Peer learning as a tool in the development of engineering education

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Abstract

Some beneficial aspects of using peer learning concepts in engineering education is discussed. Focus is put on the impact on student learning, including generic competencies such as communication skills and self-oriented learning, as well as the teacher's effort in developing and maintaining a high-quality teaching and learning environment. It is argued that peer learning concepts can facilitate a more genuine learning environment that better harmonizes with current workplace demands and the life-long learning perspective of higher education.

Introduction

Personal and interpersonal skills are fundamental to learning. For example the abilities to pose a problem, to critically review the quality and relevance of information, to communicate effectively, and to collaborate with others. It is not difficult to judge the importance of such skills when it comes to research, which is undoubtedly a process characterized by genuine learning. Generic competencies like these are also typical objectives of higher education, which in this perspective makes a lot of sense.

Although generic competencies are necessarily emphasized in the objectives of educational programmes, they are typically not as explicit when it comes to the learning objectives of courses (that ultimately build the programme). On the contrary, we sometimes tend to assume that these skills are developed in an implicit fashion, or that they can somehow be treated separately. In practice, personal and disciplinary skills are interdependent and should preferably be learned at the same time. This does not only pose a challenge to higher education, but also raises concerns about the teacher's role, competence and effort.

This paper will briefly illustrate how peer learning concepts [1] can be used to obtain a natural and creative environment where learning of disciplinary and generic skills benefit from each other. Indeed, the teacher's role can change considerably. It is however argued that the new role can be more stimulating and rewarding, and that the workload can be maintained or even reduced to some extent. Peer learning concepts can also be a useful tool in the development of new courses, which is illustrated by an example from the aerospace education at KTH.

Peer learning in the context of ...

... improved student learning

The course SD2810 Aeroelasticity at KTH has benefited from a peer learning approach since 2005. A more detailed description of this development, including student feedback, can be found in Ref. [2]. It is an advanced half-semester course in aeronautics with about 25 students every year. The course is divided into student teams (5-6 students in each) that engage with the course material in successive steps. Every week in the course constitutes a learning cycle as is illustrated in Figure 1a. The first step is an

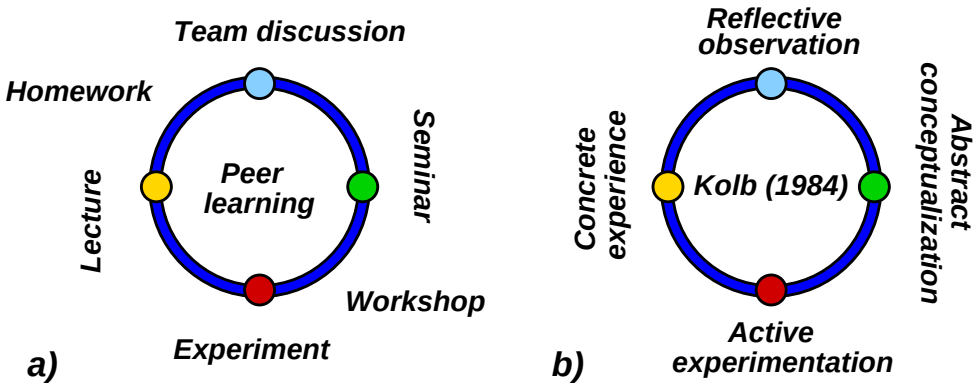

Figure 1: a) Peer learning cycle, b) Kolb's experiential learning cycle.

overview **lecture** by the teacher. In the second step, the students prepare themselves for a team discussion by carrying out some **homework**. In the third step, each team has a **discussion** about the content of the current cycle, and then contributes a few topics that they would like the course to treat in more detail. The fourth step is a full-class **seminar** about the topics that have been raised by the different teams. The final weekly step is a **workshop** where each team collaborates on computer tasks and project work in order to apply the theory in practice. In addition, a wind tunnel **experiment** is performed every third week in order to validate the developed theory and methods.

The basic principle of the described peer learning approach is that the students are encouraged to take active part in experiential learning cycles as described in Figure 1b. The different steps are designed to guide the students through four different phases of an experiential learning cycle [3]: concrete experience, reflective observation, abstract conceptualization and active experimentation, respectively.

The described approach is very appreciated by the students, and has been found to improve their disciplinary learning [2]. The main reason for this is the increased student-student interaction during the team discussions (leading to reflection and insight), as well as the increased student-teacher interaction during the class seminars. The following comment by a student support this hypothesis:

> *-The discussion groups were the best! And also that a whole week was devoted to one subject in the course. Gave me time to think and really understand the different phenomena. The layout of the learning cycle was perfect!* (2006)

... development of generic competencies

In condensed form, the overall objectives of the two-year master programme Aerospace Engineering at KTH are that a graduate should have

- good theoretical skills in aerospace modeling, analysis and design,
- ability to approach and solve complex engineering tasks,
- experience of project work and teamwork,
- experience of working in an international environment, and
- ability to communicate effectively.

Several of these objectives refer to generic competencies rather than disciplinary. As the aerospace industry is characterized by multidisciplinary technology that changes rapidly, the engineers need to be flexible and resourceful. They must be able to communicate effectively with people from different backgrounds, and to transfer their competencies across disciplines and positions in the organization.

Initially, the main objective of the described peer learning approach was to improve the students' learning of aeroelasticity. A secondary objective was to make a contribution to the programme level by introducing a teamwork dimension in the course. However, the integration of disciplinary learning and fruitful teamwork has also opened up possibilities to work more explicitly with other generic competencies. In terms of learning objectives, the most recent version of the course also aims at improving the students' ability to

- communicate effectively with students from various backgrounds,
- learn with and from other students,
- present their results and conclusions effectively, and
- review and give feedback on work performed by other students.

The key to this development is the teamwork structure. By distributing nationalities, gender and skills evenly in the different teams, a good basis for multi-cultural interaction and peer learning is formed. Here, the fact that all team members treat the same material every week has a tendency to relax the group dynamics, because it reduces the risk for major conflicts (the team effort is not too dependent on the contribution from a dysfunctional member). Although experience of handling conflicts could be another fruitful outcome, it is not a focus in the present context.

The teamwork setting will inherently introduce a need for effective communication within each team, and stimulate discussion, reflection and collaborative problem-solving. This feature can be exploited for learning of disciplinary as well as generic competencies. Consider for example the ability to write a scientific paper. A quick 'solution' would be to provide the course with a text about academic writing, like the very good one by Ashby [4], and assume that the students will read it and digest the message. Problem solved. However, some students may not be able to digest the message very well, and some students may not even read the paper due to, for example, bad time management. A more learning-oriented (but still quick) approach would be to

give each team the task to review the text, and then have a team discussion about what makes a good paper and how to actually write one.

Naturally, the next step would be to put theory into practice and write a sample paper in the course (for example, about the results of a suitable project assignment). Instinctively, it is then the teacher's task to review each report and provide a statement on its strengths and weaknesses from an academic writing point of view. Again, a more learning-oriented approach would be to organize a peer review, and first let the students review papers written by other students (using the same criteria as the teacher). To allow for an open-minded and honest review, it is here convenient to let one team review the report(s) of another team. This will not only train the students in the basics of academic writing, but also make them more receptive to a second opinion by the teacher - does he or she agree with their review?

The main purpose of the given example is to illustrate that a peer learning concept can be used as a tool for a more explicit and learning-oriented approach to the development of generic competencies. In the present case, the ability to give constructive feedback could be integrated in the same manner, as well as the ability to critically review scientific and engineering work. Of course, the learning of disciplinary and generic competencies must be in harmony in order to be effective, suggesting that a programme perspective is necessary to frame the development of multiple competencies.

... development of education

During the past three years, I have been deeply involved in the development of the previously mentioned master programme in Aerospace Engineering. In an early phase of this development it was clear that a joint KTH effort would be required to create the space branch of this programme. Having some experience of the fundamentals of orbital mechanics and rocket dynamics, I could not resist the challenge to develop an introductory course on space flight in the basic curriculum of the programme. My ambition has been to offer a course that deserves the name Rocket Science not only because of the curriculum, but also from a teaching and learning point of view. The course was given for the first time in the spring 2008, and about 30 students participated.

The previously described peer learning approach was found to be very instrumental in the course development. Both disciplinary and generic learning objectives were formulated, in a similar manner as for the aeroelasticity course. Then, one or two suitable chapters of the course book [5] were selected as the basis for each learning cycle in the course. A typical course in the programme would be based on two to four lectures every week. However, due to the peer learning concept, I only had to prepare one overview lecture every week. Consequently, my own preparatory work was significantly reduced, although a weekly review of the students' seminar topics should be taken into account here. Further, preparing and giving an overview lecture is (in my opinion) a more creative task. The main purpose of the overview lecture is to highlight basic principles and concepts, in order to help the students focus when they engage with the more detailed level.

The assessment was based on two project assignments, one on rocket dynamics and one on orbital mechanics, respectively, as well as a short oral exam with focus on the learning objectives. During a weekly workshop (after the class seminar, see Figure 1) the

student teams were given opportunity to collaborate on the project tasks. However, each student was required to write an individual report, in the form of a short scientific paper. The first report was then exposed to a peer review, as outlined in the previous section. In this case I decided to review the reports in parallel, in order to compare our opinions. The following trend was observed in this exercise: a very good agreement, including the recommended grade, was found for more ambitious teams, while less ambitious teams (mainly one) provided relevant but more sparse feedback and had a tendency to suggest a too high grade. Thus, a properly designed peer review can both train the students ability to judge the quality of a paper, and contribute relevant and useful feedback. As a result of the peer review, a couple of students showed an impressive improvement until the second project (a rather poor first report, but a surprisingly good second report).

In many aspects (but certainly not all), the course was a success already in the first attempt. Regarding the overall impression of the peer learning approach one student wrote:

> *- It was better indeed. It made for an unprecedented experience where I learned from not just the monotony of one lecturer's perspectives, but also from what my team members had to say about a topic. They had different takes on different topics and what they had to say was, more often than not, incredibly innovative and authentic. This made the course exciting and I looked forward to the home team sessions.*

This student apparently had a good learning experience, and confirms that peer learning can have a strong impact. However, another student wrote:

> *- I think that I actually learned less than usual.*

There is no universal approach to effective learning. As noted by a student in a less motivated team, "students have different levels of enthusiasm and idea of responsibility". After all, peer learning will only be effective as long as the students take responsibility for their own learning. Using a peer learning approach, the teacher will act more as a facilitator and coach than a teacher in the traditional sense. This is not necessarily an easy task, but personally I find the new role to be much more dynamic, challenging and exciting.

The following comments refer to various experiences of the development of generic skills:

> *- The course is interesting and gives the possibility to learn not just equations; its organization is very useful to improve the ability to work with other people helping each other.* (teamwork abilities)

> *- I would recommend to take this course not so much because of all the rocket science, but simply to experience a new approach to learning.* (self-directed learning)

> *- The peer review was a good exercise. It helped me to learn how to improve my writing skills.* (writing skills)

- The peer review was a very useful exercise because we understood that the grading process of a report is something difficult. (ability to review work)

- The most interesting thing was to work with other people from different countries and with different skills. (effective communication)

Regarding the overall quality of the course, two out of three students were very satisfied. One student wrote:

- I don't know if it is because of the really good quality of the course, or because I love rocket science, but I think it is one of the best courses I have taken at KTH.

This is of course very encouraging, in particular since the course was given for the first time, but several complaints regarding the effectiveness of the home team sessions and the seminars were also provided (as well as suggestions for improvement).

Concluding remarks

In this paper, some benefits of using peer learning concepts in engineering education have been highlighted. In particular, it has been illustrated that peer learning can be used for a simultaneous and mutually beneficial development of disciplinary and life-long learning competencies. This is essential if higher engineering education should be able to meet the workplace and societal demands of the future.

References

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