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Building Higher Order Thinking Skills (Hots) for Pre-Service Vocational Engineering Teachers by Applying a Multi-Method Approach to the Learning Process through Lesson Study

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ABSTRACT

This article aims to examine the implementation of a multi-method approach in the vocational engineering learning process through a Lesson Study to develop higher order thinking skills (HOTS) for pre-service teachers. This is a multiphase mixed methods design which included a series of Lesson Study activities. In the implementation phase, the multi-method learning was started through self-directed learning, followed by collaborative problem-solving by using a mixture of several techniques. The last phase was a summarization session. The results of this study indicate that a multi-method approach has the potential to develop pre-service teachers' HOTS.

Keywords: Higher order thinking skills, lesson study, multi-method, pre-service teacher, vocational engineering

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INTRODUCTION

Higher order thinking skills (HOTS) is one of the critical abilites found in the learning process, especially among higher education institutions. It constitutes as the highest level in the hierarchy of cognitive process. It includes critical, logical, reflective, metacognitive, and creative thinking. Such skills enable students to face numerous challenges; in an era when there is so much information available, but the time to

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process it is limited (Yee et al., 2015), HOTS encourages individuals to interpret, analyse and manipulate information.

HOTS is more difficult to be learnt or taught than other types of skills. However, it is also more valuable because it will bring beneficial when faced with a new different situation compared with the learnt skill. In the information era, mastery of HOTS has become a necessary competency in order to address a variety of information which sometimes contradicts one another (Brierton et al., 2016).

Pre-service vocational engineering teachers are prepared to be taught in vocational secondary schools or Technical and Vocational Education Training (TVET). TVET has aims to make workers be more incisive and enable them to interact better with their job duties (Yusop et al., 2015). In Indonesia, formal vocational education and training are offered at the secondary level through SMK (Sekolah Menengah Kejuruan), under the management of the Directorate General of Senior Secondary Education, which is under assitance of the Ministry of Education and Culture (MOEC). The new mission of MOEC is to increase the number of learners enrolling in SMK schools to achieve a greater proportion (60%) compared to those studying in academic senior secondary high schools or Sekolah Menengah Atas (SMA). This effort is being undertaken to reduce their workers' skill mismatches. Thus, it is expected to increase job creation, and to support the productivity, competitiveness, and growth of the country (Organisation for Economic Co-operation and Development [OECD], 2015). Furthermore, vocational education and training provide more direct pathways to the labour market (OECD, 2016).

The increasing number of students at vocational institutions should be accompanied by improvements in the quality of vocational education. High-quality vocational education will be achieved if the process of vocational teaching and learning is implemented effectively and met with high standard. Research has shown that the quality of teaching is a decisive factor in improving the learning outcomes of students. The results of a recent review of 20 of the world's top education systems concluded that the quality of the education system could not exceed the quality of its teachers. So, it is suggested that the only way to improve student learning outcomes is to enhance the instructional process managed by teachers (Barber & Mourshed, 2007). Teachers are required to be able to develop the learning process through the learning objectives. In line with the objective of vocational learning, which is to prepare students for work, vocational teachers have to be able to follow the development of science and technology in their field. This capability will be more easily achieved when teachers have HOTS, due to the dynamic nature of science and technology.

To enable the learner to retain HOTS for a longer period of time, or even forever, each particular skill is not applied through a single technique or process; rather, a combination of all of these processes is

employed to develop a unique learning experience. The opportunity to develop critical thinking skills can be obtained if the teacher purposely and persistently practices higher order thinking strategies in the implementation of teaching and learning, for example through open-ended class discussions, real-world problem solving, and encouraging inquiry-oriented experiments (Miri et al., 2007). Teaching collaboratively provides the instructor with an opportunity to improve their teaching practice and makes the professional development of the teacher more effective (Jao & Mcdougall, 2015).

Lesson Study has been used widely in Japan for many decades as a professional development approach that is often credited for the eternal restoration of Japanese learning instruction (Fernandez & Yoshida 2004). This professional development practice engages teachers in the process of systematically examining their teaching to become more effective (Myers, 2013). Lesson Study is a professional learning approach in which a group of teachers works together to: formulate learning objectives and long-term development; plan a design for a research lesson as an attempt to achieve those objectives; carry out the lesson in a classroom, with one team member teaching and the others gathering evidence on student learning and development; and then discuss and debrief the live lessons and evidence gathered during the learning process, and use the findings to improve the quality of both research lessons and lessons in general (Lewis, 2009).

Lewis et al. (2006) called for Lesson Study research in three areas: "(1) expansion of the descriptive knowledge base on Lesson Study; (2) explanation of the Lesson Study's procedure (that results in instructional improvement); and (3) iterative cycles of testing and refinement of Lesson Study". This research was focused on repeating cycles of testing and refinement of Lesson Study by applying a multi-method approach, which comprised a combination of three learning methods, i.e., self-directed learning, collaborative problem-solving, and summarisation, in a learning process to develop students' HOTS. The multi-method approach was employed to optimise the benefits and minimise the disadvantages of each model, especially with the aim of developing the HOTS of pre-service vocational engineering teachers.

The research goals were to answer the following questions: 1) what does the implementation of Lesson Study cycles with multi-method learning for the engineering learning process look like? 2) How effective is Lesson Study with multi-method learning in contributing towards HOTS among pre-service vocational engineering teachers? In this study, the development of HOTS in pre-service vocational engineering teachers through the application of multi-method learning will focus on analytical and critical thinking.

METHODOLOGY

Research Design

This is a multiphase mixed methods design (Creswell, 2014) which was conducted

following a series of Lesson Study activities adapted from Cerbin and Kopp (2011), as shown in Figure 1.

A multiphase mixed methods design was chosen in this research approach because it is suitable with the objective of this research that was to understand the need for an impact of an intervention program, i.e. the lesson study. This program consists of multiple phases which may go back and forth between quantitative and qualitative studies, but they build on each other to address a program objective.

Data obtained from the plan session was a set of the lesson plan. The information obtained based on data in the plan session becomes the basis of the next session, i.e. the implementation stage. At this stage, the gathered data consists of pre-service teacher's paperwork, presentation materials, summaries, and the observation sheets. The result of data analysis from the implementation stage gives information for the next session that is a debriefing session. Its session delivers transcript as qualitative data, which the information within the transcript is used as the main reason to carry out the next cycle of the lesson study program.

This article focuses on HOTS development in analytical and critical thinking through lesson study research. Analytical skill builds as the ability to make decisions based on the information gathered. Critical thinking is described as the ability in deciding what to believe or do based on reasonable reflective thinking. Pre-service teachers' scores for analytical and critical skill are gained from their collection of articles and the literature reviews that they created relating to the subject matter, the observation during class discussion, and the summaries they made.

To find out how the pre-service teacher understood with the collected article, a rubric for doing a content analysis of the

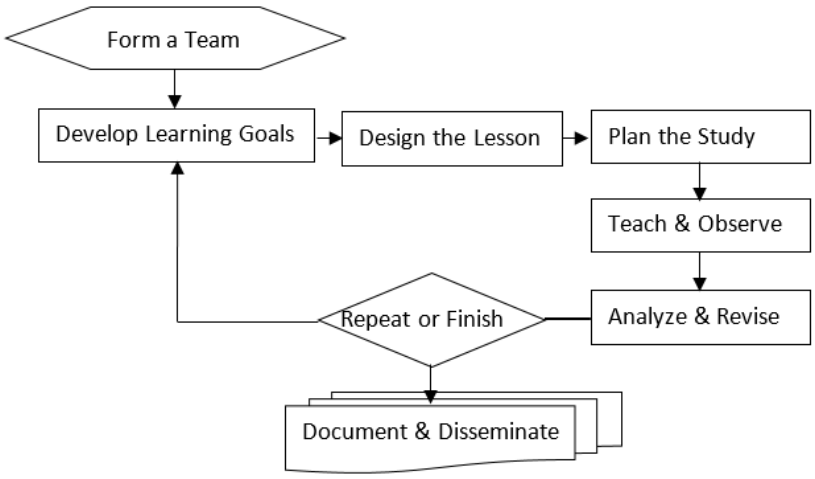

Figure 1. Steps in lesson study

pre-service teacher' written reviews was made. The analysis itself involves an iterative process. The article and the written reviews is read repeatedly, interpreting and reinterpreting the written reviews, and searching for part of the article that corresponds to written reviews. The rubric consists of items for assessing analytical skill in terms of collecting and organising information, analysing information, reading with comprehension, and identifying appropriate materials. While for assessing critical thinking, the rubrics include items to identify the source of information, to compare such information to prior knowledge, and to form conclusions.

The other data regarding to analytical skill are collected from written summaries. Pre-service teachers forced to do such analytical activities described above in order to make it not only brief but also comprehensive one. A rubric for scoring analytical skill based on summaries data consists of several key items in the relevant topic.

The observation sheet provides data regarding critical skill which is collected during class discussion. The focus of the observation is on critical skill ability in terms of identifying conclusions, reasons, and assumptions; the quality of an argument; develop and defend an idea; and draw conclusions (Larsson, 2017). The number of pre-service teachers that is shown those abilities listed on the frequency tables as a part of the observation sheet along with the description of the abilities shown.

Participants

In this study, groups consisting of three Steel Structure engineering instructors collaboratively attempted to enhance HOTS through Lesson Study research. All pre-service vocational engineering teachers attending the Steel Structure course at a Teacher Training and Education Department from a state university in Indonesia (n=68) were invited to participate. The pre-service teachers were in their fourth semester of a 4-year undergraduate pre-service teacher programme.

Procedures

Lesson Study activities was begun with the formation of the team. Once the team was formed, the members formulated lesson objectives as listed in the syllabus. In the next step, the research lesson was planned by the team by designing the type of learning to be applied. Here, learning was designed using a combination of three learning models, i.e., self-directed learning, collaborative problem-based learning, and summarisation. In the implementation phase, the learning process using a multi-method approach begun with self-directed learning, in which pre-service teachers were directed to collect information about the subject matter from various sources using Web-based Instruction. In the next session, collaborative problem-based learning was performed. A mix of several techniques, i.e., Make a Match, Pre-service Teacher Team Achievement Division, and Number Heads Together were used in this session. The last session involved each pre-service teacher summarising the process in their own words.

During the implementation stage, one of the team members served as a teacher and the others as observers. Those tasked with observing the course of the learning process were to gather data using observation guidelines that had been prepared previously (Cerbin & Kopp, 2011). The data observation results were divided into two categories. The first comprised data that came from the pre-service teachers' assignments, i.e., paperwork, presentation materials, summaries, quizzes, and final tests. The remaining data came from pre-service teacher activity observation sheets. In the next stage, the team analyzed the results of the implementation of the learning model and assessed the pre-service teachers' progress towards the learning goals through a debriefing session. If necessary, the team revised the lesson plan to produce the optimal design based on the results of the analysis. The transcripts from this debriefing session were collected.

RESULTS

The Implementation of Lesson Study Cycles with Multi-Method Learning

In the First Cycle of Lesson Study. The first cycle began with self-directed learning; all pre-service teachers had collected related papers from several sources and produced article reviews. However, this session was not taken seriously by most pre-service teachers. The pre-service teachers did not read their articles well. This was reflected from the article reviews, which merely resembled very short summaries.

Collaborative problem-based learning was performed by using a mix of several techniques, i.e., Make a Match, Pre-service Teacher Team Achievement Division, and Number Heads Together. The lesson plans describe clearly each step of the instructional design applied in this lesson study research. Each pre-service teacher was given a random card. Their group number and the problems that must be solved were listed on the card. Pre-service teachers with the same group number were gathered into one group. There were 13 groups involved in the learning activities with each group consists of 5-6 members. The problems to be solved were different for each group member. All the problems were discussed with team members, although each member of the group was responsible for solving the problems stated on their own card. During the solving of various problems, pre-service teachers performed high order thinking actions, from accessing their knowledge of law formulations and the respective conditions of the studied process to drawing connections between the characteristics of the processes already known and those unknown. They then explained and made a quantitative assessment of the results of the study (Politsinsky et al., 2015).

All the members of a group were to be ready if selected to present the results of their work in class at the end of the session. Assessments of discussions and presentations were carried out during the session. Then, each of the pre-service teachers was given a quiz. This quiz was performed to determine the effectiveness

of the learning method, as well as forming part of the achievements of each group. The group with the highest scores was named the best group and given a reward. In the last session, each pre-service teacher had to provide a summary of the process in their own words, and then the final test was taken.

During the collaborative problem-solving method, the activeness of the pre-service teachers was not evenly distributed in the classroom. Only those who already understand the purpose of learning and highly motivated to learn were seen to be active during the learning process. The instructor appeared in dividing their attention throughout the class. Summarisation also did not receive enough attention. Pre-service teachers made their summaries carelessly; moreover, some of them even cheated by copying the peers' summaries.

Based on observations made during the implementation of Lesson Study in the first cycle, the monitoring team then held a debriefing session. In this session, the team analyzed the implementation of the learning process by using a multi-method approach, the difficulties encountered, and the achievement of the pre-service teacher learning outcomes associated with learning objectives. They then agreed to some refinements for the Lesson Study process. Those refinements were: 1) The instructor should more actively cultivate the curiosity of pre-service teachers with the inducement of questions. 2) The classroom needs to be rearranged. The monitoring team needs to be positioned so as not to interfere with the mobility of teachers. The positions of pre-service teachers during the discussion with the group and their position in the summarisation session need to be set so that the purpose of each session can be achieved. 3) The instructor should give equal attention to all pre-service teachers. Pre-service teachers who did not actively need to be given more attention should be motivated to become more active. 4) Time management implementation in the classroom needs to be improved. The instructor should be more active in instructing pre-service teachers to use the time more effectively, especially when switching between sessions.

In the Second Cycle of Lesson Study. The second cycle again started with self-directed learning. This involved pre-service teachers collected articles from the web, and then asked to create a literature review which contained a summary of the content of the article, the strengths, and weaknesses of review articles, and guidance on how to apply the information from the article in the subject course. Through this technique, the pre-service teachers were encouraged to read by the aim of understanding, analyzing and identifying information.

To further streamline the discussion groups, the number of group members in the collaborative problem-based learning sessions was reduced to 3–4 pre-service teachers. The class setting for discussions would be easier for a small group. Instructors needed to be more active in instructing all pre-service teachers to move more quickly when forming groups based on the distribution of the cards.

Before starting classes, pre-service teachers were asked to pose some questions about aspects of the subject to be discussed that they had not understood based on the literature they had read previously. Then, the pre-service teachers exchanged questions and answers via a group quiz game. The group who could answer the most questions correctly would receive a reward. The instructor acted as a judge and also clarified the answers given by the pre-service teachers. With this technique, the questions discussed in class during the problem-based learning session were expected to focus on issues that had not been understood by the pre-service teachers. An outline for summarisation was given to ensure the pre-service teachers' summaries were better planned and more orderly.

The Contribution of Multi-method Learning in Developing HOTS

Pre-service teachers' score on 100 scales related to HOTS studied here were obtained by using the assessment rubrics. The final score was the average from all items which was observed covering the ability in collecting and organizing information, analyzing information, reading with comprehension, identifying appropriate materials, identifying the source of information, comparing such information to prior knowledge, forming conclusions, and drawing up a comprehensive summary.

The scores then were divided into fourth categories involving; "very good" for score 80-100; "good" for score 70-79; "fair" for score 60-69; and "poor" category for score <60. Score distribution for each criterion was based on the applicable standard assessment in the institution where this study was conducted. Pre-service teachers were graded according to the score achieved. For critical thinking skill derived from the frequency tables, students' scores are based on the number of ability criteria indicated during observation. Pre-service teachers who showed three or more abilities were in the "very good" category. It revealed two other abilities in the "good category", while bringing out one ability was in the fair category, and if it did not show any ability will be categorized as "poor".

The pre-service teachers' score related to the HOTS from the first cycle showed that some of them reached "very good" achievement (21.9%), while 40.6% were deemed "good". Fewer pre-service teachers fell into the "fair" and "poor" categories (25% and 12.5% respectively). Meanwhile, the results of the development of HOTS among pre-service teachers in the second cycle showed that 34.4% had the very good achievement and 28.1% were good, while 31.3% were fair and only 6.3% remained poor.

This research did not mention the initial score because HOTS score here derived from data collected during the lesson study program, which did not apply before. From the two cycles of lesson study conducted, the number of pre-service teachers who reached very good achievement was increasing 12.5%, while the number who placed in the poor level was decreasing 6.2%. However, the paired t- test analysis – found that there was no significant difference

(N= 68, T= -1.38, P= 0.173), between the first cycle score (mean= 71.56, SD= 7.69) and the second cycle score (mean= 73.31, SD=8.75). This showed that although there was an increasing level of HOTS achievement but not significantly made different. Implementing and improving lesson study in the next cycle needs to be done. Therefore, more significant HOTS enhancement can be obtained. .

HOTS was developed through a series of activities, started with self-directed learning, to test pre-service teachers' ability to collect, organise, and analyze information. This learning method also contributes in developing the ability to read with understanding and to identify the materials needed and not. The results were seen in the articles derived from the collected materials and in the literature reviews they produced. The pre-service teachers demonstrated their ability to identify the source of a piece of information, analyze its credibility, reflect the consistency of information, and make conclusion about the subject matter based on the information that they had collected. However, the analytical skills of the pre-service teachers still needed to be improved. Their abilities regarding to analyzing information, reading comprehension, and identifying the materials needed were not refined well. This can be observed from their performance in the quiz, where most pre-service teachers experienced difficulty in solving the problems, despite the questions being related to the articles that they had submitted.

During the collaborative problem-solving method, pre-service teachers enhanced their critical and analytical thinking skills through problem-solving activities, which involved exchanging ideas in a discussion, creating new ideas, and evaluating them. Moreover, they taught and learned with their peers. They also learned how to communicate their understanding, analyze other opinions, receive the appropriate opinions, and to draw suitable conclusions from the data provided. Creating a summary aimed to develop the pre-service teachers' skills in mapping information and, in turn, improve their analytical and critical thinking abilities, as well as to instil a deeper understanding of the meaning of information.

DISCUSSION

The Implementation of Lesson Study Cycles with Multi-method Learning

The implementation of Lesson Study in the daily learning process is in line with efforts being undertaken to achieve high-quality and sustainable professional development of teachers. Lesson Study can be adapted to meet the needs of teachers and to satisfy certain professional learning outcomes (Saito, 2012). Further, Saito (2012) suggested that it was important for teachers to consider how to enhance their quality of learning by discarding unnecessary activities and replacing them with activities that were more meaningful; this strategy must then be applied in daily teaching.

The multi-method approach which was applied in this Lesson Study allowed pre-service teachers to create, integrate, and generalise knowledge, one of the main attributes of learning (Bicknell-Holmes & Hoffman, 2000). This was an active form of learning, which was based on the process and not on facts. The pre-service teachers learned from their mistakes and failures during the process. Feedback was required to ensure pre-service teachers gained a deeper understanding. Such an approach distinguishes between inventive learning and traditional learning (Bonwell, 1998; Mosca & Howard 1997; Papert, 2000).

Pineteh (2012) proposed that lecturers should be able to creatively integrate traditional teaching and learning methods with technological advances so that the learning process would be more engaging. In this Lesson Study, a multi-method approach was applied to the subject of "Steel Structure" to enhance the HOTS of pre-service vocational engineering teachers. The multi-method approach was combined with three learning methods, i.e., self-directed learning, collaborative problem-solving, and summarisation. Through Lesson Study, pre-service teachers were considered to have become more capable of listening and collaborating with peers, as well as having become more confident and respectful (Saito & Atencio, 2013).

Self-directed learning was intended to cultivate self-education among pre-service teachers, in order to reduce their total dependency on the lecturers (Din et al., 2016) and to ensure they are better prepared for the subject before entering the classroom. Self-directed learning is a central element in higher education and encompasses any learning activities that take place outside of class hours or scheduled events. Independent activities may be in the form of online learning, studying in the library, or group work. Online learning environments help the students to gain knowledge and develop their views and interests in a way that enhances their novel and adaptive thinking (Kapenieks, 2016). In self-directed learning, something about going to happen depends on the individual's commitment and initiative. Individuals select, organize and evaluate their learning activities, which can be performed at anytime, anywhere, by any means, and at any age. Self-directed learning activities can be carried out by teachers in schools at every opportunity.

Collaborative problem-based learning is an educational approach to teaching and learning which involves groups of pre-service teachers working together to solve a problem. The problem-solving process provides an opportunity to understand the topic in more depth and to develop a comprehensive idea based on the realities encountered. The skill of problem-solving is the best criterion for evaluating the level of mastery of learning the material and is a skill that is required by any professional engineer (Politsinsky et al., 2015). Yusop et al. (2015) noted that "Problem-solving is a series of techniques, both cognitive and behavioural that can be applied in various fields or areas to generate solutions". This definition is in line with the character of

HOTS, i.e., that it does not apply only one technique, process, or skill but rather a combination of them. For this reason, this study employed problem-solving as part of the multi-method approach to the learning process. The results of previous researchers (Politsinsky et al., 2015) had indicated that problem-solving was an effective method to teach school and university pre-service teachers the general methods of mental activity, especially analysis.

Summarisation is a part of the learning strategy. Several studies have shown the benefits of summarisation (Anderson & Thiede, 2008; Thiede & Anderson, 2003). Creating a summary involves a process of presenting data from many sources to the user to make an abstract concept easier to understand (Mohan et al., 2016). The most significant increases in pre-service teacher learning outcomes occurred when summarisation took the form of a kind of recitation. This required VGNA (Verbal, Graphical or Geometric, Numeric, and Algebraic) concept activities, in which pre-service teachers were taken out of their passive learning environments and integrated into environments of active learning where, through the use of the VGNA concept activities, they were able to construct knowledge (Watt et al., 2014). Through analysing pre-service teacher's summaries, instructors could pinpoint gaps not only in the teachers' learning but also in their knowledge. The instructors were, thus, more adept at identifying their pre-service teachers' needs in order to achieve the next steps of the learning process (Limbrick et al., 2010).

The Contribution of Multi-method learning in developing HOTS

Learning methods that are appropriate for teaching and learning not only aid the learning process, but also contribute in improving soft skills among pre-service teachers (Esa et al., 2015). To ensure that these soft skills instilled in pre-service teachers, appropriate and better organized instructors are required to be more creative in devising strategies for teaching and learning (Morris, 2009). Kuhn (2005) stated that teaching focussed on improving HOTS was essential to equip pre-service teachers to participate in and contribute to modern democratic societies.

HOTS can be conceptualized as multiple, non-algorithmic modes of thinking that often deliver multiple solutions (Miri et al., 2007). Learning experiences which are considered to involve HOTS include answering questions, decision making, and critical and systemic thinking (Dillon, 2002; Zohar & Dori, 2003; Zoller et al., 2002). Formal education, from elementary school to postgraduate level, strives to produce pre-service teachers who master analytical, problem-solving, and critical thinking skills.

This multi-method approach gave pre-service teachers the opportunity to enhance their analytical skill through diverse activities, such as analyzing texts and evaluating others' opinions. Analytical skill refers to the ability to make decisions, in order to resolve both complex and uncomplicated problems, based on the information gathered. This ability is necessary for workers to solve problems that occur in the workplace and to maintain

productivity, as well as smooth functioning throughout the workplace.

Critical thinking requires a variety of skills, such as the ability to identify the source of information, to analyze its credibility, to compare such information to prior knowledge, and to form conclusions (Linn, 2000). Instructors should facilitate and encourage pre-service teachers' creative and critical thinking skills, and not concentrate too much or be too dependent on textbooks and their schools' aspirations, which are usually exam-oriented (Kabilan, 2000).

Pre-service teachers from any disciplines need to familiarise themselves with thinking analytically and critically. Phang et al. (2011) stated that all engineers should be inquisitive, analytical and critical. This statement was based on the fact that all engineers had to deal with a variety of theoretical concepts expressed in models, such as physical models of building structure systems, mechanical and electrical systems, and many others. These models should be embodied in forms that can be easily realised into actual structures. The significance of developing engineering pre-service teachers' critical thinking in their professional careers was recognized by Andreu-Andres et al. (2009), Kobzeva (2015) and Melles (2008).

In the globalization era, there is rapid dissemination of diverse ideas, techniques of production, and results of production. In relation to the world of education, this rapid process demands quick action, both from schools and pre-service teachers, to process information and apply it actively in the learning process. Through this learning process, pre-service teachers can apply the knowledge they have gained to new situations encountered in real life, by applying the skill of problem-solving. This method is known as problem-based learning and is usually undertaken collaboratively or jointly. Grover (2014) defined collaborative learning as "an active learning technique where pre-service teachers work and learn together in groups to accomplish shared goals". This technique provides pre-service teachers with the opportunity to enhance their critical skills through activities, such as exchanging ideas in a discussion, teaching, and learning with peers. Collaborative learning encourages the development of critical thinking through discussion, clarification of ideas, and the evaluation of other people's ideas. This type of learning is beneficial in improving critical thinking and problem-solving skills (Gokhale, 1995). A pre-service teacher with a high level of critical thinking usually will be more successful in defining and solving problems (Susar et al., 2015). The ability to solve problems can be gained from creative thinking which, according to Jonāne (2015), has a powerful connection to the development of meaningful learning and transfer skills.

Research has shown that problem-based learning develops pre-service teachers' attitudes such that they are more positive and encouraging in their approach to learning and helps pre-service teachers to retain knowledge longer. With a problem-based

learning approach in a collaborative learning setting, learners have the opportunity to communicate with each other, exchange diverse ideas and knowledge, or develop questions in a conceptual framework. Collaborative learning activities do not supersede lectures by the teacher, listening, or note-taking; those activities were retained and formed the basis of discussion group activities (Smith & Mc Gregor, 1992).

Politsinsky et al. (2015) stated that "Problem-solving allows: - understanding and learning the basic laws and equations, forming of the idea about their peculiarities and boundaries of application; - developing the skills and ability to use general laws for solving specific and practical tasks. The success in problem-solving is determined by the skill to perform analysis of the engineering situation, described in the problem, which is based on the skill to sort out the main thing".

Activities carried out during the educational process are directed to cultivate the ability of pre-service teachers such that they are not only able to acquire knowledge and understand ideas but can also synthesise thoughts and evaluate concepts (Brierton et al., 2016). One method of instilling HOTS among pre-service teachers is by encouraging them to actively participate in educational discourse. This term refers to activities involving discussion and the exchange of ideas, either verbal or written. In educational discourse, pre-service teachers discuss ideas, teach their peers, and learn with each other. In this research, this was accomplished through the collaborative problem-based session. This method provides an opportunity for pre-service teachers to communicate their understanding, as well as to build others' ideas (Barak & Rafaeli, 2004).

Summarisation is the process in which one presents a summary of a topic by extracting important information from textual sources (Mohan et al., 2016). In this study, summarisation was found to be helpful in developing pre-service teacher HOTS, especially the skills of analyzing and identifying information. The attainment of all of the pre-service teachers over time was associated with their involvement in Lesson Study (Had & Jopling, 2016).

CONCLUSION

Based on the above discussion, a multi-method approach to a learning process has the potential to develop the HOTS of pre-service teachers in terms of analytical and critical thinking. Self-directed learning enhanced analytical and critical thinking skills through activities involving identifying the source of information, analyzing its credibility, reflecting the consistency of information, and making conclusions. Collaborative problem-solving similarly enhanced these skills through activities in which the teachers exchanged ideas in a discussion, analyzed others' opinions, identified the appropriate opinions, and came to a conclusion with regard to diverse ideas. Summarisation was also found to be helpful in developing skills relating to analyze and identify information. Applying a multi-method approach that is tailored

to the characteristics and conditions of the pre-service teachers in each of the learning environments will improve their HOTS. The contribution of this article is to provide teachers and lecturers with information on how to design and implement a multi-method approach in their classroom learning to develop the HOTS of learners.

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REFERENCES

Anderson, M. C. M., & Thiede, K. W. (2008). Why do delayed summaries improve metacomprehension accuracy? *Acta Psychologica*, *128,* 110-118.

Andreu-Andres, A., Garcia-Casas, M., & Rising, B. (2009). Assessment of pre-service teacher participation and critical thinking in engineering pre-service teachers' teamwork. *WSEAS Transactions on Advances in Engineering Education*, *12*(6), 464-477.

Barak, M., & Rafaeli, S. (2004). Online question-posing and peer-assessment as means for Web-based knowledge sharing. *International Journal of Human-Computer Studies*, *61*, 84-103.

Barber, M., & Mourshed, M. (2007). *How the world's best-performing school systems came out on top (The McKinsey report*). London, England: McKinsey & Company.

Bicknell-Holmes, T., & Hoffman, P. S. (2000). Elicit, engage, experience, explore: Discovery learning in library instruction. *Reference Services Review, 28*(4), 313-322.

Bonwell, C. C. (1998). *Active learning: Energizing the classroom*. Green Mountain Falls, USA: Purdue.edu.

Brierton, S., Wilson, E., Kistler, M., Flowers, J., & Jones, D. (2016). A comparison of HOTSs demonstrated in synchronous and asynchronous online college discussion posts. *North American Colleges and Teachers of Agriculture*, *60*(1), 14-21.

Cerbin, W., & Kopp, B. (2011). *Lesson study guide*. Retrieved October 11, 2015, from http://www.uwlax.edu/sotl/lsp/guide.

Creswell, J. W. (2014). *Research design: Qualitative, quantitative, and mixed methods approaches* (4th ed.). California, USA: Sage.

Dillon, J. (2002). Perspectives on environmental education-related research in science education. *International Journal of Science Education*, *24*, 1111-1117.

Din, N., Haron, S., & Mohd, R. (2016). Can self-directed learning environment improve quality of life ? *Procedia - Social and Behavioral Sciences*, *222*, 219-227. http://doi.org/10.1016/j.sbspro.2016.05.150

Esa, A., Padil, S., Selamat, A., & Idris, M. T. M. (2015). SoSTeM model development for application of soft skills to engineering students at Malaysian polytechnics. *International Education Studies*, *8*(11), 204-210.

Fernandez, C. & Yoshida, M. (2004). *Lesson study: A Japanese approach to improving mathematics teaching and learning*. Mahwah, USA: Lawrence Erlbaum Associates, Publishers.

Gokhale, A. A. (1995). Collaborative learning enhances critical thinking. *Journal of Technology Education*, *7*(1), 22-30. Retrieved October 15, 2015, from http://scholar.lib.vt.edu/ejournals/JTE/v7n1/gokhale.jte-v7n1.html.

Grover, K. (2014). Teaching sustainable crop production through collaborative learning. *NACTA Journal*, *58*(2),177-178.

Had, M., & Jopling, M. (2016). Problematizing lesson study and its impacts : Studying a highly contextualised approach to professional learning, *Teacher and Teaching Education*, *60*, 203-214.

Jao, L., & Mcdougall, D. (2015). The collaborative teacher inquiry project: A purposeful professional development. *Canadian Journal of Education, 38*(1), 1-22.

Jonāne, L. (2015). Using analogies in teaching physics: A study on Latvian teachers views and experience. *Journal of Teacher Education for Sustainability*, *17*(2), 53-73.

Kabilan, M. K. (2000). Creative and critical thinking inlanguage classrooms. *The Internet TESL Journal, 6*(6), 1-3. Retrieved Oktober 10, 2016, from http://iteslj.org/Techniques/Kabilan-CriticalThinking.html

Kapenieks, J. (2016). Educational action research to achieve the essential competencies of the future. *Journal of Teacher Education for Sustainability*, *18*(1), 95-110.

Kobzeva, N. (2015). Scrabble as a tool for engineering students' critical thinking skills development. *Procedia - Social and Behavioral Sciences*, *182*, 369-374. http://doi.org/10.1016/j.sbspro.2015.04.791

Kuhn, D. (2005). *Education for thinking*. Cambridge, England: Harvard University Press.

Larsson, K. (2017). Understanding and teaching critical thinking - A new approach. *International Journal of Educational Research*, *84*(December 2016), 32-42. https://doi.org/10.1016/j.ijer.2017.05.004

Lewis, C. (2009). What is the nature of knowledge development in lesson study? *Educational Action Research*, *17*(1), 95-110.

Lewis, C., Perry, R., & Murata, A. (2006). How should research contribute to instructional improvement ? The case of lesson study. *Educational Researcher*, *35*(3) 3-14.

Limbrick, L., Buchanan, P., Goodwin, M., & Schwarcz, H. (2010). Doing things differently: The outcomes of teachers researching their own practice in teaching writing. *Canadian Journal Of Education, 33*(4), 897-924.

Linn, M. C. (2000). Designing the knowledge integration environment. *International Journal of Science Education*, *22*(8), 781-796.

Mohan, M. J., Sunitha, C., Ganesh, A., & Jaya, A. (2016). A study on ontology based abstractive summarization. *Procedia - Procedia Computer Science*, *87*, 32-37. http://doi.org/10.1016/j.procs.2016.05.122.

Melles, G. (2008). Teaching critical appraisal skills to postgraduate, English as a second language, engineering students. *Australasian Journal of Engineering Education*, *14*(2), 23-32.

Miri, B., David, B., & Uri, Z. (2007). Purposely teaching for the promotion of higher-order thinking skills: A case of critical thinking. *Research in Science Education*, *37*, 353-369. http://doi.org/10.1007/s11165-006-9029-2

Mosca, J., & Howard, L. (1997). Grounded learning: Breathing live into business education. *Journal of Education for Business*, *73*, 90-93.

Morris, A. (2009). The stretched academy: The learning experience of mature students from under-represented groups. In *The future of higher education: Policy, pedagogy and the student experience* (pp. 99-111). New York, USA: Continuum International Publishing Group.

Myers, J. (2013). Creating reflective practitioners with preservice lesson study. *International Journal of Pedagogies and Learning, 8*(1), 1-9.

Organisation for Economic Co-operation and Development. (2015). *Education in Indonesia: Rising to the challenge*. Paris, France: OECD Publishing. http://dx.doi.org/10.1787/9789264230750-en

Organisation for Economic Co-operation and Development. (2016). *Education at a glance 2016: OECD indicators*. Paris, France: OECD Publishing. http://dx.doi.org/10.1787/eag-2016-en

Papert, S. (2000). What's the big idea?: Toward a pedagogy of idea power. *IBM Systems Journal*, *39*(3/4), 720-729.

Phang, F. A., Ali, M. B., Bakar, M. N., Zanzali, N. A. A., Rahman, N. F. A., Mohtar, L. E., … & Puteh, M. (2011). Engineering elements profile among first- and final- year engineering students in Malaysia. *2011 IEEE Global Engineering Education Conference (EDUCON) – Learning Environments and Ecosystems in Engineering Education* (pp. 70–73). Amman, Jordan: IEEE.

Pineteh, E. A. (2012). Using virtual interactions to enhance the teaching of communication skills to information technology students. *British Journal of Educational Technology*, *43*(1), 85-96. http://dx.doi.org/10.1111/j.1467-8535.2011.01193.x

Politsinsky, E., Demenkova, L., & Medvedev, O. (2015). Ways of students training aimed at analytical skills development while solving learning tasks. *Procedia - Social and Behavioral Sciences, 206*, 383-387. http://doi.org/10.1016/j.sbspro.2015.10.070

Saito, E. (2012). Strategies to promote lesson study in developing countries. *Lesson study in developing countries*, *26*(6), 565-576. http://doi.org/10.1108/09513541211251398

Saito, E., & Atencio, M. (2013). A conceptual discussion of lesson study from a micro-political perspective: Implications for teacher development and pupil learning. *Teaching and Teacher Education, 31,* 87-95. http://doi.org/10.1016/j.tate.2013.01.001

Smith, B. L., & MacGregor, J. T. (1992). What is collaborative learning? In *Collaborative learning: A sourcebook for higher education.* New York, USA: National Center on Postsecondary Teaching, Learning, & Assessment, Syracuse University.

Susar, F., Saygi, C., & Halil, I. (2015). Determine the relationship between the disposition of critical thinking and the perception about problem solving skills. *Procedia - Social and Behavioral Sciences, 191*, 657-661. http://doi.org/10.1016/j.sbspro.2015.04.719

Thiede, K. W., & Anderson, M. C. M. (2003). Summarizing can improve metacomprehension accuracy. *Contemporary Educational Psychology*, *28*, 129-160.

Watt, J. X., Feldhaus, C. R., Sorge, B. H., Fore, G. A., Andrew, D., & Marrs, K. A. (2014). The effects of implementing recitation activities on success rates in a college calculus course. *Journal of the Scholarship of Teaching and Learning, 14*(4),1-17. http://doi.org/10.14434/josotl.v14i4.12823

Yee, M. H., Yunos, J. M., Othman, W., Hassan, R., Tee, T. K., & Mohamad, M. M. (2015). Disparity of learning styles and higher order thinking skills among technical students. *Procedia - Social and Behavioral Sciences*, *20*(4), 143-152. http://doi.org/10.1016/j.sbspro.2015.08.127

Yusop, M., Hadi, A., Hassan, R., Rashid, A., Razzaq, A., & Zaid, M. (2015). Application of thinking skills in career: A survey on technical and vocational education training (tvet) qualification

semi-professional job duties. *Procedia - Social and Behavioral Sciences*, *211*(September), 1163-1170. http://doi.org/10.1016/j.sbspro.2015.11.155

Zohar, A., & Dori, Y. J. (2003). HOTS and low achieving pre-service teachers: Are they mutually exclusive? *Journal of the Learning Sciences*, *12*(2), 145-183.

Zoller, U., Dori, Y., & Lubezky, A. (2002). Algorithmic, LOCS and HOCS (chemistry) exam questions: Performance and attitudes of college pre-service teachers. *International Journal of Science Education*, *24*(2), 185-203.