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Peer Assessment in Engineering Group Projects: a Literature Survey

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Abstract. Peer review has proved to be beneficial in project-based environments by involving students in the process and encouraging them to take ownership of their learning. This article reviews how peer assessment has been employed within group work for different engineering programs. Since the administrative burden is one of the common reported challenges of peer assessment, computer assisted peer assessment is also briefly reviewed. Finally, opportunities and challenges in applying peer assessment in a project-based creative engineering program are presented based on the review of the literature.

Keywords: peer assessment; problem-based learning; group work; project-based learning; engineering education; mathematics; literature survey

1 Introduction

Peer assessment has been deployed at various educational levels and curriculum areas. Topping defined peer assessment as "…an arrangement in which individuals consider the amount, level, value, worth, quality, or success of the products or outcomes of learning of peers of similar status" [27]. Various studies have proven peer assessment effective in promoting the development of teamwork and other professional skills in undergraduate students, in fostering the ability to critically evaluate their own learning and in helping students to develop a sense of ownership of their learning [1], [24].

Problem-Based Learning (PBL) is a teaching and learning approach that has been proved to benefit from peer assessment methods. PBL is a student-centered instructional approach, in which learning begins with a problem to be solved. Students need to acquire new knowledge in order to solve the problem and therefore they learn both problem-solving skills and domain knowledge. The goals of PBL are to help the students "…develop flexible knowledge, effective problem solving skills, self-directed learning, effective collaboration skills and intrinsic motivation." [11]. When PBL supports group work is also called project-based learning. While working in groups, students try to resolve the problem by defining what they need to know and how they

adfa, p. 1, 2011.

will acquire this knowledge. This procedure fosters the development of communication, collaboration, and self-directed learning skills.

Our research efforts take place at Aalborg University, Denmark, where all programs are based on PBL that supports group work. Our main interest is to improve the PBL approach in mathematics education for creative engineering (e.g. Media Technology). Such disciplines are more related to arts and humanities, and constructed in specific opposition to the technology and science. Typically, students in such studies lack basic skills in mathematics and do not relate to standard applications of mathematics.

We hypothesize that peer assessment techniques can help such students because they may force them to think on different problem solving techniques and they may increase engagement in mathematics. As an attempt to ground our hypothesis, the present article reviews how peer assessment has been employed within group work for different engineering programs. Since the administrative burden is one of the common reported challenges of peer assessment, computer assisted peer assessment is also briefly reviewed. Finally, opportunities and challenges in applying peer assessment in a project-based creative engineering program are discussed.

2 Peer Assessment in Group Work and Projects

A large number of authors have discussed the benefits and limitations of peer assessment in group work and projects [7], [9], [26]. This chapter starts with a brief review of studies within peer assessment in group work that focused on improving challenges of this learning approach. Then, we present studies that were conducted in project-based engineering education. We describe these studies using Topping's elements of a typology [27] as their descriptors to the extent the information provided by the authors allows us to do so.

2.1 Challenges of Group Work

Although group work is assumed to have positive effects on student learning, experiences from educational practice indicate that it can also introduce problems for both students and teachers, such as students who only maintain an appearance of being actively involved and students who let others do the work, also called free riders [23]. Research attempted to eliminate such problems by introducing peer assessment in group work. Initially, there was much attention on the problem of differentiation of individual contributions in group projects. Earl applied a peer assessment scheme for evaluating students' contribution to group performance based on communication skills in a Mathematics Modeling course [4]. In the same curriculum area, Goldfinch and Raeside [9] introduced an assessment technique, which also focused on easing the administrative burden of peer assessment for the lecturer, and on taking measures against an observed problem whereby over-generous students effectively penalized themselves. Kommula employed both quantitative and qualitative methods to assess the role and contribution of individual team members in a mechanical engineering program [14].

Later on, researchers put much effort on the problem of free riders in group work. Brooks and Ammons [2] introduced a group evaluation instrument for peer assessment in an undergraduate business course in order to mitigate free-rider problems and improve students' perceptions about group work. Elliott reported on an action research approach to the development and evaluation of a self- and peer assessment strategy. This approach was designed to promote student participation in group projects in a post-graduate program in clinical health sciences [5].

2.2 Peer Assessment in Engineering Projects

In the field of engineering, group work has been extensively introduced in the context of problem- or project-based learning [13]. With the aim to evaluate the teaching and learning outcomes in a first-year project-based engineering course, Neal et al. [18] used peer assessment with multiple marking techniques in a first year undergraduate engineering design course. They involved 123 students completing both individual (35% of mark) and team (65%) assessment tasks. The individual marks were awarded using Calibrated Peer Review (CPR) [22]. This method involved students marking three exemplar papers and then an actual paper, in order to calibrate student's marks. Students received marks for both their own work and the review of other's work. The group marks were given anonymously. Neal et al. incorporated this type of assessment in order to eliminate fears among students related to free riders and additional work, which is not recognized. In order to address biases, they applied the normalization factor technique [3]. This technique involves multiplying the mark awarded to a student's team (given by the instructor) by students' mark awarded by peer assessment (a normalization index) in order to get individual marks. Based on this assessment procedure, they were able to draw useful conclusions for diversity and predictability of students' performance.

Hersam et al. designed a nanotechnology engineering course employing collaborative group learning, interdisciplinary learning, problem-based learning, and peer assessment [10]. This course was given to 19 senior undergraduate students and junior graduate students, and peer assessment was employed in order to simulate working environments, where professionals are asked to evaluate one another through peer review. Group work was assigned in place of homework and peer assessment was used in order for the students to evaluate group activities and the final project. The group activity scores were 100% determined by peer assessment. For final projects, the student-generated score made up 20% of the total score. Since group work grades accounted for the 40% of the overall grade, and final project grades accounted for the 30% of the overall grade (the rest 30% was determined by a final exam), 46% of the overall course grade was determined by peer assessment. Hersam et al. found that students engaged in substantial and meaningful peer assessment and they expressed enthusiasm for the assigned group activities, which were evaluated solely by peer asssessment.

Fagerholm and Vihavainen [6] developed a tacit skills assessment framework for master students' software engineering capstone projects (from external partners) aiming at providing a decision support utility for evaluating students' teamwork proficiency. This framework consisted of an online questionnaire and used nine indicators for both self- and peer assessment of tacit skills. Within this framework, the questionnaires are filled in by students, the project coach, and the external partner. Data from the questionnaire is analyzed to provide an overall grade based on a given weighting (set by the instructor), or to indicate students that have been free-riding. Fagerholm and Vihavainen evaluated their framework with data from 18 bachelor's and 11 master's level projects (176 students), where it has been found to provide reasonable support for teachers in evaluating tacit, social, and teamwork skills. They concluded that their framework eased administrative burden for teachers and it helped to eliminate rater bias. Moreover, its dimensions were well understood, and it matched teachers' expert ratings.

Maskell introduced peer assessment within an embedded systems design course for second-year undergraduate students [17]. He aimed at eliminating the added burden upon staff that assessment in problem-based and self-directed learning introduces and at improving assessment as proposed by students in previous years (i.e. absence of individual marks, assessment criteria and expectations of staff not clearly defined, delayed and not appropriate feedback from lecturers). He negotiated assessment criteria with the students and introduced peer assessment for an individual assignment, which made up 20% of the final mark. The peer assessment process involved each student in a group assessing anonymously two assignments and then the group as a whole ranking each of them. Maskell used also a peer performance index to account for individual variations in the final group report. While the outcomes of this study were successful, Maskell pointed out that peer assessment should be introduced into early years before students form rigid views on the teaching style and the assessment format, if it is to be accepted as a valid assessment technique. Moreover, he emphasized the importance of providing a mix of assessment strategies in order to maintain certain minimum standards.

3 Computer Assisted Peer Assessment

One of the most important practical concerns in peer assessment is the burden of manual work in collecting and analyzing peer assessment data. Online questionnaires, semi-automated analysis tools and mobile technology have been introduced in order to remove much of this manual work [12], [25], [30]. Moreover, complete systems have been developed for self- and peer assessment management. Freeman and McKenzie described such a system, called SPARK, which facilitated self- and peer assessment and emphasized fairness in group work assessment [8]. SPARK^{PLUS} not only allows self- and peer assessment of group work, but also allows students to self and peer assess individual work. Moreover, it allows for judgment improvement through benchmarking exercises and it has been found efficient in calibrating academic standards amongst teaching staff in large classes [29]. In the same direction, Ohland et al. introduced the CATME system that focuses also on reducing teacher workload by providing automated peer- and self-assessment. Moreover, CATME provides a set of tools that place emphasis on handling group dynamics, group formation, and use behavioral anchors in the assessment. [20]. The SMARTER extends CATME and attempts to link educational research with teaching faculty actions to enhance learning of teamwork skills [19]. Finally, WebPA is an online peer-moderated marking system [16]. It is designed for giving individual marks to students working in groups and doing group-work, whose outcome of earns an overall group mark.

4 Discussion

The review of studies that adopted peer assessment revealed various benefits when this approach is adopted within project-based engineering. Firstly, it encouraged student involvement and responsibility and has been used efficiently to minimize the number of free riders by encouraging students to reflect on their role and contribution to the process of the group work. Secondly, it minimized confusion about assignment outcomes and expectations by introducing concrete assessment criteria, and contributed to the assignment of individual marks among group members. Thirdly, peer assessment proved to be a valid process that resulted in substantial and meaningful feedback to students. Finally, it resulted in students being involved in the process and being encouraged to take ownership of this process [28].

However, we can foresee some challenges peer assessment may introduce in project-based environments. Firstly, peer evaluation may have a negative impact on a PBL environment, which promotes a cooperative and non-judgmental atmosphere among group members [21]. In a PBL learning environment, students should feel free to make hypotheses, to ask questions and request clarification of challenging points. On the other hand, peer assessment promotes judgmental attitudes that may create tension among group members. Secondly, students may feel or even be ill equipped to undertake the assessment [15]. This is one of our biggest concerns, since creative engineering students lack basic skills in mathematics.

Based on the aforementioned strengths of peer assessment, we argue that mathematics education in creative engineering can greatly benefit from peer assessment. Nevertheless, a carefully designed framework is required in order to minimize challenges introduced by this method. This requires that students get familiar with the concepts and elements of assessment against specified criteria from the beginning and that they are provided with guidance on how to judge others' contributions. Finally, students should be continuously assisted to build a set of criteria that match the learning outcomes with regards to the output and process of the group work.

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