

Effects of small-group teaching in an electrical engineering course

Sanna Heikkinen

Aalto University
Espoo, Finland

ABSTRACT: This article compares study results in smaller and larger groups and with an emphasis on how to decrease stress and increase motivation. The study was done in the School of Electrical Engineering at Aalto University, Espoo, Finland. Two teaching and studying styles were compared and students from both groups were interviewed. The students in small-group teaching gained better grades and were motivated most of the time. The students in the traditional lecture-based course were mostly not motivated but most of them passed the course nonetheless.

Keywords: Small-group teaching, motivation, electrical engineering

INTRODUCTION

The motivation to do something new comes from inside us. Creating something new and seeing it working well gives us pleasure. There are many mass lectures and practical classes (exercise sessions) in the School of Electrical Engineering (ELEC) at Aalto University at the Bachelor level. Almost every course has to use mass lectures because the number of students is high. Student feedback suggests that there is always the possibility of doing lectures better and helping students to be more motivated.

There is a significant modernisation process going on at Aalto University, Espoo, Finland, and it has provided remarkable opportunities to test and design new kinds of teaching methods. Before implementing something new on a large scale, for example, to an entire degree programme, it is better to test it first on a smaller scale in one or two courses. Also, when trying something new, why not try something totally new or combine several older experiences?

This article presents the theories, facts and background information that relate to this project. The author outlines the structure and teaching methods of the traditional course, i.e. the control group, and also the new course is presented. The feedback from both courses is discussed in this article.

BACKGROUND AND STATISTICS

The aim of this study was to show that students participate more actively, are more motivated, are willing to use more time and can pass courses easier with better grades, if they have a bit more support and are encouraged to ask for help. They were not allowed to wait until a semester was over and an examination period commenced before they started to study, as is normal for the students in ELEC. A normal way to teach in Bachelor level courses in ELEC is to have mass lectures.

There are usually some exercise classes after lectures because of the large number of students. Teaching assistants provide guidance in exercises in smaller groups when compared to the mass lectures. However, if all students in a course took part in exercises, the groups would grow too large to be considered as small groups. The exercises are usually voluntary; thus, it has been a problem to get the students to join. If students are not studying actively during the semester, they may have problems in successfully passing the examination after the semester.

To be able to compare the results, a normal mass lecture and exercise based version of the course was also taught at the same time as a control group. Teaching resources are quite limited in ELEC as few teachers are available per course. Usually, students dislike obligatory attendance at lectures so it has been common to keep lecture attendance voluntary.

Because this was a unique opportunity, the author wanted to obtain as many results as possible. All 20 students taking part in the new course were interviewed before and after the course. Before the course, it was made clear that this new style for taking this course would not be easier than the traditional style. After the course, all students were interviewed again to obtain more feedback and their perceptions of how they felt after the course. Teachers also explained the grading during the interviews.

Table 1: The mean values of prior studies.

Course	New course	Control course
Total mean grade value of prior studies	3.23	3.21
Mean grade value of the pre-knowledge course	3.00	2.59

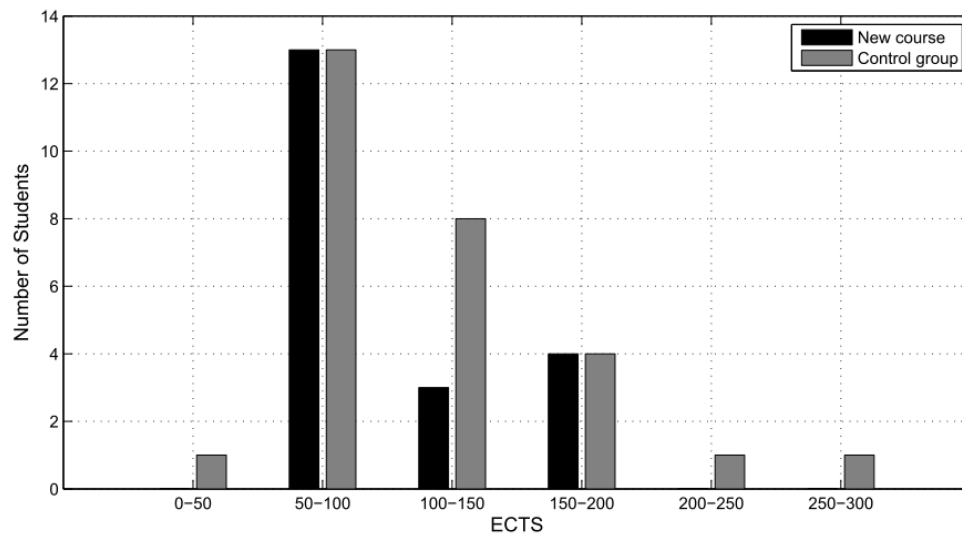


Figure 1: Number of ECTS before starting the courses.

The students in the control group had a chance to come to an interview and they received one extra examination point if they did so. Twenty-eight out of 68 students decided to join. All students in the new course and 41.2% of students in the control group were interviewed. The students in the control group had on average 116.0 ECTS (credits) before starting this course. In the new course they had on average 107.9 ECTS. The distribution of ECTS before starting the courses is shown in Figure 1.

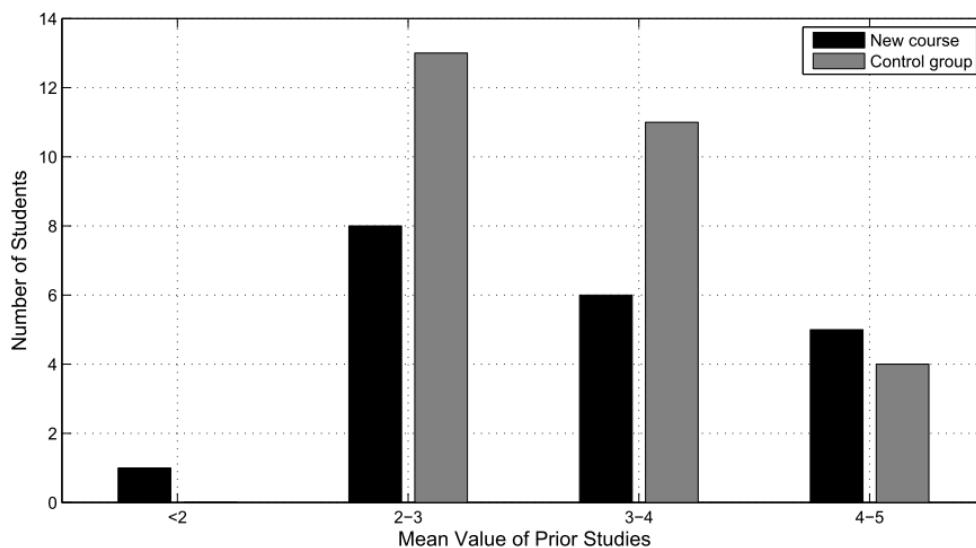


Figure 2: Distribution of mean values before starting the courses.

The students joining the control group were on average about one year older than the students in the new course. There were some older students (33 and 35 years old) in the control group which increased the mean value. The students in the control group had also studied for approximately one year longer. The students taking the new course had a total mean grade value of 3.23 and 3.00 from the pre-knowledge course. The same values in the traditional version of the course were 3.21 and 2.59. The numbers are shown in Table 1 and the detailed statistics are shown in Figure 2 and Figure 3. As can be seen from the figures, there is not much variation between the backgrounds of the students in the two courses.

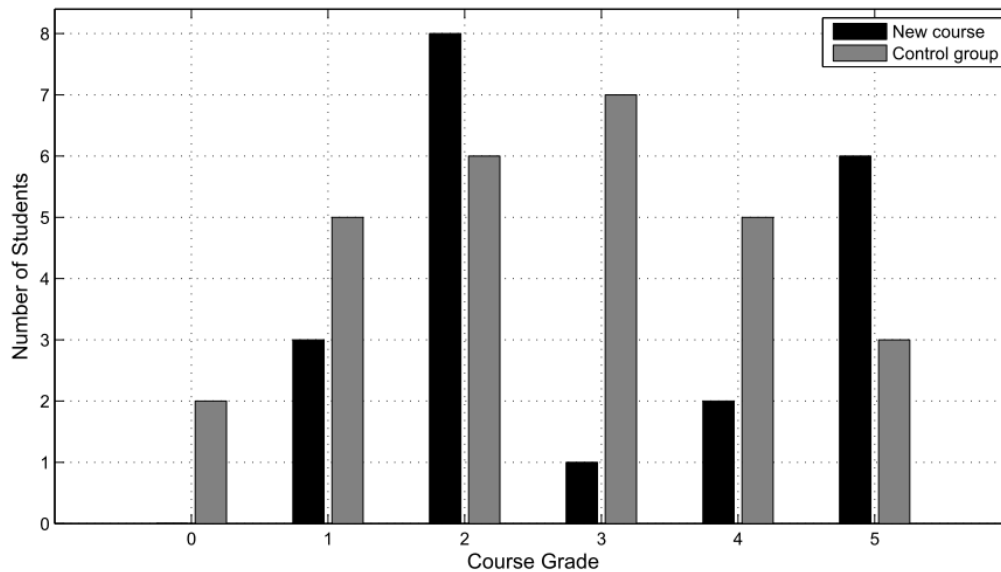


Figure 3: The grade of the pre-knowledge course.

A TRADITIONAL COURSE AND A CONTROL GROUP

In ELEC, a common problem is that although it can be statistically shown that students who take part in lectures and exercise sessions are likely to pass the course, not all students attend. About 71 registered students were in the course during 2011 and 51 students in 2010. In 2012, there were 88 registered students, including the students who took the new course. However, staff did not meet all of the students, not even at the examination.

Usually, about 15% of students take part in the exercise sessions in the traditional course. Even in the best case, only 35% of the students attend the exercises. This number is almost constant every week but the students are not always the same ones. Some students take part in the exercises every week but others join in every second week or even less often. Luckily, the lectures have a better participation percentage. Normally, about 40 to 50 students have been attending the lectures. This number has been about the same in each of the three years that were taken into account in this study.

Since 2011, there have been small examinations after every second lecture. This has increased the number of students attending the lectures every week and not just during the examination weeks. Before 2011, the number of students attending the lectures at the beginning of the course was around 50. However, this number steadily declined during the course. The same phenomenon can be observed in the other courses too.

In 2012, there were 68 students taking the traditional form of the course and 77.9% of them passed it with a grade from 1 to 5. In 2011, there were 71 students and 71.8% of them obtained a passing grade. In 2010, there were only 51 students taking the examination and 72.6% of them passed it. As can be seen, the percentage of passing grades has been about the same during the three years despite the number of students joining the course.

In the interviews, some students said that they did not feel like they had enough prior knowledge when starting the traditional version of the course. During the course, they felt that they had enough information to take the course. Insecurity at the beginning of the course made them feel uncomfortable and they were not very motivated. They were expecting to fail the course rather than to pass it with a good grade. Most of the students thought that this course had a large number of *smaller* concepts to understand and that there was too much information in total. About half of the students did not feel motivated, because they felt there was too much to study during the last week of the course. They were examination oriented and mostly started to study during the last two weeks before the examination. Many students thought that deadlines to be motivating and, thus, studied only before deadlines. If the examination is the only deadline during a course, students' motivation does not appear until just before it.

Some students reported that at the beginning of their studies, they had problems seeing how small pieces of information were connected to a larger concept. These students thought that smaller teaching groups could motivate them, because it would allow them to see that most of the other students have similar difficulties.

According to a published study, adding more project work, small-group exercises and other interactive teaching methods to courses helps students to understand concepts and build information. This study in the field of mathematics shows that students had a low pass rate in some courses. The number of passed grades increased from 55% to approximately 90% in seven years. [1] Moreover, it has been shown that small-group learning has more positive effects than individual working [2].

According to the interviews, the students in the control group would have liked to have had smaller exercise groups and more guidance when solving problems. The students would have liked to have had the same group for a longer time to retain their roles and let others have their own [3]. They said that this would make it easier to start working because they would have been aware of how the others were performing. Most of the students did not prefer lectures but wanted to have more support from the teaching staff. They also mentioned different kinds of pressure when working in a group. The pressure from the other students in a small group motivated them to work and study much harder. Other students give support but also require it.

After the course, the students in the control group did not do as well as the students in the new course, but most of them passed. The average grade among the interviewed students in the control group was 2.82 while among the whole control group, including the students who did not take part in the interview, it was 2.78. It could be seen, therefore, that the interviewed group provided a good sample of the whole course.

A NEW COURSE

There are several positive effects when using small groups in the courses. It is well known that one student in a group might know more about a specific subject than the others and be willing to share that information and teach. This situation allows students to ask for help within the group. Usually, students do not want to be the weakest part of their group and this makes them work harder. This gives the group more potential than one individual could have. [4] The theory of motivation says that a student wants or does not want to learn depending on whether a student has engagement in an activity or not, sees the value of the outcome and expects to achieve it [5].

There are two points on how to choose the size of the group. Fewer members means more common targets, but on the other hand, more members means more variety in prior skills [6]. The size of the group is an important factor when evaluating how a project should be planned. The size should be taken into account as a part of how the group can work [7]. Doing projects in groups instead of individual studying helps students make fewer mistakes. The group also works more efficiently and consumes less time while solving problems. [8]

Small groups also allow learners to discuss and share ideas and concepts with other students and teachers. An environment, a class room and a group, where ideas are actively discussed more easily results in deeper learning [9]. When starting small-group teaching, it is important to create enough interactive sessions and opportunities for the students to ask questions. Also, groups need clear material and opportunities to get immediate oral feedback. Weekly contact sessions are needed to help the students. [10]

The target in the new course was to be in one place several hours per week and to ensure that the students were doing their work, simulating or studying the given material. The role of a teacher was not to teach as much as normally, but to be present in the classroom and to help students if they had questions. This work-based teaching and studying style is based on ideas from the Conceive-Design-Implement-Operate (CDIO) strategy [11]. Also, the teachers wanted to motivate students to do the work: study and learn and not just to follow lectures passively. One of the goals was to test how students would operate if they did not have an examination and they would have to prove their knowledge through other methods.

The new course had 20 volunteer students who were selected randomly from the students who applied for the new course. Only short introductory presentations were given by teachers at the beginning of each session and the rest of the time the students worked in small groups with one or two teachers helping students during the exercise sessions. The students had calculating and simulating exercises for every class and they were asked to do their best, but not to return any solutions after the contact sessions. They had separate homework and they returned it weekly. There was no examination after the course and grades given were based on group homework, a project work and activity during the classes. Because the activity affected the grade and there was no examination, the students were allowed to miss only four out of 22 classes.

Positive feedback was widely given when students from small group courses had been interviewed. In one study, students described peer mentors as being helpful for clarifying course material and homework assignments. In contact sessions, shy students were able to ask questions and it was interesting to know how others had seen the same problem [10].

In the interviews, the students mostly gave positive feedback. None of the students regretted taking the new format course. On the other hand, most of the students thought that it would be too hard to have all courses in this format, because it requires too many contact hours and time scheduling in small groups. But they also thought that it would be

helpful to have at least one course per semester in this way. Students thought that no examinations but a lot of work was better than no work and an examinations. Most of the students also mentioned that this was a less stressful way to study in this course.

A study process has several variables, such as the number of things learned and the quality of learning [12]. It has also been shown in previous research that the motivation to learn can be predicted in course outcomes [13-16]. One attempt at motivating students was to make the teachers provide a lot of feedback to the students from their exercises and assignments. There were also two obligatory feedback forms that the students had to fill in and give to their small groups and one feedback form to give to their larger project group.

The project groups obtained also feedback from the whole class after their presentation. Most of the students said that it was a brilliant idea to give a lot of feedback: it was both good to know how the exercises affected learning and the grade but also to learn how to give constructive feedback. Feedback itself was not a part of the evaluation process, but there was the option to increase or decrease a student's grade by one if needed. The point was to motivate the students to give realistic feedback and also to work hard enough to earn positive feedback from their groups.

After the courses, all students taking the new course passed it with good grades. The members of small groups were under pressure to be at least as good as the other members, and the students seemed to be more competitive during the last weeks of the course. They studied hard and all of them obtained a grade of 4 or 5 out of 5. The average grade was 4.3. As shown in Figure 4, the students in the control group obtained grades from 0 to 5.

The average grade among the interviewed students in the control group was 2.82 and 2.78 among the whole control group, including the students who did not take part in the interview. It can be seen that the test group is a good sample of the whole course. The difference between the grades in two different teaching and studying styles is a good example of how the students can be motivated and taught in other ways and the results can be much better.

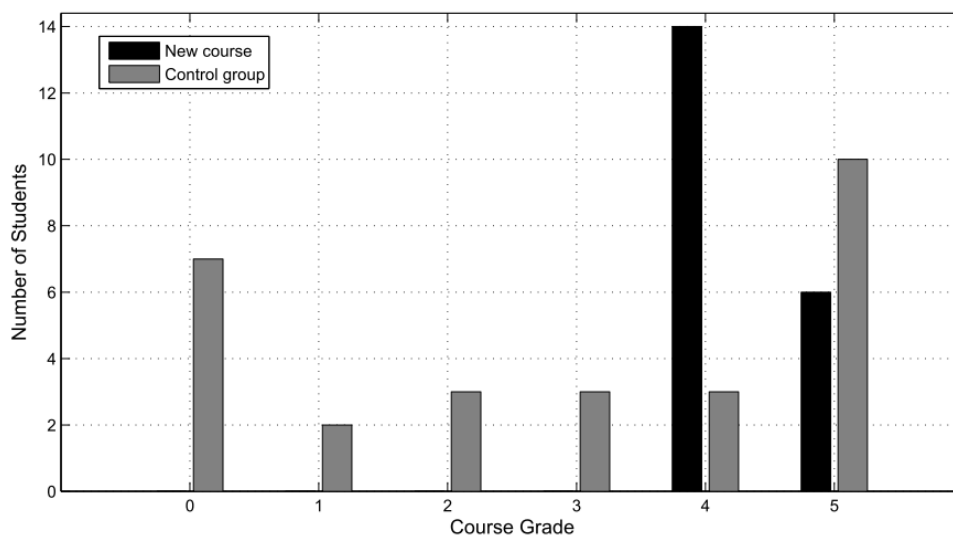


Figure 4: The grade of the course.

CONCLUSIONS

This article discussed a new course method where motivation and a less stressful way to study were the foci. The students in the new course produced better learning results and were more motivated than students in the control group. They felt that they did not have as much stress when taking the course.

The author would like to thank Professor Jussi Ryyänen for giving this opportunity to test something new in his course. She also would like to thank researcher Kim Östman and teaching assistant Heli Virtanen for their comments during the writing of this article.

REFERENCES

1. Robinson, C. and Jaworski B., Introducing group projects in the teaching of engineering mathematics. *MSOR Connections*, 10, 3, 7-10 (2010).
2. Lou, Y., Abrami, P.C. and d'Apollonia, S., Small group and individual learning with technology: a meta-analysis. *Review of Educational Research*, 71, 3, 449-521 (2001).
3. Webb, N.M., Student interaction and learning in small groups. *Review of Educational Research*, 52, 3, 421-445 (1982).

4. Turner, M.E., *Groups at Work: Theory and Research*. USA: Lawrence Erlbaum Associates, 134 (1999).
5. Biggs, J. and Tang, K., *Teaching for Quality Learning at University*. USA: McGraw-Hill International, 35-36 (2011).
6. Jaques, D., *Learning in Groups*, London, UK: Kogan Page, xi (1995).
7. Thomas, E.J. and Fink, C.F., Effects of group size. *Psychological Bulletin*, 60, 371-384 (1963).
8. Taylor, D.W. and Faust, W.L., Twenty questions: efficiency in problem solving as a function of size of group. *J. of Experimental Psychology*, 44, 360-368 (1952).
9. Dennick, R.G. and Exley, K., Teaching and learning in groups and teams. *Biochemical Educ.*, 26, 111-115 (1998).
10. Harlow, L.L., Burkholder, G.J. and Morrow, J.A., Engaging students in learning: an application with quantitative psychology. *Teaching of Psychology*, 33, 4, 231-235 (2008).
11. Crawley, E., Malmqvist, J., Östlund, S. and Brodeur, D., *Rethinking Engineering Education: The CDIO Approach*. NY, USA: Springer (2007).
12. Biggs, J., Individual differences in study process and the quality of learning outcomes. *Higher Educ.*, 8 (1979).
13. Klein, H.J., Noe, R.A. and Wang, C., Motivation to learn and course outcomes: the impact of delivery mode, learning goal orientation, and perceived barriers and enablers. *Personnel Psychology*, 59, 3, 665-702 (2006).
14. Colquitt, J.A., LePine, J.A. and Noe, R.A., Toward an integrative theory of training motivation: a meta-analytic path analysis of 20 years of research. *J. of Applied Psychology*, 85, 678-707 (2000).
15. Noe, R.A. and Schmitt, N., The influence of trainee attitudes on training effectiveness: test of a model. *Personnel Psychology*, 39, 497-523 (1986).
16. Tannenbaum, S.I. and Yukl, G., Training and development in work organizations. *Annual Review of Psychology*, 43, 399-441 (1992).

BIOGRAPHY



Sanna Heikkinen graduated with a Master of Electrical Engineering from Helsinki University of Technology (Espoo, Finland) in 2007. Ms Heikkinen has been teaching and developing courses in the School of Electrical Engineering at Aalto University, and recently commenced her PhD. Her research focuses on motivation and learning process in technical fields in higher engineering education.