Motivating Engineering Students by Providing Two Midterm Exams and Dropping the Lower Mark

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Abstract: This paper investigated the effect of grade dropping on students' performance, engagement, and satisfaction. In three different engineering courses that were taught by the author, an optional second midterm exam was offered near the end of the semester. The optional second midterm exam covered materials that were not covered by the first midterm exam. The lower mark of the two exams would be dropped for students who chose to take the optional second midterm exam. Both observational assessment (by using two-tailed z-tests and t-tests to measure the improvements in students' performance, engagement, and satisfaction) and students' feedback (through an online survey) were utilized. It was found that grade dropping led to significant improvements in students' performance on the comprehensive final exam, class attendance rates (due to the increased motivation), and students' satisfaction (as expressed in students' evaluation for the adequacy and fairness of the grading policy). The lowest-performing and highest-performing students did not significantly benefit from grade dropping. Furthermore, the effects of grade dropping were more significant for male students than for female students. **DOI: 10.1061/(ASCE)EI.2643-9115.0000024.**

Author keywords: Grade dropping; Student performance; Student engagement; Student satisfaction; Grading policy.

Introduction

Students' academic performance is affected by both cognitive and motivational factors (Richardson et al. 2012). Performance-related motivation is divided into intrinsic and extrinsic factors (Martin et al. 2018; Lin et al. 2003; Griffin et al. 2013; Matei and Abrudan 2011). Maksy (2012a, b) found that grading policy is an important extrinsic factor affecting students' performance. MacDermott (2013) found that dropping the lowest grade assignment (grade dropping) provided students with more motivation, which resulted in improving their marks on the comprehensive final exams. Hadsell and MacDermott (2010), in a study involving 1,945 students enrolled in an economics class, found that grade dropping had a marginal effect on the top students, but it improved the performance of students who did poorly on one of the prior exams by providing them with a second opportunity to demonstrate their understanding of the course materials. Nelson (1996) concluded that implementing grade dropping motivates most students to study more, which implicitly would lead to an improvement in their academic performance. However, another research study found that grade dropping had no significant effect on students' performance in the comprehensive final exam (Grant and Green 2013). Another study found that grade dropping had a negative impact on students' performance on the comprehensive final exam (Sewell 2004).

All the aforementioned studies related to grade dropping were based on evaluating students' performance in economics and/or business courses. The author is not aware of any prior research studies that investigated the effect of grade dropping on the performance of engineering students. It is well-documented that motivational factors should be viewed in context (Benson et al. 2013; Martin et al. 2018; Pintrich 2003), which means that some motivational factors, including grade dropping, could have a positive effect in some context but a negative or no effect in another context. The contextual differences among different economics courses could explain the discrepancy between the studies that found significant improvement in students' performance due to grade dropping (Hadsell and MacDermott 2010; MacDermott 2013; Nelson 1996) and those that found a negative or no effect on students' performance (Grant and Green 2013; Sewell 2004). Due to the significant contextual differences between economics/business courses and engineering courses, it is important to evaluate the effect of grade dropping on students' performance in an engineering context.

This study investigated the effect of grade dropping on the performance of civil engineering students in three different engineering courses (Introduction to Geomatics, Highway Engineering, and Traffic Engineering). The impacts of grade dropping on the following three student attributes were measured in this study by comparing those attributes for 6 years prior to implementing grade dropping and 3 years after implementing grade dropping:

- students' performance on the comprehensive final exam;
- students' engagement (in terms of average class attendance); and
- students' satisfaction (in terms of the average score given by students about how they perceived the adequacy and fairness of the grading policy).

In addition to the aforementioned observational assessment, students' feedback on grade dropping also was obtained through an online survey. To control for any potential confounding variables that were not included in the study, the period before implementing grade dropping was further divided into two subperiods, and the differences in the measured attributes (final exam marks, class attendance rates, and student evaluation scores) were compared between the two subperiods prior to implementing grade dropping. This was done to determine if there was any temporal trend in those attributes that was not explained by grade dropping. Furthermore,

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Table 1. Student outcomes in evaluated courses and their mapping to program's student outcomes

Program's student outcome	Course's student outcome		
	Geomatics	Highway	Traffic
An ability to identify, formulate, and solve complex engineering problems by applying principles of engineering, science, and mathematics.	Mapped	Mapped	Mapped
An ability to apply engineering design to produce solutions that meet specified needs with consideration of public health, safety, and welfare, as well as global, cultural, social, environmental, and economic factors.	—	Mapped	—
An ability to communicate effectively with a range of audiences.	—	—	—
An ability to recognize ethical and professional responsibilities in engineering situations and make informed judgments, which must consider the impact of engineering solutions in global, economic, environmental, and societal contexts.	—	—	—
An ability to function effectively on a team whose members together provide leadership, create a collaborative and inclusive environment, establish goals, plan tasks, and meet objectives.	Mapped	Mapped	Mapped
An ability to develop and conduct appropriate experimentation, analyze and interpret data, and use engineering judgment to draw conclusions.	Mapped	—	—
An ability to acquire and apply new knowledge as needed, using appropriate learning strategies.	—	Mapped	—

the before group (prior to implementing grade dropping) and the after group (after implementing grade dropping) also were compared in relation to the mean cumulative grade point average (CGPA) prior to taking the courses. This was to determine whether any differences in the performance between the two groups could be attributed to the differences in their overall academic performance and capabilities.

The following sections provide more details regarding the experimental design, the sample selection, data analysis, and the results. In the last section, concluding remarks and study limitations are discussed along with recommendations and directions for future research.

Evaluated Courses

Three courses were used to evaluate the effects of grade dropping on students' performance, engagement, and satisfaction. The three courses are offered at Abu Dhabi University, in the United Arab Emirates, where the author was the sole instructor of the courses. The three courses are:

- CIV 205—Introduction to Geomatics (Geomatics);
- CIV 331—Highway Engineering (Highway); and
- CIV 430—Traffic Engineering (Traffic).

Each of the three courses has a weight of 3 credit hours. An undergraduate student must accumulate 142 credit hours to complete the study program in civil engineering. The undergraduate civil engineering program at Abu Dhabi University is accredited by the ABET (2020a); and therefore, each of the three courses has certain student outcomes (Table 1), which are mapped to the program's student outcomes as suggested by ABET (2020b). In accordance with the university's policies, class attendance was taken in every class in each of the three courses. Any student who failed to attend 30% (or more) of classes was automatically withdrawn from the course due to unacceptable absence rate.

The Geomatics course is offered in the third semester of the study plan (first semester for sophomore students). It is the second course specialized in civil engineering offered in the program. The only prior course specialized in civil engineering is CIV 104 (Introduction to Civil Engineering). The course's final mark includes 30% for the midterm exam, 30% for fieldwork labs, and 40% for the comprehensive final exam.

The Geomatics course is the only prerequisite for the Highway course. Because the Geomatics course is offered in the third semester of the study plan, students who complete it are eligible to enroll in the Highway course. Therefore, although the Highway course is listed in the study plan as a senior course (in the seventh semester), it typically is taken by both senior and junior students. The course's final mark includes 20% for midterm exam, 10% for five online quizzes, 10% for a term paper, 30% for two term projects, and 30% for the comprehensive final exam.

The Traffic course is offered as a major elective course for senior students. Although it is an elective course, more than 60% of the students in the program usually take this course. This is due, in part, to the fact that the course consistently is offered every semester. Another reason for the high demand on this course is "the variety of assessment tools and the fair grading policy used in the course," as expressed by approximately 28% of students in their evaluation of teaching. The course's final mark includes 30% for midterm exam, 20% for a term project, 10% for a term paper, and 40% for the comprehensive final exam.

Experimental Design and Data Collection

The author worked as an Associate Professor at Abu Dhabi University from 2009 to 2019, and he was the sole instructor for the three aforementioned courses (Geomatics, Highway, and Traffic). The author/instructor started to implement a grade dropping policy in all three courses in the 2016 academic year, by offering an optional second midterm exam in each course near the end of the semester. The optional second midterm exam covered materials that were not covered in the first midterm exam. The second midterm exam was optional for students to take and it typically was offered two or three weeks before the final exam. Therefore, the second midterm exam covered approximately 80%–90% of the materials offered in the second half of the course. If a student opted to take the optional second midterm exam, the student's mark for the midterm exam would be the higher of the two midterm exams; and the lower mark would be dropped.

Several course attributes were measured and compared between the before group that took the course in the 6 years prior to implementing grade dropping (academic years 2010–2015), and the after group that took the course in the 3 years after implementing grade dropping (academic years 2016–2018). Tables 2–4 list different course attributes for each academic year for male, female, and all students, respectively. The following attributes were used for evaluation:

- The mean cumulative grade point average (CGPA) prior to taking the course was used to determine whether any differences in

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Table 2. Attributes of evaluated courses (male students)

Course	Academic year	Number of enrolled students	CGPA[a]	Mean final exam mark (%)	Course failure rate (%)	Mean attendance rate (%)	Mean students' evaluation[b] (%)
Geomatics	2010	26	2.81	53.7	19.2	87.6	73.7
	2011	33	2.76	56.3	21.2	88.6	70.4
	2012	38	2.80	52.9	26.3	89.7	72.8
	2013	34	2.84	54.1	23.8	87.6	73.7
	2014	46	2.78	53.6	22.7	88.6	70.4
	2015	53	2.83	53.8	23.5	89.7	72.8
	2016	41	2.77	56.9	24.4	89.2	79.6
	2017	65	2.79	59.7	20.5	91.1	83.8
	2018	38	2.82	58.8	22.2	91.7	81.4
Highway	2010	34	2.66	54.8	11.8	82.7	85.7
	2011	39	2.67	51.8	15.4	83.6	84.5
	2012	52	2.64	57.4	11.5	84.9	83.6
	2013	70	2.63	58.0	25.7	85.8	81.6
	2014	41	2.57	54.7	9.8	92.3	85.6
	2015	70	2.58	53.8	8.6	93.6	86.4
	2016	38	2.62	70.9	13.2	91.4	84.1
	2017	55	2.56	80.0	9.1	92.3	87.9
	2018	62	2.59	78.5	14.5	91.7	88.4
Traffic	2010	14	2.69	58.7	7.1	86.9	72.8
	2011	22	2.67	59.4	9.1	88.4	76.3
	2012	27	2.65	57.6	3.7	88.7	75.2
	2013	38	2.67	57.4	7.9	89.7	74.6
	2014	31	2.62	56.8	6.5	88.4	78.7
	2015	24	2.66	58.3	4.2	86.9	76.4
	2016	34	2.71	61.7	5.9	92.4	82.9
	2017	23	2.58	59.4	0.0	91.8	85.7
	2018	28	2.64	64.7	3.6	93.5	88.2

[a]Mean cumulative grade point average prior to taking course.
[b]Mean evaluation score of how students perceive adequacy and fairness of grading policy.

Table 3. Attributes of evaluated courses (female students)

Course	Academic year	Number of enrolled students	CGPA[a]	Mean final exam mark (%)	Course failure rate (%)	Mean attendance rate (%)	Mean students' evaluation[b] (%)
Geomatics	2010	10	2.91	63.4	10	91.2	73.4
	2011	13	2.89	64.2	15.4	89.9	74.8
	2012	17	2.91	61.5	17.6	91.3	76.3
	2013	18	2.93	62.4	11.1	92.4	72.6
	2014	16	2.87	61.8	18.8	91.1	75.8
	2015	14	2.86	63.7	14.3	89.7	73.9
	2016	15	2.87	65.9	6.7	90.3	78.4
	2017	17	2.89	68.4	0.0	93.4	81.6
	2018	18	2.90	66.8	5.6	91.5	83.4
Highway	2010	11	2.78	70.9	0	92.3	86.4
	2011	14	2.81	78.6	7.1	91.8	88.1
	2012	15	2.76	68.8	6.7	89.6	84.3
	2013	16	2.75	62.3	6.3	88.7	82.6
	2014	18	2.77	79.9	0.0	93.4	87.6
	2015	16	2.79	85.0	6.3	92.8	85.4
	2016	15	2.76	82.4	6.7	91.7	84.6
	2017	15	2.73	79.2	0.0	94.8	91.6
	2018	17	2.69	67.3	0.0	95.3	92.8
Traffic	2010	10	2.74	73.8	10	90.6	86.5
	2011	8	2.77	74.9	0	89.4	88.1
	2012	9	2.75	70.6	11.1	88.3	85.6
	2013	12	2.78	68.7	8.3	87.4	84.7
	2014	15	2.76	76.3	6.7	89.6	86.4
	2015	7	2.73	74.8	0.0	89.4	85.9
	2016	16	2.70	67.7	0.0	91.5	88.1
	2017	14	2.81	77.6	7.1	90.8	90.4
	2018	11	2.74	72.8	9.1	92.6	89.7

[a]Mean cumulative grade point average prior to taking course.
[b]Mean evaluation score of how students perceive adequacy and fairness of grading policy.

Table 4. Attributes of evaluated courses (all students)

Course	Academic year	Number of enrolled students	CGPA[a]	Mean final exam mark (%)	Course failure rate (%)	Mean attendance rate (%)	Mean students' evaluation[b] (%)
Geomatics	2010	36	2.84	56.4	16.6	88.6	73.6
	2011	46	2.80	58.5	19.6	89.0	71.6
	2012	55	2.83	55.6	23.6	90.2	73.9
	2013	52	2.87	57.0	19.4	89.3	73.3
	2014	62	2.80	55.7	21.7	89.2	71.8
	2015	67	2.84	55.9	21.6	89.7	73.0
	2016	56	2.80	59.3	19.7	89.5	79.3
	2017	82	2.81	61.5	16.3	91.6	83.3
	2018	56	2.85	61.4	16.9	91.6	82.0
Highway	2010	45	2.69	58.7	8.9	85.0	85.9
	2011	53	2.71	58.9	13.2	85.8	85.5
	2012	67	2.67	60.0	10.4	86.0	83.8
	2013	86	2.65	58.8	22.1	86.3	81.8
	2014	59	2.63	62.4	6.8	92.6	86.2
	2015	86	2.62	59.6	8.2	93.5	86.2
	2016	53	2.66	74.2	11.4	91.5	84.2
	2017	70	2.60	79.8	7.2	92.8	88.7
	2018	79	2.61	76.1	11.4	92.5	89.3
Traffic	2010	24	2.71	65.0	8.3	88.4	78.5
	2011	30	2.70	63.5	6.7	88.7	79.4
	2012	36	2.68	60.9	5.6	88.6	77.8
	2013	50	2.70	60.1	8.0	89.1	77.0
	2014	46	2.67	63.2	6.6	88.8	81.2
	2015	31	2.68	62.0	3.3	87.5	78.5
	2016	50	2.71	63.6	4.0	92.1	84.6
	2017	37	2.67	66.3	2.7	91.4	87.5
	2018	39	2.67	67.0	5.2	93.2	88.6

[a]Mean cumulative grade point average prior to taking course.
[b]Mean evaluation score of how students perceive adequacy and fairness of grading policy.

the performance between the two evaluated groups could be attributed to the differences in their overall academic performance and capabilities.

- The mean final exam mark was used to evaluate the effect of grade dropping on students' academic performance on the comprehensive final exam.
- The course failure rate was used to evaluate if implementing grade dropping had a significant effect on the proportion of students who failed the course.
- Students' attendance rate was used to evaluate if implementing grade dropping had a significant effect on students' engagement in terms of class attendance.
- The score given by students evaluating how they perceived the adequacy and fairness of the grading policy was used to evaluate if implementing grade dropping had a significant effect on students' satisfaction.

Students who attend Abu Dhabi University have diverse ethnic backgrounds. Most of them are from the Middle East, Africa, and Asia. English is the official instructional and communication language at the university, but it is not the first language for most students. However, as a condition to be admitted to the university, students are required to provide proof of their proficiency in English. The only proofs of English proficiency acceptable by the university are either a minimum score of 61 on the Test of English as a Foreign Language internet-based test (TOEFL iBT), or a minimum score of 5 on the academic International English Language Testing System (IELTS) test. Furthermore, students admitted to the program must take two English language courses during their first two semesters in the program (as freshmen), and they must pass those two courses before taking any further courses in the program. Because of these measures, all evaluated students were expected to be consistently proficient in English.

Because educational intervention studies usually are conducted in complex social settings with many confounding variables that cannot easily be measured, the period before implementing grade dropping (2010–2015) was divided further into two subperiods. The first subperiod was from 2010 to 2012, and the second subperiod was from 2013 to 2015. The differences in the measured attributes (CGPA, final exam marks, class attendance rates, and student evaluation scores) were compared between the two subperiods to determine if there was any temporal trend in those attributes that was not explained by grade dropping. The attributes related to year 2009 when the author/instructor started to teach the courses at Abu Dhabi University were not included in the analysis. This was to allow for a transition period for the instructor/author to become fully familiar with the university's policies and culture, and to allow the students to become more familiar with the instructor's expectations and methods of teaching and grading.

Results and Discussion

The differences in course attributes (with standard deviations) before and after the implementation of grade dropping are listed in Tables 5–7 for male, female, and all students, respectively. Two-tailed z-tests were performed to test the significance of the difference between the failure proportions in the before and after groups at the 0.05 significance level. To compare the differences in all other course attributes, two-tailed t-tests were performed to evaluate the significance of the difference between the two means (with

Table 5. Differences in course attributes (with standard deviations) before and after implementation of grade dropping—male students

Course	Attribute	Before grade dropping[a]	After grade dropping[b]	Significance test			
				t-stat[c]	z-score[d]	p-value	Degree of freedom
Geomatics	Enrollment	230	144	—	—	—	—
	CGPA[e]	2.80 (0.57)	2.79 (0.51)	0.172	—	0.864	372
	Final exam mark	**54.0 (21.4)**	**58.7 (19.3)**	**2.145**	—	**0.033**	**372**
	Failure rate	23.0	22.1	—	0.202	0.841	—
	Attendance rate	**88.8 (7.2)**	**90.7 (6.5)**	**2.577**	—	**0.010**	**372**
	Student evaluation	**72.2 (27.3)**	**82.0 (26.7)**	**3.407**	—	**0.001**	**372**
Highway	Enrollment	306	155	—	—	—	—
	CGPA[e]	2.62 (0.53)	2.59 (0.57)	0.560	—	0.576	459
	Final exam mark	**55.3 (20.2)**	**77.2 (21.3)**	**10.796**	—	**<0.001**	**459**
	Failure rate	14.4	12.3	—	0.620	0.535	—
	Attendance rate	**87.7 (5.2)**	**91.8 (4.8)**	**8.204**	—	**<0.001**	**459**
	Student evaluation	**84.4 (12.6)**	**87.2 (12.4)**	**2.266**	—	**0.024**	**459**
Traffic	Enrollment	156	85	—	—	—	—
	CGPA[e]	2.66 (0.54)	2.65 (0.52)	0.139	—	0.889	239
	Final exam mark	57.9 (19.7)	62.1 (17.4)	1.646	—	0.101	239
	Failure rate	6.4	3.5	—	0.954	0.342	—
	Attendance rate	**88.4 (5.9)**	**92.6 (6.6)**	**5.062**	—	**<0.001**	**239**
	Student evaluation	**75.9 (14.9)**	**85.4 (13.8)**	**4.852**	—	**<0.001**	**239**

Note: Numbers in bold indicate significant difference at 0.05 significance level.
[a]Academic years 2010–2015.
[b]Academic years 2016–2018.
[c]For comparing difference between two means at 5% significance level.
[d]For comparing difference between two proportions at 5% significance level.
[e]Mean cumulative grade point average prior to taking course.

Table 6. Differences in course attributes (with standard deviations) before and after implementation of grade dropping—female students

Course	Attribute	Before grade dropping[a]	After grade dropping[b]	Significance test			
				t-stat[c]	z-score[d]	p-value	Degree of freedom
Geomatics	Enrollment	88	50	—	—	—	—
	CGPA[e]	2.90 (0.39)	2.89 (0.46)	0.136	—	0.892	136
	Final exam mark	62.7 (17.2)	67.1 (18.9)	1.393	—	0.166	136
	Failure rate	14.8	4.0	—	1.958	0.053	—
	Attendance rate	91.0 (4.4)	91.8 (3.9)	1.069	—	0.287	136
	Student evaluation	74.5 (25.3)	81.3 (30.4)	1.409	—	0.161	136
Highway	Enrollment	90	47	—	—	—	—
	CGPA[e]	2.78 (0.44)	2.73 (0.42)	0.641	—	0.523	135
	Final exam mark	74.5 (18.1)	75.9 (13.8)	0.464	—	0.643	135
	Failure rate	4.5	2.1	—	0.709	0.478	—
	Attendance rate	**91.4 (4.8)**	**94.0 (3.9)**	**3.201**	—	**0.001**	**135**
	Student evaluation	85.7 (13.2)	89.8 (11.1)	1.819	—	0.071	135
Traffic	Enrollment	61	41	—	—	—	—
	CGPA[e]	2.76 (0.43)	2.75 (0.40)	0.118	—	0.906	100
	Final exam mark	73.2 (18.5)	72.4 (17.2)	0.220	—	0.826	100
	Failure rate	6.6	4.9	—	0.357	0.719	—
	Attendance rate	**89.1 (5.4)**	**91.6 (5.2)**	**2.327**	—	**0.022**	**100**
	Student evaluation	86.1 (15.1)	89.3 (13.2)	1.103	—	0.273	100

Note: Numbers in bold indicate significant difference at 0.05 significance level.
[a]Academic years 2010–2015.
[b]Academic years 2016–2018.
[c]For comparing difference between two means at 5% significance level.
[d]For comparing difference between two proportions at 5% significance level.
[e]Mean cumulative grade point average prior to taking course.

their respective standard deviations) at the 0.05 significance level. All the significance tests are listed in Tables 5–7.

The differences in CGPA before taking the courses were not significant, indicating that students in the before and after groups had similar overall academic performance and capabilities (Tables 5–7). Therefore, any differences in the performance between the two groups in the courses cannot be attributed to the differences in the students' overall academic performance and capabilities.

Implementing grade dropping resulted in significant improvements in the final exam marks for male students in two of the three

Table 7. Differences in course attributes (with standard deviations) before and after implementation of grade dropping—all students

Course	Attribute	Before grade dropping[a]	After grade dropping[b]	Significance test			
				t-stat[c]	z-score[d]	p-value	Degree of freedom
Geomatics	Enrollment	318	194	—	—	—	—
	CGPA[e]	2.83 (0.46)	2.82 (0.50)	0.231	—	0.818	510
	Final exam mark	**56.4 (18.4)**	**60.6 (19.0)**	**2.475**	—	**0.014**	**510**
	Failure rate	20.7	17.4	—	0.915	0.358	—
	Attendance rate	**89.4 (5.1)**	**91.0 (5.5)**	**3.342**	—	**0.001**	**510**
	Student evaluation	**72.8 (27.4)**	**81.8 (27.8)**	**3.586**	—	**0.000**	**510**
Highway	Enrollment	396	202	—	—	—	—
	CGPA[e]	2.66 (0.54)	2.62 (0.55)	0.851	—	0.395	596
	Final exam mark	**59.7 (21.1)**	**76.9 (16.8)**	**10.070**	—	**<0.001**	**596**
	Failure rate	12.1	9.9	—	0.802	0.424	—
	Attendance rate	**88.5 (4.9)**	**92.3 (4.4)**	**9.277**	—	**<0.001**	**596**
	Student evaluation	**84.7 (13.3)**	**87.8 (11.9)**	**2.791**	—	**0.005**	**596**
Traffic	Enrollment	217	126	—	—	—	—
	CGPA[e]	2.69 (0.55)	2.68 (0.50)	0.168	—	0.867	341
	Final exam mark	62.2 (21.3)	65.4 (17.7)	1.425	—	0.155	341
	Failure rate	6.5	4.0	—	0.972	0.332	—
	Attendance rate	**88.6 (6.5)**	**92.3 (6.3)**	**5.140**	—	**<0.001**	**341**
	Student evaluation	**78.8 (15.0)**	**86.7 (14.3)**	**4.783**	—	**<0.001**	**341**

Note: Numbers in bold indicate significant difference at 0.05 significance level.
[a]Academic years 2010–2015.
[b]Academic years 2016–2018.
[c]For comparing difference between two means at 5% significance level.
[d]For comparing difference between two proportions at 5% significance level.
[e]Mean cumulative grade point average prior to taking course.

evaluated courses (Geomatics and Highway) at the 0.05 significance level (Table 5). This is explained by the fact that providing an additional midterm exam that covered most of the materials that were not covered in the first midterm exam encouraged students to study those materials to prepare themselves for the additional midterm exam. This preparation might have led to improved performance on the comprehensive final exam. In addition, by providing an additional midterm exam to students, those who performed poorly on the first midterm exam became more motivated to study, knowing that they still had a chance to excel in the course by possibly dropping the poor midterm exam mark and replacing it with a better mark. This explanation is further supported by the significant improvement in the class attendance rates after implementing grade dropping, indicating a significant improvement in students' engagement due to the increased motivation. However, although final exam marks for female students typically were higher than those for male students, implementing grade dropping did not have a significant effect on the final exam marks for female students (Table 6). This finding further supports prior findings that motivational factors, including grade dropping, should be viewed in context (Benson et al. 2013; Martin et al. 2018; Pintrich 2003). The overall effect of grade dropping on all students (male and female) in terms of the final exam mark was significant, which could be explained by the overrepresentation of male students compared with female students (Table 7).

Grade dropping had no significant effect on course failure rates, indicating that grade dropping did not help the lowest-performing students, who would fail the course (Tables 5–7). Furthermore, the percentage of the lowest-performing students who opted to take the optional second midterm exam was lower than that of average-performing students (Table 8). Those lowest-performing students could have lacked the fundamental mathematical and scientific skills needed to advance through an engineering program, or they could have had a severe lack of motivation, such that grade dropping by itself did not adequately motivate them. On the other hand, the majority of the highest-performing students, who received 90% or more on the original midterm exam, did not take the optional second midterm exam, and therefore did not benefit from grade dropping (Table 8). The table also indicates that the improvement gained from the optional second midterm exam by the highest-performing and the lowest-performing students was less than that gained by average-performing students. This finding is consistent with previous findings from economics/business courses (Hadsell and MacDermott 2010). Based on these findings, it could be concluded that grade dropping is more helpful for average-performing engineering students, but it provides no significant advantage for the lowest-performing or highest-performing engineering students.

Students usually are asked to evaluate the teaching at the end of each semester. Among the questions they need to answer is a question about whether students perceive the grading policy of the course to be adequate and fair. Students answered that question using a Likert scale ranging from 1 (strongly disagree) to 5 (strongly agree). The average responses for each course in each academic year are listed in Tables 2–4 (as percentages), and the differences between the before and after groups are listed in Tables 5–7. Although the average evaluation was high even before grade dropping was implemented, only male students significantly improved their evaluations after grade dropping was implemented in all three courses. Evaluation scores given by female students, although higher than those given by male students, did not significantly improve after the implementation of grade dropping. However, the combined scores given by male and female students improved significantly for all three courses (Table 7). Based on these facts, it can be concluded that student satisfaction, as expressed in the evaluation scores, significantly improved after the implementation of grade dropping.

To control for any potential confounding variables that were not included in the study, the period before implementing grade

Table 8. Break down of students' marks in first midterm exams and their preference for taking optional second midterm exam

Course	Academic year	Number of enrolled students	Number of students according to marks on first midterm exam			Number of students who took optional second midterm exam		
			Highest[a]	Average[b]	Lowest[c]	Highest[a]	Average[b]	Lowest[c]
Male students								
Geomatics	2016	41	4	29	8	1 (0)	27 (19)	5 (2)
	2017	65	8	46	11	2 (1)	43 (37)	8 (3)
	2018	38	3	26	9	1 (0)	25 (19)	7 (2)
Highway	2016	38	5	20	13	1 (0)	20 (14)	10 (4)
	2017	55	9	30	16	3 (1)	29 (22)	12 (4)
	2018	62	8	40	14	2 (0)	39 (30)	10 (3)
Traffic	2016	34	6	24	4	1 (0)	24 (20)	2 (1)
	2017	23	5	16	2	0 (0)	16 (13)	1 (1)
	2018	28	7	18	3	2 (1)	17 (14)	1 (0)
Female students								
Geomatics	2016	15	4	8	3	2 (0)	8 (7)	2 (1)
	2017	17	5	9	3	1 (1)	9 (8)	3 (1)
	2018	18	6	10	2	2 (2)	10 (6)	1 (0)
Highway	2016	15	4	11	0	2 (0)	11 (7)	0 (0)
	2017	15	5	9	1	2 (0)	8 (6)	0 (0)
	2018	17	6	10	1	3 (1)	8 (5)	1 (0)
Traffic	2016	16	6	8	2	1 (0)	8 (4)	2 (1)
	2017	14	5	8	1	1 (0)	8 (5)	1 (0)
	2018	11	3	6	2	0 (0)	6 (4)	2 (1)
All students								
Geomatics	2016	56	8	37	11	3 (0)	35 (26)	7 (3)
	2017	82	13	55	14	3 (2)	52 (45)	11 (4)
	2018	56	9	36	11	3 (2)	35 (25)	8 (2)
Highway	2016	53	9	31	13	3 (0)	31 (21)	10 (4)
	2017	70	14	39	17	5 (1)	37 (28)	12 (4)
	2018	79	14	50	15	5 (1)	47 (35)	11 (3)
Traffic	2016	50	12	32	6	2 (0)	32 (24)	4 (2)
	2017	37	10	24	3	1 (0)	24 (18)	2 (1)
	2018	39	10	24	5	2 (1)	23 (18)	3 (1)

Note: Numbers in parentheses indicate number of students who improved their marks on optional second midterm exam by 5 points or more.
[a]Students who scored 90% or more on first midterm exam.
[b]Students who scored between 60% and 90% on first midterm exam.
[c]Students who failed first midterm exam (score < 60%).

dropping was divided further into two subperiods (2010–2012 and 2013–2015). The differences in the measured attributes (final exam marks, class attendance rates, and student evaluation scores) were compared between the two subperiods before implementing grade dropping. Those differences are listed in Tables 9–11 for male, female, and all students, respectively. The only significant difference between the two subperiods was in the attendance rate for the Highway course in relation to male students. This difference might be explained by the positive feedback received from the first graduated cohort, who graduated in 2012. Representatives from that graduated cohort were invited to classrooms and to an alumni meeting that was attended by then-current students in September 2012. During their visit, the alumni acknowledged that the Highway course, among several other courses, helped them find jobs. This could have inspired other students to attend classes and pay more attention to higher-level market-related courses, including the Highway course. Due to the overrepresentation of male students compared with female students, the difference between the two subperiods in the attendance rate for the Highway course in relation to all students also was significant (Table 11). This was despite the insignificant difference related to female students (Table 10).

Other than the difference in class attendance rates for the Highway course, no significant differences were observed between the two subperiods in relation to any of the remaining measured attributes (CGPA, final exam marks, and student evaluation scores). This indicates that the differences between the before period (2010–2015) and the after period (2016–2018) more likely were explained by grade dropping. However, there could be a temporal trend in the measured attributes that started in the after period (2016–2018) due to any unmeasured confounding variables, such as regional or worldwide socioeconomic changes. It was not possible to fully control for those confounding variables in this study.

Students' Feedback through Online Survey

To further understand how students perceived grade dropping, the author created an online survey that consisted of six multiple-choice questions. Each question in the survey had five possible answers that ranged from 1 (strongly disagree) to 5 (strongly agree) on a Likert scale. Students who took any of the three evaluated courses (Geomatics, Highway, and Traffic) in or after academic year 2016, when grade dropping was implemented, were invited to participate in the survey. A total of 267 students met the criteria and were invited to participate in the survey; among them, 94 students completed the survey. The survey was designed to fully maintain students' anonymity, so it was not possible to link the students' responses to their gender or academic performance. The survey questions, along with the number and percentage of students who selected each answer, are listed in Table 12.

Table 9. Differences in course attributes (with standard deviations) between two subperiods before implementation of grade dropping—male students

Course	Attribute	First subperiod[a]	Second subperiod[b]	Significance test			
				t-stat[c]	z-score[d]	p-value	Degree of freedom
Geomatics	Enrollment	97	133	—	—	—	—
	CGPA[e]	2.79 (0.57)	2.82 (0.53)	0.411	—	0.682	228
	Final exam mark	54.3 (20.1)	53.8 (18.4)	0.196	—	0.450	228
	Failure rate	22.7	23.3	—	0.1067	0.912	—
	Attendance rate	88.8 (6.7)	88.8 (5.8)	0.000	—	1.000	228
	Student evaluation	72.2 (24.5)	72.2 (28.4)	0.000	—	1.000	228
Highway	Enrollment	125	181	—	—	—	—
	CGPA[e]	2.65 (0.49)	2.60 (0.54)	0.827	—	0.409	304
	Final exam mark	54.9 (21.4)	55.6 (19.8)	0.294	—	0.769	304
	Failure rate	12.8	15.5	—	0.661	0.509	—
	Attendance rate	**87.7 (5.8)**	**90.3 (7.3)**	**3.323**	—	**0.001**	**304**
	Student evaluation	84.5 (15.6)	84.4 (12.7)	0.062	—	0.951	304
Traffic	Enrollment	63	93	—	—	—	—
	CGPA[e]	2.67 (0.51)	2.65 (0.55)	0.229	—	0.819	154
	Final exam mark	58.5 (19.6)	57.4 (24.3)	0.299	—	0.765	154
	Failure rate	6.3	6.5	—	0.050	0.960	—
	Attendance rate	88.2 (5.1)	88.5 (8.4)	0.253	—	0.800	154
	Student evaluation	75.1 (19.8)	76.4 (18.2)	0.422	—	0.673	154

Note: Numbers in bold indicate significant difference at 0.05 significance level.
[a]Academic years 2010–2012.
[b]Academic years 2013–2015.
[c]For comparing difference between two means at 5% significance level.
[d]For comparing difference between two proportions at 5% significance level.
[e]Mean cumulative grade point average prior to taking course.

Table 10. Differences in course attributes (with standard deviations) between two subperiods before implementation of grade dropping—female students

Course	Attribute	First subperiod[a]	Second subperiod[b]	Significance test			
				t-stat[c]	z-score[d]	p-value	Degree of freedom
Geomatics	Enrollment	40	48	—	—	—	—
	CGPA[e]	2.90 (0.47)	2.89 (0.41)	0.107	—	0.915	86
	Final exam mark	62.9 (21.3)	62.6 (17.4)	0.073	—	0.942	86
	Failure rate	15.0	14.6	—	0.053	0.960	—
	Attendance rate	90.8 (5.9)	91.2 (4.7)	0.354	—	0.724	86
	Student evaluation	75.1 (23.9)	74.0 (25.7)	0.206	—	0.837	86
Highway	Enrollment	40	50	—	—	—	—
	CGPA[e]	2.78 (0.51)	2.77 (0.46)	0.098	—	0.922	88
	Final exam mark	72.8 (20.6)	75.9 (17.3)	0.776	—	0.440	88
	Failure rate	5.0	4.0	—	0.229	0.818	—
	Attendance rate	91.1 (3.9)	91.7 (4.6)	0.657	—	0.513	88
	Student evaluation	86.2 (18.7)	85.3 (13.4)	0.266	—	0.791	88
Traffic	Enrollment	27	34	—	—	—	—
	CGPA[e]	2.75 (0.48)	2.76 (0.44)	0.085	—	0.933	59
	Final exam mark	73.1 (20.4)	73.3 (18.1)	0.041	—	0.968	59
	Failure rate	7.4	5.9	—	0.235	0.819	—
	Attendance rate	89.5 (6.5)	88.8 (5.1)	0.472	—	0.639	59
	Student evaluation	86.7 (17.3)	85.7 (14.6)	0.245	—	0.808	59

Note: Numbers in bold indicate significant difference at 0.05 significance level.
[a]Academic years 2010–2012.
[b]Academic years 2013–2015.
[c]For comparing difference between two means at 5% significance level.
[d]For comparing difference between two proportions at 5% significance level.
[e]Mean cumulative grade point average prior to taking course.

The results showed that 87.2% of the respondents agreed (or strongly agreed) that grade dropping helped them prepare better for the comprehensive final exam, and 74.5% of the respondents agreed (or strongly agreed) that grade dropping helped them to improve their final exam marks. These results are consistent with the observational results in Table 7. The results in Table 12 also show that 72.3% of the respondents agreed (or strongly agreed) that grade dropping motivated them to attend classes more often, which is consistent with the observational results in Table 7. The results related to the last three questions in Table 12 show that the majority

Table 11. Differences in course attributes (with standard deviations) between two subperiods before the implementation of grade dropping—all students

Course	Attribute	First subperiod[a]	Second subperiod[b]	Significance test			
				t-stat[c]	z-score[d]	p-value	Degree of freedom
Geomatics	Enrollment	137	181	—	—	—	—
	CGPA[e]	2.82 (0.52)	2.83 (0.49)	0.176	—	0.861	316
	Final exam mark	56.8 (20.8)	56.1 (18.1)	0.320	—	0.749	316
	Failure rate	20.4	21.0	—	0.131	0.897	—
	Attendance rate	89.4 (6.3)	89.4 (5.4)	0.000	—	1.000	316
	Student evaluation	73.1 (24.2)	72.7 (28.0)	0.134	—	0.894	316
Highway	Enrollment	165	231	—	—	—	—
	CGPA[e]	2.69 (0.50)	2.63 (0.51)	0.164	—	0.245	394
	Final exam mark	59.3 (21.1)	60.0 (20.4)	0.332	—	0.740	394
	Failure rate	10.9	13.0	—	0.631	0.529	—
	Attendance rate	**88.5 (5.0)**	**90.6 (4.6)**	**4.319**	—	**<0.001**	**394**
	Student evaluation	84.9 (16.2)	84.6 (13.1)	0.203	—	0.839	394
Traffic	Enrollment	90	127	—	—	—	—
	CGPA[e]	2.69 (0.50)	2.68 (0.52)	0.142	—	0.887	215
	Final exam mark	62.8 (19.9)	61.7 (20.9)	0.390	—	0.697	215
	Failure rate	6.3	6.3	—	0.000	1.000	—
	Attendance rate	88.6 (5.7)	88.6 (6.2)	0.000	—	1.000	215
	Student evaluation	78.5 (17.6)	78.9 (15.1)	0.179	—	0.858	215

Note: Numbers in bold indicate significant difference at 0.05 significance level.
[a]Academic years 2010–2012.
[b]Academic years 2013–2015.
[c]For comparing difference between two means at 5% significance level.
[d]For comparing difference between two proportions at 5% significance level.
[e]Mean cumulative grade point average prior to taking course.

Table 12. Numbers of students (and percentages) who selected different multiple-choice answers in survey used to assess how they perceived grade dropping

Question	Strongly agree	Agree	Neutral	Disagree	Strongly disagree
1. Offering two term exams and dropping the lower mark (grade dropping) helped me prepare better for the comprehensive final exam.	58 (61.7%)	24 (25.5%)	3 (3.2%)	5 (5.3%)	4 (4.3%)
2. I believe that grade dropping has helped me (or will help me) in improving my mark in the course's final exam.	51 (54.2%)	19 (20.2%)	4 (4.3%)	9 (9.6%)	11 (11.7%)
3. Grade dropping motivated me to attend classes more often in the course where grade dropping was implemented.	46 (48.9%)	22 (23.4%)	8 (8.5%)	11 (11.7%)	7 (7.5%)
4. Grade dropping showed me that the instructor was caring about me and trying to help me without compromising academic integrity.	49 (52.1%)	19 (20.2%)	10 (10.6%)	9 (9.6%)	7 (7.5%)
5. By implementing grade dropping in my class, I feel that the course grading policy became better than before in terms of fairness.	48 (51.0%)	21 (22.3%)	7 (7.5%)	11 (11.7%)	7 (7.5%)
6. By implementing grade dropping in my class, I feel that the course's grading policy adequately measured my efforts in the course.	46 (48.8%)	27 (28.7%)	8 (8.5%)	5 (5.3%)	8 (8.5%)

of the respondents agreed (or strongly agreed) that grade dropping increased their satisfaction in terms of their perception that the instructor cared about them (72.3%), the fairness of the course's grading policy (73.4%), and the adequacy of the course's grading policy to measure the students' efforts in the course (77.7%). Overall, the results of the online survey (Table 12) are consistent with the observational results in Table 7.

Conclusions

In this research study, the author was the sole instructor in three different engineering courses, in which optional second midterm exams were offered. The optional second midterm exams covered materials that were not covered in the first midterm exams. The midterm exam mark in each course was the higher mark of the two midterm exams, and the lower mark was dropped (grade dropping).

It was found that grade dropping resulted in significant improvements in students' performance on the comprehensive final exam. By providing an additional midterm exam that covered most of the materials that were not covered in the first midterm exam, students were encouraged to study those materials to prepare themselves for the additional midterm exam. This preparation resulted in improved performance on the comprehensive final exam. By offering an additional exam covering the second half of the course's study materials, students could receive feedback on their performance related to those study materials; this feedback helped the students on the comprehensive final exam. Finally, students who performed poorly on the first midterm exam were more motivated to continue studying for the course, knowing that they still had a chance to excel in the course by possibly dropping the poor midterm exam mark and replacing it with a better mark. This explanation is further supported by the significant improvement in the class attendance rate after implementing grade dropping, indicating a significant improvement in students' engagement due to the increased motivation. Grade dropping also resulted in a significant improvement in students' satisfaction, as expressed in students' evaluation for the adequacy and fairness of the grading policy.

The lowest-performing and the highest-performing students did not significantly benefit from grade dropping. Furthermore, the effects of grade dropping were more significant for male students than for female students. This finding supports prior research studies that found that motivational factors (including grade dropping) should be viewed in context.

In addition to the observational assessment, students' feedback on grade dropping was collected through an online survey. The feedback received from students was in full agreement with the results of the observational assessment.

Further research might be needed to explore the effect of grade dropping in other contexts, such as different students' cultural backgrounds. A qualitative analysis (e.g., through in-person interviews) also might be needed to fully understand how students perceive the effect of grade dropping on their performance, engagement, and satisfaction. Furthermore, possible negative effects of grade dropping were not thoroughly investigated in this research study. For instance, some students might be less willing to study for the original midterm exam knowing that they still have a second chance because of the optional second midterm exam. Additionally, grade dropping adds a greater burden on the instructors to prepare, administer, and mark an additional exam. Finally, instructors need to remind students that in real-world engineering practice, there usually is no second chance, and engineers usually are held accountable for their mistakes.

Data Availability Statement

All data (in aggregated form without any personal identifiers) that support the findings of this study are available from the corresponding author upon reasonable request.

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