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DEVELOPING SELF-ASSESSMENT INSTRUMENT FOR MEASURING PRE-SERVICE TEACHERS' TECHNOLOGICAL PEDAGOGICAL VOCATIONAL KNOWLEDGE

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Abstract

Purpose of the study: This study aims to develop a self-assessment instrument for measuring pre-service teachers' Technological Pedagogical Vocational Knowledge (TPVK). The developed instrument reviewed by experts and analyzed for the reliability and the internal consistency. TPVK, as the expansion of Technological Pedagogical Content Knowledge (TPACK), is the basis of effective teaching vocational knowledge with technology. TPVK's instrument needed to assess the profile of TPVK among pre-service teachers. Assessing current TPVK's profile among pre-service teachers is needed to formulate the appropriate efforts for the improvement in the teacher training program.

Methodology: Fifty-one survey questions were initially created based on literature and then reviewed by some experts to do the content and face validity of the instrument. The item analysis to determine the criterion of internal consistency used Pearson Product Moment regarding the data collected from two hundred and sixteen pre-service vocational teachers. The reliability of the instrument is determined by using Cronbach's alpha coefficient.

Principal Findings: The criterion of internal consistency from each TPVK component is relatively high. The lowest mean degree was 0.736 for PK, and the highest mean degree was 0.857 in the TPK component. The Cronbach's alpha coefficient for the reliability test was 0.883 in the TK component as the lowest degree and 0.937 in the PVK component as the highest degree.

Practical Implication: The results revealed that the TPVK instrument was a valid and reliable tool for assessing pre-service vocational teacher's technology, pedagogy, and vocational knowledge, especially in Indonesia, due to the language used in this instrument.

Novelty/Originality of this study: This article based on the development study to measure Technological Pedagogical Vocational Knowledge pre-service teachers' instrument as the expansion of TPACK, whereas the content knowledge focused on vocational knowledge.

Keywords: *Self-Assessment, Instrument, Technological Pedagogical Vocational Knowledge, Pre-service Teachers, Internal Consistency, Reliability.*

INTRODUCTION

Vocational education is a part of the educational system, which the primary purpose is producing skilled and semi-skilled human resources. Vocational education focuses on preparing students to master competencies and skills according to the specific fields, to have behaviors and cooperative attitudes, as well as social responsibility. Thus enable young people to participate in economic activities actively and become responsible citizens (Wang, 2012). Therefore the learning process in vocational education is designed based on a job title. The ability of vocational education to produce human resources capable of meeting the requirements of the job market and industry becomes a benchmark for the quality of the vocational education system. Students who graduate from vocational education should have relevant skills that allow them to be absorbed in industrial markets.

The difference of learning outcome in vocational education raises unique characteristics in vocational learning (Guthrie et al., 2009), namely: 1) Learning based on the real context of the world of work; 2) Encouraging a 'direct' and interactive approach in learning activities that allow students to balance aspects of thinking and work skills; 3) Establish specific learning outcomes-oriented to 'work readiness'; 4) Providing opportunities for students to collaborate and negotiate in determining their learning and assessment processes; 5) Appropriate students as 'co-producers' of knowledge and skills; 6) Acknowledge students' initial knowledge and experience as a valuable foundation for building knowledge and skills; 7) Using a flexible teaching approach that accommodates a variety of student learning styles, and 8) Appreciate social interaction in group learning

The characteristic of the 21st-century workplace, which changes enormously as the impact of the technological boom in this era need the workforce has a high adaptability skill. The vocational institutions need to install 21st-century skills during their educational process to increase their leavers' market value, employability, and readiness for citizenship. Those skills include: think critically and make judgments; solve problems that are complex, multidisciplinary, and open-ended; creative thinking and entrepreneurial oriented, skilled in communication and collaboration; using knowledge, information, and opportunities in innovative ways, as well as being responsible in finance, health, and civic responsibility (Skills, 2008). In the interest of installing those required skills for the new industrial economy, the vocational teachers, likewise vocational pre-service teachers, need to be equipped with 21st- Century competencies and become competent to carry out the 21st-Century learning (Mtebe & Raphael, 2018). Because technological developments dominate the rapid changes of the 21st century, then the teachers' competence with technology integration in the learning process is the basis for effective 21st-century learning.

Technology integration in learning that will support the achievement of 21st-century competencies is through lesson planning that uses technology to support learning objectives in certain fields. The forms of technology to support the learning process include Learning Management System (LMS) (Chanpet, Chomsuwan, & Murphy, 2018; Dağ, 2019; Dag & Durdu, 2017; Hidayat, 2019; Hidayat, Prasetiyo, & Wantoro, 2019), social media (Chuang, 2016; Jordan, 2016; Makaramani, 2015), as well as computer programming tools (Thompson et al., 2019). Teachers and prospective teachers need special professional knowledge to integrate technology, education (pedagogy), and content known as TPACK (technological pedagogical content knowledge) (Mishra & Koehler, 2006) into instructional design. TPACK exists as a framework for integrating technologies that are appropriate to the content and pedagogic approach. Various fields of science have widely used the TPACK framework, such as science education (Bilici, Guzey, & Yamak, 2016), language education (Tseng, Cheng, & Yeh, 2019), and sports education (Cengiz, 2014). TPACK's previous studies applied to active teachers (Liu, Zhang, & Wang, 2015; Masrifah et al., 2018; Mtebe & Raphael, 2018) as well as pre-service teachers (Kharade & Peese, 2014; Koh & Divaharan, 2011; Tondeur & Scherer, 2017).

Although TPACK is a framework related to teacher knowledge, however, the TPACK capacity development efforts need to be installed during the teachers' preparation program. According to Kaufman, (2014); Koch, Heo, & Kush, (2014); and Nelson, (2017), the approach and design of technology integration applied in the learning process during the teacher preparation program have a significant impact on the confidence of pre-service teachers in integrating technology into their learning later.

On the vocational field of study, Chua (2012) surveyed to measure the level of professional knowledge among Malaysian Technical and Vocational Education and Training (TVET) teachers. The instrument used was an adaptation from some previous TPACK instrument which suit with Malaysian TVET system. The instrument consists of three sections, which are section A for the demographical questions, section B for the professional knowledge based on the TPACK model, and section C for personal and organizational factors.

While another research (Mporananayo & Ng'umbi, 2019) applied questionnaires with close-ended questions in an attitude scale method called Likert Method of summated ratings. The questionnaire consists of several statements about a subject. The respondents give their response by assigning a five-scale value to each of the responses. This research uses this kind of instrument to follow the research objectives, namely, to determine the attitude of TVET teachers/trainers about their technological, pedagogical, and content knowledge level.

An instrument specifically developed to survey TPACK competencies among vocational (pre-service) teachers have not yet been identified. Therefore, developing, validating, and establishing of the reliability for an instrument that would enable the examination of the (pre-service) teachers' self-assessment of TPVK along with the evaluation of the program's effectiveness at developing (pre-service) teachers' TPVK become the goal in this study.

This article begins with an introduction that provides a brief description of TPVK and its importance. Further, to direct research according to existing theories in this field through a brief literature review. Research methodology explored includes the research approach, data collection, and the way to analyze data. Afterward, the result of the study, followed by a discussion, is presented.

LITERATURE REVIEW

Technological pedagogical vocational knowledge

TPVK is a development of Technological, pedagogical, content knowledge (TPACK), which focuses on discussing vocational knowledge content. TPACK itself is a framework used to support the use of technology in learning (Mishra & Koehler, 2006). This framework is the development of the Shulman model (Shulman, 1986) "pedagogical-content knowledge" by adding "technological knowledge" as part of essential knowledge that needs to be mastered by the teacher. TPACK emphasizes on the meeting between technology-pedagogy-content, were learning using technology will be effective when there is integration between the three components (Harris & Hofer, 2011). The TPACK framework consists of three basic knowledge, namely, content knowledge (CK) - pedagogical knowledge (PK) - technology knowledge (TK), where all are equally important for developing capabilities in integrating technology (Krauskopf et al., 2018). Figure 1 shows the interrelationship between the three basic knowledge that set up the seven components in the TPACK framework, namely:

Technological knowledge (TK), namely, knowledge related to various technologies. A simple form of technology such as pencil and paper until the high technologies such as augmented reality, educational games, interactive whiteboards, as well as software programs can be used in learning (Mishra & Koehler, 2006).

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Content knowledge (CK), refer to knowledge about a particular subject that is studied or taught (Mishra & Koehler, 2006). The teacher/instructor must understand the subject matter and how knowledge naturally differs from various spheres of knowledge.

Pedagogical knowledge (PK) is knowledge related to teaching processes and practices, including knowledge of classroom management, learning assessment, development of teaching plans, and student learning methods (Kohler, Mishra, & Cain, 2013).

Pedagogical content knowledge (PCK), namely, content knowledge that is in line with the learning process (Shulman, 1986). PCK, which combines content knowledge with pedagogical knowledge together, makes the practice of teaching certain materials better.

Technological content knowledge (TCK), i.e., knowledge of how technology and content are interrelated. Technology can produce different representations of certain content. Teachers need to understand that the use of certain technologies can change the way students understand certain content area concepts or practice specific skills (Mishra & Koehler, 2006).

Technological pedagogical knowledge (TPK) is knowledge about how to use various technologies in teaching. Teachers should choose appropriate technology types, understanding and being able to apply specific teaching strategies for technology use, and understanding the advantages and disadvantages of using technology in learning (Mishra & Koehler, 2006).

Technological pedagogical content knowledge (TPACK): knowledge needed by teachers to integrate technology into their learning in various content areas. The teacher needs to have an intuitive understanding of how the three basic components of knowledge (CK, PK, TK) interact with each other. This understanding includes how to use technology to represent material concepts along with content teaching strategies using technology through constructive means. The teacher should realize portions of content that are easy or difficult to understand and how to help students understand material content using technology. Understanding students' prior knowledge and knowledge of how technology can be used to develop new knowledge or strengthen existing ones (Mishra & Koehler, 2006).

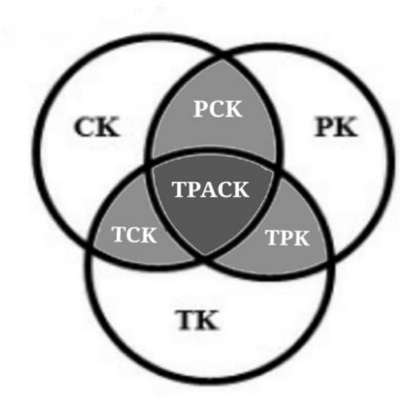

Figure 1: Seven components of TPACK

Several factors within personal (pre-service) teachers, including age and teaching experience, affect TPACK mastery levels. Generally, TPACK mastery achievement points based on self-evaluation of pre-service teachers will be lower than active teachers. The latter has had a long teaching experience (Dong et al., 2015). Although the pre-service teachers' mastery of Technological Knowledge may be better than active teachers, their limited mastery of Pedagogical Knowledge and Content Knowledge limits their potential mastery of TPACK. According to Nelson (2017), the tendency of using technology in learning by prospective teachers increases when active teachers as their mentors during the education apprenticeship program have higher TPACK points and often use technology in the learning process. While student characteristics, the learning environment both in the classroom and institutional settings, the situation of learning activities, and teacher perceptions influence the integration of technology in learning (Hwee et al., 2014; Porras-hernández & Salinas-amescua, 2013; Voithofer et al., 2019).

Content knowledge in this study focuses on vocational knowledge, which defined by Wheelahan (2015) as applied disciplinary knowledge. This kind of knowledge is in line with the objectives of the vocational curriculum, which is to direct students to practical activities as a basis for integrating and synthesizing theoretical knowledge in certain occupations (Bathmaker, 2013; Wheelahan, 2015). Vocational Experts do not only rely on knowledge of the underlying disciplinary knowledge, or on the ability to carry out specific tasks in the workplace (Winch, 2010). Vocational qualification depends on all the attributes needed to carry out practical actions at work. The attributes include working with the use of propositional and theoretical knowledge in the context of appropriate fields of work and local ethical values. Teaching methods on TVET must be able to facilitate the linkage between theory and practice to build an association between the world of work and life (Guthrie et al., 2009). Theoretical learning of scientific discipline knowledge can transform practical knowledge from certain fields of work through specific learning tools or learning models.

Measuring TPACK

TPACK framework consists of multiple knowledge domains, which consequently need more effort to define further and measure each knowledge domain. Several studies have measure TPACK with various approaches, implemented in both in-service and also pre-service teachers. The results of the studies illustrate that it was difficult to understand how teacher knowledge influences teaching practice activities. Furthermore, the reliability, validity, as well as the efficiency of measurement for each approach, also presents challenges.

Mishra & Koehler (2006) designs a quantitative survey instrument to measure pre-service teachers' perceptions of the learning environment, the evolution in pre-service teacher's thinking regarding the course content, and how the components of the TPCK framework were developing in pre-service teachers over the semester. The survey instrument consisted of 35 questions, consists of two short answer questions and 33 (thirty-three) of 7-point Likert-scale questioners. The focus of this study is on cognitive processes. Mishra and Kohler's study revealed that teacher knowledge of technology in teaching and learning is dynamic, and the context of the activity takes place is heavily influencing the development of that knowledge. Some items of the instrument used in this study were designed according to the specific characteristics of the learning surveyed, for example, referring to group work activities. Consequently, these specific items may not apply to other learning environments and need to be rearranged or even eliminated (Abbitt, 2011).

Another assessment approach used by Koehler, Mishra, & Yahya (Koehler et al., 2007) is content analysis techniques to examine detailed notes collected from artifacts produced by the groups constructed. The collected artifacts were notes from group discussions, emails between group members, and observations made during the semester. The data was then organized into "discourse episodes." Data were analyzed using a coding protocol developed from seven TPACK framework knowledge domains. The limitation of this study is the possibility of subjectivity and bias in coding, although during the process of coding, have applied multiple researchers as well as use multiple coding intervals. Moreover, the assessment applying this method is time-consuming and specific to the unique context in which it was used (Schmidt et al., 2009).

A survey method used to measure the level of in-service teacher professional knowledge (Chua, 2012). Data from the survey also used to classify the emerging factors that influence instructor knowledge. Furthermore, to obtain an in-depth understanding regarding the factors that influence the knowledge, an interview session was carried out. Through the interview, the researcher will be able to gain information to know the factor that influences the level of teachers' knowledge based on descriptive statistical analysis as well as the qualitative analysis from the interview.

A TPACK Assessment based on pre-service teachers' performance was conducted, which augmented by a self-assessment survey (Akyuz, 2018). Several theories underlie this method (Voogt et al., 2012), which states that TPACK assessments are more accurate if teachers show what they can do with technology in their subjects to improve teaching and learning. Considerations in using self-assessment to measure TPACK are (1) ease of administration, (2) reflecting teacher intentions, (3) future-oriented, (4) there is a correlation with the quality of instructions, and (5) an integral part of the teacher's belief system (Scherer, Tondeur, & Siddiq, 2017).

METHODOLOGY

Research Design

This study is an exploratory sequential mixed methods study (Creswell, 2014). Experimental sequential mix methods have been increasingly developed in education research as a protocol to collect and analyze data for legitimizing knowledge claims (Subedi, 2016). An initial qualitative phase of data collection and analysis came from the results of experts' reviews regarding the construct theories and face validity of the instrument. The quantitative phase of data collection and analysis is following in the form of a survey study toward vocational pre-service teachers.

Respondents

Respondents in this study were two hundred and fifty pre-service vocational teachers recruited through convenient sampling from three different teacher training and education institutions in Indonesia. Two hundred and sixteen respondents returned and filled out the questionnaire. The respondents were 54% males, and 46% were females. All respondents have their laptops to support their learning both during class sessions and also during self-learning at home. They learned vocational knowledge in the term of theories in the classroom as well as practical learning in a workshop. The classrooms equipped with a projector and an internet connection while the workshop provides technology by each field.

Research tool

The four phases of developing the TPVK instrument in this study were: (1) arranging the blueprint based on theories, (2) a proposal of survey items for seven domains of TPVK, (3) expert review, and (4) conducting item analysis and confirming validity and reliability of the instrument. The first step in developing the TPVK instrument was setting the blueprint's instrument. The instrument involves the explanation of each indicator for its variable of TPVK based on theories. Variables in TPVK following the TPACK framework of Mishra & Koehler (2006).

Based on the instrument's blueprint, the next step was making the list of related questions and arranges them into a set of pre-ready use TPVK surveys. After that, the instrument reviewed by three experts. The first expert was a bilingual vocational expert, who judges the inline between sentence orders taken into the instrument to the referred theory, as well as the previous instrument surveys from literature. This kind of expert validation needed because of majorities theories regarding TPACK written in English, as well as the previous instrument surveys. Meanwhile, Indonesian pre-service teachers were testing the TPVK instrument developed in this study. The instrument was written in Bahasa Indonesia to facilitate respondents' understanding. The second expert was an evaluation expert who gives judgment review regarding the face validation of the instrument. Furthermore, the third reviewer was a TPACK expert who was reviewing instruments based on its suitability with the concepts of framework TPACK.

Research procedure

By using the resulted items on the survey, a bilingual vocational expert made a review to verify per the language used and theory. Then professor who was experts in the evaluation field, especially in instruments tools which affiliated to teacher training and education was invited to examine whether the surveys' instrument meets the standard of good evaluation instrument. An expert who is knowledgeable in TPACK was invited to examine the construct theories of the survey, whether all items were relevant and complete. All factors should be supported by appropriate indicators based on literary study. The items made must be able to represent each indicator so that the internal construct model was obtained. The revised instrument was then re-reviewing by three experts until fullfill the standards from the experts.

Statistical procedure

Item analysis to determine the criterion of internal consistency (Gable & Wolf, 1993) was conducted used Pearson product-moment. Item scores should show the same tendency as the total score, which represents the construct score measured. The items with the values of factor loading lower than 0.30 mean less consistency and should be excluded from the instrument. Cronbach's alpha was adopted to test reliability. The Cronbach's alpha coefficient indicates whether instrument consistent when used for repeated measurements (AERA, APA, & NCME, 2014). The instrument is defined to be reliable if the reliability coefficient is 0.7 or more. All statistical tests were two-sided with a significance level of 0.05.

RESULT AND DISCUSSION

Instrument Development

This instrument was developed based on Valtonen et al. (2017). The study began with arranging the blueprint based on theories, resulting in two indicators for each PK and PCK variable, and one indicator for each VK, TK, TPK, TVK and TPVK variable. Based on the indicators, the next step on arranging blueprint was by considering the items of nonreliable and reliable with the vocational learning by sorting out the items that not meeting with the fields from Valtonen's survey. Further was adjusting the terms used in the rest items to better suit the context of vocational education because of the Valtonen's study in the context of science. After that, write the additional items needed to meet the minimal items of each indicator, which indeed meet with the indicator builder theories.

This research resulted in a proposal of survey items for seven domains of TPVK consist of 51 items in total. Items no 1-10 refer to questions of PK followed by questions of VK as items no 11-16. The items no 17-21 were questions of TK while the items no 22-33 were questions of PVK. The question of TVK covered by items no 35-38 while the items no 39-44 were the question of TPK, and the seven last items, no 45-51, refer to questions of TPVK. The difference number of indicators of each TPVK variable listed in the blueprint as a result of the literature study affects the number of items of each TPVK variable. There are variables defined by only one indicator, while other variables have two indicators. At least five items represent each indicator.

This instrument used a 6-point Likert-type scale to assess respondents' knowledge of TPVK areas. Point 1 refers to "I need a lot of additional knowledge about the topic", while point 2 means that "I need some additional knowledge about the topic". Point 3 describes a condition of "I need a little additional knowledge about the topic". Point 4 that was "I have some knowledge about the topic." Point 5 refers to "I have good knowledge about the topic". The last point six refers to "I have strong knowledge about the topic."

Experts Review

Based on the result of the bilingual expert review, it needs to make some changes to the structure or the meaning of the scale items. Besides, more appropriate synonymous words need to replace some words. According to the input from the instruments' expert from the Teacher Training and Education faculty, the instrument needs some improvements so that the instrument display is suitable for use and can measure traits optimally. The improvement is to provide items in relatively equal numbers for each indicator, with a minimum of 5 items per indicator. To minimize the potential for respondent misunderstanding, instructions for filling out the questionnaire need to be given at the beginning of the questionnaire, followed by an example of filling out the questionnaire. Each item should be written in not more than two (2) lines to avoid the tendency of boredom in respondents. Expert TPACK provides improvement suggestions on statement items for the Vocational knowledge component. The statement should go directly to the specific characteristics of vocational knowledge to be more easily understood by respondents. Like a sentence, "basic theories and concepts from vocational knowledge and skills" turned into "basic theories and concepts of work procedure-related my vocational field." With feedback from the experts, some changes were made to the instrument.

The professor who was an expert in the instrument tool and who was an expert in TPACK give construct validation. A construct is an instrumental tool from the theoretical object of the interest that resulted from its goal of instrument design including the used context (Wilson, 2005). It should be located in the main part of knowledge in a constructive way in order to lead in the domain of inference extant theory contribution. (Cavanagh & Koehler, 2013).

Construct of the TPACK framework could be viewed as one constructor as the seventh construct. Koehler, Shin, & Mishra (2012) viewed TPACK as one construct with describing how teachers' understandings of the three basic knowledge of TPAC (TK, PK, and CK) can interact with one another to produce effective discipline-based teaching with educational technologies. While Schmidt et al. (2009) view TPACK as a composite of the seven constructs. This construct comprises three kinds of base knowledge (TK, PK, and CK), three kinds of knowledge resulted from the interactions between those three base knowledge (PCK, TPK, and TCK); and the interaction between that interaction knowledge, which named technological pedagogical content knowledge (TPACK). Each construct is sufficiently different from the others to warrant separate specifications.

This study views TPVK as a composite of the seven constructs. This study used theoretical literature reviews and empirical research literature reviews as a source of information that helps illustrate the constructed model. The constructed model for the Technological Pedagogical Vocational Knowledge consists of comprises seven components, which are PK, TK, VK, PCK, TVK, TPK, and TPVK.

Item analysis

According to Gable & Wolf (1993), the items that have the criterion of internal consistency less than 0.30 should be removed to determine the inclusion of the items in the survey. As seen in figure 2, all 51 items have the criterion of internal consistency more than 0.30.

The high degree of standard of internal consistency indicates that the items were closely interrelated within each component. The items builder from one variable should all measure the same thing because they came from one construct theory. Consequently, all items in one variable should be correlated with one another. Therefore the items meant to assess the same construct yield similar scores. The TPVK components with the lowest and highest mean of the criterion of internal consistency were PK (mean=0.736) and TPK (mean= 0.857), respectively. Thus, high internal consistency might meant that the instrument measure all aspects of a construct. The items with internally consistent responses suggested that the items measure the same construct. Conversely, things that are not internally consistent show varied responses from the article to the object, which means that the items are not well written. Therefore the respondents might interpret differently.

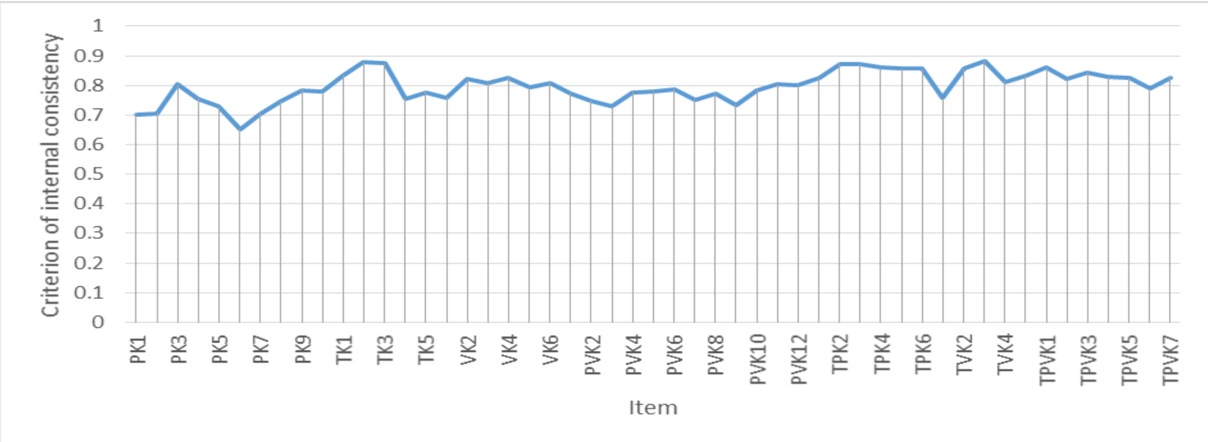

Figure 2: The criterion of internal consistency

Self-assessment instruments as a tool for measuring students' abilities accepting criticism because students are considered unable to assess their abilities objectively and students can overestimate their abilities. However, a self-assessment instrument widely used with several considerations. The self-assessment instrument was relatively cost-effective and easy in designing, administering, as well as in scoring. Furthermore, it promotes greater student awareness and self-regulation, as well as their participation during the assessment process (Brown, Dewey, & Cox, 2014). Self-assessment has been used regularly either as the sole measure (Hidayat, 2019; Schmidt et al., 2009; Zelkowski, Gleason, & Cox, 2013) or as a complement to other measures in TPACK assessment (Baran, Chuang, & Thompson, 2011; Hwee, Koh, Chai, & Hong, 2014; J. L. K. Hwee, 2013). Self-assessment instruments need to be arranged more specific and closer to real conditions to obtain more accurate data (Brown et al., 2014).

Reliability

Table 1 present the result of the instrument's reliability test. The extent to which the instrument measures the unidimensional construct, Cronbach's alpha is used (Zelkowski et al., 2013). Cronbach's alpha coefficient generally increases along with the increase of the correlations between the items. According to DeVellis (2017), the acceptable level of Cronbach's alpha coefficient is 0.70, when greater than 0.80 is mean good, meanwhile, when greater than 0.90 is mean excellent. The result indicated that the instrument could use to measure the multiple indicators of the same construct. From table 1, it sawed that the Cronbach's alpha coefficients within each domain of TPVK's component in the range of 0.883 till 0.937. All components of TPVK reach Cronbach's alpha coefficient greater than 0.80. Therefore it is categorized as useful. PVK, TVK, and TPVK categorized as excellent because of the gain coefficient greater than 0.90. With this Cronbach's alpha coefficient, it could conclude that the instrument developed in this study has the consistency to measure TPVK when used in different measurement times.

Table 1: Cronbach's alpha coefficient of the instrument

TPVK component	Cronbach's alpha coefficient
PK	0.905
TK	0.883
VK	0.892
PVK	0.937
TPK	0.928
TVK	0.885
TPVK	0.923

The instruments with high reliability mean that the instrument will give the same results to tests' results on a person when measuring several times in different periods. When the instrument is used to test several people with the same level of ability, it will give the same score. Reliable instruments will provide small measurement errors. Thus, a reliable instrument is an instrument with a small degree of error. The reasonably high reliability of the TPVK instrument developed in this study meant that this instrument is reliable enough to be used in measurements.

CONCLUSION

One purpose of this paper was to elaborate on the process of development of the TPVK instrument and its validity and reliability. Through the series of validation done by experts, it was obtained a theoretical model from the instrument TPVK stated to be valid. The criterion of internal consistency from each TPVK component is relatively high. The lowest mean degree was 0.736 for PK, and the highest mean degree was 0.857 in the TPK component. The Cronbach's alpha coefficient for the reliability test was 0.883 in the TK component as the lowest degree and 0.937 in the PVK component as the highest degree.

LIMITATIONS AND STUDY FORWARD

As a recommendation for future research is to validate the instrument TPVK through confirmatory factor analysis as well as investigate the path analysis of components of (pre-service) teachers' TPVK through statistical methods such as modelling of the structural equation. Moreover, the more potent way to examine TPVK among pre-service teachers or in-service teachers is by using this instrument along with classroom observational techniques, including interviews and video analyses through a mixed-methods research design.

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CO-AUTHORS CONTRIBUTION

The first author is responsible for drafting the article, arranging graphics, and revising the manuscript until approving the final version to be published. The second author contributes in revising the draft article critically for important intellectual content. The third author carried out the analysis and interpretation of data. The fourth author contributes to composing the substance of the conception and design of data acquisition.

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