Measurement of TPACK self-efficacy for pre-service science teachers

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Abstract. This study aimed to measure the TPACK self-efficacy of prospective science teachers based on Koehler and Mishra's technological pedagogical content knowledge (TPACK) theoretical framework. The instrument in this study was developed by Kiray, which consists of seven subscales; the total number of items was 55. To test the instrument, 158 students were used as respondents. Research respondents comprised 312 students in a senior year from the Faculty of Math and Science Universitas Negeri Semarang. Confirmatory factor analysis was performed for the construct validity of the scale. The analysis results showed that the number of items from 55 to 49 items and eight subscales. The Cronbach alpha internal reliability coefficient was calculated using SPSS 20.0 as 0.968; reliability composite 0.959, which means the scale developed was feasible to measure TPACK self-efficacy perception of pre-service science teachers. The results obtained indicate that the average TPACK self-efficacy was in the medium category.

1. Introduction
The era of globalization demands the ability of teachers more than ever. The teaching and learning process is not only transferring knowledge but also training skills. Teaching skills require a lot of experience and years to master them by handling many assignments simultaneously [1]. Nowadays, it is not enough for a teacher to have only pedagogical and content skills, but also must have adequate technological skills. Pre-service teachers must be provided with effective tools and abundant experience because it is not easy to do. They need to be well informed, also given the awareness that with their abilities, teachers can have a tremendous effect on their surroundings [2]. Technology-based learning is called effective and innovative when the TPACK framework can make knowledge mutually integrated between technology, pedagogy, and content. A teacher must understand the learning material as well as students so that learning can be effective. In addition, experienced teachers can build on their knowledge based on students and different aspects of the classroom. They plan their learning carefully and adopt instructional and management routines more often [3].

TPACK is a combination of learning between the use of technology, content, and pedagogy initiated by Koehler and Mishra and implemented in the learning process in the classroom [4]. Technological Knowledge (TK) is also known as knowledge about computers, the internet/web, and digital materials [5]. Technological knowledge also includes the use of means of communication in the form of the internet, social networks, email, forums, chat, and so on; besides this, it can also be a research tool [6 7 8]. Digital technology consists of laptops, mobile phones, google, iPad, and so on as well as social
networking sites are now used by many people to complement the formal learning method; even several researchers try to investigate this phenomenon [9]. Content Knowledge (CK) is "knowledge of the actual subject matter that must be studied or taught". It means that the teacher must understand what they are going to teach to students and also the subjects [10]. In every knowledge, there are various kinds of different content, and the teacher must understand this, especially when teaching it to students. In Indonesia, science includes physics, chemistry, and biology. Pedagogical knowledge is the knowledge that discusses the process and practice or learning method. The component of pedagogical knowledge comprises classroom management, teaching strategies, techniques to evaluate, and the nature of the students. Akhtar also described that some of the factors that contribute to making the teaching process effective to be implemented consists of knowledge of the subject matter, knowledge of students, knowledge of the cognition of students, and knowledge of teaching and decision making [11]. Furthermore, teachers must also know how the nature of students, positive learning outputs and apply teaching and learning theory [12].

Pedagogical content knowledge is something that is related to how to blend the content and the pedagogy into understanding [13]. In each learning content, there is pedagogical content knowledge that is different from one another so that the combination of pedagogical and content can make it better. Technological content knowledge is knowledge related to how technology can contribute to learning content. This means that teachers must know exactly what content they are teaching and how it can be changed using technology. In short, technological content knowledge is dealing with how technology and content influence each other [10]. Technological pedagogical knowledge discusses how technology can shape the character of learning, or it can be said that PCK is the relationship between subjects and pedagogy [13]. The knowledge that must be mastered by teachers, namely integrating technology and learning, is called Technological Pedagogical Content Knowledge. The three basic components of knowledge consisting of content, pedagogy, and technology must be used appropriately so that teachers can have an intuitive understanding of the interactions between the three components. Overall, TPACK is the knowledge that unites content integration and pedagogical knowledge using technology [12].

Self-efficacy is the belief in a person that he can go through all kinds of obstacles and problems. Self-efficacy can be specific or general, and this self-belief has an effect on feelings, thoughts, and motivation [14]. Self-efficacy is also believed as self-belief in the ability to solve various problems and achieve the expected results. In addition, self-efficacy also affects what action to choose, how much effort is spent, and endurance to deal with it. A person with high self-efficacy also has great effort and will never give up [15]. In guiding teachers towards developing knowledge for teaching with technology, a useful method is needed. TPACK allows a teacher to be involved and motivated students to explore learning content to a greater level. It is further explained that the TPACK model shows that content knowledge that integrated technology and pedagogical skills can create effective and innovative learning. TPACK is important for prospective pre-service sciences teachers to be able to provide active and innovative learning. This study aimed to measure the TPACK self-efficacy of pre-service science teachers based on the Koehler and Mishra technological pedagogical content knowledge theoretical framework.

2. Method
This study used quantitative research methods, as respondents were 312 pre-service science teachers in a senior year from the Faculty of Mathematics and Natural Sciences, Universitas Negeri Semarang, consisting of physics, chemistry, and biology students. The TPACK scale used in this study was adapted from the results of [16] development by following Koehler and Mishra technological pedagogical content knowledge framework and was tested on 158 students. Initially, it consisted of 55 items, 7 subscales, then became 49 items and 8 subscales. Each item on the scale has a response category consisting of five options. In this study, SPSS 20.0 was used to calculate Cronbach's Alfa internal reliability coefficient. To determine the validity of the scale construct, confirmatory factor analysis was used, and the result was 55. Also, Kaiser Normalization, as well as Varimax rotation, were used to
measure the validity of each knowledge domain scale. The score levels of the instrument are high, medium, low, and very low.

3. Result and Discussion
The first TPACK self-efficacy scale factor analysis was composed of 7 subscales, 55 items, and ten subscales. After analysis, subscale 8 was reduced by 2 items; subscale 9 reduced by 2 items; and subscale 10 was reduced by 1 item, bringing the item to 50. Then on the remaining survey items, a second-factor analysis was carried out. It shows that 1 item must be discarded, so the final result is 49 items left. Furthermore, in the third rotation, the result becomes 8 subscales, consisting of technological knowledge, pedagogical knowledge, content knowledge, pedagogical content knowledge, technological content knowledge, technological pedagogical knowledge, technological pedagogical content knowledge, and technological pedagogical management. The Cronbach's Alfa internal reliability coefficient was calculated on the remaining items on each subscale. The alpha coefficient values ranged from 0.81 to 0.92 for the eight TPACK subscales. The results of the TPACK instrument show good internal consistency reliability. The following Table 1 shows the survey results of self-efficacy.

| Dimension                                | Self-efficacy (%) |
|------------------------------------------|-------------------|
| 1: Technological Knowledge               | 62.33             |
| 2: Pedagogical Knowledge                 | 59.97             |
| 3: Content Knowledge                     | 63.16             |
| 4: Pedagogical Content Knowledge         | 64.37             |
| 5: Technological Content Knowledge       | 53.44             |
| 6: Technological Pedagogical Knowledge  | 67.38             |
| 7: Technological Pedagogical Content Knowledge | 64.40 |
| 8: Technological Pedagogical Management | 63.22             |
| Average                                  | 62.28             |

The average TPACK self-efficacy of science teacher candidate students is 62.28, which indicates that the results are quite sufficient. Students who have confidence in themselves about how to organize, implement, solve problems and self-performance show that they have high self-efficacy [17]. Academic self-efficacy is considered as an internal source of information that can activate student motivation in the first stages of the behavioral process, meaning that the first weeks of learning are an important time for students so that it is hoped that schools can make programs to improve student academics which have an impact on increasing self-efficacy [18]. According to [15], achievement motivation is a driving force for someone to try to do something well and succeed. This encouragement can come from outside or from within himself so that students who show the best performance are students who have the motivation to excel. Therefore, self-efficacy can promote awareness aspects [19], both in preparing for certain tasks and in carrying out existing tasks. The medium category obtained from the research results is because the students have not implemented adequate teaching practices; they only practice peer-teaching twice. In the study of [20], Danielson describes teaching practice related to more than 70 elements which then becomes 20 components in four domains, consisting of: first, planning, and preparation, which refers to instructional skills and is related to learning objectives. Second, the classroom environment, namely skills that discuss how to create a class that is conducive to learning. Third, namely instruction, and fourth, is a professional responsibility. By conducting peer teaching, it is hoped that it can make a positive contribution to prospective teachers, such as the results of research
conducted by [21], which stated that peer teaching provides an opportunity for them to evaluate their strengths and weaknesses in teaching, besides that they can also learn about developed timing. Planning, asking questions, management of the class, using different materials and examples, and physical appearance during the teaching process.

The lowest self-efficacy score is technological content knowledge, and this is because pre-service teachers do not understand what technology should be applied in learning. Students are still in their early senior year and have not implemented peer teaching, so the utilization of technology content in learning is low. As explained by Koehler and Mishra, teachers are required to be creative and flexible when implementing technology in the classroom. Besides that, teachers must also understand how technology affects the content field [22]. Teachers need skills to transform the learning content; as pointed out by [23], the authors introduced Welliver's instructional transformation model, which describes the stages in the process of technology integration by teachers consisting of socialization, utilization, integration, reorientation, and revolution.

Based on the results, the pre-service science teachers showed a high score in technological pedagogical knowledge but a low score in technological pedagogical content knowledge. With the low scores obtained, pre-service teachers must be given training like [24] by conducting training in a learning environment that implements face-to-face blending learning environments and four main and 18 online sub-components. The results obtained were significant differences in the mean and post-test scores between the control class and the experimental class, which were quite significantly related to TPACK and classroom teaching skills. The important role that teachers have is how to integrate technology into learning because they have a responsibility for this. Therefore, teachers are expected to have the ability to use technology in education effectively [25 26 27].

4. Conclusion

The results of measuring TPACK self-efficacy of pre-service science teachers, which comprise of technological knowledge, content knowledge, pedagogical knowledge, pedagogical content knowledge, technological content knowledge, technological pedagogical knowledge, technological pedagogical content knowledge, and technological pedagogical management, were in the medium category. These results make it possible to improve academic achievement. Increasing knowledge about TPACK is very necessary because teacher knowledge will influence teacher actions in class.

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