On the Necessity of Midterm Exams in Electrical Engineering Courses

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INTRODUCTION

In recent years there has been much research on new approaches and methods in teaching. A lot of effort is placed on e-learning and examining how well it assists in academic teaching and what are the preferred methods for e-learning and distant learning [1-4]. On the other hand many papers deal with more fundamental aspects of learning such as the differences between students from rural and urban backgrounds and between male and female students [5], the effect of grading homework on students' achievements [6], how does working in groups contribute to the individual student [7], what is the role of laboratories in undergraduate studies [8] and how does accreditation affect students' performance [9]. More recent research tried to measure how a course grade can affect students' future choices [10], and how classifying exercises can support individual learning [11].

In many undergraduate and graduate courses the lecturer chooses not to place the entire weight of the course on one final exam or one final project and give the students a midterm exam. The midterm exam which is usually much shorter in content than the final exam allows the lecturer to place a mirror in front of the students and show them how well they are doing so far in a course, without having to wait for the finals. The main advantages of a midterm exam are: 1. the lecturer can view the academic level of the students during the semester (something which is more difficult to do when addressing homework since one can never really tell if the homework was done individually, in a group or copied from a previous source), 2. The students can test themselves and find how well they are actually doing, 3. The students need to toe the line as far as the curriculum is concerned and not be left behind in the material and 4. If the midterm grade is part of the course final grade (e.g., 80% final exam and 20% midterm exam) then it may assist those that did well during the course, but were not at their best at the final exam, to obtain satisfactory grades. In some courses the midterm exam is mandatory and its grade is always taken into account when calculating the final grade, while in other courses the midterm exam is taken into account only if its grade is higher than the one obtained in the final exam.

The main drawbacks of the midterm exam are as follows. 1. It either takes place instead of one lecture or recitation (thus decreasing the number of teaching hours in the semester) or it takes place as an extra meeting (forcing the lecturer and students to be present at the university or college at irregular hours). 2. Many times students miss lectures in other courses during the week preceding the midterm exam since they want to study for the exam and thus their chance to succeed in other courses deteriorates.

In this paper the author tries to answer the question, do midterm exams actually contribute to the students, by comparing the final grades in final exams of several courses for students that attended the midterm exam and for those who did not.

1 THE ACADEMIC DATABASE

The author used a database of undergraduate students that he taught between 2005 and 2014 in two Colleges of Engineering that will be named College1 and College2 from this point on. The students were either Electrical Engineering students or Software Engineering students. Three courses were examined: 1. Electronics 1, an introductory course in circuit theory taught in the 1st year of undergraduate studies at College1 between 2005 and 2011, 2. Signals and Systems, a fundamental 2nd year course for undergraduate students given at both College1 (between 2005 and 2014) and College2 (between 2011 and 2014), and 3. Introduction to Electronic Communications, a more advanced 3rd year course for undergraduate students given at College1 between 2005 and 2014.

The choice of courses is not random. On the first year of college, students are not yet aware of the standards of higher education and the variety of students is quite immense. This is why a 1st year course that is an introductory to many of the courses that the students will encounter later on is the first choice for this work. Next we differentiate between obligatory courses that every student has to take (whether he/she likes it or not) and specialization courses that students choose to take as they want to specialize in these areas of interest. This is why the author chose one 2nd year obligatory course and one 3rd year specialization course.

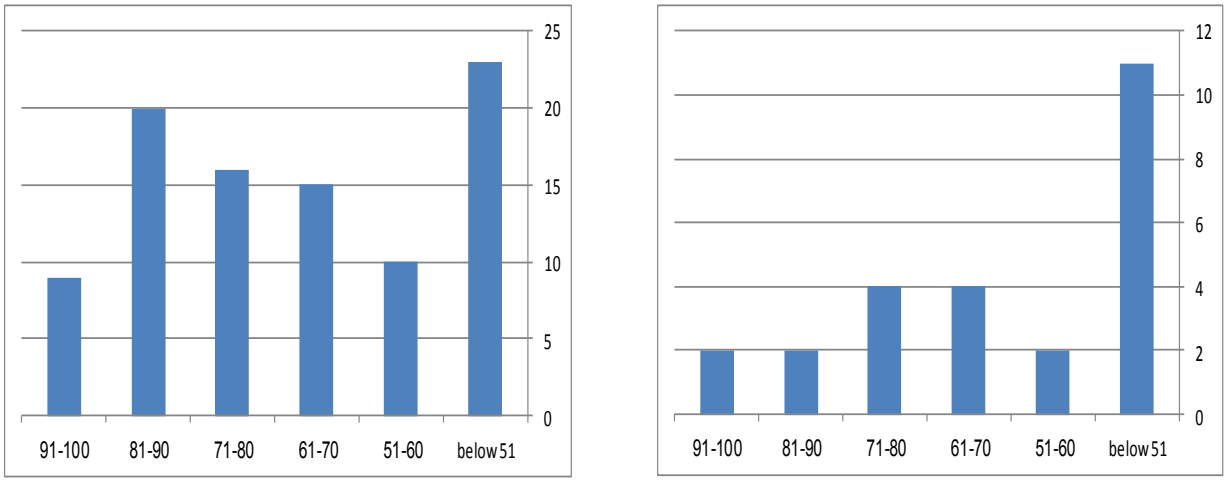
In total 686 students took the courses (Colleges in the author's country, are characterized by small classes) from which 541 (78.8%) took the final exam in each course. In all courses the final grade was comprised of the grade of the final exam, the grade of the midterm exam and the grade given to homework assignments. The midterm grade could be up to 30% of the final grade, and homework could grant the student up to 10% of the grade. The midterm was not compulsory but if either a student chose not to take the midterm exam or his/her grade was lower than the one obtained in the final exam, then the grade of the final exam was weighted as 90% of the final grade (rather than 60%).

In this work we do not use the data regarding homework grades since it is almost impossible to determine whether a student actually answered the homework questions by himself or asked a friend or copied the solution from the solution given in the previous year. For this reason we focus on the impact of the midterm exams. Only 328 students attended the midterm exams (60.6% of all students attending the final exam) and the purpose of this work is to determine whether or not attending the midterm exam has an impact of the grade of the final exam.

2 PRIMARY RESEARCH RESULTS

We start with the students that took the course Electronics1 at College1 during the period 2005 to 2015. This is a 1st year course that gives the students the basic concepts in circuit theory and serves as a filter to filter out all the students that are

not really fit to become engineers. 184 students took the course, from which 118 took the final exam. From these 118 only 93 took the midterm. The students that took the midterm got an average grade of 62.7 (out of a possible 100) in the final exam (with a standard deviation of 26.5) while students that did not take the midterm exam got an average grade of 54.6 in the final exam (with a standard deviation of 25.5). Note that the standard deviation is quite high, due to two main reasons: the small number of students and the fact that this is a 1st year course and the diversity amongst students is quite large (after the first year the weaker students drop out of college). The grades histograms are given in Fig. 1, where one can see the large percentage of failures within the group of students that did not take the midterm exam (the average grade was 70.3). Although most students that did well during their midterm exam also did well in the final exam, several students that did well in the midterm exam became complacent and did not study hard enough for their final exam, while other students that failed in the midterm exam realized that they must make a change and studied harder for the final exam. Thus no immediate correlation was found between the midterm grade and the final grade.



(a) (b)

Fig. 1. Final grade histograms for (a) students in Electronics1 that took the midterm exam and (b) students that did not take the midterm exam.

Next we turn to the course in Signals and Systems. This course was given to 9 groups at College1 during the period 2005 to 2014 and to 6 groups at College2 during the period 2011 to 2014. At College1, 114 students took the final exam from which 69 also took the midterm exam. The students that took the midterm exam got an average grade of 75.6 in the final exam (with a standard deviation of 15.6) while students that did not take the midterm exam got an average grade of 67.6 in the final exam (with a standard deviation of 24.2). At College2 166 students took the final exam from which 93 also took the midterm exam. The students that took the midterm got an average grade of 77.5 in the final exam (with a standard deviation of 16.3) while students that did not take the midterm exam got an average grade of 55.8 in the final exam (with a standard deviation of 24.3). The grades histograms are given in Fig. 2. Note that the diversity amongst students that took the midterm exam is much lower than in the previous example. Again, no immediate correlation was found between the midterm grade and the final grade.

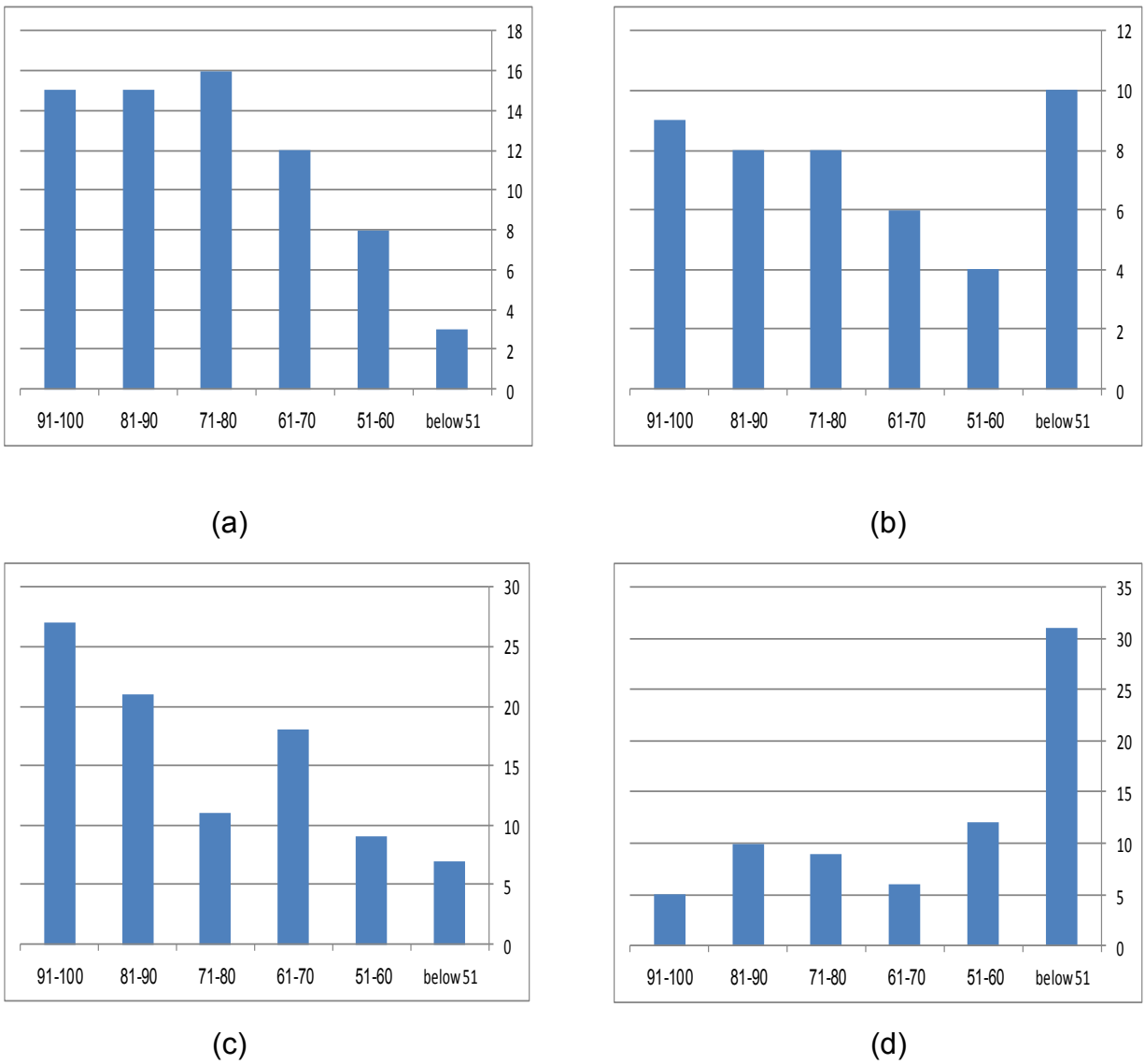
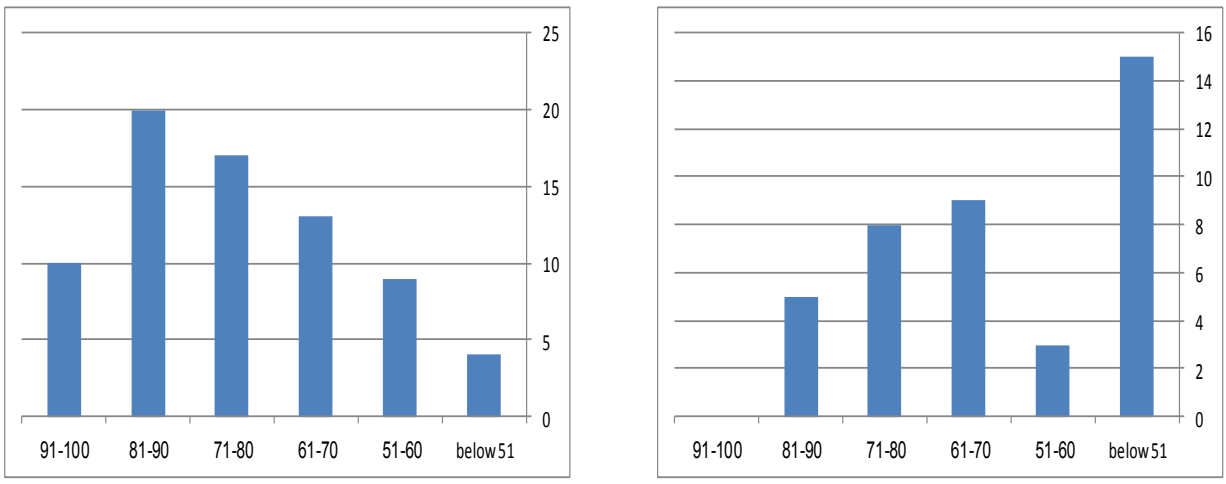


Fig. 2. Signals and Systems final grade histograms for (a) students at College1 that took the midterm exam and (b) students at College1 that did not take the midterm exam, (c) students at College2 that took the midterm exam and (d) students at College2 that did not take the midterm exam.

Finally, the author observed the course Introduction to Electronic Communications, which was given to 9 groups at College1 during the period 2005 to 2014. 113 students took the final exam from which 73 also took the midterm exam. The students that took the midterm got an average grade of 74.7 in the final exam (with a standard deviation of 14.2) while students that did not take the midterm exam got an average grade of 49.1 in the final exam (with a standard deviation of 22.3). The grades histograms for this test case are given in Fig. 3.



(a) (b)

Fig. 3. Final grade histograms for (a) students of the course Introduction to electronic communications that took the midterm exam and (b) students that did not take the midterm exam.

As one can see there's a significant improvement in the grade obtained in the final exam for students that took the midterm exam. Again, no immediate correlation was found between success in the midterm exam and success in the final exam.

In total, 328 students who took the midterm exams obtained an average of 72.8 in the final exam while 213 students who did not take the midterm exams obtained an average of 56.9 in the final exam. There are several possible reasons for this result. First, attending the midterm exam forces the students to focus and study during the semester and not just in the week before the final exam. Thus, students that attended the midterm exam come to the final exam more prepared. Second, students that attend the midterm exam become acquainted with the way the lecturer writes questions and with solving such questions in a limited time frame, thus when they reach the final exam they have a better notion of what to expect and thus they do better in the final exam. The third option is that the students that attend the midterm exam are the brighter and more diligent students and thus they have the potential to succeed in the final exam, while others choose not to attend the midterm exam because they either think that they are not sufficiently good, or they are not willing to spend sufficient time on studying. The level of significance of this last option is not very high, as the average grades in the midterm exams did not differ much from the grade of the final exam and were not extremely high (the ratio between the difficulty level and the duration of the exam is more or less the same in the midterm exam and in the final exam). A forth possible explanation might suggest that a midterm exam motivates the students to succeed in the final exam, since those who did well feel that they have already taken a big step towards excelling in the course and those who did not know that they have to study harder in order to succeed. At the same time, those who do not attend the midterm exam and were indifferent to it are also indifferent to the final exam.

3 OVERALL CORRELATION BETWEEN MIDTERM EXAM GRADES AND FINAL EXAM GRADES

After showing that students that attended the midterm exam obtained higher grades in the final exam, on the average, than those that did not attend the midterm exam, we now wish to find whether there's a correlation between the actual grade obtained in the midterm exam and the grade obtained in the final exam. To test the connection between these parameters we address only the students that attended the midterm exams and use the complete database rather than just one course, to achieve improved accuracy. Fig. 4 shows a 2-D histogram presenting the number of students that scored certain grades in the midterm exam and in the final exam, where there are six groups of grades: 0-50, 51-60, 61-70, 71-80, 81-90, and 91-100. One thing stands out of the image, students that did well in the quiz also did well in the final exam. Actually 63.5% of the students that scored more than 90 in the quiz also scored more than 80 in the final exam.

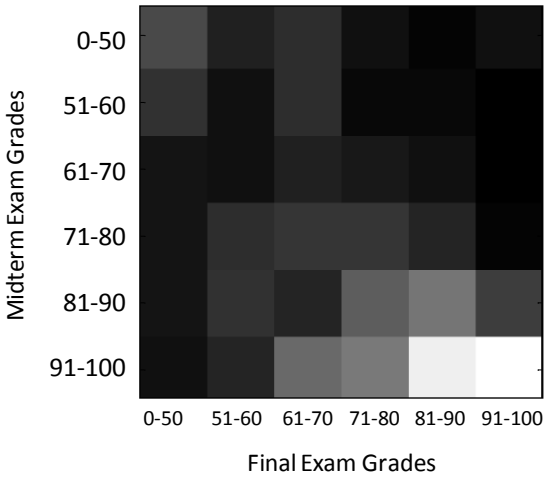


Fig. 4. Final grades versus midterm grades histogram, taking into account all students that took the midterm exam. Bright areas indicate a large percentage of students while dark areas indicate a small percentage of students.

However, since the number of students in each grade group is different it is difficult to see if there's a correlation between the grade in the quiz and the grade in the final exam. For this reason the authors show a second plot in which the number of students in each grade group is normalized. The result is given in Fig. 5. Although the main diagonal is slightly stronger (brighter) than the other regions in the plot there's' no clear cut connection between the quiz grades and the final exam grades.

4 VARIANCE IN GRADES ALONG THE FIRST THREE YEARS OF STUDYING, AND GENDER DIFFERENTIATION

The effect of midterm exams on the final grades varies from one academic year to another. In first year courses: 78.8% of the students that attended the final exam also took the midterm exam. They scored an average of 62.7 in the finals (apposed to 54.6, for the others). In second year courses (both colleges): a total of 57.9% of the students that attended the final also took the midterm, i.e. 42.1% did not. They scored an average of 76.7 and 60.3 in the finals, respectively. In third year course: 64.6% of the students that attended the final also took the midterm, i.e. 35.4% did not. They scored an average of 74.7 and 49.1 in the finals, respectively.

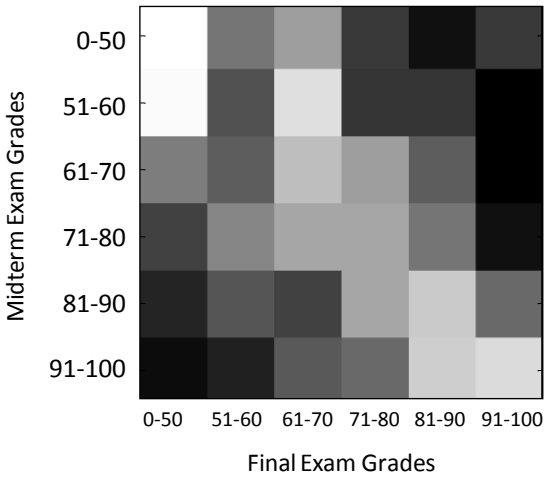


Fig. 5. Histogram of final grades versus midterm grades after normalizing the number of students in each group, taking into account all students that took the midterm exam. Bright areas indicate a large percentage of students while dark areas indicate a small percentage of students.

The results indicate that during the first year the students are still motivated to attend the midterm exams. However, the grades in the first year course (that serves as a filter course to filter-out the less competent students) are extremely low and students might feel that taking the midterm did not assist that much. In the 2nd and 3rd years the number of students that took the midterm exam decreased, while the differences in the final grades between students who took the midterm exam and those who did not - increased. In the 2nd year course the average grade of students who took the midterm exam was 16.4 points higher than that of students who did not, while in the 2nd year course the average grade of students who took the midterm exam was 25.6 points higher than that of students who did not. This means that the students were not aware that attending the midterm exam might help them even after the 2nd year and thus when they attended a more difficult course, being a specialization course, the number of students that attended the midterm exam barely increased, while the grades of those who chose not to attend the midterm exam suffered a severe blow.

The author also addressed gender differentiation. In the first year female students who took the midterm exam scored in the final exam 24.7 points more on an average than male students. On the second year the difference drops to 15.1 points and on the third year female students scored 4.4 points less than male students. Female students are a minority among electrical engineering students: an average of 9.3% of the students in the first year, 8.7% in the second year and only 5.3% in the third year. This makes the total numbers too small to make any feasible assumptions on the reasons for this gender differentiation.

5 SUMMARY AND CONCLUSIONS

In this paper the author viewed several electrical engineering and software engineering courses over a period of 10 years to determine the correlation between attending midterm exams and succeeding in the final exams. The results show that the correlation is high. The results do not show correlation between higher grades in the midterm exam and higher grades in the final exam. The conclusion of this work is that midterm exams are important both to the students and to the lecturer and

conducting them usually assists students in obtaining better grades. It is also suggested that such exams should become compulsory to motivate students to study during the semester and potentially improve their chances of excelling in the courses.

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