

Research Article

Implementation of TPACK through Lesson Study: Pre-service Science Teachers' Initial Knowledge in an Earth and Space Science Course

Aristo Hardinata^{1*}, Ely Djulia¹, Halim Simatupang¹, Rizky Hasanah², Budi Harianto².

¹Department of of Biology, Science Education Program, Universitas Negeri Medan, Medan, Indonesia

²Pre-Service Science Teacher, Department of Biology, Science Education Program, Universitas Negeri Medan, Medan, Indonesia

ORCID

Aristo Hardinata: <https://orcid.org/0000-0001-8660-3440>

Ely Djulia: <https://orcid.org/0000-0002-4204-6299>

Halim Simatupang: <https://orcid.org/0000-0003-1349-1286>

Abstract.

Teaching and learning at school cannot be replaced by robots or technology. However, teachers who cannot adapt to technological developments will be unable to compete in the field. TPACK is an educational theory that discusses the teacher knowledge needed to integrate technology into education effectively. Teachers with TPACK skills cannot only prepare students with scientific knowledge, but they can also integrate technology into science learning. Therefore, the long-term goal of this research is to instill the TPACK aspect of pre-service science teachers in order to prepare teachers who can compete in the development of Industry 4.0. The research method was descriptive quantitative research, where the process of implementing aspects of TPACK through lesson study was explained clearly, as well as descriptions of meaningful numbers related to the initial TPACK abilities of pre-service science teachers. A random sampling method was used to select 62 pre-service science teachers who attended the earth and space science course in the science education program at Universitas Negeri Medan. The results of the study indicated that the TPACK ability level of pre-service science teachers was generally still low. It is hoped that this initial data can be a reference for researchers in implementing aspects of TPACK through lesson study in earth and space science courses.

Keywords: TPACK, Pre-service Science Teachers, Earth and Space

1. INTRODUCTION

In order to meet the global need for human resources who will be technologically literate, of course all aspects in the field of education must be prepared to suit industry demands, both in terms of curriculum, students, and teachers who are facilitators for students in the learning process. This was further strengthened by the fact that during the Covid-19

Corresponding Author: Aristo Hardinata; email: aristohardinata@unimed.ac.id

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Pandemic, learning in schools could not be carried out using the face-to-face method, which would be dangerous and possibly increase the spread of Covid-19. Therefore, the government requires every school to implement distance learning in the process requiring teachers to be able to master internet and computer technology in online and online learning [1]. But in reality, based on research before that there is still a low awareness of teachers in Indonesia in using the internet and computers in learning for various personal reasons as well as facilities and others [2]. This is certainly a challenge that must be solved immediately considering the importance of mastering technology by students as future generations. Over the years, teachers have always found that they can integrate digital technology into their teaching practice [3]. Therefore, its presence is simple, to form students who will use technology, teachers must first be prepared who are able to master technology in the learning process. Therefore, lecturers who are engaged in teacher education must be able to use technology effectively in their lectures so that pre-service teachers can gain learning experience using technology [4].

Talking about preparing teachers who are able to integrate technology in learning, it is always associated with the development of the technological pedagogical content knowledge (TPACK) framework [5]. The TPACK framework covers several domains of teacher knowledge consisting of: the technological knowledge (TK); the content knowledge (CK); the pedagogical knowledge or pedagogic knowledge (PK); the technological content knowledge (TCK); the pedagogical content knowledge (PCK); and the technological pedagogical knowledge or knowledge of pedagogical technology (TPK). In the last decade or so, the TPACK framework has quickly become a widely used conceptual framework in the field of teacher education, especially since teacher education programs began redesigning their curricula to provide a systematic and meaningful way of preparing literate teachers to integrate technology and education [5–7]. The Earth and Space Science course is one of the mandatory courses that must be followed by prospective science teachers at the Science Education Study Program, Universitas Negeri Medan. This course is taught with topics consisting of composition and layers of the atmosphere, climate classification, seasons and weather, lithosphere layers, rocks, volcanism, natural disasters, the universe, the solar system, the sun, planet earth, stars, and celestial bodies. these topics contain the concepts of earth and space science and relate to the technologies required in their application. Therefore, to be able to teach these subjects well to students, teachers must have good pedagogical knowledge, for example, what kind of approach is needed to provide understanding to students, what learning models are needed, what learning media are appropriate, and able to arrange instrument that can measure students' ability to this subject. In

addition to pedagogic abilities, teachers must also master the previously mentioned content. and last but not least, teachers must also have technological capabilities in the application of concepts related to earth and space science subject matter.

Various studies have been carried out related to earth and space science courses. Lindell et al (2006) in their research stated that in order to prepare professional teachers for learning earth and space science, the course “Instructional Techniques in Astronomy” was developed and looked at the effectiveness of these courses on teacher professionalism from the perspective of teachers and instructors [8]. Love et al (1993) in their article also explained that NASA collaborated with Jackson State University to develop programs for teachers and students to have an interest and understanding of Earth System Science. This program aims to prepare individuals who are professionals in the ESS field and increase students’ interest in ESS [9]. In addition, Miller (1993) mentions that the WGBH Educational Foundation collaborates with various parties such as NASA Education, and scholastic software to develop innovative and interactive learning media for junior high and high school students so that they can achieve their goal of making education successful through telecommunications [10].

Based on the literature study that researchers have done, there is very little and even no specific research on how to design good learning to apply earth and space science to students. Meanwhile, to be able to achieve a learning goal, it is necessary to have good preparation by a competent teacher. Therefore, to achieve this goal, the closest step that can be taken is to prepare prospective teachers at universities. In this study, lesson study was applied to see the professional development of teachers, especially in earth and space science learning materials. Lesson study consists of “Plan”, “Do”, and “See” stages. At the “Plan” stage, science teachers, lecturers and the entire lesson study team need to prepare learning designs along with what kind of learning tools will be developed to teach science teacher candidates so that they have TPACK competence and are able to teach earth and space science learning materials . For this reason, it is necessary to have prior knowledge of the ability of prospective science teachers related to TPACK and earth and space science course materials by conducting their initial competency test. With this initial knowledge of the ability of the prospective science teacher, it is hoped that the lesson study team can develop lecture designs and equipment for earth and space science lectures at the “Plan” stage and apply the lecture designs at the “Do” stage and then evaluate the design and equipment of lectures, so that optimal lecture designs and equipment are obtained to be able to prepare professional science teachers, especially in teaching earth and space science.

2. RESEARCH method

This research method was a descriptive-quantitative research methods, which aim to describe and reveal a problem, situation, event as it really was or reveal more in-depth facts about the conditions in the field about the TPACK ability of Pre-service science teachers in the Earth and Space Science course prior to the implementation of Lesson Study to improve the professionalism of Pre-service science teachers. This descriptive study only tries to describe clearly and sequentially to the research questions that have been determined before the researcher enters the field and there is no special treatment or hypothesis as a guide to the direction of the research. The quantitative approach in this study was to describe the results of the TPACK ability test of Pre-service science teachers who attend Earth and Space Science course at the Science education study program, Universitas Negeri Medan in the 2021/2022 academic year. In addition, interview data will also describe the knowledge of Pre-service science teachers about TPACK. The instrument used in this research is an essay question. The Essay questions used are structured in such a way as to follow the TPACK aspects, namely pedagogic knowledge, content, and technology related to earth and space sciences. The Essay developed consists of 30 questions consisting of 10 questions about pedagogy, 10 questions about content, and 10 questions about the application of technology in earth and space science. Data collection was done by giving essay questions that had been developed to prospective science teachers who had attended lectures on earth and space science in the science education study program at Universitas Negeri Medan, Indonesia. This study described the achievements of prospective science teachers in the TPACK aspect in earth and space science material by presenting the average score obtained by prospective science teachers in each aspect of TPACK.

3. result and discussion

In this section, it will be explained the findings of the average achievement of pre-service science teachers in each aspect of TPACK as well as differences in TPACK achievement results based on gender differences. The results of interviews with prospective science teachers about their opinions on TPACK will also be presented.

3.1. TPACK Ability of Pre-service Science Teachers on Earth and Space Science Course

The measurement of the TPACK ability of prospective science teachers in this study was carried out using the TPACK test measuring instrument that had been developed previously. This test measuring instrument consists of 20 questions, each of which is representative of the TPACK aspect, namely Knowledge Technology (TK), Content Knowledge (CK), Pedagogical Knowledge (PK), Technological Content Knowledge (TCK), Pedagogical Content Knowledge (PCK), and Technological Pedagogic Knowledge (TPK). The results of measuring the TPACK ability of pre-service science teachers can be seen in Fig. 1.

This TPACK capability measurement was carried out at the beginning of the Earth and Space Science course. This measurement aims to determine the teacher's initial ability to TPACK. It is hoped that the results of this measurement can be used as initial data or initial knowledge for further research, namely the application of TPACK-based learning through Lesson Study.

Figure 1 it can be seen that the TPACK ability of prospective science teachers in earth and space science courses is still below the average except for content knowledge (CK) abilities with an average of 80.3 and Pedagogical content knowledge (PCK) with an average score of 70.4. Further facts that can be seen from the graph show that all aspects of TPACK related to technology have an average score below 60, with a score of 55.5 for technological knowledge, 56.5 for technological content knowledge, and 57.2 for pedagogical technology knowledge. This is in line with Burak Demirtaş's (2021) research which found that there is a causal relationship between ICT integration and aspects of TPACK in teacher-candidate learning [11]. Based on this theory, it can be concluded that the prospective science teachers who take earth and space science courses really need the integration of ICT in the lecture process so that they are accustomed to using technology.

Based on the table data above, it can also be seen that the average TPACK score for science teacher candidates is in the sufficient category. This result is in line with the results of previous research conducted which found that the average TPACK ability of prospective chemistry teachers was in the sufficient category [12].

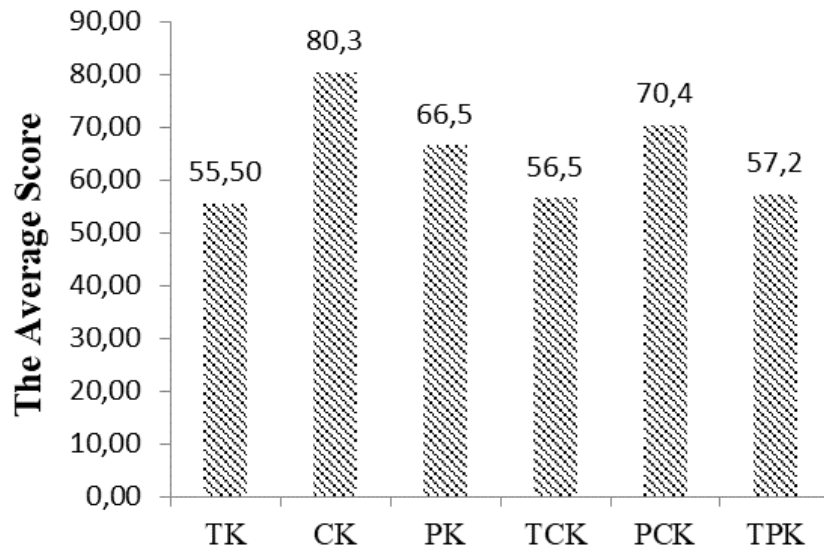
The lack of achievement of prospective science teachers in TPACK aspects such as TK, TCK, TPK, and other aspects cannot be ignored because to achieve TPACK competence, all aspects of TPACK must be fulfilled. Nova Susianti et al (2022) in their research found that almost all variables from TPACK, namely 12 variables have a direct

relationship with each other. Several variables that have a direct relationship include CK with TPACK; CK with PCK; CK with TCK; PK with TPACK; PK with PCK; PK with TPK; TK with TPACK; TK with TCK; TK with TPK; and TPK with TPACK [13]. Therefore, it can be concluded that all aspects of TPACK are related to each other and cannot be taught separately. To achieve good TPACK competence by pre-service science teachers, all aspects of TPACK must be mastered. This was in line with the results of previous research conducted which found that chemistry teachers did not have a perception of TPACK on electrolyte and non-electrolyte materials due to the teacher's lack of knowledge of technology. However, after the teacher was prepared for learning through the lesson study approach, in cycle 1 the teacher reaches the level of perception (Pn) and in cycle 2 the teacher is at the level of conception (Cn) [14]. This proves that the activities arranged in such a way through the lesson study approach can improve teacher competence.

The fact that the integration of ICT and TPACK in lectures or teacher training can affect teachers' TPACK abilities can be seen from the results of previous research who found that the average achievement of the TPACK criteria for biology teachers in the province of Aceh was in the very good and good categories [15]. The biology teachers in this assessment were experienced teachers and have educator certificates. Where an educator certificate in Indonesia can be obtained if the teacher has met the category and followed a series of tests which include tests for mastery of technology, pedagogy, and subject content. However, from this study, it was also found that there was no significant difference in TPACK competencies based on certification and teaching experience which was certainly a surprising fact. Therefore, with this finding, the writer wants to see how the influence of TPACK-based learning through Lesson Study can affect the TPACK competence of prospective science teachers in earth and space science courses.

3.2. TPACK Ability of Pre-service Science Teachers based on Gender Differences

In this study, researchers also looked at the differences in the achievements of pre-service science teachers in each aspect of TPACK based on gender differences. This measurement is expected to provide an overview of how gender differences affect the ability of teachers' TPACK. The results of measuring the ability of TPACK in each aspect based on gender can be seen in Fig. 2. It can be seen from Fig. 2 that the average score of male science teacher candidates is higher than female science teacher candidates in every aspect that involves technology such as TPK, TCK, and TK, although



TPACK Ability of Pre-service Science Teachers

Figure 1: TPACK ability of pre-service science teachers in earth and space science course.

the difference is not very significant. This is in line with the previous research who found that there was no significant difference between the ICT competence and TPACK of pre-service teachers based on gender differences [11]. Meanwhile, female science teacher candidates are superior to male teacher candidates in TPACK content and pedagogic aspects such as CK, PK, and PCK aspects.

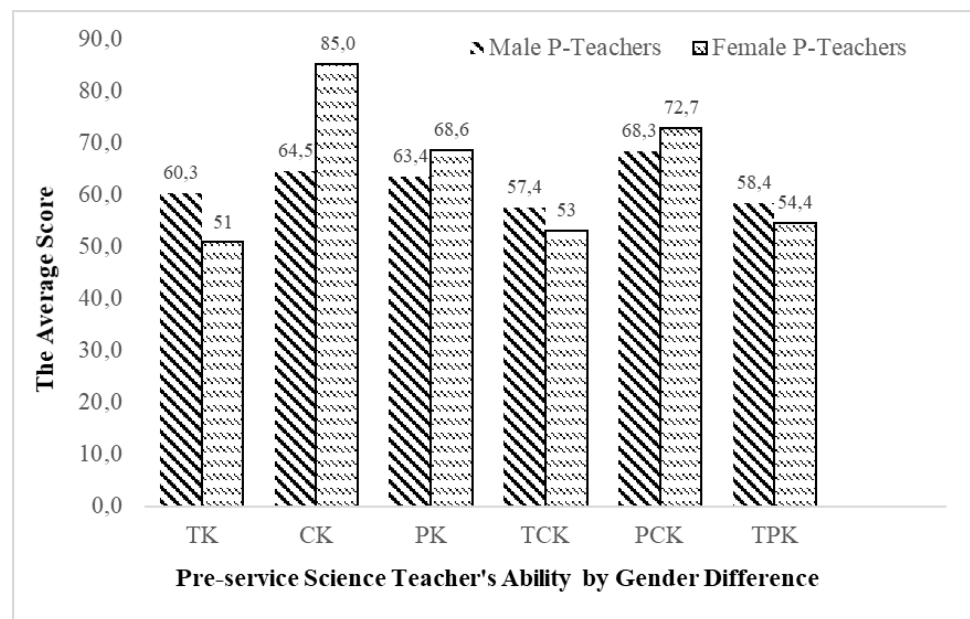


Figure 2: Pre-service science teacher's ability by gender difference.

3.3. Results of Interviews with Pre-service Science Teachers about TPACK in Earth and Space Science Courses

In this study, interviews were conducted with pre-service science teachers related to the TPACK concept to strengthen the previously obtained data. interviews about teachers' prior knowledge related to TPACK competencies can be seen in Table 1.

TABLE 1: Summary of some interview questions for science teacher candidates related to TPACK competencies.

| Questions | Answer | | |
|---|--------|----|----------|
| | Yes | No | Not Sure |
| Do you know the definition of the term TPACK? | 2 | 40 | 20 |
| Have you ever taken ICT courses in your study program before? | 0 | 62 | 0 |
| Have you ever taken courses related to pedagogy in your study program before? | 62 | 0 | 0 |
| Have you ever received lessons related to earth and space science in junior high or high school before? | 2 | 30 | 11 |
| Technology in learning is very important to be mastered at this time in order to compete with the times? | 0 | 50 | 12 |
| Technological, pedagogic, and content aspects of learning are as important for educating students in schools? | 0 | 62 | 0 |

Based on the results of the interviews above, it can be seen that more than 50% of the prospective science teachers interviewed had never heard of the term TPACK. Another interesting fact is that the prospective science teacher participants who participated in this study had previously taken courses related to pedagogy and conversely, they had never taken ICT courses. This result is certainly in line with their TPACK test results where the average test results related to technology are in the low category, while those related to pedagogics are in the medium category. Likewise with the content of earth and space science they had previously obtained at school so that test results related to content were obtained in the medium category.

Based on the interview, it was also found that almost 90% of pre-service science teachers who participated in this study agreed that technology was important in learning, and they agreed that aspects of technology, pedagogy, and content were just as important when teaching students in school. The previous research stated that based on a literature review on TPACK, TPACK has a significant impact on teachers and prospective teachers. Professional teachers are teachers who have all TPACK knowledge and are able to apply it through technological knowledge [16].

4. CONCLUSION

Based on the results of the research and discussion above, it can be concluded that the TPACK competence of pre-service science teachers in earth and space science courses was still in the low category, especially in aspects related to technology, and in the medium category in aspects related to pedagogy and content. There were differences in gains in several aspects of TPACK based on gender differences, but the differences were not significant. Based on the interview, it can also be concluded that the courses they took previously related to ICT, pedagogics, and earth and space science content can affect their TPACK competence. Based on the results of this study, it can be concluded that it is necessary to develop training for prospective science teachers, especially based on the TPACK aspect. One of the efforts that can be made for future research is to develop lecture designs in science education study programs through lesson study on all subjects to prepare prospective science teachers.

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