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An Online Peer Assessment Method in Computational-based Engineering Courses: combining theoretical and computer tools

Fatemeh Javidan[a]
Federation University Australia, Mount Helen Campus, PO Box 663 Ballarat VIC 3353 [a]
Corresponding Author's Email: f.javidan@federation.edu.au

ABSTRACT

CONTEXT

As its name suggests, peer assessment involves each student to take active part in providing feedback and in some cases, evaluation of the learning outcome of their peers. Peer assessment can introduce several advantages to the learning process such as increasing the student motivation, critical thinking and development of qualitative and quantitative arguments. This research proposes a peer assessment method for computational-based assignments and describes the process of implementing it in an online "Structural Analysis" subject.

PURPOSE OR GOAL

Some experts have criticised peer assessment procedures and questioned the ability of students to provide reliable evaluation. There are concerns raised in the literature on the usefulness and reliability of student peer reviews including inconsistency in the feedback and quantitative assessment marks. This study aims to implement an online tool to increase the engagement and partnership of students in the virtual environment and replace some of the lengthy computational processes with computer-based tools. The goal of the proposed method is also to increase the reliability of peer assessment activity by providing evidence-based evaluations.

APPROACH OR METHODOLOGY/METHODS

The design of the peer assessment task has been implemented in a second year "Structural Analysis" subject on the topic of "Analysing Indeterminate Structures". The delivery of this task was examined in a methodological approach as well as an executional approach. In the methodological approach, benefits were investigated, and comparison was made with previous peer-assessment procedures. The execution of this task which includes a combination of manual calculations and computer methods is outlined using available LMS tools.

ACTUAL OR ANTICIPATED OUTCOMES

The method proposed in this study introduces benefits to student learning and engagement in theoretical computational-based topics. This method is built on suggestions to mitigate some of the downsides of peer assessment reported in previous literature. For instance, to escape the double volume of computational effort, to reduce the reluctancy of students and to eliminate the potential errors they make in evaluating the computational work of their peers, the assessment phase is proposed to be done using a "Structural Analysis" computer software.

CONCLUSIONS/RECOMMENDATIONS/SUMMARY

Online peer assessment combining theoretical methods and computer-based approaches has provided a means to overcome some of the shortcomings traditionally associated with this approach. These improvements include an increase in the level of consistency and reliability of peer-assessment results compared to traditional approaches. The implementation of the method also shows approximately 25% increase in student active participation.

KEYWORDS

Computational-based courses, peer assessment, online teaching

Introduction

Assessment of Computational Engineering Subjects

Engineering assessment is conducted mainly in the form of engineering design projects and invigilated examinations. Engineering assessment methodologies generally include descriptive designs, observations and meta-analysis and experimental designs (Olds, Moskal, & Miller, 2005). Engineering education is progressing towards interactive teaching approaches and a number of innovative methods such as project-based learning, research-oriented approaches, flipped methods and collaborative projects have been introduced and adapted in engineering design assessment (Bell, 2010; Sankaranarayanan et al., 2020). While these techniques have shown significant improvements in evaluating student learning experience of engineering concepts and their practical applications, the assessment of computational theory-based topics have remained mostly in the same conventional form.

Engagement in the online space

Before the occurrence of the COVID-19 pandemic, engineering education was taking a slow pace towards online education, e-learning and implementation of ICT in teaching practice (Banday, Ahmed, & Jan, 2014). With the recent transition to online teaching, much of the literature has focused on increasing the engagement of students virtually and how to efficiently design and transfer content to the online or blended space (Muller-Karger & Steiner, 2020; Vogel Heuser, Bi, Land, & Trunzer, 2021). Mainly, the importance of online tool implementation and student evaluation is discussed in these research publications.

For a successful online assessment design, there needs to be an effective level of collaboration between the students and educators as well as the availability of fundamental support and virtual facilities. While the majority of institutions use a type of online learning management system, taking advantage of the full capacity of the online facilities might be prevented due to the lack of familiarity or insufficient time for teachers to move in this direction (Christie & Jurado, 2009). Among the many approaches in education engagement, Peer Assessment (PA) has been identified as a great method in engaging students in online engineering theoretical courses (Bishay, 2020).

Peer Assessment

Overview

As its name suggests, peer assessment involves each student to take active part in providing feedback and in some cases, evaluation on the learning outcome of their peers. Peer assessment can provide valuable learning benefits not only to the assessed students, but also to the assessors themselves which can enhance the learning outcomes. Peer assessment can increase the student motivation (Magyar & Haley, 2020), boost the level of critical thinking as well as the qualitative and quantitative arguments developed on the concept (Usher & Barak, 2018). Peer assessment helps students gain a deeper understanding of the topic and learn from their peers' mistakes which can encourage them to self-reflect and self-improve.

Peer Assessment in the engineering context

Feedback is given in a variety of different ways, including peer evaluation of individual performance, or group work (Bezuidenhout, 2020), and can include formative or summative feedback. The assessed learning can be based on soft skills, hard skills and technical skills (Zhang, 2012). Although assessment in the engineering discipline requires covering a combination of the above skills, the majority of peer assessment activities previously described and designed focus on soft skills rather than technical knowledge. Examples of these types of peer assessment methods include evaluation of writing in engineering

(O’Mahony, 2021), journaling, and oral presentations (Petchamé et al., 2020). Peer assessment of technical skills, however, is an important skill in the career of engineers, enabling students to review and identify errors in design documentations, manual and computer calculations of engineering projects. A reason that can contribute to a lower interest in using peer assessment in technical topics is the complexity and lengthiness of the processes and the high possibility of errors encountered in the assessment procedure.

Some research is found in engineering education focusing on the peer assessment of technical skills. A meta-assessment project-based peer assessment process was developed requiring student groups to work on a part of two projects and perform a peer assessment on the two projects in which they contributed (Wengrowicz, Dori, & Dori, 2017). Hersam et al. conducted a peer assessment by forming an evaluation committee by students evaluating the project conclusions of other groups and assigning a score based on a defined marking criteria which was mostly focused on soft skills and 20% on technical accuracy (Hersam, Luna, & Light, 2004). In a computer programming course, students critically judged and marked other students’ scripts. In this work, an automatic test system was used to help check the assessment process by running each student assignment against various test inputs (Sitthiworachart & Joy, 2004). A peer assessment task was implemented in a civil engineering subject based on marking a traditional problem-based assignment or tutorial against a worked solution to evaluate students’ knowledge in large class settings (O'Moore & Baldock, 2007).

Bishay (2020) introduced a peer assessment task as part of a teaching method of Finite Element Modelling (FEM). The results of this study compared the exam scores of a traditional FEM course with those of the novel approach including a peer assessed project which showed a significant improvement and higher engagement compared to the traditional approach. A project-based chemical engineering course including peer-evaluation strategies also showed enhanced learning outcomes and quality of teaching and learning based on student survey results (Cifrian, Andrés, Galán, & Viguri, 2020).

The proposed method

Implementation in a “Structural Analysis” subject

A PA method was designed and delivered in a “Structural Analysis” subject in a second year Civil Engineering bachelor program. The assessment task included various phases to cover a combination of learning outcomes of the subject. The preliminary phase of this PA task was completing the teaching session of a manual Structural Analysis method used for finding the internal forces and moments in an indeterminate structure called the “Slope-deflection Method”. This prepared students for initiating the task and provided them with an understanding of the manual computational methods. Once the manual calculations are covered in the topic, the PA process is initiated. Various phases of the PA activity are outlined in Figure 1.

The design of the peer assessment task was done using the workshop activity on Moodle. Once the initial Moodle settings were complete, the Analysis question was released to students and the PA activity moved to the second phase. Each student was provided with a question unique in its input parameters, but all questions were kept consistent in the level of difficulty. Students were required to complete the assigned question using the manual computational methods of the “slope-deflection method”.

Upon completion of the submission phase, students were trained in a structural analysis software as an alternative method to conduct structural analysis. It is important that the sequence of the manual and computer-based learning sessions is kept in line with the PA phases. At this stage, the peer assessment phase was made available on the workshop activity. Following certain guidelines and examples on assessment strategies, students used the computer software to perform an accurate evaluation of their peers’ manual computational submission based on their assigned question inputs. The assessment criteria and outputs to be assessed were broken down for students in a structured way to elicit a more diverse feedback procedure (Hicks, Pandey, Fraser, & Klemmer, 2016). These included the evaluation of the deflections and internal forces (bending moments and shear force values) at specific locations in the structure. The evaluation results as well as the computer-based evidence were provided and submitted by students at the end of the assessment phase.

This method combines two learning outcomes in a single task. The peer review process is also part of the assessment due to being considered an independent learning outcome in developing technical learning skills in students. During all phases of the task the instructor accesses and reviews submissions and a final feedback is provided to all students on their manual calculated submissions as well as the computer-based evaluations.

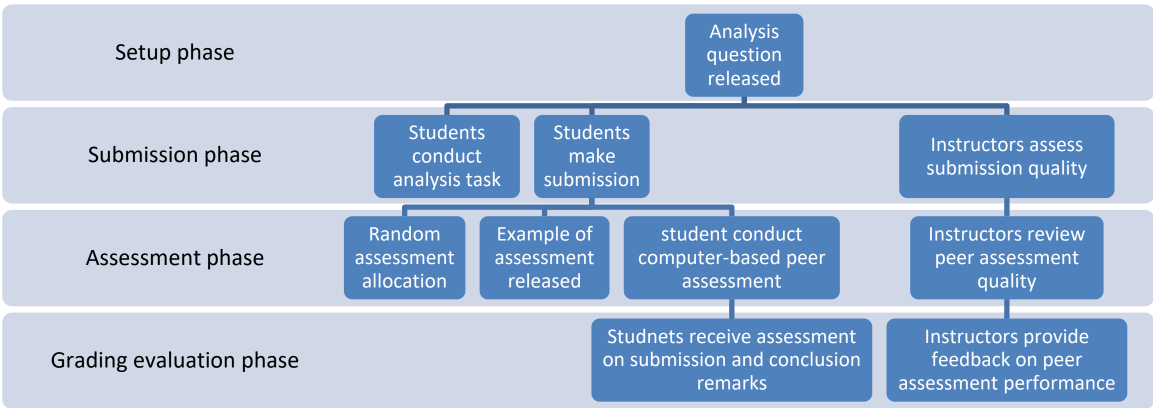

Figure 1: Peer assessment process flow chart

Analysis of the method

Some experts have criticised the peer assessment procedures for students and questioned the ability of students to provide reliable evaluation (S. E. M. Meek, L. Blakemore, & L. Marks, 2017). The concerns raised by this study on the usefulness of student peer reviews are in the form of inconsistency in the feedback as well as quantitative assessment marks. It is shown that only 43% of grades provided by students were within 5% of the tutor's grade. An extent of biased assessment has also been observed, where student with high quality work tend to provide a higher quality of feedback compared to students who did not do well. Furthermore, some experts criticised the ability of students to provide a reliable assessment and reported inconsistencies in feedback and quantitative marks (S. E. M. Meek et al., 2017). The peer assessment process was also found to fail in achieving the expected benefits (Naveh & Bykhovsky, 2021). As opposed to the higher final marks reported by Bishay (Bishay, 2020), Naveh and Byskhovsky (2021) mention that "this [type of assessment] might have contributed to lower grades in the course".

The proposed PA activity in this study employs methods to eliminate or alleviate the effect of a number of issues raised by previous researchers and also those observed in the delivery of technical assessments by the author. The issues along with the proposed strategies are listed in Table 1. Some of the proposed methods were adopted based on suggestions arising from previous research literature, while others are an inclusive result of the present PA activity. The novel approach of combining a computer-based Structural Analysis task with the peer assessment process has provided an effective opportunity to overcome some of these issues. A major concern lies within the reliability of peer assessment when it comes to technical and manual computational topics. Using a computer software tool reduces the risk of errors and provides a certain level of consistency among the revisions. The use of computer methods will also provide the assessed students and also the instructor, with acceptable evidence on the evaluation which can enrich the learning experience. Furthermore, this reduces the students' time spent on the evaluation phase and makes the task more interactive while incorporating a second learning outcome of the course. Finally, the instructor will spend an efficient amount of time on the overall revision of the manual calculations as well as the assessment outcome by taking advantage of the computer-based evidence.

Table 1: Issues associated with PA and proposed methods to tackle them

Issues associate with PA	Methods employed to address issue
Bias in marking and lack of trust (Matinde, 2019)	Automatic (Søndergaard & Mulder, 2012), random and blind assessment allocations (Naveh & Bykhovsky, 2021)
Mechanisms for distributing assignments and collecting reviews (Søndergaard & Mulder, 2012)	Use of the Workshop tool on Moodle (Naveh & Bykhovsky, 2021)
High possibility of error in manual computational courses	The use of a computer software for accuracy of evaluation
Minimising the influence of ‘‘rogue’’ reviewers (Søndergaard & Mulder, 2012)	Detailed layout for qualitative assessment (Cifrian et al., 2020), evidence-based software assessment process
Inconsistent marking (Sarah E. M. Meek, Louise Blakemore, & Leah Marks, 2017)	Assigning more than 1 assessor (Naveh & Bykhovsky, 2021), evidence-based software assessment process
Motivating students to complete the reviews (Zhang, 2012), reluctancy of students in participating in peer assessment due to the high volume of work (Matinde, 2019)	Replacing theoretical methods with computer calculations in the evaluation phase to increase student motivation and speed up the process
Negative feeling of students in spending time and being bored (Matinde, 2019)	Reducing the scale of assignment/project (Bishay, 2020), defining the purpose clearly and improving students' perception (Matinde, 2019)
Time spent by the educator for the final assessment	Use of evidence-based software assessment process to increase speed
Technicality of assessment criteria	Introduction of numerical criteria based on the software results
Maintaining validity and reliability in the grading (Zhang, 2012), preventing student errors even in computer modelling	Introducing methods to check validity or address discrepancies in computer methods
Detecting and preventing plagiarism (Søndergaard & Mulder, 2012)	The use of randomised inputs for each student (Matinde, 2019)
Some students have mentioned while they consider these tasks important, they do not have enough time to work on them (Staubitz & Meinel, 2020)	Peer assessment is part of the subject learning outcomes and is also assessed

While the use of computer modelling to evaluate manual calculations increases the level of accuracy and reduces possibility of errors, there is still a possibility of errors being made in the process of creating the models and defining the inputs in the software by students. To avoid this, students were asked to perform and provide a series of checks on the computer-generated results. These checks are based on basic Structural Analysis theories such as the equilibrium of forces and moments and the validity and compatibility of signs, directions and values of deflections and forces.

It was previously observed students lose interest and the level of engagement reduces in calculation-based topics. While the use of theoretical procedures predominantly results in a reduction in the engagement and interest of students, the implementation of the proposed interactive PA method showed a noticeable increase in the level of engagement, interest and activity of students. A session including parts of the PA activity at least 25% increase in the level of student participation and the overall engagement was observed. This was obtained from a total of 30 enrolled students and the level of engagement was based on the student activity and number of interactions made in the session in which parts of the PA activity was implemented. Furthermore, in giving the feedback as part of the PA activity, students provided arguments as to why and to what extent the manual calculations were conducted correctly which involved an increased level of critical thinking regarding the calculation of internal force values, diagrams, and deflection outcomes. This also resulted in an enhanced learning experience for their own understanding of the manual calculations necessary for the "Structural Analysis" procedures.

Limitations of method and further suggestions

This study focuses on the design and implementation of a peer-assessment task for evaluating the technical knowledge and hard skills in a calculation-based engineering course by incorporating computer-based methods. While the method of implementation is described in detail, further studies are required to provide insight on the students' perspective on their experience throughout the PA activity. It is suggested that a survey is designed and distributed among students participating in the PA activity to evaluate their learning experience, engagement, level of confidence during the computer modelling as well as the assessment phases of the task. Furthermore, a quantitative analysis of this method from the student results in the proceeding assessments is recommended to be examined which can provide a better understanding of the general effects of this novel assessment method.

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