Role of Peer Assessment in Facilitating Computational Thinking among Pre-Service Teachers

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Abstract: Peer assessment has been employed as an effective learning strategy to enhance cognitive practices such as problem-solving and reflection practices. A case study was conducted to explore the effects of online peer assessment as a learning strategy of computational thinking among pre-service teachers. The peer comments were analysed and coded by adopting a coding scheme of comments to investigate the significance of the peer-reviewing process in facilitating the learning of computational thinking. Each student was required to design a lesson by integrating the computational thinking facets into their lesson plan. Upon submitting the lesson plan to the instructor, they were engaged in a blind review process. The students worked in a group to review and provide constructive comments on their peers' lesson plans. By adapting a peer-reviewing cognitive process model, this article provides evidence that the peer-reviewing process played a critical role in facilitating the learning of Computational Thinking. The findings indicate that the peer assessment strategy can develop pre-service teachers' problem-solving competencies. It was suggested that all students be informed about the purposes and learning benefits of the peer-review process to optimise the learning outcomes.

Keywords: Peer assessment, peer-reviewing, learning strategy, computational thinking, pre-service teacher, teacher education

1. Introduction

According to Sondergaard (2009), peer assessment can increase student engagement and social interaction, encourage learning reflection, and develop diagnosis and evaluation skills. Peer reviewing that emphasises formative feedback fits under the category of peer assessment. Peer reviewing is an evaluative problem-solving process that engages students in detecting text problems, diagnosing them, and generating solutions to improve the problems (Cho & MacArthur, 2011). The higher-order thinking (HOT) is defined as "new information and information stored in memory interrelates and/or rearranges and extends this information to achieve a purpose or find possible solutions in complex situations." (Lewis & Smith, 1993, p.136). Problem-solving is a cognitive process through which knowledge, skills, and personal experiences are mobilised to identify problems, find solutions, and resolve conflicts effectively (Hoi et al., 2018). Computational thinking (CT) emphasises individuals' cognitive process (Shute et al., 2017), developing the pre-service teachers' CT competencies and enabling them to integrate CT into their teaching contexts. A case study was conducted to explore peer assessment as a learning strategy in facilitating pre-service teachers' learning of CT, guided by the research question: How does the peer-reviewing process foster problem-solving competencies in the learning of CT among pre-service teachers?

2. Theoretical framework: Reviewing as a problem-solving process

This study adapted the cognitive model developed by Flower et al. (1986) to investigate how the reviewing process fosters the students' HOT, particularly problem-solving skills. Figure 1 presents three features of the model: (1) the process results in the call for the use of knowledge; (2) various information flows between processes - in practice, the flow of information from one process to another result in a shift in the reviewer's attention, in which the reviewer's cognition shifts from one subprocess to another; (3) the flow of information between knowledge and process as well as between

different processes is highly reciprocal. The process of Evaluation, Diagnosis, and Strategy Selection has led the reviewer to re-think the goals and suggest making some necessary modifications, which is to redraft or revise the task based on the diagnosis of the problems. Finally, this may lead the reviewers out of the reviewing process, reflect on their task and conduct necessary modifications.

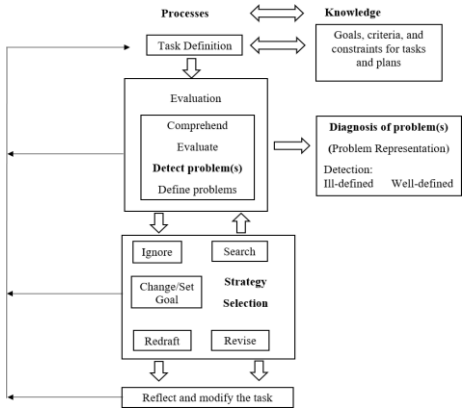

Figure 1. The cognitive model in the peer review process adapted from Flower et al. (1986)

3. **Research design and data analysis**

This study adopted a case study approach. The participants were selected based on the following criteria: (1) pursuing their Bachelor's Degree in Education; (2) enrolling in the Educational Technology course. Thirty-eight participants were in their third-year undergraduate studies and had no prior knowledge of CT. The participants attended a twelve-week CT module session, in which they learned about the six CT facets of cognitive process: decomposition, abstraction, algorithms, debugging, iteration and generalisation. Each participant was required to design a CT-integrated lesson plan: integrating CT facets based on the learning objective(s) of the lesson plan. Subsequently, the participants were divided into groups of four to review each other's lesson plans and submit their feedback through TEAMMATES. TEAMMATES is an online peer feedback system for student team projects. In implementing the anonymous peer assessment, each participant was given an account with a code as identification, allowing them to post and check their peers' feedback from TEAMMATES. Participants were given a CT framework (adapted from Shute et al., 2017) and guiding questions to facilitate the review process. The criteria of the review process: (1) identification of the integration of CT facets, (2) justification of the integration of CT facets based on the learning objective(s) of the lesson. The first author acted as the instructor who conducted the lessons online due to the campus closure during the Covid-19 pandemic. The lesson recordings were then uploaded onto Google Drive.

In data analysis, the comments generated by the participants in the reviewing process were coded. Each comment was assigned into three main categories: strength, weakness or off-task. First, the 'praise' category under the strength: good remarks on what constituted the strength of the task. Second, the weakness category consists of three sub-categories: (1) 'problem detection': identify a problem without diagnosing the problem; (2) 'problem diagnosis': detected and diagnosed a problem without suggesting any possible solution; (3) 'solution suggestion': the idea included a solution to improve the problem regardless of whether the idea had a statement of problem diagnosis. Third, off-task category: task-unrelated comments. The investigator triangulation involved two researchers, and the inter-coder reliability was conducted where one researcher coded all of the comments, and the second coder independently coded 50% of randomly selected comments. When there were discrepancies in the coding results, the discussion was conducted until a consensus was reached.

4. **Results, discussion, and conclusion**

The students' comments were coded based on the three main code categories. However, one comment was coded in more than one category. The inter-coder reliability for the coding was 0.83, which suggested a near-perfect agreement (Cohen, 1960). A total of 480 comments from all 38 students were analysed and assigned into five categories. The frequency of each code indicated that the students

were actively engaged in the problem-solving processes, in which they needed to review their peers' work by identifying and diagnosing the problem(s) and proposing appropriate solutions. 369 (76.9%) comments were categorised under the strength (praise). The comments that were categorised as weakness made up 256 (53.3%): 98 (20.4%) problem detection, 58 (12.1%) problem diagnosis, 100 (20.8%) solution suggestion, and 20 (4.2%) off-task.

First, the findings reported from the analysis of peer comments have demonstrated that peer-reviewing facilitates participants' CT learning experience while receiving feedback from peers and producing feedback for peers, concurred with the studies conducted by Cho and MacArthur (2010). The students' perspectives on the differences between receiving and generating reviews, teasing out the HOT processes activated through the learning-by-reviewing, and highlighting the role of these processes in enhancing their CT learning. This study's results concur with the findings of Nicol et al. (2014), i.e., the peer assessment process is perceived as beneficial because it actively engages students in HOT, for instance, critical thinking, reflection, and learning transfer.

Second, the findings of this study support the effectiveness of peer assessment in scaffolding problem-solving processes by considering problems, constructing the problem spot, and articulating contextual constraints. The problem-solving process stimulates the participants' HOT to identify the problems or deficiencies in the CT-integrated lesson design, thus prompting them to diagnose and propose appropriate solutions based on their interpretation of the lesson design. HOT processes were activated to develop the participants' problem-solving competencies. The findings are also congruent with the studies of Çevik (2015) and Nicol et al. (2014), in which the online peer assessment strategy positively contributes to students' problem-solving skills. The participants' problem-solving skills improved more substantially by providing feedback than receiving feedback because participants engaged in problem-solving processes while providing the feedback, such as identifying and analysing problems, developing, evaluating and justifying solutions.

To conclude, this study suggests two key insights: (1) peer assessment facilitates students' CT learning in designing CT-integrated lessons, and (2) peer assessment can be used as a learning strategy to develop students' HOT; in particular, reviewing processes develops students' problem-solving competencies. The results of this study provide important implications for teacher educators and educators, as teachers are key agents of change in teaching and learning (Voon et al., 2019). The researchers suggest that all students be informed about the purposes and benefits of the peer-review process. Limitations needed to take into account: First, the sample of this study comprises a homogenous group of participants, and the results may not be generalisable to other settings. Second, the modules were conducted online, and a few participants could only watch the lesson recordings due to the unstable internet connection.

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