular, their troubleshooting skills. Two of the implemented projects are shown in Figures 3 and 4 below.

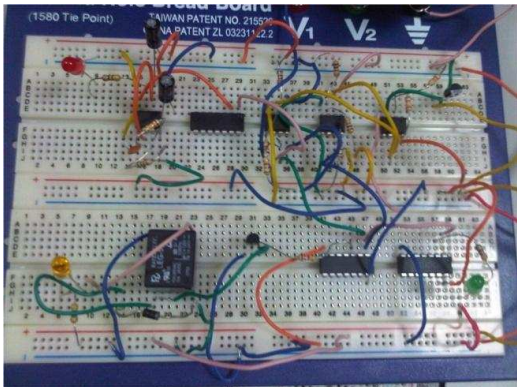


Figure 3: An implementation of Project 1.

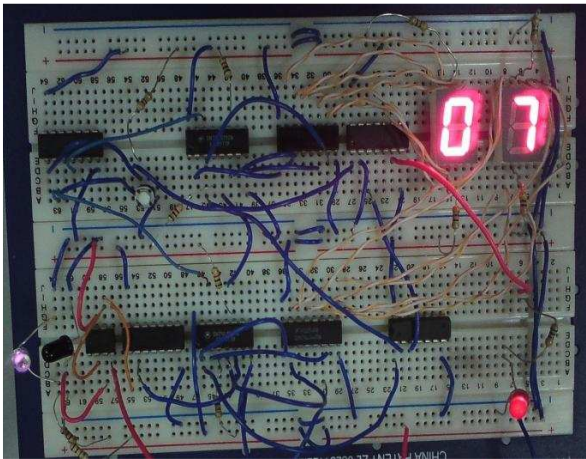


Figure 4: An implementation of Project 3.

EDUCATIONAL EFFECTIVENESS

In order to determine the effectiveness of this projects-based course, a questionnaire was prepared and distributed to 68 students who took this course. A total of 61 responses were received. The evaluation questionnaire consisted of 9 statements. For each statement, students were asked to choose from “Strongly Disagree”, “Disagree”, “Strongly Agree”, and “Agree”. The results of this survey are summarized in Table 1. As none of responses included any "Strongly Disagree" option, this column is not shown in the table. A graphical presentation of these results is shown in Figure 5. For this figure, "SA", "A", and "D" correspond to “Strongly Agree”, “Agree”, and “Disagree”, respectively. An analysis of the results obtained from students' feedback is presented in the following.

Table 1: Students’ response to evaluation questionnaire.

No.	Statement	Number of Students		
		Strongly Agree	Agree	Disagree
1	After completing the course projects, I better understand the related theoretical topics of the course.	36	25	0
2	Course projects have improved my design skills.	42	18	1
3	Implementation of course projects improved my practical skills.	42	17	2
4	Course projects helped me improve my troubleshooting skills.	25	32	4
5	The extra effort required by course projects is worth the experience gained through the projects.	21	37	3
6	I feel more confident now to design and implement a practical project.	21	36	4
7	The laboratory experiments alone are not sufficient to provide the required confidence and experience.	22	35	4
8	Team members learned and benefited from the knowledge and experience of one another.	24	32	5
9	I found the course projects highly beneficial.	39	22	0

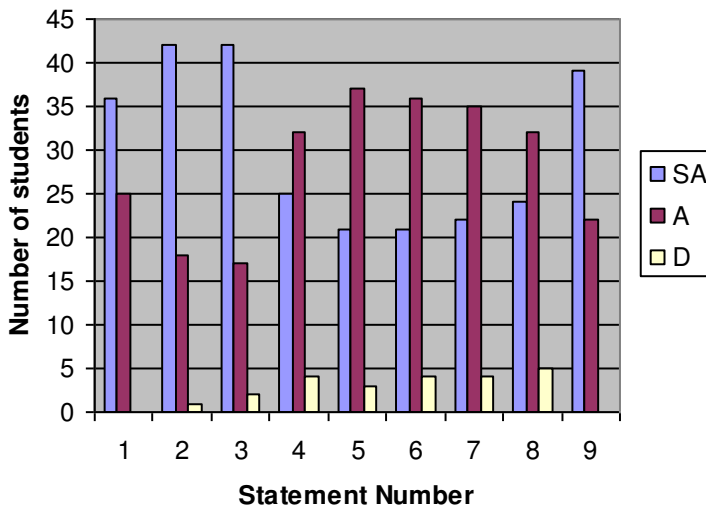


Figure 5: Graphical representation of students' response.

A study of the students' response makes it quite clear that the projects-based course has made significant contribution in developing their design, implementation, and troubleshooting skills. This is indicated by an overwhelming majority of 98% students agreeing (or strongly agreeing) for the design skills, 96% students for implementation skills, and 93% students for troubleshooting skills. Furthermore, there is unanimous agreement (100%) that course projects had helped them better understand the related course topics. Also, vast majority of students (93%) have agreed that course projects had improved their confidence in designing and implementing practical projects. Finally, all students without any exception, found the course projects highly beneficial. It is interesting to note that 95% students believe that extra effort required for completing course projects (in contrast with traditional experiments based on handouts) is worth the experience gained through the projects. Somewhat similar percentage of students (93%) has agreed that laboratory experiments alone are not sufficient to provide the required confidence and experience. This supports the projects-based approach adopted by the EE Department at AUST.

CONCLUSION

By presenting the case study of a specific projects-based course (Design with ICs), this paper has highlighted the significance of course projects in developing design, implementation, and trouble-shooting skills of EE students. Course projects, based on the material covered in the classroom, were designed, simulated, implemented and tested in the laboratory by student teams. This is in contrast to traditional approach of conducting experiments in the laboratory using prepared handouts. Analysis of students' feedback about the course projects has clearly indicated the effectiveness of such projects in achieving the intended outcomes of this projects-based course. In addition to developing their design and practical skills, the course projects helped improve their understanding

of related theoretical topics and increased their confidence level in designing and implementing practical projects. While the projects-based approach demands extra effort from the students, it was encouraging to note that an overwhelming majority of students indicated that the extra effort is worth the experience gained through the projects.

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THE EFFECT OF PHYSICS PLACEMENT TESTS AND REMEDIAL PHYSICS COURSES ON THE PERFORMANCE OF UOS ENGINEERING AND SCIENCES STUDENTS

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ABSTRACT: The results of a study that was carried out over the past ten years to investigate the impact of Physics Placement Tests (PPT) and Remedial Physics (RP) courses on the performance of University of Sharjah (UoS) engineering and sciences students is reported. The performance of three groups of students was evaluated. The first group (G1) included students who registered in the colleges of Engineering and Sciences prior to the 2004/2005 academic years; the year during which the University of Sharjah implemented PPT and RP as an approach to assess students' physics and mathematics background. Hence, students in G1 were admitted into the program without taking PPT or RP. The second (G2) and the third groups (G3) included first year students who were admitted into their respective programs after the academic year of 2004/2005. G1 included students who were placed in Physics I after passing the PPT, while G3 included students who did not meet the PPT cut score and had to take RP before they were admitted into their program of study.

The results of the study showed that the passing percentage in Physics I has improved by 10% after implementing the PPT and RP approach. It was also found that students PPT scores had higher correlation coefficient with Physics I grades (0.7) than High School Physics grades (0.2). This is an indication that PPT is a good approach for properly assessing students' physics background. It was also found that students in G3 attained higher grades in Physics I than their counterparts (G2). In addition to their better performance, G3 students had significantly lower dropout and withdrawal rates than students in G2 and G3.

Our study concludes that PPT and RP courses have a pronounced impact on students' performance, not only in Physics I, but in subsequent advanced courses as well. It was also found that PPT tests and RP courses have influenced other educational quality attributes such as lowering withdrawal, drop-out rates, and provided students with extra time to adapt to the college life and atmosphere. The conclusion is that the PPT and RP courses improved the quality of education at the Colleges of Engineering and Sciences at UoS.

KEYWORDS: Physics Placement Tests; Remedial Physics; Engineering and Sciences Students; Background Assessment; Students Performance; Education Quality.

INTRODUCTION

A low rate of student success is a widespread and persistent characteristic among postsecondary institutions in Introductory College Physics (Physics I and II) [1]. For example, at the University of Sharjah, the passing percentage in Physics I and Physics II hover around 60%. Typically, up to 50% of students fail the first midterm, and by the end of the term, the portion of those enrolling who succeed (i.e., complete the course with a grade of D or better) around 60%. The 10% increase is attributed to students' ability to catch up and get adapted to the college atmosphere and assessment tools [2]. It is widely

believed that the main factor contributing to low passing percentage among freshmen college students is the inadequate physics background students are assumed to have had during high school [1-4].

A common approach, used to improve the success rate in these courses, is to identify unprepared students (those with weak physics background) and provide them with “Remedial Physics” or “Preparatory” physics courses [5-8]. The purpose of this course is to help the students strengthen (or upgrade) their physics background. Students who have acquired adequate physics background during high school are exempted from taking RP courses. To this end, a Physics Placement Test (PPT) has been developed and administered in many international, regional as well as local postsecondary educational institutions with the aim of identifying students with weak physics background, and “filtering” them out [9]. The PPT is designed to test the students’ conceptual knowledge in the areas of kinematics (position, velocity, and acceleration – one dimensional motion) and dynamics (adding forces, collisions– one dimensional motion, and Newton’s laws). The test also examines the students’ basic mathematical skills. Students are given ninety minutes to complete the test during which they are allowed to use their calculators and provided with a formula sheet. Samples of the PPT is made available at the Applied Physics Department, UoS website (www.sharjah.ac.ae).

Students who fail to meet the cut score are asked to take Remedial Physics (RP), which is a course designed to strengthen the students’ physics as well as mathematical background and problem solving skills. The course is comprised of topics including introduction to units and measurements, kinematics in one dimension, vectors, introduction to work-energy-theorem, power, fluids, electrostatics and simple circuits. The course outcomes include providing students with basic knowledge of the above mentioned topics, which are covered in more depth and depth in Physics I and II. Special attention and emphasis are given to skills such as problem solving, critical thinking and concept visualization. These attributes are believed to be important for understanding topics covered in physics I and II. In addition to cognitive content, the course gives students the opportunity to adapt to the college life and atmosphere, which is believed to be among the leading factors that tend to affect students’ performance during the first semester of their college experience [9]. The course evaluation and assessment tools are identical to those used in courses taught in the respective colleges, which give the students an additional advantage. The course does not count in the students’ accumulative GPA and it is set as a “Pass/Fail” course, with the passing mark set at 60%.

One of the important factors in PPT is setting the cut score. This is the minimum score the students have to obtain in order to be admitted into Physics I. At the Applied Physics Department (UoS), the cut score is set in consultation with the respective colleges. In deciding the cut score, the most important factor to be considered is the performance of students in Physics I in comparison to their score in PPT. This is usually obtained from previous data. At the UoS, it was found that students who scored 50% or more in the PPT did not have difficulty passing Physics I. Another factor that was considered when setting the cut score was the enrollment capacity, i.e. the number of students needed for each program *versus* the number of applicants.

Several research studies have investigated the effectiveness of placement tests and remedial courses and their role is gauging the “true” level of the students [e.g. 10-16]. Among these studies is that of Sturtz and McCarroll [10], who monitored the progress of students who failed to meet the cut score of the New Jersey College Basic Skills Placement Test (NJCBSPT) in mathematics. These students were placed in remedial mathematics courses. Upon successful completion of this course, students were admitted into Calculus I. The study included a comparison of the performance of these students in comparison to the students who were able to meet the cut score and registered in Calculus I without taking Remedial Math. The authors concluded that there is clear evidence showing that students who took remedial math had higher grades than the other batch of students who did not have to take it. In addition, the authors stated that students who took remedial physics courses scored better in advanced courses.

Truman [11] piloted a 2-year study, which aimed at monitoring the performance of students who took remedial courses before registering in first year college courses. The results of the study indicated that students who were placed in courses higher than their level (i.e. scored less than the placement test cut score) attained lower scores in first year courses. In addition, the withdrawal percentage among this batch of students was higher than those who were placed in courses appropriate to the level as determined by the placement test [10].

It is evident from the work of Sturtz and McCarroll, and Truman as well as others, that the importance of placement tests and remedial courses goes beyond improving the students' physics background. In addition to lowering the drop-out and withdrawal rates, researchers have shown that students who took remedial courses are given the chance to get acquainted with the university life and the pressures it brings with it [14-16]. It should be highlighted here that postsecondary institutions worldwide consider this approach (i.e. placement tests and remedial courses) as an important tool for attaining high quality education and improving their ranking among other institutions. In fact, one of the criterion set by international agencies such as McClean of Canada [17], when ranking institutions, are the acceptance standards, include acceptance standards, which included placement test cut scores.

Critics of such an approach pointed out to several disadvantages of placement tests and remedial courses [18-21]. A summary of these disadvantages include:

- Remedial courses tend to prolong the program of study, which may add to the education cost for the institution as well as the student [18,19].
- Placement tests tend to scare students from post-secondary education [19].
- For students who were not able to meet the cut score, the placement tests tend demoralize them, leading them to accept registering in less prestigious (low quality) institutions. In some cases, it may lead students to drop-out [19].
- The money and time spent on placement testing and remedial courses should be directed towards improving the quality of education at the high school level to eradicate the problem at its roots [18].

- Placement Tests tend to reduce the number of students enrolled into the Colleges of Sciences and Engineering. For private universities this is not welcome news since it affects their revenue [20].
- In institutions where not all departments require students to take the placement test, students will be more inclined to register in departments, which do not impose such requirement. This leads to migration of students to these departments, which may lead to shutting down certain programs.

It should be noted here that most of these concerns are driven by economic factors, which depend on students' enrollment. This is more pronounced for private institutions, where a high percentage of their revenue comes from students' tuition fees. Nevertheless, these concerns need to be addressed, especially if this approach found to have low impact on student performance.

Our objective in the remaining sections is to examine the effectiveness of the PPT and RP courses approach on improving the physics background of the students at the Colleges of Engineering and Sciences at the University of Sharjah (UoS), United Arab Emirates (UAE). In addition, we will examine its impact on the students' performance in Physics I and Physics II.

MATERIAL AND METHODS

Established in 1997, the University of Sharjah (UoS), United Arab Emirates (UAE), started implementing the placement testing and remedial courses approach for the subjects of physics and mathematics in the academic year 2004/2005. The decision came about in response to the lower than expected performance of students in various introductory courses, which included in addition to Calculus I, Physics I, other college and university requirements. The decision was taken in consultation among colleagues in Colleges of Sciences, Engineering and representatives from registration, administration and curriculum committee. Ever since, students registered in all Departments of the Colleges of Engineering and Sciences, have to pass the Physics and Mathematics Placement Tests before they can register in any of their program courses. Students who fail to do so are asked to take remedial courses before they are admitted to their program of study (see UoS website: www.sharjah.ac.ae).

Our study included a comprehensive examination of the effectiveness of the Physics Placement Test (PPT) and Remedial Physics (RP) based on statistics collected at the Applied Physics Department from the academic year of 1999-2000 until 2008-2009. The goal is to examine the effect of the PPT and RP on the performance of students, and thus on improving the quality of education at Colleges of Engineering and Sciences. To effectively achieve this goal, the discussion will focus on the following points:

- A comparison of the overall performance (average grades and passing percentage) of students in Physics I and Physics II before and after implementing the PPT and RP approach.

- Investigating the effect of RP on the performance of Physics I students, and compare their performance to students who met the cut score of the PPT and enrolled in Physics I without taking RP.
- The effect (if any) of RP on the performance of students in subsequent years (advanced courses).
- Compare other educational attributes such as the withdrawal and drop-out rates of students who took PPT and RP to those who achieved the cut score and enrolled directly to the respective programs.

The source of the data presented in this study includes the course-archived files of PPT and RP, Physics I and Physics II. These course files contain course outline, learning outcomes, assessment tools, mid-term and final exams, as well as course statics, which include grade statistics and class average as well as course report. These files are available for all semesters since the establishment of the university.

RESULTS AND DISCUSSION

1. Effect Of Placement Tests On Students' Overall Performance

As mentioned above, the placement tests were first implemented in the academic year of 2004-2005 in response to complaints from teaching faculty about the students' weak mathematics and physics background. The latter had a direct implication on the overall GPA and passing percentage, which was 65% (D+) and the low passing percentage (around 50%). A number of reasons were suggested for this low percentage, the most pronounced of which is that students did not gain adequate physics background in high school [22]. This was not a straightforward issue to discuss, especially since these high school graduates have attained very high grades in high school physics [23,24]. Concerns about physics teaching approaches in high schools as well as the assessment tools were raised, especially since it was evident that these grades were inflated and do not provide proper assessment of the students' level [23,25,26]. Whatever the reasons may be, the natural solution that was suggested is to administer the placement tests, with the hope that these will properly assess the student's proper level, regardless of what the grade the obtained in high school physics. Table 1 summarizes the placement test results for the period 2005/2006 Fall semester to the Spring 2009-2010.

It is evident from the Table 1, that the average passing percentage in the placement test is 51%, with a slight edge for female students (about 2%). Further examination of the results of the students who passed the test reveals that the students' grade average in the PPT was about 63%. It should be noted that this is the grade average for these students in high school physics was 87%, with a high percentage among them have 95% and above. This implies that almost 50% of the students registered end up taking RP.

The most important and relevant statistics in this study is the effect of the placement test on improving the passing percentage and GPA of the students in Physics I and may be Physics II. The answer to such question is presented in Figure 1, which shows a comparison between the results of Physics I before and after the implementation of the placement test.

Table 1: Placement Test Results from 2004-2005 until Fall 2009-2010

Academic Year	Male			Female			Total		
	No of Students	Pass	Fail	No of Students	Pass	Fail	Total Students	Passes	Fail
2004-2005 Fall	96	50%	50%	73	41%	59%	169	46%	54%
2005-2006 Spring	30	57%	43%	8	63%	37%	38	58%	42%
2006-2007 Fall	241	44%	56%	173	44%	56%	414	44%	56%
2006-2007 Spring	78	55%	45%	36	39%	61%	114	50%	50%
2007-2008 Fall	268	51%	49%	207	41%	59%	475	47%	53%
2007-2008 Spring	33	45%	55%	31	52%	48%	64	52%	48%
2008-2009 Fall	323	44%	56%	209	49%	51%	532	46%	54%
2008-2009 Spring	80	61%	39%	79	62%	38%	159	62%	38%
2009-2010 Fall	337	51%	49%	323	52%	48%	660	52%	48%

Figure 1 shows that there is a 10% increase in the passing percentage. In addition it was found the GPA of the students' grades improved by almost 5%. Since almost 50% of the students have been "*filtered out*" by the placement test, i.e. those who did not meet the cut score of the PPT, one would expect the passing percentage of the classes to be higher. It should be noted that the results of Physics II was not affected after the implementation of the placement test. This is expected since Physics II is a continuation to Physics I and there is a strong correlation between the results of both courses regardless of the placement test.

The second important comparison was between the PPT scores, high school physics grades and the final grades in Physics I. The results for one batch of students are shown in Figure 2. It was found that the correlation coefficient between PPT scores and grades obtained in high school physics was low (i.e., $R = 0.4$), while the students final grades in Physics I were found to have high correlation coefficient ($R = 0.72$). This is a clear indication that the placement test provided better assessment of the students' physics background, and effectively "*filtered out*" un-prepared students. A similar comparison has been reported by McFate and John Olmsted III [5] on placement tests for chemistry students.

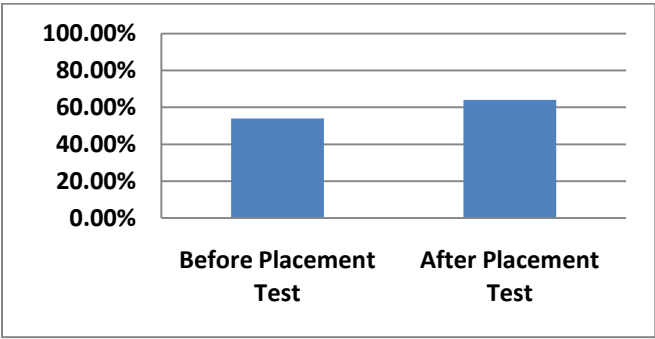


Figure 1: Comparison between students’ passing percentage before and after the placement test.

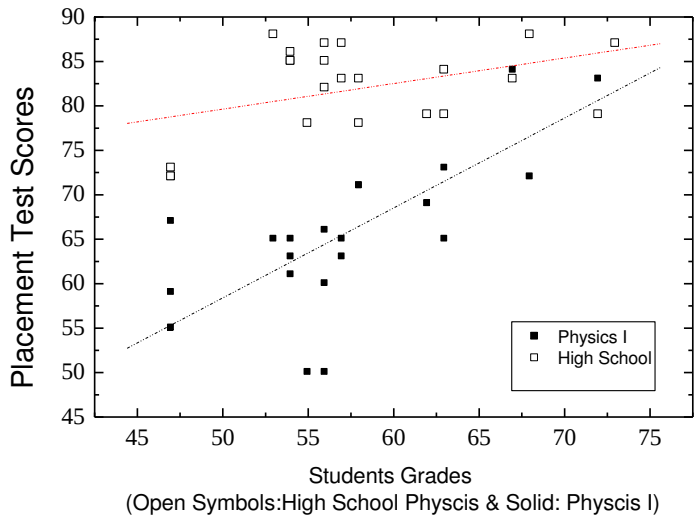


Figure 2: Correlation between PPT scores and High School Physics grades (open symbols) and Physics I scores (closed symbols).

2. Remedial Physics and its Effect on Improving Students’ Overall Performance

Students who failed to pass the PPT are asked to take RP. The course is designed to cover topics that similar to those covered in Physics I, but taught at lower level; similar to that of High School Physics. The main objective of the course is to strengthen the students’ physics background. Students have to score 60% or higher in the course in order to “Pass” the course. The course does not count in the students’ AGPA and it is assigned zero credit hours so that students do not feel pressured to get high scores in the course. University regulations and bylaws, including

assessment tools, absence, online teaching and learning tools, and lecture systems are applied to the RP course. This was suggested to provide students with an added bonus and expose them to the university atmosphere and get acquainted with the college environment before they start their academic program [1].

In this section, the performance of students in RP as well as the effectiveness of RP on the performance of students will be discussed. First, the performance of the students who enrolled in Physics I after passing RP will be compared to students who met the cut score of the PPT and enrolled in the same course without taking RP. To effectively do this, the progress of three groups of students was monitored for several years. The first group, G1, included students enrolled in Physics I without having to take the PPT. These include Engineering and Sciences Students in academic years prior to 2004-2005; the year during which the placement tests was first implemented. The second group (G2) included first year students who passed the placement test and were admitted into academic program without taking RP. The third group (G3) included students who did not meet the cut score of the PPT and had to take RP before they were admitted into their respective academic programs. A summary of the comparison is presented in Table 2.

The first observation in Table 2 is that the students' performance (measured by the passing %) for groups G2 and G3 was higher than that of G1. In addition, G3 (students who took remedial Physics) had better overall passing percentages in both semesters. A second important observation from Table 2 was that students belonging to G3 not only scored higher grades in Physics I, but their drop-out and withdrawal rates were lower than their peers in other groups. It is also interesting to note that when the performance of the same batch of students were followed up in advanced courses (including Physics II), it was found that the performance of G3 students is slightly higher than their counterparts [27].

Table 2: A comparison between the performance of the groups of students (G1, G2 and G3).

Group	No of Students	Voluntary Withdrawal	Spring 2003-2004							Passing %
			Absent	Forfeit	A	B	C	D	F	
G1	61	11	10	3	0	1	11	11	25	48%
Spring 2004-2005										
G2	35	4	1	1	2	5	7	10	9	74%
G3	12	2	2	0	1	3	3	2	1	90%
Spring 2005-2006										
G2	57	-	3	5						59.2 %
G3	25	-	0	1						66.7%

CONCLUSIONS AND RECOMMENDATIONS

The effectiveness of both Physics Placement Tests (PPT) and Remedial Physics (RP) course was investigated. The parameters studied were related to quality of education including proper assessment of students' physics background, students' performance and overall GPA as well course overall passing percentage. It was found that the physics grades obtained in high school did not provide "true" representation of level of the students. This was evident from the low correlation coefficient between PPT results and High School Physics Grades. On the other hand, PPT scores correlated much better with Physics I grades. It was also found that PPT improved the passing overall percentage of Physics I by about 10% as well as the students grades by an average of 5%. In addition, our investigation showed that students who had to take the RP course achieved higher grades as well as higher passing percentage than those students who met the cut score of the PPT. The results of the study clearly support PPT and RP as an approach to improve the quality of education in the Colleges of Sciences and Engineering. In conclusion, the PPT and RP courses approach may have some disadvantages, most of which are related to added cost and prolonging the program of study, however, these are outweighed by the advantages this approach brings. It is expected that in the long run, the effect of PPT and RP courses on the quality of education at UoS will pay its deviance through the enhancing the image and reputation of the institution. It is however, recommended that PPT and RP should be carefully designed and administered so that they serve the purpose they are intended for. The times and frequency of the PPT and RP should be revised. For example, students should have the option to take the test before the regular program begins and be able to do a re-sit the test if they wish to. Remedial courses should be available in the summer to allow students to enroll in the regular fall session.

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ENTREPRENEURSHIP, SMALL BUSINESS MANAGEMENT, AND INCUBATION: NEW ENGINEERING EDUCATION TRENDS

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ABSTRACT: Since 2000, the beginning of the second intifada, the Palestinian economy is suffering badly and landing a job is a challenge for experienced engineers not to mention recent graduates. ANERA initiated the establishment of six IT center of excellence in six Palestinian Universities to help create an entrepreneurship environment and help create jobs. Moreover, it initiated a business fundamental course that covers the topic of entrepreneurship and small business management. The Islamic University of Gaza ran this course for two semesters for a total of six credit hours. Students were chosen based on a certain criteria and distributed on several engineering disciplines. The course was piloted over two years for the years 2006-2008 and 104 students enrolled. The course was taught by several experts. The first part of the course covered three main topics: business communications, business fundamentals and finally the entrepreneurship; while the second part of the course covered three topics: how to get fund, the structure and law of the corporate, and building a business plan. At the end of the course students were divided into teams where each one presented a business plan for a new company and each team was evaluated by a team of expert based on their technical merit and their business plan. Graduates of this course were able to use this knowledge in developing their senior year projects. Moreover, some of the graduates of this course were selected to enroll in IUG ICT incubator as a result of their senior year projects and business plan. This paper will show the details in developing this course, the novel mechanics of running it successfully, the outcomes of this course, the potential of its graduates, and finally successful stories.

KEYWORDS: Entrepreneurship education; IUG; Incubator; Business Fundamentals.

INTRODUCTION

With the emergence of the knowledge-based economy, more attention has come to entrepreneurs and how they can make effective use of innovation, integrating information and knowledge in order to constantly create value for them. The platform of entrepreneurship is the most important policy in technology innovation, entrepreneurial information diffusion, and operation fund access. Entrepreneurship is emerging as the engine of economic growth and job creation in communities throughout the world [1]. In a business environment the community with leadership that understands its crucial role in supporting entrepreneurship has a clear advantage.

Information and Communication Technologies (ICTs) are now widely accepted by developing countries as a critical tool in their efforts to eradicate poverty, enhance human development, and achieve development goals. Therefore, infrastructure initiatives and development strategies incorporating ICT are being increasingly promoted and launched over the world. Engineering and IT education is the vehicle to transfer entrepreneurship skills and move to entrepreneurship education [1].

Palestine occupied territory and split in two geographical parts: West Bank and Gaza Strip, has very scarce natural resources and still without any control on its borders; thus, is relying heavily on foreign aids and donations. Since ICT industry does not depend on physical movement, the Palestinian National Authority (PNA) endorsed ICT to develop its domestic economy; thus, minimizes the effects of Israeli military restrictions on movement, and communicates with the rest of the world [2].

With 50% of its population below the age of 15, with literacy rate of 92%, the highest in the Arab world, with its human resources as the only natural resources at hand, the PNA is trying jump into the ICT revolution by utilizing its young educated population and started to focus on ICT as one of the main economic driver and employment segments [3].

ICT industry does not require major initial investments and that ICT products and services are not bounded to the Israeli military measures of closures or lack of control over borders, the PNA set the stage to build its ICT national strategy. The PNA through the Ministry of Telecommunications and Information Technology successfully mainstreamed ICT as part of its national development strategy over the past decade.

Building a Palestinian information society that facilitates information access to all and adopting IT as basic means of moving the Palestinian people forward and achieving its goals in all facets was adapted as Palestinian's ICT strategy in 2005 [2]. The local market is not growing and the economy is suffering; thus, no new employment activities will be in the near future. Therefore, the only chances is in creating micro and small ICT enterprises that will pick up the pieces and solve the unemployment problem, help in solving the poverty problem, and utilize the energy and power of youth. The driving force behind this will be entrepreneurs who will create their teams and build up their companies from scratch.

The persistence of high unemployment in Gaza Strip has become a major challenge to the Palestinian people. The excess supply of graduates has become more numerous. Between 1995 and 2005, educated unemployment rates rose from 21% in 1995 to 32% in 2005. The number of unemployed graduates doubled four times during that period, increasing from 20 thousand in 1995 to 80 thousand in 2005 [4]. Yet, the higher education sector is not demand driven in supplying specific outputs to the local labor market. Therefore, there is a need to diversify and upgrade the quality of all Palestinian institutions of higher education given that the major objective of higher education system is to supply the society with highly skilled, well-trained and active graduates [5].

Over the last five years, Gaza Strip was in the mix of a blockade by the Israeli army. The economy suffered a great deal of damage and employment opportunities diminished very quickly. The ICT field was no better than any other field, were local companies closed their doors and the only survivors where a few ones that managed to serve the local demands. Most type of employment was either temporary or part-time.

The Islamic University of Gaza (IUG) is an independent Palestinian institution located in Gaza. IUG is the first higher education institution established in Gaza in 1978. Currently,

IUG has ten faculties and more than 40 departments introducing BA, B.Sc., MA, M.Sc., and higher diploma in a variety of disciplines. The academic staff at IUG for the academic year 2008/2009 is 535. Students specialized in engineering and IT account for about 3500 students. The Engineering College recently won the 2009 Islamic Investment Bank Prize.

The goal of the Islamic University of Gaza (IUG) is to offer means for enhancing overall economic growth and development in Gaza Strip and creating employment opportunities. IUG has developed several academic links and signed several agreements of academic cooperation with international agencies and universities. It has also conducted several projects in collaboration with local and international organizations and institutions situated to upgrade the skills of its graduates.

Graduates in engineering and ICT field from IUG ranged over 280 annually. Most of them are facing unemployment. In order to reduce the unemployment numbers, the Islamic University of Gaza in partnership with ANERA started a pre-incubation business training course. The course runs for two semesters and covers six credit hours. The course covers business fundamentals such as feasibility studies, work plans, capital venture, business financing, marketing, start-up companies, and entrepreneurship. Over the last three years, over 180 students completed this course. This course is intended to help graduates to start-up their own companies and help them realize their future as entrepreneurs.

This paper documents IUG experience in implementing this course and designing the educational activities. This paper also shows the details of the course specifications, the novel mechanics of running it successfully, the outcomes of this course, the potential of its graduates, and finally assessment and evaluation of the course. This paper also contributes to transfer engineering programs to entrepreneurship education. The developed model will help other engineering programs in the Arab world to benefit from this experience and give clear view of all activities that were performed during the last three years.

This paper is organized as follows: section 2 covers the course specifications, section 3 describes the course implementation over two years, section 4 covers the course assessment and evaluation, and paper is concluded in section 5.

COURSE SPECIFICATIONS

As part of ANERA policy to develop and enhance ICT in Palestine, ANERA helped six Palestinian universities in building IT centers of excellence. One of these centers is being established at IUG, INTEL ICT Center of Excellence. ANERA continued its support of the Palestinian universities and offered help in developing the skills of ICT graduates and enhanced their business and entrepreneurs skills. The objective of ANERA was to develop and promote entrepreneurial learning, in a lifelong learning perspective, as a central pillar in the wider effort to promote competitive economies.

The “ANERA Business Fundamentals course for IT and Engineering Students” had two objectives. One was to put in historical perspective the growth of venture capital and private equity financing by analyzing why it has grown, why and how it has changed and where it may likely grow in the future. Two was to introduce students to the various sources of financing for start-ups and expanding technology companies and through case studies, assigned projects, lectures and guest speakers developed analytical methodologies and techniques to define capital needs and access financing sources. Sources of financing examined included private and business angel investors, PNA supported funds, venture capital, donation funds and corporate investment funds.

The course outcomes were such that graduates of this course were expected to: Recognize real practical aspects on business fundamentals and entrepreneurship; Develop feasibility study for an ICT business idea; Recognize market share and develop marketing strategy for products/services; Build a financial strategy on financing business ideas; Work effectively with others and develop leadership skills in developing business proposal.

The approach was practical and hands-on with emphasis on problem solving, student presentations, group interaction and meetings with practitioners from the local area. Attention was given to financial theory, risk assessment, risk-reward tradeoffs, valuation techniques, term sheets, due diligence questions, financial reports for monitoring progress towards meeting milestones, exit strategies, networking and presentations to investors [5].

Case studies from local and regional area were assigned for students to critique in the first course while in the second course teams prepared business plan. A list of specific readings and assignments by class date and a bibliography were posted on the course website.

The course required weekly attendance and prompt arrival in class. Students succeeded in this class when they carefully did the assignments on time and actively participated in class discussions. Together these represent 70% of a student's grade. The business plan project represents 20% of the grade and the presentation and the report the remaining 20%.

The case study was presented by teams of 2-4 students. The team presentations were short and required students to guide the class through a case in less than 20 minutes and distribute a 1-2 page handout. Grades were determined by succinctness and clarity of presentation.

The business plan project is a team effort, 2-4 students. The focus of the business plan project was requesting and justifying financing for a business. The first step was a convincing plan that included an executive summary, the market for the product or service that the company provided, the business model, the management team, the financing plan and how this will be executed including amount, timing and sources of funding with implications of the financing strategy for ownership (cap table) and investors (rate of return), cash flow and the balance sheet, and the risks-reward analysis as well as the value added proposition to investors, proposed exit strategy and term sheet.

The project is an investment proposal, less than 20 pages (typed, double space) excluding attachments, e.g., detailed financials. Teams were invited to make a 10-20 minute power point presentations to public audience.

The course topics include: Business communications, reporting and spreadsheets, business fundamentals: accounting, marketing, management, finance and business ethics, entrepreneurship: venture capital, stages of finance and sources of capital, getting funding: venture capital, financial theory, banks and venture capital and providers of capital, corporate structures and laws, protecting your idea, building a business plan: business plan, market, product/service, budgeting and management, and ecommerce [6-8].

The ANERA course is six credit hours distributed evenly into two semesters. The course was allocated the amount of \$60,000 over two years where it covered students' tuition fees, textbooks, instructors fees, supervision and coordination, and facilities. The course textbook is titled: Business: An Integrative Approach, third edition, by Fred Fry, Charles Stoner, and Richard Hattwick, (Irwin/McGraw-Hill, New York, NY), 2003. The course used the following references: David Gladstone, Venture Capital Investing, Englewood Cliffs, Prentice Hall, 2004; Mark Van Osnabrugge and Robert J Robinson, Angel Investing, Harvard Business School, 2000; Andrew Sherman, Raising Capital, 2nd edition, Amacom Books, 2005; Josh Lerner, Felda Hardyman and Ann Leamon, Venture Capital and Private Equity: A Casebook, John Wiley and Sons, 2004; Paul Gompers and Josh Lerner, The Venture Capital Cycle, MIT Press, 1999; Gompers, Paul and William Sahlman, Entrepreneurial Finance: A Case Book, John Wiley & Sons, 2002.

COURSE IMPLEMENTATION

According to the agreement between IUG and ANERA; IUG lunched the first part of ANERA course in the second semester of the academic year 2006-2007. The course was give the names and codes: Business Fundamentals 1 &2, BUSE 4391 & 4392. The targeted students were 3rd year IT students (IT and computer science), and 4th year engineering students (electrical, computer, and industrial). The course was run and taught by the Business College.

The enrolment criteria for this course was : Student should be 3rd year IT or 4th year engineering, have a GPA above 80%, be fluent in English (oral and writing), be committed to take the sequence of the two courses, and consider applying the course outcomes in his/her graduation project. The course offered tuition free with free textbooks. The course is repeated for two years and a total of 104 students enrolled. Enrolled students for 1st year totaled 51 students distributed as follow: IT 23, Computer Science 2, Computer Engineering 14, Electrical 6, Industrial 6, where preferences were given to students who met the criteria and registered first. Enrolled students for 2nd year were 53 students distributed as follow: 20 IT, 3 Computer science, 13 Computer Engineering, 11 Electrical Engineering, and 6 Industrial Engineering.

The course had an academic coordinator who was in charge of dealing with instructors and students. He also dealt with grades, assignment, course schedules, case studies, and communication between students and instructors. The course also had an administrative coordination who handled the cooperation among the three colleges and the external communication with ANERA. He also oversaw the implementation of the course as planned, in addition to assuring the quality of course outcomes.

The course was taught by 14 experts with PhD degrees covered 25 topics where each one covered topics in his research and interest area. All instructors were from the Business College except one from IT but was from outside the university. Teaching was carried out mainly in English. The course materials were available through the course website and the instructors' websites. Students were not able to receive the textbooks due to the siege on Gaza, although the textbooks were ordered in advance. Teaching was carried out in a workshop setting which required active participations from students.

The student's evaluation criteria in the course were based on the following: 70% assignments, 20% Case study and 10% presentation and report. Students appreciated the Evaluation criteria, although feedbacks on assignment were late (delayed most of the time). Forms for evaluation the reports and presentations were not provided. The Business College Dean complained of the high grades in the course (average around 88), although this is understandable taking into consideration the quality of enrolled students. Public presentations and assessment of students work were held at the end of the semesters and external experts participated in evaluating students work.

The case studies and business plans were evaluated by course teachers, deans of concerned faculties and external guests (UNRWA and ANERA). All case studies students performed, were under direct supervision of specialized instructors. Each instructor was responsible of monitoring and evaluating the progress of each case study. Case studies were connected to the students' senior project where students implemented a business plan for their projects. Business Plans were for: Xnovel for Handicrafts Products, Smart House, IT Entrepreneurs, Hi – Tec Company, Alawael Co. – Software Development, Al-Rayah Co. – Engineering & IT, Smart – Way Cartoon, SCADA Pioneers, The Pioneer Company, PCB's Manufacture & Design, Jenan IT Company, Pharmaceutical Company, Publisher company, NET Solutions company Smart Company, Pharmaceutical Factory, Baladna company for Cheese.

Four projects were accepted to be hosted at the IUG ICT incubator. Two teams were able to start up their companies, Xnovel for Handicraft Products and Alawael Co.- Software Development. One project won the College of Engineering 2008 Best Senior Year Project Award, Smart House.

COURSE REVIEW AND EVALUATION

At the end of the second year of running this pilot course a decision must be on whether to adapt this course as part of engineering and IT curricula or not. If adapted how it will fit in and how it will be run. In order to accomplish this task, a review and evaluation

committee was formed. The committee consists of five experts from inside and outside the university (one from the national review team of IT and engineering programs, another is the head of the quality unit at the university).

Several activities took place to assess the course such as: Committee members interviewed a sample of the course students, students who completed all the course phases, committee members met the course teacher and deans of both Engineering and IT Colleges in addition to the heads of department participated in the course. After that, meeting with the academic affairs were organized in order to discuss results and consultate with them on further actions. The committee also met with course instructors and dean of Business College. The committee also reviewed all course documents, conducted questionnaire targeting students and graduates of the course and course instructors. These activities were distributed over two weeks. The committee issued a review report that evaluated the academic and financial aspects of the course.

The committee concluded that the course was a great success and a fresh air in both engineering and IT programs. Instructors were able to transfer their experience to their students during their meeting and supervision of the case studies. Students were highly satisfied with the instructors' qualifications, experience and performance in this course. Engineering students were the most satisfies with the course outcomes since it developed their administrative and management skills. The course exposed them to new field of knowledge, enabled them to expand their skills beyond their specialization, and opened new field and horizons for employment. The Business College did an outstanding job in running the course and the supervision of the business plans.

The feedback on assignment was weak and most of the time delayed greatly. Students complained that the amount of information and activities were enormous and that required to designate more time and efforts to the course. A majority in the students complained about the number of instructors (14) that resulted on not getting acquainted with them. Students were not satisfied with the grading criteria for presentations and reports that were not based on standard forms.

The committee made the following recommendations: Changing the course title to Business Fundamentals and Entrepreneurships, adapting the course by both engineering and IT programs as elective course, continuing with Business College to run the course, reducing the number of instructor to about 4-5 each semester, using forms in grading presentations and reports and providing timely feedback to students, assigning supervisors for the case studies and business plans to monitor and follow their progress, creating and designing course web site that will contain all needed materials, adding a final exam as part of the grading criteria with not more than 30% weight and finding funding to provide tuition and textbook free course.

SUMMARY AND CONCLUSIONS

Providing Engineering and IT colleges' students with basic business fundamentals helps them in establishing and funding their IT related business as it raises the managerial

aspects of their study. Depending on this view, ANERA supported a pilot course, business fundamentals, that were designated to engineering and IT students.

This paper talked about a partnership between the IT and Engineering and the Business Colleges in running an entrepreneurship education. The course was run greatly by the Business College. The course setting was not typical and the evaluation criteria were not the standard. The course was run over two semesters and 104 students enrolled in it. 14 instructors were involved in teaching 25 topics related to small and medium enterprises and entrepreneurs. The course provided an entrepreneur education and gave students an opportunity to develop practical skills in developing their own enterprises; thus, creating their own employment.

In order to measure the success of the pilot course, the pilot course was assessed and evaluated by an committee to decide whether to approve the course as an elective course for both Engineering and IT students or not and it was recommended to be an elective course. This recommendation showed that the course was successfully managed and taught in commitment with the course description ANERA proposed.

The course ran smoothly and student performed well in this course. There were some successful stories where some teams were hosted at IUG ICT incubator, others started up their own companies, and one team won an award. The Business College was very successful in the delivery of the course. The limited number of students in the session (25 students) was a factor in the success of this course. The course was adapted at both IT and Engineering Colleges as an elective course.

The paper make the following recommendation: engineering programs should concentrate on entrepreneurship education and provide their students with tools to enable them to create their own employment, engineering programs should study this experience and form a team to adapt this course as part of their curriculum either as elective or compulsory course. The Business College is the right place to run this course. A team of instructors should teach this course and the student's grading criteria should be selected carefully with written exam, if part of it, not to account for more than 30%.

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Comparisons of Engineering Education

DO UAEU CIVIL ENGINEERING GRADUATES GET COMPARABLE EDUCATION TO GRADUATES OF WESTERN UNIVERSITIES?

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ABSTRACT: Civil engineering in the United Arab Emirates has been the focus of the country's developments since its birth 39 years ago. The profession of civil engineering is, without doubt, the cornerstone of UAE economy. However, most of the civil engineers who work in the countless projects in UAE are graduated from non-UAE universities. This probably raises a concern about the quality of the civil engineering education in UAE. This paper is an attempt to investigate this concern through presenting a comparative study between the civil engineering program at the United Arab Emirates University (UAEU) and several North American universities. This study will help assessing the quality of the civil Engineering program at UAEU and providing new directions for improvements.

KEYWORDS: Civil Engineering Program; UAE University; Curriculum Development; Higher Education.

INTRODUCTION

The United Arab Emirates University (UAEU) is the oldest and probably the most comprehensive educational and research institute in the UAE. UAEU was established in 1977; only few years after the birth of UAE. Now, UAEU includes ten colleges that offer more than fifty Bachelor Degrees and fifteen Masters Degrees in different field. In May 2009, the UAEU announced the launch of the first PhD program at a national university in the United Arab Emirates. The Civil Engineering Department at UAEU was established in 1980. The name was changed later in year 2003 to the Civil and Environmental Engineering Department (CEED) as an indication of the department involvement and care about emerging environmental issues that was reflected in the courses offered to the students. Yet, the name of the program remained the Civil Engineering (CE) Program till date. Graduates from the department receive Bachelor degrees in Civil Engineering.

Faculty members and staff of the CEED have been always looking for excellence in the educational services they provide to the students. The department received the recognition of "Substantial Equivalency" form the Accreditation Board for Engineering and Technology (ABET) in 1998 and 2004 for six years each. This recognition indicates that the program offered in the CEED at UAEU has been equivalent to similar accredited programs in USA and other countries during the period from 1998 to 2010. In 2007, ABET allowed programs from universities outside USA to apply for full accreditation. This was not the case before 2007 and "Substantial Equivalency" was considered to be

similar to full accreditation. The CEED has applied for full accreditation of the CE program at UAEU and the process is currently ongoing.

CIVIL ENGINEERING PROGRAM AT UAEU

The CEED offers a traditional Civil Engineering (CE) program with emphasis on design, computer skills, and hands-on laboratory experience. Students take nineteen core courses that cover all basic civil engineering areas, and select three out of seventeen elective courses to integrate, in a balanced way, the broad civil engineering disciplines. Students in the CEED take courses in four major areas of civil engineering; namely structural engineering and design of concrete structures, water resources and environmental engineering, transportation and highway engineering, and geotechnical and construction management. Courses offered in these four disciplines are categorized according to the area in Table 1. Elective courses are listed by area in Table 2. Student enrolment in the CEED is among the highest in the College of Engineering. The enrolment of students in the department is continuously increasing. Table 3 also provides information about the number of sections offered in all courses offered during the last academic year. The average number of students per section is fifteen. Students are required to take three elective courses from four baskets (Table 2) covering the aforementioned disciplines.

The program also incorporates and integrates different themes other than engineering including mathematics, humanities and science. Table 4 classifies courses (other than specialized civil engineering courses) into different theme groups. Students enrolled in these courses will build the basic elements that will help them to be prepared for a professional career in the CE discipline. For example, the program offers early introduction to engineering design, where the experience begins with “Introduction to Engineering Ethics and Design” and “Engineering Practice and Entrepreneurship”. In these courses, students start to develop necessary skills, which are culminated later in the specialized courses and the “Graduation Project (I & II)”. Also, students in the CEED are required to complete 33 credit hours of college-level mathematics and basic science courses beyond the University General Requirements Unit (UGRU). These courses include Math courses, Statistics course, Physics and Engineering Applications courses, General Microbiology course, and General Chemistry and Engineering Applications course. Courses of Mathematics and Basic Sciences contain sufficient hours to cover the material usually contained in math, chemistry and physics courses. Hands-on experimental laboratories are used in the physics, chemistry, and microbiology courses. Study of mathematics is beyond trigonometry and includes differential and integral calculus and differential equations. Civil engineering students take chemistry (with lab) and differential equations/linear Algebra in the sophomore year.

Engineering probability and statistics is another area that is covered in the CE program that would help any student to continue his/her studies in the civil engineering discipline. Engineering probability and statistics competence is developed as part of laboratory assignments in several courses, where students perform statistical analysis of the results. Engineering courses also include probability and statistics. For instance, the “Eng. Statistics” deals with statistical analysis as a tool to solve problems.

Table 1: Technical Core Courses by Area in the CE program at UAEU.

Code	Course	CHs
Water and Environment		
CIVL 270	Introduction To Environmental Eng.	2
CIVL 325	Water Resources	3
CIVL 375	Water & Waste Water Tech.	3
CIVL 345	Fluid Mechanics For Civil & Arch Engrs.	3
	Total	11
Surveying And Transportation		
CIVL 330	Transportation Eng.	3
CIVL 335	Surveying	3
CIVL 433	Highway Engineering	3
	Total	9
Geotechnical And Construction Management		
CIVL 442	Foundation Engineering	2
CIVL 445	Construction Management	3
CIVL 340	Soil Mechanics	3
	Total	8
Structural Engineering		
CIVL 310	Structural Analysis	3
CIVL 360	Concrete Technology	3
CIVL 365	Reinforced Concrete Design I	3
CIVL 412	Reinforced Concrete Design II	4
CIVL 417	Structural Steel Design	3
GENG 240	Statics	3
GENG 305	Mechanics of Materials I	3
MECH 390	Engineering Materials	3
	Total	25

Table 2: Technical Elective Courses by Area in the CE program at UAEU.

Course	CHs
Water and Environment	
CIVL 520 - Special Topics in Water Resources and Env. Eng.	3
CIVL 522 - Advanced Environmental Engineering	3
CIVL 524 - Geo-Environmental Engineering	3
CIVL 525 - Hydrology	3
Surveying And Transportation	
CIVL 530 - Special Topics in Transportation Engineering	3
CIVL 531 - Topographic Surveying	3
CIVL 534 - Computer Aided Mapping	3
CIVL 538 - Advanced Highway Engineering	3
CIVL 539 - Traffic Engineering	3
Geotechnical And Construction Management	
CIVL 540 - Special Topics in Construction Management	3
CIVL 541 - Special Topics in Soil Mech. and Foundation Eng.	3
CIVL 547 - Advanced Construction Management	3
CIVL 548 - Advanced Geotechnical Engineering	3
Structural Engineering	
CIVL 510 - Special Topics in Structural Engineering	3
CIVL 515 - Advanced Concrete Technology	3
CIVL 517 - Matrix Structural Analysis	3
CIVL 552 - Advanced Steel Design	3

Table 3: Course and Section Size Summary during the last academic year.

Course Title	No. of Sections Offered in last academic Year
Introduction to Environmental Engineering	5
Structural Analysis	6
Computer Aided Drawing	6
Water Resources	3
Transportation Engineering	3
Surveying	6
Soil Mechanics	4
Fluid Mechanics	6
Concrete Technology	4
Reinforced Concrete Design I	4
Water and Wastewater Technology	3
Reinforced Concrete Design II	3
Structural Steel Design	3
Highway Engineering	3
Foundation Engineering	3
Construction Management	4
Special Topics in Structural Engineering	4
Statics	6
Mechanics of Materials I	6
Engineering Materials	6

Also, the "Transportation Engineering" contains Probability & Statistics content. Working in teams is important to acquire the techniques and skills needed in leadership, making decisions, communicating, building trust and managing conflicts [1]. Such techniques and skills especially in oral and written communication require a comprehensive approach of a taught course [2,3]. CEED students at UAEU are exposed to significant hands-on experience and collaborative learning through several design courses and projects as well as the industrial training. Each student must spend one semester as internship to fulfill requirements for graduation. CEED students develop strong oral and written communications through multidisciplinary teamwork in courses and projects which has resulted in a significant improvement in the quality of student's presentation skills. One manifestation of this is the increased involvement of industry partners in both industrial training and graduation projects. The students become more rounded and more prepared to engage in practical engineering tasks.

An essential criterion that has been carefully considered when setting the current version of the CE program curriculum is to ensure the consistency between the curriculum and the intended program educational objectives and program outcomes. A revised set of program outcomes has been implemented since March 2008. A summary of the revised CE program outcomes that describe what the students are expected to know or be able to do by the time of graduation from the program. These outcomes are:

- An ability to apply knowledge of mathematics through differential equations, calculus-based physics, chemistry and biology

- An ability to apply knowledge in the technical areas of structural engineering, construction management, surveying and transportation engineering, water resources and environmental engineering, and geotechnical engineering
- An ability to design and conduct civil engineering experiments, as well as to analyze and interpret data
- An ability to design structural, highway, transportation, hydraulic, environmental, and geotechnical engineering systems, components, or processes to meet desired needs
- An ability to function on multi-disciplinary teams
- An ability to identify, formulate and solve civil engineering problems
- Adherence to ethics, safety, professional responsibilities and licensure
- An ability to communicate effectively in oral, written, graphical and visual forms
- Comprehend the impact of engineering projects and solutions on the society and the local and global environment
- Recognition of the need for, and an ability to engage in life-long learning
- A knowledge of contemporary issues related to Civil Engineering
- An ability to use advanced techniques, skills and modern engineering tools necessary for engineering practices
- An ability to apply basic concepts in management, business, public policy and leadership

The program outcomes are intended to help the program graduates to achieve the following longer-term program objectives:

- Be committed to highest standards of ethical practices, and high level of awareness of social, economic, and environmental issues relevant to the civil engineering profession.
- Successfully deal with real life civil engineering problems and achieve practical and optimum solutions based on sound science and engineering knowledge.
- Efficiently design, build, and/or evaluate a civil engineering system/component to satisfy certain client needs per design specifications and/or interdisciplinary requirements.
- Effectively use modern engineering tools in all aspects of professional practices including technical communications.
- Develop and update their knowledge, leadership and skills to keep up with the rapidly evolving technologies.

Table 4 shows the consistency between the core courses offered by the CE program courses and the above mentioned program outcomes. The same table indicates that each outcome is addressed by at least six courses. Accomplishment of all intended long-term objectives by the program core courses is illustrated in Table 5. In view of the information provided in Tables 4 and 5, it can be observed that the courses offered to CEED students ensure full coverage to the program educational outcomes and objectives.

Table 4: Mapping CE Core Courses to the CE Program Outcomes.

CE Courses	CE Program Outcome												
	O1	O2	O3	O4	O5	O6	O7	O8	O9	O10	O11	O12	O13
GENG 240 - Statics	√	√			√	√		√			√	√	
CIVL 270 – Introduction to Env. Eng.	√		√	√	√		√			√	√		
GENG 305 - Mechanics of Materials I	√	√	√	√	√	√		√				√	√
MECH 390 – Engineering Materials	√	√	√					√			√	√	
CIVL 310 - Structural Analysis	√					√						√	
CIVL 315 - Computer Aided Drawing		√			√	√		√				√	
CIVL 325 - Water Resources	√	√	√	√	√	√	√	√	√		√	√	
CIVL 330 - Transportation Engineering		√		√				√	√			√	
CIVL 335 - Surveying	√	√	√		√	√	√	√			√	√	√
CIVL 340 - Soil Mechanics	√	√	√	√	√			√			√	√	
CIVL 345 - Fluid Mechanics For Civil & Arch	√	√	√	√	√			√					
CIVL 360 - Concrete Technology	√	√	√	√		√	√	√			√	√	
CIVL 365 – Reinforced Concrete Design I	√	√		√		√		√		√	√	√	
CIVL 375 - Water & Wastewater Technology	√	√	√	√	√		√			√	√		
CIVL 412 - Reinforced Concrete Design II	√	√	√	√		√		√					
CIVL 417 - Structural Steel Design	√	√		√		√		√	√		√	√	
CIVL 433 - Highway Engineering	√	√	√	√			√		√			√	
CIVL 442 – Foundation Engineering	√	√		√		√		√				√	
CIVL 445 - Construction Management	√	√				√	√	√				√	√
CIVL 495 - Industrial Training		√		√	√	√	√	√	√	√	√	√	√
CIVL 585 - Graduation Project I	√	√	√	√	√	√	√	√	√	√	√	√	√
CIVL 590 - Graduation Project II	√	√	√	√	√	√	√	√	√	√	√	√	√

Studies have shown that engineering design is a crucial concept in the total educational and learning experience [4], and its success depends on the implementation of a program which integrates a number of desirable educational approaches. The major design experience presented by the CEED primarily aims at producing competent alumni fully equipped with the highest and latest international standards of design. In order to successfully achieve this objective, students utilize their earlier civil engineering knowledge already acquired in their engineering science courses from the core of the curriculum as well as those from the technical electives. In addition, students acquire further CEE knowledge and skills through multiple means: industrial training, field trips closely related to the courses content, as well as the continuous and mutual class discussions tackling the realistic problems and constraints in the field of civil and environmental engineering. To enhance this major design experience, various field trips are organized to ensure that the CEE students are able to establish a balance between

their on-campus course work and the realistic needed engineering standards and different constraints which they will experience in their future professional careers. Such trips provide an excellent opportunity for the students to have a better understanding of the realities of professional practice relevant to economical, environmental, ethical, health, safety and social aspects.

Table 5: Mapping of CE Core Courses to the CE Program Objectives.

CE Courses	CE Program Educational Objectives				
	1	2	3	4	5
GENG 240 - Statics	√	√	√	√	√
CIVL 270 – Introduction to Env. Eng.	√	√	√	√	√
GENG 305 - Mechanics of Materials I		√	√	√	√
MECH 390 – Engineering Materials	√	√	√	√	√
CIVL 310 - Structural Analysis		√	√	√	√
CIVL 315 - Computer Aided Drawing		√	√	√	√
CIVL 325 - Water Resources	√	√	√	√	√
CIVL 330 - Transportation Engineering	√	√	√	√	√
CIVL 335 - Surveying	√	√	√	√	√
CIVL 340 - Soil Mechanics	√	√	√	√	√
CIVL 345 - Fluid Mechanics For Civil & Arch		√	√	√	
CIVL 360 - Concrete Technology	√	√	√	√	√
CIVL 365 – Reinforced Concrete Design I	√	√	√	√	√
CIVL 375 - Water & Wastewater Technology	√	√	√	√	√
CIVL 412 - Reinforced Concrete Design II		√	√	√	√
CIVL 417 - Structural Steel Design	√	√	√	√	√
CIVL 433 - Highway Engineering	√	√	√	√	√
CIVL 442 – Foundation Engineering		√	√	√	√
CIVL 445 - Construction Management	√	√	√	√	√
CIVL 495 - Industrial Training	√	√	√	√	√
CIVL 585 - Graduation Project I	√	√	√	√	√
CIVL 590 - Graduation Project II	√	√	√	√	√

The climax of the major design experience in the CE program is reached through the capstone six credit-hour courses (graduation project I and graduation project II) which are performed over the entire senior year of study. This capstone experience of the college study ensures that the CEE graduates are appropriately prepared to become successful practicing engineers upon graduation. The offered projects are classified into two categories either a design-build or a design-study (analysis) type. In both categories, students make full use of the knowledge and skills acquired in earlier course work. The administration of the project, including the coordination to monitor the development progress, the student evaluation, the application of the college-wide format for developing and writing, and the organization of common lectures is carried out by a college-wide supervisory unit. The unit, in addition to the previously mentioned roles, ensures cooperation with industry in the country where appropriate and formation of interdisciplinary teams within the college. The grading of the project does not only tackle the technical content, but also the professional conduct and progress of the team.

CIVIL ENGINEERING PROGRAMS IN USA (ABET CRITERIA)

The criteria of the Accreditation Board for Engineering and Technology (ABET) ensures that graduates of accredited engineering programs are adequately qualified to enter professional work life. CE is accredited by ABET and it is a well-recognized degree program in the USA. ABET goals are to guarantee quality graduates from the engineering programs, to adequately provide graduates with skills, and to motivate improvements in the engineering education. The 2010–2011 ABET CE program criteria related to curriculum and faculty are listed below [5]. ABET has given design in engineering education very special attention; engineering programs should not only teach design courses but also integrate design concepts into their engineering curriculum [6].

Curriculum

The program must demonstrate that graduates can: apply knowledge of mathematics through differential equations, calculus-based physics, chemistry, and at least one additional area of science, consistent with the program educational objectives; apply knowledge of four technical areas appropriate to civil engineering; conduct civil engineering experiments and analyze and interpret the resulting data; design a system, component, or process in more than one civil engineering context; explain basic concepts in management, business, public policy, and leadership; and explain the importance of professional licensure.

Faculty

The program must demonstrate that faculty teaching courses that are primarily design in content are qualified to teach the subject matter by virtue of professional licensure, or by education and design experience. The program must demonstrate that it is not critically dependent on one individual.

COMPARISON BETWEEN CE AT UAEU AND SELECTED US UNIVERSITIES

A comparative study is performed to assess the CE program against CE programs in five well known US universities. These universities are listed in Table 6. The study included the number of credit hours devoted in each program to several engineering and none engineering requirements. None engineering requirements include courses related to languages, social sciences, communication, humanities, arts, economy; ethics...etc. courses related to engineering requirements are separated into math and basic sciences courses, engineering core courses, civil engineering core courses, civil engineering elective courses, industrial training and internships, and a graduation project. Table 6 summarizes outcomes of this comparative study.

Among all programs listed in Table 6, CE program at UAEU has the highest total number of CHs in the program as well as total CHs. This is because UAEU provide 42 CHs of none engineering requirement much more than all other universities. The highest other university is Missouri university of science and technology which require 24 CHs of none

engineering courses. Another reason of the high number of total CHs preferred by the CE program in UAEU is the inclusion of CHs of industrial training and graduation projects in the total CHs of the program. This is not the case in most universities as shown in Table 6. None of the selected universities count CHs for industrial training; and the maximum number of CHs devoted for graduation project is 3 CHs. To have a fair comparison, we excluded these CHs from the total count of CHs offered by the program as shown in the last column in Table 6. This column shows that the total count of CHs from college requirements as well as specialization core and elective course in the CE program at UAEU is comparable to the other universities used in this study. Again, the CE program at UAEU ranked second from this prospective (with 102 CHs) after the University of Kansas (110 CHs). The math and science courses and the engineering core courses are both called college requirements.

Table 6: Comparison between CE program at UAEU and selected CE programs in USA.

University	University Requirements			Total	Math/ Science	Engineering Requirements					Total CHs in the Program	Total CH	Total of EC, CEC, CEE and GPs
	C & L	SS	FF		Math/ Science	EC	CEC	CEE	GP	IT			
University of Oklahoma	9	9	3	21	33	3	53	12	3	0	104	125	101
University of Kansas	9	9	4	22	36	6	56	12	0	0	110	132	110
Penn State University	12	15	1	28	29	21	19	30	3	0	102	130	99
University of Texas-Austin	6	18	3	27	29	20	30	18	0	0	97	124	97
Missouri University of Science & Technology	3	0	24	27	31	18	40	12	3	0	104	131	101
Purdue University	0	10	18	28	32	10	30	30	3	0	105	133	102
United Arab Emirates University	6	18	18	42	29	12	52	9	6	15	123	165	102

C&L: Communication and language; SS: Social Science/Humanities/Arts/Ethics/Economy; FF: Professional/Free Electives; EC: engineering core; CEC: civil engineering core; CEE, civil engineering elective; GP: graduation project, IT: industrial training

There are 33 CHs for math and science in the CE program at UAEU; 29 of which are provided by college requirements courses, while the other 4 are part of other civil engineering core courses. Therefore, the total CHs for math and basic science offered in the CE program at UAEU are comparable to the other universities included in the study. In fact, CE program at UAEU ranked second after University of Kansas (with 36 CHs). It is worth mentioning here that ABET requires 32 CHs related to math and basic science.

With a careful look at this table, one could separate two different philosophical views of civil engineering education. In the first, more CHs are devoted to core civil engineering courses than elective civil engineering courses. Universities following this philosophy are

University of Oklahoma and university of Kansas in addition to UAEU. Other universities such as Penn State University and Purdue University follow the other philosophy of offering approximately equal share between core and elective civil engineering courses. This discussion shows that the CE program at UAEU provides comparable civil engineering education to similar programs in well-known US universities. However, a need may appear to reduce the university requirements CHs or at least exclude them from university education and slightly increase CHs of elective civil engineering courses.

SUMMARY AND CONCLUSIONS

This paper presented a comparative study between the civil engineering (CE) program at the United Arab Emirates University (UAEU) and several North American universities. First the paper presented the CE program at UAEU. Results of the study showed that the CE program at UAEU provides comparable civil engineering education to several programs in well-known US universities. However, there is still a room for improvement. There might be a need to reduce the university requirements CHs or at least exclude them from university education so that students spend less time in the university before graduation. Also a slight increase in the CHs of elective civil engineering courses might be needed in the future.

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TRANSPORTATION ENGINEERING EDUCATION IN UNDERGRADUATE CIVIL ENGINEERING CURRICULA IN THE MIDDLE EAST

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ABSTRACT: Transportation engineering education is one of the sub-disciplines of civil engineering. Unlike many other sub-disciplines of civil engineering, transportation engineering education is often reduced to a single obligatory course. This paper summarizes a survey conducted to provide a closer look at transportation engineering education coverage in a number of universities in the Middle East. For this purpose, the civil engineering curriculum of 16 well-known programs from nine different countries were reviewed. The authors found that over 62 percent of the universities require at least two obligatory courses in transportation engineering. For these universities, this counts for about 4 percent of their curriculum. One-third of universities (3 out of 9) offering 4-year programs require two obligatory courses in transportation engineering. The paper concludes with several recommendation, including conducting a detailed survey of the content of the introductory transportation courses and to organize a transportation engineering education conference in the Middle East.

KEYWORDS: Transportation Engineering Education; Civil Engineering Curriculum; Transportation Education in Middle East.

INTRODUCTION

Transportation is a catalyst to economy and development; and as such, investment in transportation infrastructure will continue to rise especially with the ever-increasing demand for transportation of people and freight. With more and more transportation projects currently being implemented or planned in the Middle East, the demand for qualified and well-educated transportation engineers is also growing in parallel.

In most of the Middle East, transportation engineering education is imparted as a sub-discipline of civil engineering education. However, for most of civil engineering sub-disciplines, there is a logical sequence of courses leading to the required sub-discipline advanced level courses such as structures, geotechnical, and water resources. For example, the sequence of courses from physics, statics, and mechanics of materials lays the foundation for the advanced structures courses. For other disciplines, however, this sequence is less obvious or even present. One of these sub-disciplines is transportation, where most universities offer only one or two courses at best. Furthermore, most students arrive to the transportation course with no prior technical background or knowledge of transportation, except for their experience as drivers, bus riders, or pedestrians. Furthermore, many civil engineering programs teach the course too simplified to make it appropriate to the student relevant background. As a result, the transportation engineering course is often viewed by students as an orphan course, not connected to their previous courses; and therefore civil engineering students view it as not relevant to their career goals or interests.

The purpose of this paper is to provide a closer look at the transportation engineering education in some of the universities in the Middle East. For this purpose, a simple survey of about 20 civil engineering programs was conducted to realize the relevant weight of transportation engineering in their curriculum.

LITERATURE REVIEW

A survey of U.S. universities with ABET accredited undergraduate civil engineering programs found that 81 percent of the 90 programs required at least one course in transportation engineering (with an average of 3.1 credit hours), and that only seven of the 90 responding programs required another obligatory advanced course in transportation engineering [1]. A similar survey of 26 Canadian universities with accredited undergraduate engineering programs found that 62 percent of the 26 programs required one course or less in transportation engineering; and only seven programs required two courses in transportation, resulting in 88 percent of the surveyed universities requiring two courses or less in transportation engineering [2]. The study concluded that these surveys are an indication that civil engineering undergraduates in North America have insufficient body of knowledge to function effectively and efficiently at a professional standard in transportation engineering; and therefore they are learning on the job [2].

In 1986, Khisty conducted a survey of transportation professionals to determine their views on the contents and topics of a required transportation course in a typical undergraduate Civil Engineering program [3]. The results are compared with a similar survey of transportation educators. Substantial correspondence existed in the views expressed by practitioners and educators. In 2004, Turochy conducted surveys a similar survey to determine the relative importance of topics that should be covered in the introductory transportation course [4]. He compared his findings to Khisty's survey and noted changes happened during the 20-year period.

In 2007, Kyte conducted a more comprehensive survey to gain a better perspective on current practice in transportation engineering education [5]. This survey was answered by 120 civil engineering faculty members who teach the introductory undergraduate transportation engineering course. The survey provides a closer look at both what students should know and how they are taught transportation engineering. It was found that of the 224 civil engineering programs in the United States, 80 percent require one or two undergraduate transportation engineering courses and 72 percent of these programs offer this course in the junior year. There are two common approaches to teaching the course: 65 percent of instructors teach it as a traffic or highway engineering course; and only 24 percent use a multimodal perspective. Further, the survey identified seven essential topics as by more than two-thirds of the instructors responding to the survey: relationship between vehicle characteristics and highway geometric design standards; the relationship between safety/geometric elements of a highway; the relationship between human factors/highway geometric design standards; the principles of capacity/level of service for uninterrupted flow facilities; the principles of the four-step transportation

planning process; the fundamentals of traffic stream models; and the principles of capacity and level of service for interrupted flow facilities.

SURVEY AND RESULTS

To provide a closer look at transportation engineering education in the Middle East, the authors reviewed the curriculum of 16 civil engineering programs from Jordan, Palestine, Lebanon, Saudi Arabia, Kuwait, Bahrain, Qatar, Oman, and United Arab Emirates. All of these universities follow the credit-hour system and most of them are public universities. For sake of saving time, the authors used these universities web sites to gather the required information for this paper, assuming these universities maintained an up-to-date information regarding their civil engineering curriculum.

Table 1 lists these universities and provide details of the civil engineering curriculum of the universities surveyed. Almost half (7 out of 16) of these universities require students to complete successfully 155 to 168 credit hours; i.e. these are typically 5-year civil engineering programs. The other universities have 4-year civil engineering programs requiring 133 to 146 credit hours. Figure 1 shows the distribution of the relative weight of transportation engineering credits to overall civil engineering curriculum.

As one can see in Table 1 and Figure 1, the 16 universities vary significantly in terms of the number of credit hours for their obligatory transportation engineering education. Six of the universities (37.5 percent) require only one obligatory transportation engineering course (3 credit hours or about 2 percent of their civil engineering curriculum). All of these universities follow 4-year civil engineering programs. Nine universities (56.25 percent) require two obligatory transportation engineering courses (6 or 7 credit hours or about 4 percent of their civil engineering curriculum). Of these universities requiring six or more transportation credit hours, three universities (American University of Beirut, American University of Sharjah, and Bahrain University) follow 4-year civil engineering programs. Only one university (6.25 percent), i.e. the Jordan University of Science & Technology, requires three transportation courses and a lab with a total of 10 credit hours (about 6 percent of their civil engineering curriculum).

In summary, over 62 percent of the universities require at least two obligatory courses in transportation engineering. For these universities, this counts for about 4 percent of their curriculum. One-third of universities (3 out of 9) offering 4-year programs require two obligatory courses in transportation engineering.

It is worth mentioning that almost all universities offer elective advanced courses in transportation engineering for their students. There is no consensus on the transportation engineering course name/title. Over half of the programs have a course titled transportation engineering or transportation systems. Over half of the programs have a course titled highway engineering. Only two programs (12.5 percent) require pavement design/engineering course. Four programs (25 percent) offer an independent transportation lab.

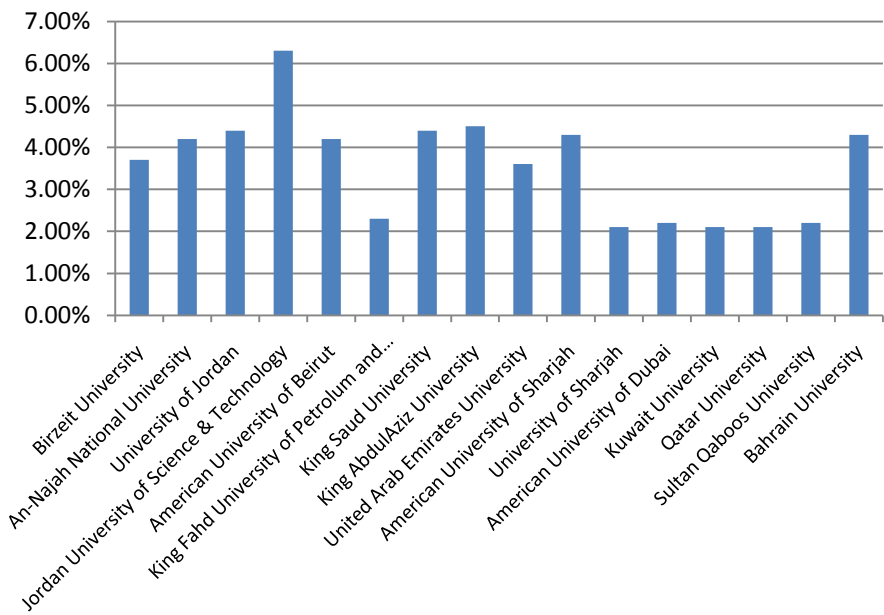


Figure 1: Distribution of the relative weight of transportation engineering credits to overall civil engineering curriculum in surveyed universities.

SUMMARY AND CONCLUSIONS

This paper summarizes a survey conducted to provide a closer look at transportation engineering education coverage in a number of universities in the Middle East. For this purpose, the civil engineering curriculum of 16 well-known programs from nine different countries were reviewed. The authors found that over 62 percent of the universities require at least two obligatory courses in transportation engineering. For these universities, this counts for about 4 percent of their curriculum. One-third of universities (3 out of 9) offering 4-year programs require two obligatory courses in transportation engineering. Most universities offer elective advanced courses in transportation engineering. There is no consensus on the transportation engineering course name/title. Over half of the programs have a course titled transportation engineering or transportation systems. Over half of the programs have a course titled highway engineering. Only two programs (12.5 percent) require pavement design/engineering course. It is worth mentioning that 25 percent of the surveyed programs offer an independent transportation lab.

The authors recommend that civil engineering program to offer two transportation engineering courses in their undergraduate civil engineering curriculum. Though this paper sheds some insight into transportation engineering education in the Middle East, a

more detailed study is necessary to investigate further details regarding this issue. Detailed analysis of the introductory transportation engineering courses is an important step towards achieving a unified outlines to these courses, highlighting the skills and topics future transportation engineers would need.

Table 1: Summary of Data Collected from Surveyed Universities.

Country	University	Total Program Credit Hours	Compulsory Transport Eng. Credit Hours		Names of Compulsory Transport. Courses	Elective Transport Engineering Courses Offered?
Palestine	Birzeit University	162	6	3.7%	Transportation Engineering; Highway Engineering	Yes
	An-Najah National University	166	7	4.2%	Transportation Systems 1; Transportation Systems 2; two Transportation Labs	Yes
Jordan	University of Jordan	160	7	4.4%	Highway & Traffic Engineering; Pavement Design; Highway Engineering Lab	No
	Jordan University of Science & Technology	159	10	6.3%	Transportation Engineering; Pavement Materials & Design; Highway Geometrics; Highway Lab	Yes
Lebanon	American University of Beirut	143	6	4.2%	Highway Engineering; Transportation Engineering and Lab	Yes
Saudi Arabia	King Fahd University of Petroleum and Minerals	133	3	2.3%	Transportation Engineering	No
	King Saud University	160	7	4.4%	Highway Engineering; Transportation Systems	Yes
	King AbdulAziz University	155	7	4.5%	Transportation Engineering; Highway Design & Construction	Yes
	United Arab Emirates University	168	6	3.6%	Highway Engineering; Transportation Engineering	Yes
United Arab Emirates	American University of Sharjah	140	6	4.3%	Highway Engineering; Transportation Engineering	Yes
	University of Sharjah	140	3	2.1%	Transportation Engineering	Yes
	American University of Dubai	137	3	2.2%	Transportation Engineering	Yes
	Kuwait University	144	3	2.1%	Transportation Engineering	Yes
Qatar	Qatar University	146	3	2.1%	Highway Engineering	Yes
Oman	Sultan Qaboos University	136	3	2.2%	Highway Engineering	Yes
Bahrain	Bahrain University	138	6	4.3%	Highway Engineering; Traffic Engineering	Yes

Given needs in both workforce and academia, our recommendation is to organize a transportation engineering education conference in the region, which will be an opportunity to bring together university faculty and transportation professionals to focus on the undergraduate transportation engineering education in the region and to identify ways in which it can be collectively improved.

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COMPARISON OF CIVIL ENGINEERING CURRICULA IN THE ARAB MIDDLE-EAST COUNTRIES

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ABSTRACT: This paper compares undergraduate civil engineering curricula in Arab countries located in Western Asia, known as Bilad Al Sham, and the Arabian Peninsula. A review of the course requirements at 24 universities located in 11 countries is presented. Specifically, the study addresses degree requirements related to science, mathematics, statistics and probability, general education, free electives, English language, engineering fundamentals, computer proficiency, required civil engineering courses, and technical electives. The study showed that most curricula take either 4 or 5 years to complete. The number of credit hours can be as little as 131 and as large as 180 credits, with an average of 155. The humanities, social science and foreign language requirements at traditional universities can be very low, whereas the same requirements can be almost a full-year of study at Western-style universities that are located in the same region. Some Arab universities, particularly those with large number of faculty, follow a track system, which provides for specialization in one of the various civil engineering disciplines. As a result, the curricula of such universities are loaded with many technical courses that are obligatory. The Western style universities, on the other hand, are heavy on fundamentals, but give the student more choices with regard to technical elective courses.

KEYWORDS: Civil engineering; Curriculum development; Education; General education; Technical electives.

INTRODUCTION

Civil engineering is a professional field that addresses the planning, design, construction and maintenance of the built environment. Traditionally, environmental engineering has been considered a part of civil engineering, although this field has recently grown to the extent that it has become independent of civil engineering. Real-life application lies in the works of buildings, bridges, tunnels, roads, canals, dams, and water and waste water treatment facilities. In its broadest definition, civil engineering includes many sub-disciplines such as structural engineering, geotechnical engineering, transportation engineering, environmental engineering, water resources engineering, materials engineering, coastal engineering, surveying, and construction engineering and management. Compared to other engineering disciplines, civil engineering is the oldest engineering discipline. Remains of ancient feats, such as the Egyptian pyramids, Greek temples, Roman road systems, and Islamic dams and mosques are based on civil engineering principles.

The core courses in a civil engineering curriculum reflect the fact that this field focuses to a large extent on the study of the built environment. In general, civil engineering students start their education with basic physics, chemistry and calculus courses. This is followed by courses on surveying principles, mechanics, construction materials, geology and structural analysis. A civil engineering curriculum is usually rounded out with courses on hydrology, concrete and/or steel structures, foundation design, highway design,

water/waste water treatment and construction management. Depth in a particular area is often achieved through technical electives in the program.

With regard to the Middle East, civil engineering is among the largest departments in many college/school of engineering in universities located in these countries. This is because the construction industry and civil infrastructure building greatly dominate the economies of countries in this region. A close inspection of the civil engineering undergraduate curricula in the various Arab middle-eastern countries shows considerable differences in the number of years of study, number of credit hours, science and mathematics courses, technical courses, nontechnical courses, and internship requirements. These differences in curriculum requirements are due to local accreditation demand, quest of international accreditation, origin of the educational system within the country, and pressure (or lack of it) for curriculum development. While some differences in curriculum requirements from one regional country to another are healthy and expected, significant changes in curricula in neighboring countries can lead to pressure on students to obtain degree equivalency or taking extra credits, possibility of rejection of a foreign degree by the local engineering syndicate, and reduced work opportunities abroad. This paper compares undergraduate civil engineering curriculum structures in Arab countries located in 11 Arab countries located in Western Asia, known as Bilad Al Sham or Greater Syria, and the Arabian Peninsula. A review of the courses and laboratories from representative universities in each country is presented. Specifically, the study addresses requirements related to science, mathematics, statistics and probability, general education, free electives, English language, engineering fundamentals, computer, required civil engineering courses, and technical electives.

LITERATURE REVIEW

Curriculum development and continuous search for improvement to avoid reaching a steady state situation in a study program are goals of all institutions of higher education and accrediting agencies. As a result, there are extensive research efforts that are devoted to investigation of differences in Civil engineering curricula and the motives behind these variations. In the past, many studies had focused on curricula within a particular region with the same culture/geographical relation; however, recent studies have extended the scope to cover countries in different continents.

In two recent studies conducted at the University of Florida (UF), the Civil engineering curriculum at that university was compared with those at two foreign institutions, one in Pakistan and another in Thailand. The study showed that the differences between the curricula were driven by the socio-economic characteristics, as well as the national and industrial needs. Also, the foreign curricula adapt a track system, where the students select one of the Civil Engineering disciplines and focus more on it, while the UF program mainly concentrates on providing the students with a broad technical background through a well-rounded curriculum, with more attention to the communication skills and multidisciplinary education [1,2].

In a more general study than the ones reported at UF, Russell and Stouffer conducted a survey of about 40% of the civil engineering programs in the United States [3]. In their analysis, they considered three major sets of courses covering the areas of basic math and science, general education and engineering courses. In addition to considering the current curricula, they also investigated the historical changes in the average national curriculum in the US. As a result of this survey, they examined the satisfaction of the curriculum to ABET accreditation requirements. In conclusion, they found out that the Civil Engineering curriculum is highly technical and lacks focus in other areas, such as liberal arts, professional skills, and systems thinking.

In contrast to the conclusions reported by Russell and Stouffer, Sparling and Kells showed that the general trend of reducing the number of credits in Civil Engineering programs and increasing the breadth in covering Civil Engineering basics have created an argument that the technical competency gained in a four year degree is not adequate for the practical work [4].

Recent research in the area of civil engineering education has focused on the different aspects of curriculum development, design, and modification methodologies. Some of these studies showed the approaches used to modify, change, develop, or review a specific curriculum in one program based on various reasons and demand. Some of the factors that affect the curriculum development and the challenges faced are discussed in these studies [4-14].

Accreditation and professional societies requirements have a great impact on curriculum content and structure. For example, Bardet et. al considered the performance assessment of Civil Engineering curriculum as part of the ABET and ASCE requirements [15]. They have proposed a systematic approach to evaluate the student performance across the overall curriculum when considering the ABET accreditation requirements and the Body of Knowledge of the ASCE. They have developed direct assessment methods that result in some quantitative measures of student performance without significantly affecting faculty work load in preparing these documents.

Similar studies were conducted to evaluate engineering education in the Arab world and to address challenges facing the educational system in these countries [16-18]. These studies are considered in the next section.

CHALLENGES

Historically, education in the Arab world was strongly encouraged since the dawn of Islam, particularly to understand the holy Qur'an and the Prophet's teachings. The Qur'an includes several passages that refer to civil engineering principles, such as [19]:

"Then, who is the best? He (the one) who lays the foundation of his building (home) on devotion to Allah and His Good Pleasure? Or he who lays the foundation of his building on a weak sand-hill ready to break to pieces? And it (the mosque) does break to pieces with him, into the fire of Hell. And Allah does not guide people who do wrong." V 109, Sura 9, At-Tauba.

Formal engineering education in the Arab world started before World War I in 1913 at St. Joseph University in Beirut, Lebanon. Later, between 1925 and 1950, seven other universities started to cover engineering education in Algiers, Cairo, Alexandria, Baghdad, Aleppo, and Khartoum. By 1955, about 8500 students were enrolled in various engineering departments, this number reached over 40,000 by 1970, and is projected to have spiraled to over 100,000 by 2010 [16,17].

Curricula Challenges

Several challenges faced the engineering education since the beginning, some of which are still valid nowadays. The major ones for instance are: (i) there is no unified engineering educational system, (ii) the cultural and teaching language influence the curricula significantly, and (iii) the lack of clear engineering school identity in terms of emphasis of teaching or research emphasis.

Quality of Graduates Challenges

After more than 50 years of engineering education, other challenges have developed and need to be addressed to improve the quality of the graduates. These challenges are: (i) graduates lack of design capability and creativity, (ii) deficiency in critical and independent thinking, (iii) narrow view of engineering and related disciplines, (iv) weak communication skills, (v) inefficient use of time and resources, (vi) inexperience in working in teams, and (vii) lack of independence in learning and/or conducting search [18].

Engineering Educators Challenges

Jones and Oberst reported that there are four main areas where engineering educators need to focus their attention for future improvement [20]. The areas are national employment policies, quality assurance mandates, role of women and access to higher education.

Due to the demographic diversity in the Arab region and especially in the Gulf, local authorities are constantly striving to increase the employment of locals in various governmental positions. Although engineering students are being taught using English textbooks following international standards, the majority of graduates will work in the local market. Consequently, educators need to integrate entrepreneurship skills into the curriculum as well as collaborate with public agencies and private businesses to expose the students to local issues. This includes the use of metric units and local codes of practice. This should facilitate the use of global technical standards to solve local problems.

In the last decade or so, engineering programs in the Arab region have been paying increasing attention to local and international accreditation in an effort to commit to quality assurance. ABET is at the top of the list of prestigious and demanding agencies for accrediting engineering programs in the US and abroad. Perhaps at this stage of development, a trans-national quality assurance model, similar to that of Latin America, is more suitable for the Arab region.

To increase the interest and aspiration of women in engineering, strong mentoring programs need to be established. Also, creating entrepreneurship programs would help women design jobs that could be sustained despite their family obligations. This would enhance the level of engineering education among women.

The engineering educators should support career counseling and advising services at several educational levels, as far as primary and secondary schools for raising interest among young under-privileged individuals. Also, establishing bridge programs enabling working adults to return to school and invest in an engineering education would help the programs.

Professional Engineering Registration Challenges

Currently, requirements for professional registration in engineering syndicates in the various Arab countries are not uniform. For example, the minimum requirement for professional registration in Lebanon is a Bachelor of Engineering (BE) degree. Hence, graduates with a Bachelor of Science (BS) degree would not be able to join this professional organization unless they complete a graduate level degree, which could be a problem for those graduates with low grade point average. Similarly, the syndicate of engineers in Egypt demands a 5-year degree program, irrespective of the degree designation (BS or BE). As the number of American style universities offering a 4-year degree program in the middle-east region is on the rise, this requirement becomes a major challenge for graduates of such programs.

METHODOLOGY

In an attempt to investigate Civil Engineering curricula in the Arab Middle-east countries, this paper focuses clearly on the civil engineering curriculum as it is currently being offered to undergraduate students in the region at institutes of higher education. It presents the results of an analysis of 24 of the region's undergraduate civil engineering programs. The countries from the Arabian Peninsula that are considered in the study are the United Arab Emirates, Saudi Arabia, Oman, Bahrain, Qatar, Kuwait, and Yemen. The considered countries from Bilad Al Sham region are Lebanon, Syria, Jordan, and Palestine. Public, private and semi-private institutions from the considered countries are investigated, but graduate programs are excluded. Information on the curricula was obtained either from the University's web site or personal contacts with faculty working at the university. The obtained information was classified into the following categories:

1. General Information
2. Science requirement
3. Mathematics
4. Statistics / Probability
5. General Education
6. Free electives
7. English language
8. Engineering fundamentals
9. Computer literacy
10. Required civil engineering courses

- 11. Civil engineering elective courses
- 12. Capstone design course
- 13. Professional training or internship
- 14. Other requirements

The analysis describes the composition of undergraduate education as well as particular course sequences and requirements. It outlines the common areas of education and points of diversion among the civil engineering curricula. The minimum, maximum, and mean number of credits in each of the above areas was determined.

RESULTS

This investigation showed that all the considered civil engineering programs in the Arab middle-east region are based on the semester system. The name of the degree is either Bachelor of Science (B.S.) or Bachelor of Engineering (B.E.) in Civil Engineering. One-half of the programs require 4 years to complete, while the remaining programs require 5 years. The number of credits hours varies significantly from one country to another, and even within the same country. The minimum number of credits to complete the degree is 131 and the maximum is 180, with a mean value of 155.

Nontechnical Course Requirement

The nontechnical course requirement consists of courses related to science, mathematics, statistics, probability, humanities, social sciences, English language, and free electives. The study showed that this requirement is not uniform among the considered programs, as shown in Figure 1.

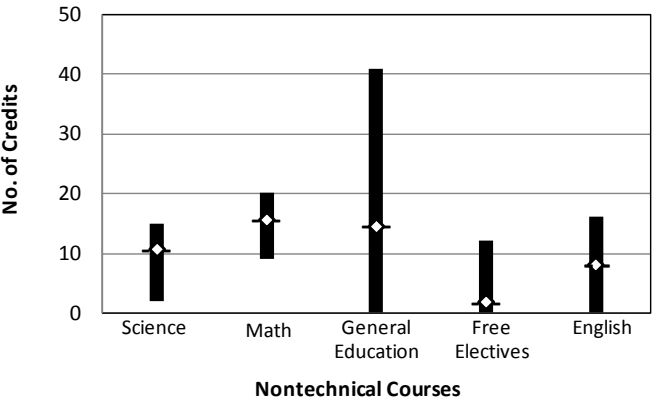


Figure 1: Credit hour range and mean for the nontechnical courses.

The science requirement varies between 2 and 15 credits, with a mean value of 10.6. For most programs it included physics and chemistry, but for a few programs either the chemistry was waived or biology was added to physics and chemistry. The mathematics requirement included courses in calculus, differential equations, linear algebra and numerical analysis. As expected, most programs had heavy emphasis on calculus,

compared with other fields. The number of credit hours of mathematics varied between 9 and 20 credits, with a mean value of 15.5. While only two programs did not require statistics and/or probability, the rest obliged either 2 or 3 credits on the subject. Among the areas that had the most no uniformity among the programs is the general education requirement, which includes courses in humanities, social sciences, Arabic language and religion. In general, this requirement at traditional universities can be very low, whereas the same requirement can be almost a full-year of study at Western-style universities that are located in the same region. The study showed the number of general education credit hours ranged between 0 and 41, with a mean equal to 14.4. Sixty percent of the curriculums did not include free electives, defined as courses that a student chooses to take because he/she is interested in the subject matter covered in the courses. Such courses can be related to the major, or they can be totally unrelated. For the considered programs that included free elective courses in their curriculums, the credit requirements ranged between 4 and 12. The English language requirement included courses in communication and technical writing. The number of credit hours of English varied between 0 and 16 credits, with a mean value of 8.0.

Technical Course Requirement

The technical course requirement consists of courses related to engineering fundamentals and applications. Again, the study revealed that this requirement varies considerably among the considered programs, as shown in Figure 2.

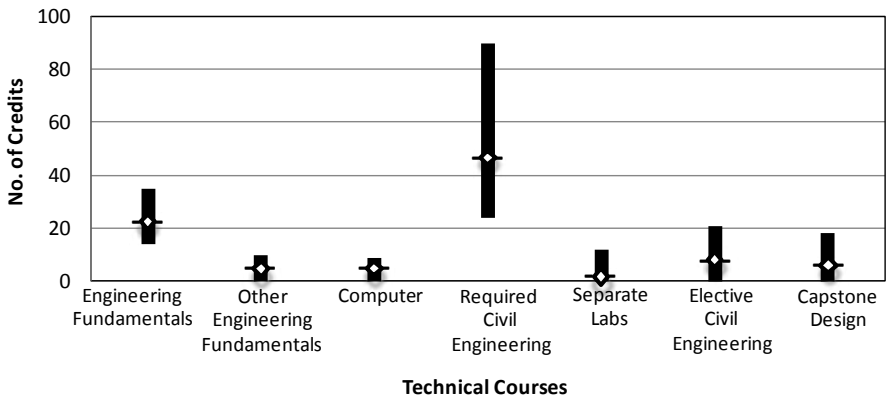


Figure 2: Credit hour range and mean for the technical courses.

In this study, “Engineering Fundamentals” are defined as courses related to engineering mechanics (solid and fluid), material science, surveying, graphics, and engineering geology. Other courses offered by an engineering college/school to freshman or sophomore students, such as Introduction to Engineering or Introduction to Civil Engineering, are also a part of this category. The study showed that the number of credit hours of courses in Engineering Fundamentals varied between 14 and 35 credits, with a mean value of 22.3. The category of “Other Engineering Fundamentals” refers to courses in thermodynamics, electrical circuits and engineering economy. It was found that all but

3 programs required courses in this area. Specifically, the number of credit hours of courses in Other Engineering Fundamentals varied between 0 and 10 credits, with a mean value of 4.5. With regard to computer literacy, almost all programs included courses in computer programming or analysis. The credit requirement ranged between 0 and 9, with a mean of 4.7. While the majority of considered programs had laboratory components embedded in related courses, there were some curricula which had separate labs. These labs were related to fluid mechanics, construction materials, soil mechanics, etc., with credit hours ranging 0-12, with a mean value of 1.7.

All programs cover most of the specialty areas of civil engineering through required analysis and design courses. Such courses are on construction materials, structural analysis, reinforced concrete design, steel design, soil mechanics, foundation design, hydrology, hydraulics/water resources, water/waste water treatment, environmental engineering, construction management, quantity surveying/cost analysis, and/or highway design. The number of credit hours of required civil engineering courses varied between 24 and 90 credits, with a mean value of 46.6. The technical elective course requirement includes advanced courses in the various civil engineering disciplines. It considered curricula, the number of credit hours varied between 0 and 21, with a mean value of 7.9. Obviously, the programs that have a few number of required courses have a large number of technical electives; thus, their curricula can be considered track-based. This is particularly true for departments with large number of faculty and students, which offer students the opportunity to specialize in one or two areas within civil engineering.

With regard to the capstone design project requirement, often referred to graduation project, the credit hours significantly varied among the programs from as little as 0 to as high as 18, with a mean of 5.8. Credits hours associated with professional training or internship was not consistent in all the considered curricula, ranging between 0 and 15.

SUMMARY AND CONCLUSIONS

This study compares 24 undergraduate civil engineering curricula in Arab countries located in Bilad Al Sham and the Arabian Peninsula. It addresses degree requirements related to science, mathematics, statistics and probability, general education, free electives, English language, engineering fundamentals, computer proficiency, required civil engineering courses, and technical electives. The findings of the study lead to the following conclusions:

1. The number of credits hours varies significantly from one country to another, and even within the same country. The minimum number of credits to complete the degree is 131 and the maximum is 180, with a mean value of 155.
2. The science requirement varies between 2 and 15 credits, with a mean of 10.6. For most programs it included physics and chemistry, but for a few programs either the chemistry was waived or biology was added to physics and chemistry.

3. The mathematics requirement concentrates on calculus, but includes differential equations, linear algebra and numerical analysis. The number of credit hours of mathematics varied between 9 and 20 credits, with a mean value of 15.5.
4. The most no uniformity area among the programs is the general education requirement. The study showed the number of general education credit hours ranged between 0 and 41, with a mean equal to 14.4.
5. The number of credit hours of English language varied among the studied programs between 0 and 16 credits, with a mean value of 8.0.
6. The number of credit hours of courses in Engineering Fundamentals varied between 14 and 35 credits, with a mean value of 22.3.
7. With regard to computer literacy, almost all programs included 1 or 2 courses in computer programming or analysis.
8. The number of credit hours of required civil engineering courses varied between 24 and 90 credits, with a mean value of 46.6.
9. The credit hours technical elective course requirement varied between 0 and 21, with a mean value of 7.9.
10. The credit hours for capstone design projects significantly varied among the programs, ranging between 0 and 18, with a mean of 5.8. Credits hours associated with professional training or internship was not consistent in all the considered curricula, ranging between 0 and 15.

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CAN A THIRD-WORLD UNIVERSITY BECOME A WORLD-CLASS UNIVERSITY?

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ABSTRACT: Building a world-class research university is a dream for many developing countries. This paper discusses the prerequisites for building world-class universities and highlights the challenges to be faced by developing countries. The Saudi-Arabian experience and Korean experiences are discussed in brief and the factors that may lead to achieve a world-class university status by universities in developing countries are discussed.

KEYWORDS: Research University; World-Class University.

INTRODUCTION

Building world-class research universities is a dream for many developing countries. It is believed that building such universities would enhance the strategic development plans for these countries. Each nation links its future to world-class education building as it expects that such education would prepare highly qualified professionals, to promote progress in science and technology, and to transmit national culture and traditions. Building world-class universities, therefore, constitutes a key link in the national general development strategy of many developing countries.

Top universities in developing countries are, therefore, under tremendous pressure, and have made their schedule to move fast to upgrade themselves into world-class research universities in a relatively short period. They have implemented many policies at an unprecedented rate. In many developing countries; for example China, India and Brazil, building world-class universities became a national movement and many resources were invested into it. The governments in some newly industrialized countries and regions; for example South Korea and Taiwan, have invested highly in their top universities for about two decades, but they still have a long way to go to reach the end of the world-class university. This raises the legitimate question: Could a university be transformed into a world-class one only with great investment and strong will? The answer is obvious. Simply, because building a world-class university is not something that we can do overnight. We have to study first the universal characters of such a university and to explore what makes a world class university.

These are the issues that governments, university administrators, educators, students, stakeholders and other concerned people need to understand before they move to build world-class universities. It is important, however, to keep in mind that each nation is unique and their universities can survive and prosper only if they meet the needs of their own society.

WHAT MAKES A WORLD-CLASS UNIVERSITY?

According to Wang [1] the world-class university must be: truly international, open, critical, inclusive and must enjoy academic freedom, academic autonomy and democratic leadership. In the following subsections the major elements of these criteria of world Class University will be discussed with reflections on universities in the developing countries.

Internationalism

The world-class university must be truly internationalized. At present nations are more and more connected by economical ties and by an extended global knowledge network. The motivation for the development of the modern university is to meet the human curiosity for exploring truth and discovering knowledge. As the university is in the center of the international knowledge system, university internationalization has become a megatrend. The world-class universities recruit first class professors and enroll students from around the world. They organize big research projects across borders and study global issues influencing human living conditions. They prepare graduates with the global understanding and awareness. This trend constitutes a serious challenge for the developing countries which intend to build world-class universities as it puts these universities in the developing countries in a dilemma. When they aspire to becoming world-class universities, they have to set quality standards set by western universities. But the closer they come to western standards, the more graduates they produce leave for western countries. This brain drain is a part of the unfair international exchange of higher education. This would raise the question whether it is a wise policy to invest heavily in these universities to run them into prep schools for western universities? There are no easy answers for this question.

Openness

The world-class university must be open. A university is different from a business as it does not operate for profit and it does not have commercial secrets to guard. It is not like a government agency that needs to guard its gates to protect national security. This does not mean that the university does not need to serve the national development. The university seeks grants from government agencies, but in general situations it is not engaged in classified research as its main mission is to conduct basic research. The university signs research contracts with business usually with the condition that the research outcome be published. It is believed that the mission of research can be best carried out only if professors can freely discuss their research discoveries with their colleagues (including colleagues in other fields and outside their own university). The world-class university has to establish free and open environment where students, professors, junior instructors, senior professors, and administrators treat each other equally and exchange ideas without restrictions. The world-class university must be open to the outside world. This dictates that the university medium of instruction must be the same as that used in their local society so that the university can serve the society as a cultural center. The university administration and decision making process must be open and transparent. The process of the university president selection, faculty recruitment and

promotion, and faculty benefit policy-making all must be open. Openness is essential for the free exploration and transmission of knowledge. Third-world universities, in general, are not as open as the world-class universities. They are more influenced by government policies and regulations. As the universities turn to be more bureaucratic, the open atmosphere turned to be eroded. Therefore, for third-world universities a very important step towards world-class status must be establishing an open culture and a system supporting openness.

Critical Thinking

The world-class university must be critical. The critical spirit is an essential nature of the university. When people use their critical eyes to judge knowledge already obtained, they have begun the process of developing new knowledge. The university can do better than any other agencies in providing an environment tolerant and generous to critical thinking. This environment must be protected by the university internal system. However, in third-world countries, national development depends on social stability to a certain degree. Stability is the need of development and survival. The traditional value is to respect authorities in all fields and at all levels. Criticism is regarded as a destructive force, but not a constructive or progressive force. Therefore, the third-world universities are much less critical than the world-class universities.

Inclusiveness

The world-class university must be inclusive. The university is more inclusive than any other societal institution. Firstly, it covers all kinds of fields, including science, social sciences and humanities, including not only traditional basic disciplines, but also new inter-disciplines, or those obsolete disciplines without much practical value such as ancient languages, or those disciplines and fields that have not been widely recognized. Secondly, people, without any sort of non-academic discrimination, all can find their place in the university. Certainly, this inclusiveness has limits even in the world-class universities. But they are richer, have longer histories and better understanding of the importance of inclusiveness. Universities in developing countries are less inclusive as they cannot afford such inclusiveness on the one hand, but on the other, they lack proper understanding of inclusiveness. So, third world universities have much work ahead to become more inclusive.

Academic Autonomy

Academic autonomy is a privilege that only the university enjoys. In general, the quality of a university is positively correlated with the academic autonomy it has. The world-class university enjoys more academic autonomy than other higher education institutions. The university is a place where scholars pursue truth and higher learning takes place. Only scholars truly know how knowledge can be best obtained and transmitted, and truly understand the content and complicated nature of knowledge. The university needs therefore to reach an agreement with the government and other social institutions to protect academic autonomy. However, only an agreement cannot really guarantee the university has academic autonomy, as the government and decision-makers sometimes

cannot help to interfere in university internal affairs. Though intentions could be noble, the result might be a disaster for the development of the university. Then in some developed countries the laws are set to clearly govern the relations between the university and the government. Moreover, in order to guarantee the autonomous status of the university, intermediate organizations have been established in some western countries, such as The Higher Education Funding Council in U.K., The American Council of Education and the Association of American Universities. These intermediate organizations operate as a buffer or a lubricating system between governments and universities. They guard academic autonomy whilst maintaining university academic standards. There are also accreditation associations, which organize university or discipline evaluation. As they are non-government agencies, they conduct assessment on the basis of university voluntary participation. They can do this more publicly and objectively than the government. In this way university autonomy is protected and the government is relieved from pressure.

Unfortunately, academic autonomy is not a part the developing countries culture. The university is usually regarded as a tool to realize national aims. There are no laws to protect academic autonomy or organizations to support it. If we want to promote a third-world university to world-class status, the government has to let some of its powers go, so that universities can gain autonomous status to make decisions on their own affairs. University initiative is best encouraged in a decentralized decision-making environment. In turn, university authorities need to grant academic freedom to their faculty members.

Academic Freedom

Academic freedom is a core requirement for research universities. Of primary importance is the freedom to undertake research and publication in one's area of research and to teach without any restrictions in one's area of expertise. Academic autonomy and academic freedom are two interrelated concepts but clearly mean different things. If the society and the government protect and respect academic autonomy, certainly a better environment will be produced for academic freedom, but the faculty will not have academic freedom automatically. Academic freedom is the right of scholars to pursue their research, to teach, and to publish without control or restraint from the institutions that employ them. It recognizes the right of academics to define their own areas of inquiry and to pursue the truth as they see it. Academic freedom can make a significant contribution to promoting the quality of both institutions and system as a whole, but it needs to be understood and respected, both within institutions and by bodies to which they are accountable.

The world-class universities have effectively implemented a tenure system and auditing system to protect academic freedom for a long time. In third-world countries, with the lack of understanding and respect of academic freedom, and not establishing the necessary system or regulations to protect it, and with the decision-making more centralized, the instructors are working in an unstable situation, and these trends cannot take our universities closer to world-class status.

While we stress the importance of academic autonomy and academic freedom, we must realize that there is no absolute academic autonomy or academic freedom. The university must serve the society and satisfy social needs expressed by the government. The best way to preserve self-governance is by way of outstanding performances – the price of autonomy is eternal self-discipline. Academic autonomy and social accountability, academic freedom and self-discipline are eternal issues that need to be balanced. Academic autonomy and academic freedom may cause some disorder in university development.

Democratic Leadership

The university is the most democratic institution in the society by its essential nature. Loosely connected departments or colleges and schools representing different disciplines constitute the university. Though different disciplines are more interrelated now, each of them still has its own language, paradigms, perspectives, and its own culture and values. This is very different from business or government agencies. In a business, all parts depend on each other and are organized with the central aim of making a profit. In a government agency, all divisions are connected to form a tightly knitted network. All divisions act under the order of the agency head. But in the university, the leadership must be democratic and connective. The leaders at the university must be able to coordinate departments, colleges and schools to achieve the university aim and to carry out the university mission. When decisions are made at lower level, usually the decisions are more rational and the decision-making process is more efficient and the departments, colleges and schools are more willing to carry them out.

One more major difference between the university and the business or government agency is that the professors do not regard themselves as employees who need to report to their presidents or other administrators. As special knowledge workers, they are mainly responsible only to their students and the truth.

The decision-making in the university must be more democratic than in the business or the government agency. All the decisions related to academic affairs must be made by faculty members, or their representing organizations, such as the senate and the academic council. Just in these forums, can the culture, values and standards be discussed, correlated and respected. Certainly, the decisions related to students' affairs must be discussed with the students or their representing organizations. The students are a major body that constitutes the university, and they are not the subordinates to the professors or the administrators. Sometimes the point of view that the professors together with the students are the university is not widely understood, and even on the campus this point is often neglected or forgotten.

One important step to build a world-class university is to have a university constitution that clearly puts down a democratic procedure of decision-making. Additionally, the rights and obligations of professors and students must be clearly stated.

CHALLENGES IN BUILDING WORLD-CLASS UNIVERSITIES

The above mentioned issues are all related to concepts or system issues. The experience of some newly industrialized countries tells us that huge investment alone cannot turn a higher education institution into a world-class university. From their experience we can at least conclude the following points.

1. It takes a long time to build a world-class university. It may take a decade or even a shorter period to establish a great business, but it takes a much longer time to build a world-class university. A pragmatic attitude does not help to build a world-class university.
2. First class professors, excellent students and scientific innovations cannot be bought only with money. What are needed are not only high levels of investment but also a systematic environment friendly to academic freedom and academic autonomy.
3. The universities in developed countries must understand the dilemmas that they are facing when they try to move to the status of world-class universities. Universities in developing countries must be internationalized, but when they become more internationalized, they lose more intelligent young people. When they try to be more open and more inclusive, they find that they lack the necessary funds to do so. When they tend to be more critical, they have to be conscious about social stability, a necessary condition for national development. When they try to build the system of academic autonomy and academic freedom, and formulate a decentralized decision-making procedure, they realize that we do not have such a tradition. But they have to learn system reconstruction and concept renovation. Not only must the university learn it, but also the government and the general public must learn it too.
4. There seems to be a delicate balance between academic freedom and a viable research university. In Singapore, scholars are free to express their views on issues directly related to their fields of expertise, but not on broader issues. At the same time Singapore has been successful in building research universities and establishing collaboration with respected universities abroad. It seems that reasonably successful research universities can be built under conditions of incomplete academic freedom so long as the restrictions are not too severe, although broad comparisons show that universities with the greatest amount of academic freedom do best as effective research institutions.

In addition to the above mentioned observations, Altbach [2,3] findings show that additional challenges face universities in developing countries aspiring to acquire the status of a world class university. According to Altbach, these challenges are: funding, selection of research fields, autonomy and accountability, globalization of science and scholarship, contribution of private universities, respect of ethical norms and recruiting and retaining first class professors. In the following a brief description of these challenges with reflections on the universities in developing countries will be given.

Funding, Commercialism and Marketing

The basic cost of operating a research university has increased, placing more stress on traditional funding sources, mainly governmental, and forcing institutions and systems to

seek new revenues. The intrusion of market forces and commercial interests into higher education is one of the greatest challenges to universities everywhere. The marketplace has brought universities greater resources, better students, a far larger capacity for advancing knowledge, and a more productive role in the local economy. At the same time, it has diminished the sovereignty of universities over their own activities, weakened their mission of serving the public, and established through growing commercial entanglements at least the potential for undermining their privileged role as disinterested arbiters of knowledge.

For developing countries, the challenge of the market is particularly serious because there is less basic financial stability and a weaker tradition of academic autonomy. External market pressures can quickly affect the entire institution. For research universities, market forces may significantly shift the direction of research, the focus of the academic profession, and the financial balance of the institution. It is clear, however, that if research universities are forced to rely increasingly on their own resources for survival, market forces will determine institutional directions and priorities.

Selection of Research Fields

A culture of research, inquiry, and quality is an essential part of a research university. Because of the financial pressures, there is a trend toward applied and often profit-oriented research, which can be more easily funded than basic research and may yield profits for the university. The commercialization of research has significant implications for research universities. It changes the orientation of the research community to some extent by emphasizing commercial values rather than basic research.

Research universities in developing countries will need to select fields of research that are affordable and linked to national needs and priorities – for example, agriculture or some areas of biotechnology. Appropriate links with private-sector companies, including multinational corporations, may be necessary, and a balance between applied and basic research will need to be worked out. Work in the sciences is only one part of the research agenda of a university. The social sciences and humanities are often neglected, because the hard sciences are seen to be more profitable and prestigious. Yet the social sciences and humanities are important for the understanding of society and culture. Disciplines like history are of course relevant, as well as newer fields such as policy studies. They are also considerably less expensive than the hard sciences.

Autonomy and Accountability

The tension between autonomy and accountability is a perennial concern for academic institutions. Universities' tradition of academic autonomy involves the ability to make their own decisions about essential academic matters and to shape their own destiny. At the same time external authorities, including funders, governmental sponsors, and other organizations, held some control over higher education. In the era of mass higher education, demands for accountability have increased given the higher education's rising impact on both the economy and society. Higher education is both a significant state expenditure and of growing relevance to large numbers of people. The demand for

contemporary accountability almost always comes from the government; the source of much of the funding for higher education.

Research universities have a special need for autonomy, and the current demands for accountability are especially problematical for them. While academe in general needs a degree of autonomy to function effectively, research universities must be able to shape their own programs, carry out a long-term perspective, and manage their budgets and academic community. Not only do research universities require steady funding commitments, but they also do need autonomy to develop and maintain their strengths. The academic community itself is the best judge of the success of programs. Basic research, especially, must have the autonomy to develop, since it typically emerges from the interests and concerns of the faculty.

Accountability has become an ever more powerful force – reflecting not only the concerns of government authorities, but increasingly market forces as well. Students have demanded greater knowledge of the performance of academic institutions, and commercial enterprises, linked ever more closely to academic; they also demand information and often influence over academic policies. This is, of course, an essential part of contemporary higher education. In this context, research universities, with their need for autonomy, face a difficult environment in the era of markets and accountability.

The Globalization of Science and Scholarship

At present science is truly global in scope. Research results are immediately available worldwide through the Internet. Scientific journals are circulated internationally, and academics contribute to the same publications. Methodologies and scientific norms are used worldwide more than ever before. Scientific equipment, ever more sophisticated and expensive, is available everywhere. The challenge consists not only of laboratories and infrastructures but also the definitions and methodologies of science and scholarship. Scientific globalization means that participants are linked to the norms of the disciplines and of scholarship that are established by the leaders of research, located in the major universities in the United States and other Western nations. The themes and subject areas of interest to leading scientists and institutions may not be relevant to universities in the developing countries. Involvement in world science means, in general, adherence to established research paradigms and themes.

The high cost of science results in serious problems for academic institutions – without a long tradition of research and the required infrastructures and equipment. It is no longer sufficient to build an infrastructure that permits research on local or regional themes if a university wishes to join the “big leagues”. Universities that wish to be considered research oriented need to participate in the international scientific network and compete with institutions and scientists worldwide. The costs of joining the league of research universities is an especially serious problem for developing countries, with funding problems and no experience of building such institutions. The world of global science is expensive to join, and sustaining participation is also costly.

Globalization permits everyone to participate in the global marketplace of science, scholarship, and ideas. At the same time, globalization subjects all the participants to the pressures of an unequal global knowledge system dominated by the wealthy universities, and impose the norms and values of those institutions on everyone.

Contribution of Private Universities

Almost all research universities outside the United States and Japan are public and state supported. The fastest-growing sector of higher education worldwide is private. With only few minor exceptions, the new private institutions focus on teaching and providing credentials to students in professional and other fields, often in specialized niche areas. Specialization is particularly as aspect of the rapidly expanding for-profit sector of private higher education. The sector is never concerned with building research capacity, since research does not produce profits rapidly. New private universities are not full-fledged academic institutions with a range of disciplines in most fields of science and scholarship.

A small number of non-profit private universities may succeed in building research capacity to raise their status and contribute broadly to education and research. The rise of the private sector, with its lack of focus on research, may threaten the research role of universities in most of the world, especially in developing countries where the private sector and the for-profit universities are rising very fast with no declared intention to contribute to any research activities.

Research Universities and Ethical Norms

In some parts of the world, universities do not adhere to strict ethical norms. Corruption is a problem and grants and promotions may be awarded for reasons unrelated to quality and merit. For research universities, adherence to ethical norms and academic honesty is of special importance. Universities are, of course, part of a broader social and political system, and if the government is rife with corruption and favoritism; as is usually the case in most developing countries, academe will not be immune. The problem of academic corruption in its many facets is present in some developing countries. Bribery in student admissions and the awarding of degrees, flagrant plagiarism by students and academics, widespread cheating on examinations and other forms of clearly unacceptable behavior has become endemic. In a healthy academic system, when such behavior takes place, it receives the condemnation of the academic community and is rooted out.

The situation is even more dangerous when it directly involves the academic profession. Poor academic salaries contribute to unprofessional professorial practices. Widespread illegal selling of lecture notes and other course materials by professors, in many developing countries, is linked to the need of academic staff to earn enough money to survive [4]. Selling academic posts is a common practice in some countries, and awarding professorships on the basis of ethnic, religious, or political factors is widespread as well.

While corrupt practices are damaging in any academic environment, they are toxic to the culture and ethos of the research university. The ideal and practice of ethical values are central to the research university. Excellence and intellectual quality are key criteria for student admissions, academic hiring, promotion, and reward in research universities. The underpinnings of these academic institutions depend on the ethical values. Widespread violations will inevitably make it impossible for a research university to flourish.

The Academic Profession

The professoriate is central to higher education. Research universities rely especially on the quality and focus of the academic profession, and current developments relating to the professoriate worldwide are not favorable for either the profession or for research universities.

Research universities require full-time professors, scholars, and scientists who devote their full professional attention to teaching and research as well as other governance and management at the universities. The lack of full-time faculty is one central reason why Latin American countries have failed to build research universities.

Along with full-time commitment, salaries must be sufficient to support a middle-class lifestyle as professors must be solid members of the middle class in their country. Frequently, full-time professors generate a significant part of their incomes through consulting, moonlighting at other institutions, or, at some universities, by taking on extra teaching loads in fee-producing programs. These arrangements detract from the core functions of the professoriate and make full academic productivity difficult to maintain. In some disciplines, consulting work, applied research for industry, and other links with external agencies may provide useful synergies for academic work, but in many countries outside work and dependence on additional income are deleterious to the research university. Just as problematic, academic salaries, overall, have stagnated worldwide while the remuneration for similarly educated professionals, outside universities, has in some countries increased quite dramatically. In order to attract the “best and brightest” to academe, salaries must be competitive.

Teaching responsibilities must be sufficiently limited to allow time and energy for research. In the United States, the standard teaching load in most research universities is two courses per semester or four per academic year. In some scientific fields, even less teaching is expected. Similar teaching loads are common in Europe. In many developing countries, much more teaching is required, leaving little time for research. The most active research-focused professors in the United States undertake a significant part of their teaching in graduate programs, which helps to link teaching with research and increases productivity. In European countries, with doctoral programs that are mainly focused on research, professors are given sufficient time for doctoral supervision and mentoring. Few developing countries have instituted these practices.

The academic profession must have a career ladder that permits professors to be promoted up the ranks of the profession on the basis of their performance and the quality

of their work, and a salary structure determined by performance. In most regions of the world, promotion up the academic ranks is largely a matter of seniority and not of demonstrated performance in teaching and research. In the majority of countries, academic salaries are determined by seniority, rank and, in some places, discipline rather than by job performance. This is especially true for countries where academics are considered civil servants. Civil service status provides strong guarantees of permanent employment but seldom measures productivity as an element of promotion.

The challenge is to link reasonable guarantees of long-term employment, both as a means of ensuring academic freedom and as a way of providing employment security and ensuring institutional loyalty.

WORLD-CLASS UNIVERSITIES IN DEVELOPING COUNTRIES

Many developing and middle-income countries need research universities to participate in the expanding knowledge and service-oriented economy of the 21st century. Aspirations, however, must be tempered by realities. The goals of research universities in developing countries necessarily differ from those of the large industrialized nations. For developing countries, the goals include the following core elements.

Establishment and Retention of Scientific Community

Research universities employ scientists and scholars in a range of disciplines. Without these institutions, highly trained academics would leave the country – as it happens today in many developing countries that lack these institutions – or would fail to be trained in the first place. Research universities provide the institutional base for top professors, scholars, and scientists who compare what is happening at the frontiers of science in all the fields and can participate in the global scientific community. The institutions retain local talent at the same time as they produce additional talent. The academic community in the local research university can communicate with scholars abroad and can participate in the global scientific community.

Relevance of Research and Teaching to Industry and Society

Local research universities are the only institutions that are able to focus attention on local needs. They understand the specific problems of the country in which they are located and are able to focus attention on these themes. External institutions have neither the interest nor the knowledge to do so. Research universities can bring international scientific trends to bear on local problems and contribute to the development of domestic industry, agriculture and society.

Cultural and Social Development and Critique

Research universities everywhere constitute centers of culture and critique. In developing countries, they are of special importance in this regard because there are few other societal institutions with relevant expertise. Research universities are often the only

places with a critical mass of experience and resources in a range of cultural areas. These institutions also provide social commentary, analysis and critique. Again, they are uniquely positioned for these roles; they have an academic freedom and a community of faculty and students interested in a range of disciplines. While political authorities may find criticism unwelcome, it is of central importance for the development of a civil society.

Research and Analysis in the National Language (s)

Research universities must, of course, function in the international languages of science and scholarship. Simultaneously, they have a responsibility to disseminate research and analysis in local languages. Indeed, they may provide a key source for national-language development by producing scientific and literary work in the language and building up vocabulary. The role of the local languages in developing country research universities is a highly complex one. In many developing countries higher education takes place in foreign languages and the issues are quite complex. But it is clear that research universities play a key role in supporting and developing local languages.

Educating a New Generation of Scientists, Scholars and Technicians

It goes without saying that the central role of the research university is – education the training of the next generation of educated personnel for the society.

The aspirations of the research universities in developing countries must be realistic. With the exception of a few of the largest and most successful developing nations, including China and India, aspiring to compete with Harvard or Oxford or to build a top-ranking world-class university is not a reasonable goal. Rather, developing countries can seek to compete with second-rank but quite distinguished research universities in the industrialized world such as Indiana University in U.S.A and York University in U.K. It is also necessary to select specific areas of science and scholarship to emphasize. Most research universities provide instruction in the main academic disciplines, and many have associated professional schools such as medicine and law. Few research universities are outstanding in all fields. Some smaller developing countries may lack the funds to build and sustain a research university. In such cases, it may be possible to build a regional research university. Information technology makes this more practicable.

But investing in infrastructure may prove the easiest part. The most sought-after commodity is high-caliber faculty leaders and scientists – and the major challenge is recruiting and retaining them. We fear the recent initiatives will not be sustainable if they mostly depend on imported staff and expertise. The developing countries urgently need to develop local talent and a technical workforce to sustain planned science and technology programs.

Developing countries should establish joint committees to coordinate and develop initiatives that enhance national capabilities and regional competitiveness in science and technology. They could help put the region on the global research map by identifying economically important and regionally relevant research areas to focus on. Such

committees should be home grown, to better appreciate local issues, but should include external advisors for guidance and direction.

The developing countries could finance science that meets local and regional needs but also makes an impact internationally. For example, the Gulf States might invest in a regional diabetes research center to tackle the high prevalence of diabetes or in a state-of-the-art energy research and development center because of the region's vast energy resources.

The development of first-class universities and top-level research centers requires a large investment of time and money, and yearly performance evaluation is crucial in order for the recipients to move in the right direction and to be accountable for their actions.

SAUDI-ARABIAN EXPERIENCE

Can a developing country like Saudi Arabia build a world-class university? How to develop a research university which can compete with world flagship universities presents challenges on a number of fronts; and this is especially true in the case of a country like Saudi Arabia that has been peripheral for so long and has only joined the ranks of middle-income countries relatively recently. Furthermore, it is becoming increasingly difficult for a middle-income country to become a competitive player in the international knowledge system, because the fiscal demands of playing on the world's stage of science and scholarship are growing exponentially.

In the most recent QS Top Universities 2009 Ranking [5], King Saud University (KSU) and King Fahd University of Petroleum and Minerals (KFUPM) were ranked 247 and 266 respectively. This leap by the two universities is less to do with improvements in research competence but more to do with a noticeable presence of foreign students, post-doctoral fellows and highly-cited adjunct faculty members at the two universities. Here we clearly see QS's heavy reliance on internationalization in its rankings of world universities.

There are several issues that the Saudi higher education system has encountered due to its rapid growth and transition. Many universities have experienced rapid expansion, or rather "exploration", without having the opportunity to make adequate adjustments to their missions, functions and structures. Instead, such universities offer similar programs and majors without any real, functional differentiation among various levels of schooling. All universities in Saudi Arabia consider top American Universities as the "defining institution" and attempt to model themselves after them. Since most professors in Saudi universities, earned doctoral degrees from universities in the U.S., their idea of the university was the one which was learned through their own experience at their alma maters. Thus, it is not surprising to find that the American pattern has served as a benchmark in recent self-directed efforts to restructure Saudi higher education.

In order to promote quality research among the faculty, newly hired faculty at KFUPM are required to have established publication records in internationally renowned science

journals and to participate in a yearly review process. The research records of the top-ranking U.S. schools have served as a benchmark in evaluating the progress of yearly academic accomplishment and productivity at KFUPM. Various internal evaluations of progress have been conducted at the university, college, departmental, and research group levels. A self-evaluation appears to be the only reasonable way to assess academic achievement and progress, for there is no “right” formula for a flagship university in the periphery to become world class. KFUPM bolstered its graduate program by providing graduate students with generous stipends and research assistantships. Also, the postdoctoral program was introduced and continuously expanded in order to support young scholars. Additionally, there is considerable infrastructure support, including an electronic library with easy access to various academic databases, high-tech computer labs, and a housing facility for international scholars and students.

At KFUPM more efforts are needed to enhance global connections and cooperation. One possible way to achieve this goal is to implement a joint-degree program with foreign universities and other scholarly exchange programs. This would result in regularly inviting internationally accomplished scholars in various fields for both short-term and long-term residences.

SEOUL NATIONAL UNIVERSITY EXPERIENCE (SNU)

According to the QS TOP UNIVERSITIES Ranking [5], the world ranking of Seoul National University (SNU) has dramatically and steadily increased from 93rd in 2005 to 47th in 2009. Even though this ranking may be controversial, the trend of a consistent increase in ranking gives a sense of the direction of SNU's self-strengthening efforts. The achievements of SNU are indeed remarkable and should serve as a model and encouragement to other middle-income countries with similar aspirations and determinations. Seoul National University (SNU) outreach efforts now include academic exchange programs with about 90 universities in 27 countries around the world. In 2005 there were more than 700 foreign students at SNU. Over the last five years the number of foreign professors has doubled to 58. SNU supports graduate students for their overseas studies and their participation in international conferences. These overseas experiences are particularly important in that they give junior scholars a strong sense of self-confidence in their competitive status in the international arenas. Some of the lessons that can be learned by reflecting on the experience of SNU are [6,7]:

1. The fundamental strength of the secondary education system. Students who enter university do so after passing tremendous amount of high quality preparation. Korean students ranked among the top three countries in terms of problem-solving and mathematical skills. Thus, it is not surprising SNU, which admits only the most able students from a wider pool of students who already exhibit high level problem solving and mathematical skills, has the potential of becoming a world-class university.
2. The quality of undergraduate education received by the students while at SNU. SNU was second only to the UCB in producing more undergraduate students who later earned doctorates from American universities between 1999 and 2003.

3. The strong and committed relationship between a mentor and disciple that serves as a potent academic force for graduate programs.

One of the reasons behind the doubts that a middle-income country can establish a world-class university is the issue of institutional autonomy, which is particularly critical for academic innovation and freedom. Since central governments in many middle-income countries are attempting to build world-class universities to promote economic growth, it is a tremendous challenge for academic institutions to maintain a meaningful level of autonomy. In fact, it has been difficult for SNU to remain autonomous as a public institution, especially because it was a main recipient of public financial resources. To receive adequate funding, SNU has had to compromise its autonomy, and this is something which has made it difficult to maintain consistent policies. Given their insufficient financial resources, even private universities face this dilemma – albeit to a lesser extent. Among the “four essential freedoms” of a university, SNU lacks the freedom to determine “who may be admitted to study”.

FACTORS THAT MAY LEAD TO ACHIEVE WORLD-CLASS UNIVERSITY STATUS

The focus of higher education reform policies should be on comprehensive and fundamental change. Although quantitative measures have been taken, they should not be the sole approach in creating a world-class academic institution.

The delicate balancing act between institutional autonomy and the role of the central government is critical for building a world-class research university in middle-income countries. While the government should provide financial and institutional support, academic autonomy is a critical aspect of the intellectual environment that promotes academic freedom and innovation.

Scientific knowledge is not immune to political and ideological forces. A challenge that will require ongoing attention is the task of enabling a university in a middle-income country to find a niche in the global intellectual community while maintaining a commitment to the country’s unique traditional heritage without compromising the institution’s international competitive edge. Participation in the global community of world-class universities as a competitive partner requires enormous reserves of determination, tremendous effort, and a plethora of resources. Even while taking as a benchmark the models developed and refined in the core industrial countries, middle-income countries should not abandon their own intellectual traditions. These countries need to be relevant in the global intellectual community while being mindful so as not to become victims of any emergent tendency towards intellectual neo-colonialism in the 21st century.

SUMMARY AND CONCLUSIONS

Research universities are defined here as academic institutions committed to the development and dissemination of knowledge in a range of disciplines and fields and featuring the appropriate laboratories, libraries, and other infrastructures that permit teaching and research at the highest possible level. Research universities educate students, usually at all degree levels including the undergraduates – an indication that the focus extends beyond research. Indeed, this synergy of research and teaching is a hallmark of these institutions, which employ full-time academics who hold doctoral degrees.

The research university is a central institution of the 21st century – providing access to global science, producing basic and applied research, and educating leaders of the academe and society. Worldwide, there are very few research universities – they are expensive to develop and support, and the pressures of mass production have placed priorities elsewhere. For developing countries, research universities are especially rare, and yet they are especially important as key ingredients for economic and social progress. The research university educates the new generation of the personnel needed for technological and intellectual leadership, develops new knowledge so necessary for modern science and scholarship, and, just as important, serves as an element of worldwide communication and collaboration.

In establishing and fostering research universities, developing countries face problems that are to some extent unique. The experience of world-class universities in the developed countries and universities in the developing countries aspiring to acquire the world-class status tell us that huge investment alone cannot turn a higher education institution into a world-class university. Moreover, it may not be possible for each country, especially those with very small population, to have a research university, but many developing and middle-income countries can develop universities with research capacity and the ability to participate in the world knowledge system. Smaller countries can form regional academic alliances to build enough strength in selected fields to promote participation in global science. However, academic institutions in small or poor countries cannot compete with the Oxforwards or Harvard's of the industrialized nations. But most countries can support at least one university of sufficient quality to participate in international discussions of science and scholarship and undertake research in one or more fields relevant to national development.

China, India, South Korea, Chile, Taiwan have placed emphasis on developing world-class research universities. Several of Africa's traditionally strong universities are seeking to improve their quality in an effort to achieve research university status, with assistance from external funders, although, in general, it lags behind in the levels of academic development of the other continents.

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