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Comparison of Natural Science Teacher's TPACK Assessment Results based on Differences in Educational Background, Working Period, and Gender

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Abstract

Teacher knowledge is an aspect of dynamic and contextual competence. In the field of education, one form of knowledge considered suitable to global developments in the current 21st-century is teacher's technological pedagogical content knowledge (TPACK). For this reason, this study examines the natural science teacher assessment results, measured employing an essay instrument. The assessment was carried out based on group differences in three factors considered influencing the assessment results. A total of 250 natural science teachers in Banten Province were voluntarily given questions within the TPACK framework to be done online. Automatic scoring was applied in this assessment to get a consistent score from the answers given by the participants. The assessment score data were then analyzed by descriptive-quantitative research methods. The first results revealed in this study were based on educational background factors, where the highest mean score was obtained by a group of teachers with less suitable educational backgrounds. In the teacher group based on different working periods, the highest mean score was attained by the group of teachers with more than ten years of working period. In addition, the analysis results by gender indicated that the mean score of female teachers was slightly higher than that of male teachers. In this case, there was no significant difference in the scores between the groups based on the different tests performed on all the compared factors.

Keywords: TPACK, teacher assessment, essay instrument.

Introduction

In its report, SEAMEO INNOTECH (2010) described the primary framework summarized from various policies on teacher competency standards or teaching in several Southeast Asian countries, consisting of 1) professional knowledge, 2) professional skills, 3) professional characteristics, 4) ethics and personal/professional values, and 5) professional development and lifelong learning. These teacher competency standards can function, among other things, as a basis for teacher professional development, as has been made by the National Staff Development Council (2007) (in Maciejowska et al., 2015), with criteria comprising content knowledge, quality teaching, various learning needs, student learning environment, and teacher learning process. In addition, teacher competency standards can also be a framework or basis for teacher assessment instruments, such as the teacher competency test in Indonesia, which is based on pedagogical and professional competencies as part of teacher competency standards. Related to this, several studies have revealed teacher competency or performance measurement activities that showed the factors influencing it, with

varying results; in other words, there is no separate influencing factor, and there is a contextual influence.

Teacher competency testing and certification programs in Indonesia have also experienced several phases in the implementation process (Kuntarto, et al., 2019; Sumaryanta, et al., 2018). As a pre-certification test and pre-professional development program, the competency test is a national program for several specific purposes, including mapping and determining follow-up actions in continuous professional development. In this regard, the assessment on competency test activities and teacher certification employs instruments that have changed, whether used separately or in combination, in their implementation. The forms of instruments utilized include teacher portfolios, performance tests, peer assessments, and multiple-choice and description written tests. The changes or uses of a different assessment instrument are essentially based on various considerations relevant to the test purpose.

On the other hand, the increase in infrastructure and technology tools globally has enabled the broader use of technology, including enhancing its potential use in education (Njiku et al., 2020). However, previous policies that did not support the use of technology and innovation in education need to be changed significantly. Besides, teachers' use of information technology tools must be reinforced by policies that become standards in accordance with current conditions and sustainability (UNESCO, 2011). Several countries in Southeast Asia have also explicitly included technological knowledge in the teaching profession standards applicable in their countries, such as Brunei Darussalam and Singapore (SEAMEO INNOTECH, 2010). Moreover, several teacher standard documents in many countries have covered the ability to use communication and information technology as teacher standards (Permana et al., 2021). In the Indonesian context, one of the pedagogy and professional core competencies is the use of information and communication technology in learning and professional development (The Ministry of National Education, 2007). In this case, one of the frameworks that have begun to be widely applied in the teacher competency programs' assessment or development related to technology is technological pedagogical content knowledge (TPACK).

This TPACK framework is vital in the learning implementation because technological knowledge is more than just knowing about technology; it is a deep understanding of technology required to use it in effective learning, communication, problem-solving, and decision making (Koehler & Mishra, 2008, 2009). In this case, contextual constraints, such as the technology tool availability and the student population characteristics, have a major impact on the teacher's TPACK development. The TPACK framework has also been employed to frame other constructs believed to influence technology integration, such as self-efficacy and self-confidence in utilizing technology for effective learning (Graham et al., 2009). Further, TPACK will make effective use of technology and pedagogical techniques in a constructive way to teach content and can help solve difficulties faced by students (Koehler & Mishra, 2009).

Furthermore, Shulman's (1986) perspective on three content knowledge categories, (a) content knowledge, (b) pedagogical content knowledge, and (c) curricular knowledge, was developed by emphasizing technological problems in learning into the TPACK concept following global technological developments (Koehler & Mishra, 2006). Currently, technological pedagogical content knowledge (TPACK) has been deemed one of the most important models, which elucidates the teachers' competence to successfully teach with technology (Schmid et al., 2020). As a framework, TPACK is constructed with basic and integrative knowledge: content knowledge (CK), pedagogical knowledge (PK), technological knowledge (TK), pedagogical content knowledge (PCK), technological content knowledge (TCK), technological pedagogical knowledge (TPK), and technological

pedagogical content knowledge (TPCK) (Koehler & Mishra, 2006; Koehler et al., 2013). In addition, three basic elements of teacher knowledge, including content (C), pedagogy (P), and technology (T), are central, in which the diagram also displays the connections, interactions, affordability, and boundaries between the three components in the form of PCK, TPK, TCK, and TPCK and are within the learning context framework (Abbitt, 2011; Harris et al., 2009; Koehler & Mishra, 2006). Concerning this, the content knowledge to be taught is one of the initial provisions provided in the teacher competency development, apart from pedagogy and assessments required to help students learn content and the technology needed to accommodate the teaching and learning process (Großschedl et al., 2019; Koehler et al., 2013).

Moreover, TPCK differs from the content, pedagogical, and technological knowledge concepts partially, or when it stands alone since it not only adds the use of technology to content knowledge and pedagogy but also provides for the development of transactional relationships between the three (Koehler & Mishra, 2005, 2008). Meanwhile, Cox and Graham (2009) argued that as an innovation from the previous TPCK concept, TPACK refers to teacher knowledge on how to coordinate the implementation of certain subject activities or specific topic activities, with particular topic representations utilizing the current developing technologies to facilitate student learning. When teachers have adequate TPACK, it will enable them to utilize technology in a student-centered learning approach and encourage inquiry learning rather than just using it to support teacher knowledge transmission (Chai et al., 2010) or for presentations only (Harris et al., 2010; Harris et al., 2009).

According to Angeli and Valanides (2009), TPACK has a transformative epistemological nature, in which, in this transformative view, TPCK will be influenced by TPK, TCK, and PCK but not directly affected by the basic knowledge component. Meanwhile, according to them, Koehler et al.'s (2007) explanation has not shown TPCK as a separate "body of knowledge" owned by teachers, so that it needs to be further clarified regarding the views used, transformative or integrative.

In addition, testing the relationship between gender or differences in gender and technological knowledge in learning is based on the assumption that there are differences in mindsets, habits, and interests in different technologies between males and females. The similarity in the self-efficacy and skill level in utilizing information and communication technology for male and female teachers also makes gender differences material for practical discussions about TPACK (Gebhardt et al., 2019). Previously, several studies have uncovered similarities, differences, or no relationship between TPACK levels and gender differences in teachers.

In this case, Koehler et al. (2012) have reported the use of five different research instruments to assess TPACK: self-reports, open-ended questionnaires, performance appraisals, interviews, and observations. Instruments in the form of self-reports are the most frequently used to measure TPACK (Koehler et al., 2012; Willermark, 2018). However, differences in perceptions in translating TPACK and understanding different frameworks among researchers have implications for the instrument type employed to gauge TPACK (Fisser et al., 2015). Assessments in the form of performance appraisals and observations are carried out quite a lot, in addition to peer assessment, self-assessment, portfolios, e-portfolios, performance exhibitions, and case and problem-based inquiries considered more authentic. The uses of assessment instruments deemed more authentic, such as cores and papers, observations, and tests in the form of essays, also make the results more meaningful and become an accurate basis for the follow-up to enhance teachers' professionalism or competence.

Moreover, teacher education programs should provide opportunities for prospective teachers to develop their TPACK to integrate technology effectively into teaching (Bilici et al., 2016). The

TPACK level of prospective teachers will increase if they are allowed to learn and practice technology tools for learning (Bilici et al., 2016; Guzey & Roehrig, 2009; Niess, 2005). Thus, the use of computers is the beginning to increase the technology integration in education so that prospective teachers should be given the opportunity to gain competence and confidence in utilizing computers for teaching and learning (Teo, 2008; Yaghi, 2001). These improved perceptions of competencies, including TPACK and technology integration into teacher and learning, can be obtained through appropriate training or lecture strategies.

As (Russell et al., 2007) affirmed, teachers who serve longer in a school tend to use technology less than teachers who have just served in a new school, either as new teachers or transfer teachers. Meanwhile, Cox (2013) pointed out that teachers who have been teaching for a longer time get less lecture material on the technology application in learning than teachers who are currently just starting to teach. In addition, teachers who have passed certification have performed better than before and compared to teachers who have not been certified. For this reason, differences in experience or working period become a subject that continues to develop in learning practices in accordance with the development of teaching strategies and innovations in learning.

Factors that can affect the teacher knowledge level is also a dynamic subject. The difference in context makes the research results related to these factors different. The instrument form in the assessment carried out in the study is also likely to affect the research results conducted. Thus, this study revealed novelty aspects in the TPACK assessment results of natural science teachers related to the use of assessment instruments in the form of essay questions. The essay questions used are thought more authentic than the multiple-choice questions (Aalaei et al., 2016), which were more commonly used previously in the context of teacher competency assessments, especially in Indonesia. This study also focused on differences in educational background, working period, and gender of natural science teachers as factors regarded affecting the TPACK level.

This study aimed to determine the similarities or differences in the TPACK assessment results based on differences in factors that could affect the TPACK knowledge level possessed by natural science teachers. The differences in the assessment results carried out can then be used as the basis for providing follow-up or developing competency improvement programs for these teachers. Hence, the problem formulation for this research is "What are the TPACK assessment results for natural science teachers with different educational backgrounds, working periods, and gender?".

Methodology

This research is a descriptive quantitative research (Gall, Gall, & Borg, 2003). The research data were taken from the results of filling out the question instruments by 250 natural science teachers in the Banten Province randomly. Question instruments were distributed online in the form of Google Forms to participants, who were the natural science teacher group members. Participants were involved in the study voluntarily, and there were no restrictions on criteria and numbers.

The instrument given in the form of questions was asking for limited essay answers. The instrument was based on the TPACK framework, limited to four aspects of integrative knowledge: PCK, TCK, TPK, and TPCK. The instrument had also been tested for validity and reliability in previous research and development. The participant's answer data were then scored automatically utilizing the UKARA computer program, managed by the Center for Assessment and Learning of the Research and Development Agency, Ministry of Research, Education, and Culture of the Republic of Indonesia. The scoring results were then analyzed quantitatively descriptively using SPSS 2.0 soft-

ware. A discrimination test (t-test) on each factor was also carried out as part of the data analysis process from the scoring results.

Results

The results of the research investigation are divided into three parts, according to the factors that are the focus of the analysis, namely the result of TPACK assessment based on teacher educational background, the results of TPACK assessment based on teacher work period, and the results of TPACK assessment based on gender differences.

1. The assessment results based on educational background of the participants are presented in Table 1.

Tabel 1. Result of TPACK Assessment Based on Teacher Educational Background

Category	n	Minimum	Maximum	Mean
Not Suitable	32	8.33	66.67	31.51
Less Suitable	49	12.50	70.83	35.29
Suitable	169	0	79.17	34.91

The first descriptive statistical calculation produced was an analysis of differences in educational background. This educational background was divided into three categories: “suitable”, “less suitable”, and “not suitable”. The highest mean score was gained by the group of teachers with less suitable educational backgrounds, then the group of teachers with suitable backgrounds, and the lowest was the group of teachers with not suitable backgrounds. In Table 1, it is also shown that for all groups, the mean score of the assessment results was in a low category as it was still below the score of 50.01. Individually, the highest score was attained by the participant in the group of teachers with a suitable background. The data obtained also exposed that of the 250 participants, most participants were teachers with suitable backgrounds. In addition, the discrimination test (T-test) results showed that the assessment results for these groups of teachers were not significantly different (significance value > 0.05).

2. The assessment results based on the working period of participants in teaching natural science in junior high schools are shown in Table 2.

Table 2. Results of TPACK Assessment Based on Teacher Work Period

Category	n	Minimum	Maximum	Mean
< 5 years	70	4.17	70.83	33.69
5 – 10 years	10	12.50	54.17	28.34
> 10 years	170	0	79.17	35.27

For this working period, it was differentiated into three working periods: less than five years, five to ten years, and more than ten years. In Table 2, it is displayed that the group of teachers with the longest working period got the highest mean score, followed by the group of teachers with the fewest working period and the group of teachers with five to ten years of working period with the lowest mean score. Based on the discrimination test (T-test) results on the data, the values for the three groups were not significantly different (significance value > 0.05). The mean score for all groups of the working period was also in the low category. The highest individual scores were achieved by a participant in the group of teachers with more than ten years of working. In addition,

the number of participants in the group of teachers with a working period of more than ten years dominated this study.

3. The assessment results based on the gender differences are as displayed in Table 3.

Table 3. Results of TPACK Assessment Based on Gender Differences

Category	n	Minimum	Maximum	Mean
Female	174	4.17	79.17	35.11
Male	76	0	75.00	33.28

It was revealed that female teachers scored slightly higher on the mean than the male teacher group. Based on the discrimination test, the two group results received a significance value of more than 0.05, or the mean score was not significantly different. Besides, the mean scores for both gender groups were in a low category. Table 3 also exhibits that the participant which got the highest score was a female teacher. For this study, of the 250 participants, there were far more female teachers than male teachers.

Discussion

In this study's results, the low mean score might be influenced by several factors, including the questions' difficulty level, the participants' seriousness and preparation, and the question form of limited essays. Of course, the questions' difficulty level varied; however, the questions in the TPACK framework will tend to be more difficult for participants to answer when their knowledge has not been actualized according to current learning developments (Graham et al., 2009). In addition, in this study, participants were involved voluntarily and were not limited by specific criteria so that they would not prepare well and might not give high seriousness when answering questions since there were no consequences for the results. Essay questions were also not usually done by teachers in competency assessments. Besides, generally, essay questions also give lower results than multiple-choice questions that are more commonly applied. In short or limited description answers, the assessment subject does not have the opportunity to guess or get clues about the answers from the choices given (Rios & Wang, 2018).

The first comparison made was on the assessment results for differences in the teachers' educational backgrounds. Notably, for natural science subjects at the junior high school level in Indonesia, the teacher's background considered suitable is actually not entirely suitable. Today, natural science teachers are generally teachers with an educational background in the science group partially or not integrated science. These conditions could undoubtedly affect the assessment results combining material in the field of physics and biology. Therefore, as previously explained, the data obtained were relatively acceptable, stating that the teachers' TPACK with suitable backgrounds and meeting the criteria for natural science teacher certification was not necessarily better in knowledge than teachers with less suitable backgrounds. Based on statistical comparisons, there were also no results supporting the background's suitability to get a better average result or significantly different from the group of teachers with not suitable backgrounds.

Similar conditions have also been uncovered by other studies' results related to teacher competency tests in Indonesia. For teachers who already have an educator certificate and have met the requirements to teach, their performance or competence levels were not strongly correlated with graduation after the certification process (Brotosedjati, 2012; Siswandoko & Suryadi, 2013). However, different results have been shown by several other studies on almost the same problem in dif-

ferent contexts. Indications that teacher performance or competence could be improved by a teacher certification program are, among others, based on research conducted by Koswara and Rasto (2016), Phytanza and Burhaein (2020), and Rostaviana (2018). Related to the assessment performed in this study, the results described from the use of the instrument could be considered to have been in harmony with previous studies concerning the effect of the educational background's suitability on teacher competence.

In this case, TPACK is integrated knowledge that can be acquired through appropriate learning or training. If the education of prospective teachers does not carry out an integration process between knowledge of pedagogy, content, and technology, then graduates will have low integrative knowledge as a result. As Harris et al. (2009) and Shulman (1987, 2015) asserted, TPACK or PCK is an integrative knowledge that can develop in the education of prospective teachers and teachers through the process of learning the constituent knowledge in an integrated manner. This research assessment's results shown above could be an indication that the possibility of relevant teacher education was still lacking in implementing this integrated knowledge learning strategy. Thus, the improvements that can be made must principally be comprehensive, starting with the education of prospective teachers and then on the development of the teaching profession to increase the TPACK needed for teaching.

The second factor to be compared was the working period, divided into three groups. A longer working period did not make the participants' knowledge in this study had a significantly different group score than the group with less working period. A slight difference was seen in the group mean, where teachers with the most working period had the highest mean scores. However, on the other hand, the mean score of the group of teachers with the fewest working periods was also not the lowest. The analysis result that can be explained for these conditions is that the difference in working period cannot be used as a basis for concluding that teachers with fewer working periods have less knowledge than teachers in the longer working period group. The insignificant difference in values and a large number of participants can also bias the conclusion. The fact is that all groups of teachers based on the working period in this study received a mean score, which was low as they had not yet reached the minimum expected value.

The relatively similar results to this study have been revealed by the research results by Phillips (2009) and Haris (2014). Based on the conclusions they described, the working period did not correlate with performance or competency improvement. Meanwhile, according to Russell et al. (2007), teachers who have been teaching for less than ten years tend to use technology more for teaching preparation and assign students to make assignments utilizing technology than teachers who have taught more than ten and 15 years. These studies' results indicate variations in the working period's effect on teacher performance related to technology.

Furthermore, the working period factor is related to the experience a teacher has in teaching. This experience can be embedded into knowledge that can be applied repeatedly and sometimes more meaningful than the knowledge gained from teacher education. Indeed, many teachers who have been on duty for longer working periods have participated in various professional development programs. However, if looking at the assessment results in this study, there was no indication that experienced natural science teachers learned more than natural science teachers who had little experience in increasing TPACK. Meanwhile, Cox (2013) is of the view that technology integration can actually create more problems than solutions, especially for teachers with longer working periods. This view is associated with teaching routines and styles that have been ingrained in teachers who have been teaching for a long time, making it difficult to change. Therefore, teachers with a long

working period are also more likely to have low TPACK levels, which is inversely proportional to their experience.

Nevertheless, other studies explained different results regarding the working period's impact on teacher performance or competence. Teacher performance and competence could be considered to include the knowledge measured in this study. Indrawati's (2013) and Fenster's (2014) research findings indicated that the working period affected teacher performance in carrying out learning. Different experiences impacted the way students worked and learning outcomes. Based on those studies, more experienced teachers had better teaching abilities. This condition actually occurred in this study, although not as a group. Individually, the highest score was obtained by a teacher with a longer working period. A more in-depth study of the data also showed that almost 75% of the 51 participants who scored at least 50 were participants with more than ten years of working. It signified that although the mean for each group in this study did not show any effect on the TPACK value, high scores were generally attained by participants with longer working periods.

Related to this, the age difference factor tends to be in line with the working period and can be a factor with the potential to be a differentiator in the ability to utilize technology for learning. The age's influence on the ability to use information technology devices has previously been explicitly investigated or involved several other factors by several researchers. Generally, the researchers found that the age factor did not significantly affect the teachers' ability or perception in utilizing technology for learning. As expressed by Tweed (2013), according to his research, age, teaching experience, gender, and intensity of professional development in technology did not play an essential role in teacher efficacy and use of technology in the classroom. Indeed, some of these studies did not show that the age factor directly impacted TPACK or the ability of teachers to utilize technology tools for learning. However, from these findings, it also denotes that it is not certain that older teachers will have lower TPACK than younger teachers, or vice versa. Therefore, as previously explained, working period or age factors did not entirely affect the knowledge level possessed by teachers at this time.

In addition, the factor of gender differences was tried to be analyzed because several studies on the use of technology in learning that have been conducted have also scrutinized its relationship with these variables. The relationship testing is based on the assumption that there are differences in mindset, habits, and interest in different technologies between men and women. The basic assumption for this factor is that, in general, male teachers will be more interested and accustomed to using technology for learning than female teachers. Naturally, men are also more interested in learning technology than women, who are more likely to be users; thus, male teachers are assumed to have higher TPACK levels than women. However, the assessment results showed that although not significant, the mean score of female teachers was higher than that of male teachers in this study.

Several previous research results also revealed relatively the same results as this study. No significant difference was found between the teachers' ability and habits in using technology concerning gender differences. It signifies that there was no gender tendency affecting TPACK or knowledge to apply technology in learning. However, on the one hand, other studies have shown that male teachers are more experienced in using technology tools, especially computers, and their applications, and on the other hand, female teachers are more interested in teaching by applying good pedagogy (Zhou & Xu, 2007). Therefore, this study's results could be interpreted that female teachers can also have better knowledge, although they do not necessarily implement their knowledge better than male teachers.

Conclusion

Comparison for educational background and working period factors revealed that consecutive results were not shown consistently for group differences. Meanwhile, there was no significant difference in the mean TPACK score for different groups for the three factors of the discussion subject. For the educational background factor, the highest mean score was actually obtained by a group with a not suitable educational background, not a group of teachers with a suitable background. For the working period factor results, the group of teachers with the longest teaching experience got the highest score, but it turned out that teachers with less than five years of learning experience also had a higher mean TPACK score than teachers in the group with five to ten years of working period. For comparisons on gender differences, the female teacher group scored slightly higher on the mean than the male teacher group. In addition, the mean score of the TPACK assessment results for each group based on the factors discussed was all in the low category. For this reason, this research can be followed up by expanding the variables discussed and adding more participants so that confidence in the research results will be higher.

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