Assessing pre-service science teachers’ technological pedagogical content knowledge (TPACK) on kinematics, plant tissue and daily life material

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Abstract. The purpose of this study was to examine pre-service science teachers’ technological pedagogical content knowledge (TPACK) on integrated science. Ten questions were implemented to 21 pre-service science teachers during school science course. Science topics involved was kinematics, plant tissue and daily life materials. During a semester, PSTs were asked to analyze the science contents demanded by Indonesian Curriculum. Moreover, the questions were given to measure PSTs’ seven constructs of TPACK. Data technological content knowledge (TCK) as the best construct posing by PSTs which is 95.24. The lowest construct is content knowledge (CK) which is 20.24. This finding implies the necessity of program promoting PSTs’ content in subject matter course specifically for kinematics. The score of pedagogical knowledge (PK) is 71.43. The score of PCK is 38.10. The score of TK, TPK and TPACK are 80.95, 61.90 and 80.95 respectively. Thus, it is essential to prepare the PSTs ability to connect science topics and the nature of science and use of various ways of representation or examples to deliver certain content. Moreover, it is believed that the PSTs low ability to comprehend the context is the most factor influencing their low PCK.

1. Introduction
The effectiveness of technology implementation in science teaching is currently being a concern [1]. Numerous studies found problems on digital technology integration into science teaching. A dominant factor causing the problem is teachers’ technological pedagogical and content knowledge (TPACK). Thus, teachers and pre-service teachers are strongly recommended to improve their capability in integrating technology into their teaching [2].

Technological pedagogical and content knowledge (TPACK) is knowledge connected to teachers’ ability in integrating technology into their classroom effectively [3]. TPACK consists of seven constructs which are three fundamental and four interplay constructs. Three fundamental domains are content knowledge (CK), technological knowledge (TK), and pedagogical knowledge (PK). Those three
domains interact each other producing the interplay constructs, that, pedagogical content knowledge (PCK), technological content knowledge (TCK), technological pedagogical knowledge (TPK) and technological pedagogical and content knowledge (TPACK).

Various studies had been conducted to unpack pre-service and in-science teachers’ TPACK. It is found that Technological pedagogical knowledge is believed to be factor that has the strongest relationship to TPACK [4]. Science teachers’ experience in integrating technology into science learning is limited by their less technological knowledge [5]. There is no significant relationship between value added model score and individual TPACK constructs [6]. In addition, there are three types of technology integration posed by science teachers. The types are technology-infusive (TI), technology transitional (TR), and planning and design (PD) [7]. However, there has been no study investigating pre-service science teachers’ TPACK in detail manner. This study was aimed at investigating pre-service science teachers’ TPACK on certain science contents. The science contents chosen were ‘kinematics, plant tissue and daily life material’.

2. Method

A descriptive method was used to examine pre-science teachers (PSTs)’ TPACK on ‘kinematics, plant tissue and daily life material’. Twenty one PSTs joined the study in the context of the study is school science 1, that is, a course aiming at strengthening pre-service science teachers’ contents as well as pedagogical knowledge. During a semester, PSTs were asked to analyse the science contents demanded by Indonesian Curriculum. The topics were ‘kinematics, plant tissue and daily life material’.

This study used written test consisting of 10 questions. Each of questions were arranged to measure certain construct of TPACK. Content knowledge were assessed by two questions asking about kinematics, one question asking about plant tissue and one question asking about daily life material. Pedagogical knowledge (PK) was assessed using a question about inquiry learning. Pedagogical content knowledge (PCK) was assessed using a question about the most appropriate strategy to encourage students in learning Newton Law I.

PSTs’ pedagogical content knowledge was assessed using question about the most appropriate strategy to encourage students in learning Newton’s Law I. Technological knowledge (TK) was assessed using question about software for data processing program. Technological content knowledge (TCK) was assessed by asking the learning software below best used for teaching kinematics. The condition supported by using animation in teaching kinematics was asked to assessed PSTs’ Technological pedagogical knowledge (TPK). Furthermore, PSTs’ were asked how the use of interactive multimedia helps improve students’ comprehension in learning kinematics for exploring their Technological pedagogical and content knowledge (TPACK).

3. Result and discussion

This part describes the seven constructs of TPACK. Data gained are expressed in chart. Moreover, an explanation is given accomplished by brief discussion.

3.1. The PSTs’ seven constructs of TPACK

In this study, PSTs were asked to answer questions addressing seven constructs of TPACK. The data of PSTs’ seven constructs of TPACK is shown in figure 1.

![Figure 1. The PSTs’ seven constructs of TPACK.](image-url)
Figure 1 shows the average score of PSTs' on every TPACK constructs. The data reveals that the highest score is reached for technological content knowledge which achieves 95.24. The lowest score is on content knowledge which is 20.24. The score of pedagogical knowledge is 71.43. The score of PCK is 38.10. The score of TK, TPK and TPACK are 80.95, 61.90 and 80.95 respectively. This finding reveals the low score of PSTs’ CK particularly in learning kinematics. In order to unpack PSTs’ content knowledge details, the average score of CK for each topic is shown in table 1.

| No | Content               | Average score |
|----|-----------------------|---------------|
| 1  | Kinematics            | 7.14          |
| 2  | Plant tissue          | 47.62         |
| 3  | Daily life materials  | 19.05         |

Table 1 depicts the average score for the three assessed contents. The PSTs achieve the lowest score on Kinematics. The score for plant tissue and daily materials are 47.62 and 19.05 which are considered to be low either. This finding shows PSTs' low content knowledge. Nevertheless, PSTs’ TCK and TPACK reach high score which are 95.24 and 80.95. This finding implies that there is no association between content knowledge and the two interplay constructs of TPACK. CK is found to be not in line with TCK. CK is believed as predictor for PCK and TPACK [8]. On the other hand, in science teaching especially, pre-service teacher should reached by technological content knowledge to build learning experience in their classroom [9].

3.2. Pre-service science teachers’ fundamental domain of TPACK

TPACK is built by three fundamental domain which are CK, PK and TK [10]. Within this study, TK is found to be the highest domain achieved by PSTs that is reaching 80.05. PK is the second highest that is 38.10. The lowest score is for CK, which is 20.24. This finding implies the need of preparation course for those three domains. CK is knowledge about specific content [10]. Provisioning in all science content course will help PSTs to master the content deeply and broadly. PK is knowledge about pedagogy. Preparation in courses delivering learning theory, teaching strategy, curriculum and cognitive development will help the PSTs to better prepare their pedagogical knowledge before they start to develop interplay constructs. Similarly, technological knowledge will better help the development of TPACK.

3.3. Pre-service science teachers’ PCK and TPACK

Pedagogical content knowledge is knowledge about strategy for teaching certain subject matter [11]. Technological pedagogical and content knowledge (TPACK) is considered to be the result of interaction between knowledge of technology and PCK [8]. Data in figure 1 shows pedagogical content knowledge as the second lowest construct. Meanwhile, technological knowledge achievement is very high. This finding indicates that TPACK is not literally associated with the fundamental domains. An interaction technological knowledge and pedagogical content knowledge is needed to support PSTs’ TPACK as a comprehensive knowledge.

PCK is built of PCK-CK which needs the accuracy of CK. It is important to connect between topics and the nature of science and use of various modes of representation or examples to deliver certain content [12]. The low score of content knowledge proves that without deep understanding of the concept and the nature of science, PSTs will have the low PCK either. Another internal construct of PCK is and contextual knowledge (PCK-CxK) [12]. The context provided in the instrument measuring PCK within this study is Newtonian Law I. The PSTs’ were asked to find the most appropriate strategy to encourage students when learning Newtonian Law I. Based on this study, it is believed that the PSTs low ability to comprehend the context is the most factor influencing their low PCK.
3.4. Pre-service science teachers’ TCK and TPACK
Technological content knowledge (TCK) refers to knowledge about appropriate technology for teaching particular content [10]. PSTs’ TCK in this study reach 92.24 which is very high. This fact indicates the strong support of technological knowledge in building TCK. Meanwhile, content knowledge does not deeply affect this interplay subscale. This finding implies the necessity of attention on pre-service science teacher technological knowledge to prepare their TCK.

Based on the study, the score of TCK is not in line with the score of TPACK. This finding echoes perspective stating the most influential domain of TPACK in TK and PCK. Various intervention can be implemented for enhancing technological pedagogical and knowledge, such as, technology infused lesson planning [13], using wikis and collaborative learning [14], and program by situated learning theory [15].

3.5. Pre-service science teachers’ TPK and TPACK
Data shows PSTs’ score on technological pedagogical content knowledge (TPK) is 61.90. The finding indicates moderate level of TPK. TPK refers to the knowledge about the utility of technology to support effective teaching strategy [16]. TPK can be reviewed by means of examining level of technology integration which are: 1) adaptation 2) adoption 3) entry 4) infusion 5) transformation [17]. Thus, in order to unpack the level of TPK specifically, a study on PSTs’ level of technology should be conducted. Moreover, a study on constrains connected to the implementation of technology into classroom activities is necessary because TPK is viewed as knowledge of the influence of technology in teaching and learning, as well as the affordances and constraints on technology associating with pedagogical strategy to conduct classroom activities [18].

4. Conclusion
Based on the study the highest score of PSTs’ TPACK is reached for technological content knowledge (TCK) which is 95.24. The lowest score is on content knowledge (CK) which is 20.24. This finding implies the need of program preparing PSTs’ content in subject matter course especially for kinematics. The score of pedagogical knowledge (PK) is 71.43. The score of PCK is 38.10. The score of TK, TPK and TPACK are 80.95, 61.90 and 80.95 respectively. Thus, it is important to prepare the PSTs for connecting between topics and the nature of science and use of various modes of representation or examples to deliver certain content. Moreover, it is believed that the PSTs low ability to comprehend the context is the most factor influencing their low PCK.

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