PEER LEARNING WITH SMALL MEANS: A CASE STUDY OF IMPLEMENTING PEER LEARNING IN A LABORATORY EXERCISE

Jonas Hansson

KTH Royal Institute of Technology, 100 44 Stockholm, Sweden

Peter Kolmskog

KTH Royal Institute of Technology, 100 44 Stockholm, Sweden

Ylva Odemark

KTH Royal Institute of Technology, 100 44 Stockholm, Sweden

Anna-Karin Högfeldt

KTH Royal Institute of Technology, 100 44 Stockholm, Sweden

ABSTRACT

Peer learning in teaching is a common method which makes students share their problems and learn from each other. It is often used to increase students´ understanding and level of deep learning. In this study, the peer learning concept has been applied to a laboratory exercise and a comparative study has been performed. The study consists of two cases, a reference group, which performed the exercise in a traditional way, and a peer learning group, which performed the exercise in a modified way. In the peer learning group, the students were encouraged to ask each other for help and an additional presentation was added in order to further increase the interaction between students. The outcome was evaluated through classroom observations, a questionnaire, and a short knowledge test. The results show that the peer learning approach had different positive effects. When the students were instructed to ask each other for help, there was an apparent change in the students´ behaviour. The students in the peer learning group were more active and more creative compared to the reference group. They also had better results on the knowledge test and were more satisfied with the exercise. This demonstrates that small changes to an existing laboratory exercise can increase the understanding, involvement and creativity of the students. In this case, this was also achieved without an extended workload on the teacher.

KEYWORDS

Peer learning, laboratory exercise, case study, increased learning, cooperation

INTRODUCTION

During the last decade, requirements have been emphasized on development of generic skills for students of all levels. The three main categories of generic skills are basic skills, interpersonal skills and peer-related skills. Their importance is clearly stated in the eight key competences for lifelong learning provided in the European Union legislation [1] from 2006 and the new Swedish degree of ordinance from 2007. Generic skills are especially emphasized in engineering education, with the CDIO initiative as a good example in this development. In engineering educations laboratory exercises are widely utilized as a way to develop these skills as they are much more practical and professionally related than many other learning environments that the student might work in during his or her study time. Still, there is a notion that students still find and see themselves as receivers of information, rather than active learners or problem solvers.

A method that has gained a lot of interest lately inter alia regarding the benefits of generic skills development is peer learning [2], [3]. Peer learning is something that has always occurred as humans interact and can be defined as "the acquisition of knowledge and skill through active helping and supporting among status equals or matched companions" [3]. In Vygotsky's theories about the zone of proximal development (ZPD) a person's competence is not of interest. Instead, the focus is on her potential understanding and action [4]. Being outside the ZPD really means confining oneself to activities that involve doing what is already known. However, as pointed out by Säljö [5], there is always unspoken knowledge that can be understood and used via interaction in the ZPD. In Vygotsky's terms, this zone is the gap between what students already know and what they achieve with the guidance from a teacher or a more capable peer. Consequently, it is important to assist the student who wants to learn by providing communicative support or scaffolding [6]. The metaphor of scaffolding is often defined as the provision of structures within the ZPD to bridge the previously mentioned gap. Topping reports that the effects of peer learning have been positive when well structured and well implemented [3]. In this study we were arranging the structure of a laboratory exercise to increase each student's interaction with a status equal, but more capable peer. This was an effort to bring the students in the ZPD through scaffolding from their peers.

The aim was to investigate if minor changes to a laboratory exercise could improve the learning outcomes with respect to knowledge, skills and attitudes. The minor changes needed to be feasible to perform for the instructor, without an extended workload.

METHOD

The present study is a comparison of a group of students performing an ordinary laboratory exercise (the reference group) and a group of students performing the same laboratory exercise in a peer learning situation. The groups were evaluated by the use of a questionnaire, a knowledge test and classroom observations.

The study was performed in the laboratory exercise *"Optical grating and mass spectrometry"*, which is part of the course *"Electromagnetism and wave motion*". The students attending the course, which was given in Swedish, were second-year students in chemical engineering at KTH Royal Institute of Technology. A total of 20 students of mixed genders took part in the study, ten in each laboratory exercise group.

The structure of the laboratory exercise

The reference group performed the laboratory exercise in the standard manner:

1. In advance the students got a laboratory instruction manual, including theory, practical guides and the main tasks. They were told to read it before the laboratory exercise.

2. When the class started and the students entered the laboratory exercise classroom, they seated themselves at one of five benches with laboratory equipment, two students at each bench.
3. The instructor announced that the exercise was a part of a study for evaluating laboratory exercises and informed the students that they should fill in a questionnaire and perform a short knowledge test at the end of the exercise. One more person was present in the classroom and presented as an observer for the study. (Step 3 was part of the study and is not normally performed.)
4. The exercise started with the instructor giving a short introduction of the most important theory, functionality of the equipment, and practical issues for the exercise.
5. The students performed the tasks described in the instructions. The first task was to calibrate the instrument followed by three problems: Problem A, B, and C. During this time the instructor was available for questions.
6. As each pair finished the exercise they were asked by the observer to fill out the questionnaire and perform the knowledge test for which they were allowed to use 10 minutes.

Two changes were introduced to the peer learning group compared to the reference group and an overview of the structure can be found in Figure 1. Both of the changes aimed to increase student-to-student interactions. First, the students were instructed to help each other between the pairs. Secondly, the structure of the exercise was changed in order to introduce cooperation between pairs. The changes were introduced at step 4 and 5, as described below.

The peer learning group performed the laboratory exercise in the following manner:

1-3. Same as for the reference group.

4. The exercise started with the instructor giving a short introduction of the most important theory, functionality of the equipment and practical issues for the exercise. The instructor ended by saying: “If you have any questions during the lab, before turning to me with your issue, please ask another student pair to see if they might have encountered a similar problem. As you know, explaining is a good way to learn. If many share the same problem, we can discuss it together.”
5. The students were told by the instructor to start by calibrating the equipment, and when finished they would get a new task. The pairs were not expected to finish the calibration at exactly the same time, so of all five pairs in the room, the two pairs finishing first were assigned problem A and the three other pairs were assigned problem B (slightly less difficult than problem A). When all groups had solved their first task (A or B) they were instructed to explain their task, method and solution to another pair. They were also told that they would need the calculated values from each pair in order to calculate a mean value for the whole group, meaning that all groups would have to solve both problems. Two tables with papers and colored pens were set up beforehand for the purpose of these discussions, one table for two pairs and the other one for three pairs. After finishing the discussion the students went back to their benches and performed the task just described to them (Problem A or B). After solving this problem all pairs simultaneously performed problem C. After all problems were solved and mean values were calculated the instructor led a short group discussion about the results.
6. Same as for the reference group.

Borglund has reported that when several pairs of students work on the same problem, it is common that they struggle with the same issues without discussing it with other pairs [7]. By explicitly instructing the students to cooperate we intentionally tried to avoid that type of situation. Also, a commonly emphasized problem associated with peer learning is that group dynamics can become destructive due to competence threats between peers [3]. Buchs et al.

report that providing students with complementary information instead of identical information reduces confrontations and competence threat [8]. This is what we aimed to accomplish in the peer learning group by the discussion of problems A and B. Providing the students with the common task of calculating a mean value for the problems is another incitement for making an effort to help each other.

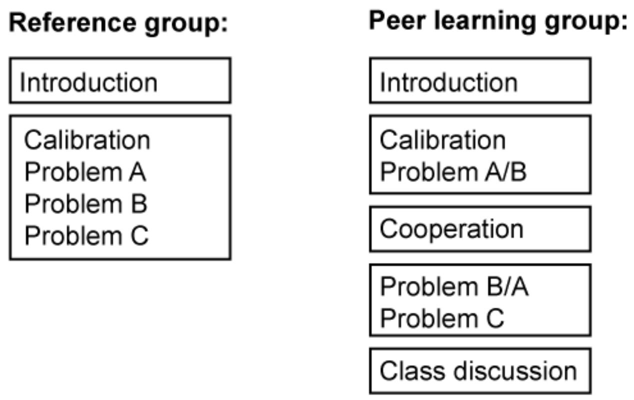

Figure 1. Comparison of the structure of the exercise for the reference group and the peer learning group. Borders are used here to separate the parts, and indicate an intervention by the instructor.

Data collection

To be able to assess the difference between the two groups three methods of data collection were used: observations, a questionnaire, and a knowledge test. The students were informed about the questionnaire and the test at the beginning of the session, as previously described. They were however not aware of the existence of a reference group and a peer learning group.

To collect observations, one extra person, the observer, was present in the classroom during the exercise. The task of the observer was to observe and make notes of the students´ behaviour during the exercise. In addition to making qualitative observations, the observer also counted the number of questions being raised to the instructor. The use of an observer sitting in on laboratory sessions has previously been used by for example Magin and co-workers [9].

The questionnaire, which was anonymous, was filled out by the students at the end of the exercise. It consisted of 12 questions, of which 1-3 were introductory questions, 4-8 treated student satisfaction and involvement, 9-10 were about received assistance, and 11-12 evaluated the reporting and presentation of the results of the exercise.

In order to estimate the level of deep learning obtained by the students, the exercise finished with a short knowledge test, for which the students were allowed 10 minutes to finish. The students were asked to fill in their name on the test, in order to increase their motivation even though it was pointed out that the test did not affect their grades. The knowledge test consisted of five questions in total, and was designed to cover the most important concepts of the exercise. The correction of the test was blind, i.e. the person who corrected the test could not trace if a student belonged to the reference group or the peer learning group. Each answer was awarded zero, one or two points depending on the quality of the answer and the sum was calculated for each individual. Mean values and standard deviations were calculated for both groups, and a Wilcoxon’s rank sum test was performed.

RESULTS

The results from the questionnaire, knowledge test and classroom observations are reported below.

Questionnaire
Each student indicated their level of agreement to the 12 statements below:

Introductory questions
1. I read the lab instructions carefully before the lab
2. I consider myself to have knowledge about the subject before the lab
3. I believe that the lab content is relevant to the course

Student satisfaction and involvement
4. I am more curious about the topic now than before the lab
5. I am satisfied with the structure of the lab
6. I felt involved in the lab
7. I felt that I could absorb the contents of the lab
8. I was given enough time for conducting the lab

Assistance
9. I was given enough help from the instructor
10. I was given enough help from my fellow students to handle the tasks in the lab

Presentation of results
11. The fact that tasks would be presented to the instructor motivated me to understand the content while experimenting
(Note: In the questionnaire given to the peer learning group the word instructor was changed to fellow students.)
12. The presentation process increased my understanding of the lab

Figure 2 shows the mean level of agreement to the statements in the questionnaire, where 1 represents the lowest level of agreement and 6 the highest. The mean level of agreement ranges from equal to 0.7 higher in the peer learning group for all the 12 statements except statements 3 and 9.

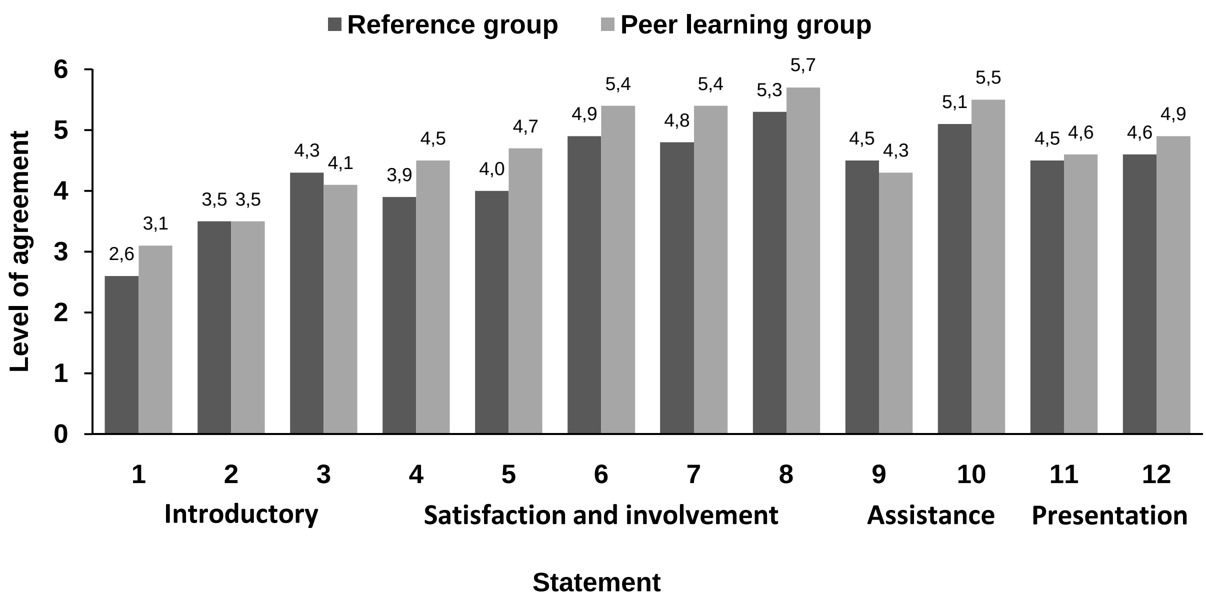

Figure 2. The results from the questionnaire.

In general the differences in each question between the two groups are minor. We can however distinguish some trends suggesting generally higher levels of agreement to most statements for the peer learning group. The major differences are found in the statements 4-6 regarding the students' satisfaction and involvement. This indicates that the students in the peer learning group were more curious about the subject, more satisfied and more involved compared to the reference group.

Knowledge test

Figure 3 shows that the average score on the knowledge test was 6.9 in the peer learning group, and 5.2 in the reference group. The test result for the peer learning group was higher on each of the five test questions, with the difference ranging from 0.1 to 0.6 (out of 2). Assuming no group difference, a two-sided Wilcoxon rank-sum test yields a p-value of roughly 0.06, indicating significance on the 10-percent level.

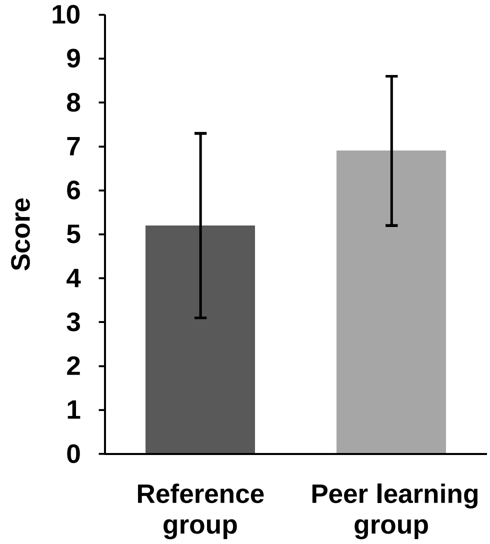

Figure 3. Diagram illustrating the results from the knowledge test. The mean value and the standard deviation was 5.2 and 2.1 for the reference group, and 6.9 and 1.7 for the peer learning group.

Observations

Some examples of observed events in the two groups are listed in Table 2 below.

Table 2. Observed events.

Reference group	Peer learning group
Initially a large confusion about what to do.	Initially a large confusion about what to do.
Most students asked the instructor for help when a problem occurred without trying to solve it themselves first. One group even tried to ask the observer for help.	Most questions were asked in the beginning, some of those were redirected to another student pair and some were answered by the instructor and discussed in front of 2 or more pairs.
Students spent a lot of time just waiting for the instructor to answer their question without doing anything themselves.	The students were engaged in their tasks.
Students generally sat down on their chairs. There was little movement in the classroom.	A lot of movement in the classroom, with students asking other groups for assistance. At one instance a pair sitting in one corner of the room walked to the other side of the classroom knowing the group sitting there had encounter their problem previously.
Only discussion within the pairs. Very few interactions between pairs, although in a few cases students asked the pair being closest to them a question.	The students showed no signs of dislike when being asked a question by another pair.
Some questions assigned to the instructor were aimed at finding out the “correct answer” to the problem/question.	The students showed more signs of creativity, e.g. one pair attached the cord of the mouse to the monitor in order to improve a visually estimated curve fitting.
One group which was falling behind needed a lot of assistance towards the end.	No group was falling behind.
It took between 2 hours and 45 minutes to 3 hours and 15 minutes for everyone to finish the exercise.	All pairs finished the lab after 2 hours and 40 minutes.
A total of 50 questions were raised to the instructor during the laboratory exercise.	A total of 7 questions were raised to the instructor during the laboratory exercise.
The constant asking of questions resulted in a very stressful situation for the instructor.	The instructor was able to step back and monitor the progress of the group.

During the laboratory exercise the students seemed to have the intention to work together and solve problems in the group. In the reference group the students hesitated to ask their peers, perhaps having the notion that it was not allowed. In the peer learning group on the other hand, once the students were told that they were allowed to ask their peers questions they acted as they usually do outside the classroom when solving problems together, for example when forming informal study groups.

DISCUSSION AND CONCLUSIONS

Our study aimed at investigating if minor changes to a laboratory exercise could improve the learning outcomes with respect to knowledge, skills and attitudes. The structure of the exercise was changed and the students were encouraged to assist each other in their work.

The knowledge test indicated increased learning, and the questionnaire revealed positive attitudes in the peer leaning group. The observer reported classroom activities in the peer learning group that are essential for developing generic skills.

The restricted number of subjects could be seen as a limitation of our study. On the other hand the two groups were composed randomly. We regard the utilization of several evaluation methods as strength, as well as that the results from all of them support the general notion of an improved laboratory exercise.

The peer learning group performed better on the knowledge test. The increased level of understanding indicates that a more participative approach stimulates deep learning, which is in accordance with the work done by Biggs and Tang [10] and Bain [11].

The questionnaire indicated that the students in the peer learning group felt more curious about the subject, more satisfied and more involved compared to the reference group. It is also worth noting that the peer learning group felt that they could absorb the content of the exercise (statement 7) at the same time claiming that they received less help from the instructor compared to the reference group. Even if the students perceived that they had not received sufficient help from the instructor, they thought that they had assimilated the content of the exercise. This suggests that knowledge had been achieved working with peers, through cooperation and peer teaching – a situation to be compared to learning within the ZPD [4].

From the observations we conclude that the students in the peer learning group acted in a way they were familiar and comfortable with. When being more passive learners, as in the reference group, the standard classroom environment prevents the students from using their natural and self-obtained learning skills. One should therefore strive towards creating laboratory exercises where the classroom is an environment for natural and efficient learning activities. Crouch and Mazur [12] also state that students develop complex reasoning skills most effectively when actively engaged with the material, and that cooperative activity engages students effectively.

There was a major difference in the amount of questions raised to the instructor by the two groups. In the peer learning group the students asked their peers for help, which made them move forward solving the problem without spending time waiting for the instructor. This made it possible for the instructor to get a better overview of the progress of the group and to minimize the stress combined with repeatedly answering questions.

Changing the structure of the exercise and creating natural tollgates decreased the risk of students getting behind and losing interest. By making everybody end at the same time it was possible to gather all the students to discuss the results. This short discussion might also have contributed to the better performance of the peer learning group, since the students had a chance to structure their thoughts and discuss difficult parts to gain higher levels of deep learning.

We would also like to convey that this study resulted in a continuation of the peer learning concept in this laboratory exercise. Although not part of this study, similar effects as those reported by the observer in this study have been observed by the instructor for the subsequent groups.

In conclusion, with a small change of structure, and by encouraging students to ask each other for help, improvements to a laboratory exercise could be made. The results demonstrate that a peer learning approach is an effective way of improving students´ knowledge and skills. The cooperation allows students to develop their own personal and professional skills and attitudes, which is an integral part of the CDIO initiative.

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Biographical Information

Anna-Karin Högfeldt is a lecturer in Higher Education Development at KTH Engineering Education Research & Development. She teaches in courses in the field of Teaching and Learning in Higher Education, and works with quality assurance and development projects at KTH and internationally.

Jonas Hansson is a PhD student in Cell Physics at the Department of Applied Physics at KTH Royal Institute of Technology in Stockholm, Sweden. His research is within the field of microfluidics for medical diagnostic applications. He teaches laboratory exercises in physics and biophysics.

Ylva Odemark is a PhD student at the Mechanics Department at KTH Royal Institute of Technology in Stockholm, Sweden. Her research is within fluid mechanics, and she has taught laboratory exercises at the Fluid Physics Laboratory at KTH as well as seminars and tutorials in mechanics and fluid mechanics courses for engineering students at different levels.

Peter Kolmskog is a PhD student at the Department of Materials Science and Engineering at KTH Royal Institute of Technology in Stockholm, Sweden. His research is within developing

high-strength steels and he is mainly involved in instructing laboratory exercises for students in the third year of their studies.

Corresponding author
Jonas Hansson
KTH Royal Institute of Technology
AlbaNova University centre
SE-106 91 Stockholm, Sweden
+46730560805
jonhans@kth.se