Research Article

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Vocational teachers' perspective toward Technological Pedagogical Vocational Knowledge

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Abstract: The character of current students who are technology-savvy and the fast development of educational technology raises challenges for teachers to take advantage of these conditions to make learning effective. Technological, Pedagogical, Vocational Knowledge (TPVK) come as a framework for the effective use of technology in teaching and learning in vocational fields. This research aimed to capture the Indonesian secondary vocational non-Information and communications technology (ICT) teachers' perspective toward TPVK for 21st Century Learning (CL). Research with a mixed-method approach was conducted during the second semester in the 2019/2020 academic year. Sixty-five secondary vocational building engineering teachers from nine schools located in Central Java, Indonesia were recruited as survey respondents. The instrument used was a self-assessment questionnaire, lesson plan rubric, and observational protocol enriched with interview protocol. Results from this study show that the in-service vocational teacher shows readiness for TPVK 21st CL at the intermediate level. The TPVK component with the highest mean point is Pedagogical knowledge, while the lowest point is on the Vocational knowledge component. The lesson plan prepared by teachers and learning practiced performed by teachers showed less fitness of technology integration in learning with the strategies and objectives of the curriculum.

Keywords: survey study, teachers' perspective, Technological Pedagogical Vocational Knowledge, Vocational teacher, 21st Century learning

1 Introduction

The use of technology in learning is growing rapidly in the 21st century, along with the fast-moving technological developments. Teachers can take advantage of various forms of technology to support their teaching, such as animation [1–3], simulation [4–6], Augmented Reality [7–9], as well as an online learning platform [10–12]. For technology to be used effectively in learning, teachers need to have a good understanding of how to link learning technology with subject content and learning strategies applied [13].

A technological, pedagogical, content knowledge (TPACK), is developed as a framework to deal with the usage of technology in the instructional process [14]. It was derived and expended from Shulman's [15] model “pedagogical-content knowledge” with additions of “technological knowledge” had to be acquired by teachers as essential knowledge. Through the TPACK framework, it is hoped that teachers can plan and implement technology integration in instructional design for learning certain content [16]. Harris & Hofer [17] pointed out that TPACK's emphasis is on the intersection between technology-pedagogy-content to gain effective learning through technology.

The TPACK framework consists of three basic knowledge, namely knowledge of content-pedagogy-technology, where the three are equally important for developing capabilities in integrating technology [18]. Figure 1 shows the relationship between the three basic knowledge that make up the seven components in the TPACK framework, namely:

Figure 1: Seven Components of TPACK

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- (a) Technological knowledge/TK, known as knowledge defined by Mishra & Koehler [14] as knowledge related to various technologies, from simple ones such as pencil and paper to digital technologies such as the internet, digital video, educational games, interactive whiteboards, and software programs.
- (b) Content knowledge/CK, namely knowledge of a specific studied or taught course [14]. The teachers must enhance the core of materials going to be transferred by their nature to diverse domains.
- (c) Pedagogical knowledge/PK refers to the on-going activities in a class during the lesson [19]. This covers lesson plan development, assessment of learning, class management, and learning methods.
- (d) Pedagogical content knowledge/PCK, namely learning process knowledge which is in accordance with the characteristic of specific content [15]. PCK differs for different content areas because PCK combines content and pedagogy to develop better teaching practices in specific content areas.
- (e) Technological content knowledge/TCK, namely knowledge of how technology and content are related. Mishra & Koehler [14] mentioned that technology can generate new representations of certain content. It is expected that teachers understand that by using certain technologies, they can change the way students practice and understand the concept of certain content areas.
- (f) Technological pedagogical knowledge/TPK, namely knowledge of how various technologies can be used in teaching. Including components of the TPK according to Mishra & Koehler [14] namely choosing the appropriate type of technology, understanding and being able to apply certain teaching strategies for the use of technology, and understanding the advantages and disadvantages of using technology in learning.
- (g) TPACK, which is the knowledge that teachers need to include technology within the content coverage into the teaching activities [14]. Teachers need to have an intuitive understanding of the complex interactions between the three basic components of knowledge (CK, PK, TK). This understanding covers how technology is used to represent material concepts, teaching strategies of content materials constructively using technology, how technology can be used to help students understand the difficult parts of material content, comprehending students' preceded knowledge including to empower achieved ones through the assistance of technology.

The TPACK framework can be applied to various scientific fields, for instance in science education [13], language education [20], and sports education [21]. The components of TPACK evolved according to the specific fields in which the TPACK framework is implemented, such as the technological Pedagogical Science Knowledge (TPASK) in the science field [22], English as Foreign Language (EFL)-TPACK in the language field [23], as well as Global Pedagogical Content Knowledge (GPACK) for effective integration of global agriculture concept [24]. And although TPACK is a teacher's ability in teaching, research related to TPACK does not only need to be carried out on in-service teachers [22–24] but also necessary for prospective teachers [25–27].

Technological, pedagogical, vocational knowledge (TPVK) is a development of TPACK by focusing on content knowledge components on vocational knowledge. Some experts put forward theories related to this dimension of vocational knowledge (VC). Winch [31] states that VC should not only cover disciplines of knowledge related to practical work skills but must fulfill two further objectives, namely a higher understanding of the role of the field of work in society, as well as the personal development of individuals. This opinion is in line with Gamble [32] that the vocational curriculum should prepare students for work as well for further study. Therefore, the vocational curriculum must contain both theory and practice. The vocational curriculum needs to provide students with access in two directions, namely access to theoretical knowledge that supports vocational practice in certain fields of work, as well as access to knowledge that depends on the workplace context. Vocational knowledge must accommodate the combination of disciplinary knowledge and situational knowledge. Disciplinary knowledge is related to specific scientific theories whereas situational knowledge is closely related to tasks in certain fields of work [33].

Wheelahan [34] defines vocational knowledge as applied disciplinary knowledge, correlated to the goal in the vocational curriculum, which is to encourage students' mastery of practice areas as well as theoretical knowledge that supports the practice. The vocational education curriculum is based on knowledge of applied disciplines that are different from the academic qualifications. The applied disciplines consist of disciplinary knowledge that has been recontextualized for use in the field of vocational practice.

The need for disciplinary knowledge in practical procedures, one of which is to check whether claims of knowledge or new practical procedures have consistency with propositions that are generally accepted in scientific subjects, for example in the manufacture of certain measuring or testing equipment [31]. Vocational Experts can't rely solely on underlying knowledge for particular duties in

the workplace. However, vocational expertise depends on all the attributes required to take effective action, namely working with theoretical and propositional knowledge in a context appropriate to the field of work and local ethical values.

Furthermore, Wheelahan [34] states that ignoring the difference between the two knowledge weakens both. The role of educational institutions and workplaces as places of learning is equally important in vocational education. Learning that focuses only on the workplace will negate students' access to disciplinary concepts. Whereas learning that focuses only on theoretical knowledge in educational institutions does not give students access to knowledge that depends on the workplace context. The vocational curriculum, therefore, needs to provide students with access to both types of knowledge - to theoretical knowledge that supports vocational practice in the field of work, and to the knowledge that is dependent on the workplace context [33].

Bathmaker [35] mention the list of knowledge and skills that make up vocational education, which includes: 1) theoretical knowledge relevant to the practical field of work; 2) knowledge that involves learning about the field of practice itself; 3) knowledge of "how-to", related practical knowledge or technical skills, and the application of these skills and knowledge to solve problems in the workplace; 4) application of theoretical knowledge; 5) application of practical knowledge; 6) various personal and interpersonal skills and attributes that can be transferred.

Vocational education is an education pathway that prepares students primarily to work in certain fields. It mainly puts on its attention to set students for having specific skills, competencies, behaviors, and attitudes of cooperation and social concern, thus enabling young generations to be involved in the economy, strengthen social cohesion, and positively contributed to society [36]. Formal vocational education in Indonesia is the Vocational High School (Sekolah Menengah Kejuruan/SMK) at the secondary school level.

The general objective of vocational education is to develop job competencies. Meanwhile, there are six specific objectives of vocational learning outcomes, namely: mastering work procedures according to the field, having knowledge and being able to use them effectively, mastering functional literacy, having pride and concern for their fields, understanding the economic and social value of a job, and having a sense of desire, knowledge and always try to improve one's abilities through independent learning [37]. These objectives make vocational learning different from academic learning in general. These differences arise because there are differences in the nature of knowledge, information, and experience, and also differences in how learning content is defined and delivered.

In the vocational field, procedural knowledge (how) is as important as propositional knowledge (what), supported by the knowledge needed for performance. Presentation of information and experiences in vocational learning is represented episodically (based on previous knowledge and experience), conceptual (according to principles and definitions, equivalent to propositional knowledge), and through action (what can be done based on initial knowledge and accepted concepts) [38]. Further, Guthrie *et al.* [35] mention that vocational education's curriculum content is greatly influenced by the needs of the workplace. The approach used in many Asian countries, including in Indonesia is a competency-based curriculum. Competence from the point of view of constructivism theory is a process by which individuals construct their meanings so that they develop an approach to reality that enables them to act. Competence involves ability in planning, controlling, coordinating, monitoring, and self-evaluation, as well as performance in various tasks that require special skills [31].

The difference of vocational learning from academic learning in general causes special features in vocational learning areas, namely [38]: 1) real workplace learning; 2) encourage interactive and direct learning approach towards balanced practical skill and mindset; 3) set up clear learning results to be ready entering the world of career; 4) provide chances to have partnership and discussion for instructional process and assessment; 5) place students as 'co-producers' of knowledge and skills; 6) recognizing students' prior experience and knowledge to be a valuable basis for skills and knowledge; 7) apply a dynamic teaching approach corresponding to varied learning styles; and 8) appreciate the existence of social interaction within learning in groups.

The main point of vocational education and training is to build a techno-science-socio-cultural culture. The technology culture developed with the support of science builds convenience in every aspect of community life in a socio-cultural manner, in an order of life with local, national, regional, and global dimensions [39]. Indonesian National Qualification Framework [40] emphasized that vocational education must be closer to the skill needed to be successful in the workplace. The workplace in the 21st century requires mastery of critical thinking, creativity, collaboration, and communication skills or better known as 4C [41]. In line with the theme of long-term education development 2005-2025 planned by the government [42], the development of vocational education in Indonesia is directed at increasing international competitiveness as a foundation in building the nation's independence and competitiveness in facing global competition.

Vocational school teachers need to have sufficient knowledge to be able to plan and implement the learning that supports the mastery of 4C in accordance with their respective vocational skill areas. Learning vocational content that integrates technology with appropriate learning strategies can be a path for achieving vocational learning goals. Therefore, this research was conducted to measure the mastery of TPVK 21st CL - as the development of TPACK 21st CL for vocational teachers. Knowing the level of vocational teacher TPVK mastery is important to be able to plan a continuing professional program for teachers that supports the improvement of TPVK skills of teachers.

In general, TPACK measurement can be carried out in two ways, namely self-assessment survey [40, 41], and performance-based assessments [13, 42]. The use of more than one measurement method will provide a more complete picture of the TPACK among respondents because each method will support each other [13, 43, 44]. This research was conducted to capture the extent of the teacher's TPVK ability through three methods, namely self-assessment survey, lesson plan assessment, and teaching observation, to obtain a deeper picture. The results of this study can be used as a basis for formulating policies for professional development programs for teachers. By doing so, hopefully, the ability of teachers to integrate technology in accordance with their learning fields of knowledge can be continuously improved.

2 Method

This is mixed-method research. A survey method used a self-assessment questionnaire compared with lesson plan analysis and field observations were conducted in this study. Data collected from questionnaires and lesson plan analysis were analyzed quantitatively, while data from field observations were analyzed qualitatively. This study was conducted during the second semester in 2019/2020 of the Indonesian academic year. The 6-point Likert-type scale of validated and reliable self-assessment questionnaire [48] was used to measure the seven-element of TPVK. The questionnaire used has gone through four stages of development, namely (1) arranging the questionnaire's blueprint based on theories of TPVK, (2) drafting survey items for the seven TPVK domains, (3) reviewing the draft of survey items by experts, and (4) conducting item analysis and confirming validity and reliability of the instrument. The questionnaire consists totally of 54 items consisting of 10 items for pedagogical knowledge (PK), 6 items for vocational knowledge (VK), 5 items for technology knowledge

(TK), 12 items for vocational pedagogical knowledge (PVK), 6 items for technological pedagogical knowledge (TPK), 5 items for technical vocational knowledge (TVK) and 7 items for technological pedagogical vocational knowledge (TPVK).

A paper-based survey was used to measure the TPVK's self-assessment among vocational teachers. Purposive sampling was used as a sampling technique to collect respondents for this survey study. The secondary vocational teachers as respondents involved in this study were 65 secondary vocational building engineering teachers who come from nine secondary vocational schools in Central Java Province, Indonesia. The respondents consist of 63% male teachers and 37% female teachers. Most of them (78%) have teaching experience for more than 20 years. 60% of them stated that they had attended training related to the use of ICT in learning. Statistical descriptive analysis was conducted to analyze data from the self-assessment questionnaire to get a percentage (%), mean (M), and standard deviation (SD).

The lesson plan analysis was conducted using a rubric adapted from Harris, Grandgenett, & Hofer [49]. Four criteria were used to analyze how the lesson plan integrates technology into the learning plan. The four criteria are conformity of learning objectives with technology, the suitability of instructional strategies and technologies, suitability of technology selection with learning objectives and instructional strategies used, and overall suitability of materials, learning strategies, and learning technologies applied in the lesson plan. The rubric applied a four-point scale to assess each criterion. The lowest point (point 1) indicates that the composing components of the criterion do not match each other, while the highest point (point 4) indicates that all the constituent components of the criterion match together strongly. Nineteen lesson plan documents were stratified pragmatically collected from 65 teachers who were involved in the self-assessment survey. Two researchers analyzed those lesson plan documents by giving points in each criterion. Then inter-rater reliability with intraclass correlations (ICC) was conducted to determine the data's reliability in terms of the Cronbach alpha and the intraclass relationship on a single judge as well as the average judgments. The reliable data were then analyzed descriptively statistically in terms of mode.

The pragmatic sampling field observations enriched with interviews were conducted with 4 teachers who taught 4 of the 19 lesson plans previously analyzed. A protocol observation used was adapted from Harris, Grandgenett, & Hofer [49]. The points of observation were on the theme of learning being taught, learning strategies or main learning activities carried out, and the use of technology during the learning process. Two researchers together made observa-

tions in each observed learning class. A semi-structured interview was conducted immediately after each class observation. The protocol interview consists of two main questions as the area of interest in this study, namely: strategy used to deliver learning content and the use of ICT in the learning process. Content analysis was applied to analyze data from observations and interviews.

3 Result and Discussion

3.1 TPVK's self-assessment

The results from TPVK's self-assessment survey among secondary vocational teachers shown that PK has the highest achievement among the three fundamental elements of TPVK with a mean of 4.10 (SD = 0.94), followed by TK (M = 3.90; SD = 1.03) and VK (M = 3.85; SD = 0.95). The highest achievement for intermediate elements reached by TPK with a mean of 4.06 (SD = 0.98) followed by PVK with mean = 4.00 (SD = 0.86) and TVK with a Mean of 3.99 (SD = 1.07). The mean for the TPVK element was 3.84 (SD = 0.97). Table 1 displays the percentage of respondents (N = 65) with a certain rating scale point on each TPVK element.

Table 1 shows that the teacher's assessment of their knowledge of the components of the TPVK mostly shows a positive assessment with point ≥ 4 , although it is still dominated by point 4 (have knowledge). Among the three basic components in forming the TPVK, the best achievement was obtained in PK competency with 77% of respondents claiming to "have knowledge" from ordinary to excellent levels. Teachers' extended experiences in teaching have formed a fairly stable knowledge of the pedagogical knowledge of teachers [50, 51]. Research results from Chua [52] show that there is a positive relationship between teaching experience and the TPACK ability of teachers. Teaching experience for more than 20 years by the majority of respondents (78%) in this study has resulted in a high point of PK. PK is a core component in the active and ongoing development of teachers' TPACK [53]. Therefore, with good PK mastery, the development of other components will be easier.

There were 32% of respondents with TK point ≤ 3 . The amount was higher compared with other components. This condition is in line with the research results from Doering, Koseoglu, Scharber, Henrickson, & Lanegran [54] with the context of American geography teachers which showed that TK remained the lowest of all TPACK domains. Likewise, the results of research from Chua [52] in the context of Malaysian TVET instructors, showed that TK is the lowest

mean point among other TPACK basic components. The respondents of this study were non-ICT vocational teachers, so in general, there was no demand for technological skills. Research conducted by Nuni [55] was concluded that the TK ability of non-ICT vocational teachers is lower when compared to ICT teachers.

The lack of teacher knowledge related to technology has an impact on other technology-related knowledge components, namely TPK, TVK, and TPVK, indicated by the percentage of respondents with point ≤ 3 more than 20%. This condition is in line with the statement from Isiyaku, Ayub, & Abdul Kadir [56] that teachers' computer self-efficacy is the main influence of their perceived usefulness of ICT in learning. Likewise with the result of research by Anas & Musdariah [57] which places teachers' technological competencies and skills as the first requirement to become technology-literate teachers. The teachers with technophobia will be blocked from the actual use of technology and its integration in teaching and learning.

The teacher's lack of experience in integrating technology into learning certainly affects the level of ability of the TPK, TVK, and TPVK as a whole. The lack of teachers in integrating technology into learning apart from the teachers' and students' attitudes toward ICT integration [58], is also influenced by the many obstacles that must be faced by teachers. Salehi & Salehi [59] revealed some of the problems faced by teachers in applying technology in learning, namely insufficient technical supports at schools, little access to the internet, and the shortage of class time. Other obstacles are software and hardware limitation, school culture, grade level, physical space [60], limited access to equipment, limited technical knowledge, and limited infrastructure [54].

Figure 2 below illustrates the number in percent of teachers who perceive still need additional knowledge from a little to a lot (point 1-3) and those who perceive to "have knowledge" to "have strong knowledge" (point 4-6) on the seven components of the TPVK.

If seen in Figure 2 above, it appears that more than half of the teachers stated that they "have knowledge" in all the components of the TPVK. However, when viewed the percentage of point 4 to point ≥ 4 , it was still dominated by point 4 (56%-67%), as shown in Figure 3. It indicates that teachers assess their level of ability as just "know", not yet mastering it well, moreover at the expert level. Instructors in the field of technology tend to be competent in their knowledge of individual components of TPACK but not on the integration of these components for effective teaching. Engineering teachers need to have an agreement that it is important to have a balanced combination of knowledge

Table 1: The percentage of secondary vocational teachers regarding TPVK

Point	Point's Meaning	PK	TK	VK	PVK	TPK	TVK	TPVK
1	Need much additional knowledge	0%	0%	1%	0%	2%	2%	2%
2	Need some additional knowledge	6%	10%	8%	6%	6%	8%	10%
3	Need a little additional knowledge	15%	22%	22%	16%	15%	17%	13%
4	Have knowledge	44%	41%	47%	50%	45%	41%	51%
5	Have good knowledge	31%	21%	20%	26%	28%	26%	22%
6	Have excellent knowledge	4%	5%	3%	2%	4%	6%	3%

Figure 2: TPVK capabilities of vocational non-ICT teachers **Figure 3:** Percentage of point "4" to point ≥ 4 in secondary vocational non-ICT teachers

concerning the content, learning methods, and technology knowledge [61].

3.2 Analysis of the lesson plan documents

The TPVK evaluation based on the analysis of the lesson plan documents prepared by teachers consists of four criteria, namely Curriculum & Technology Objectives (use of technology-based on curriculum), Learning Strategy & Technology (use of technology in teaching and learning activities), Technology Selection (technology suitability with curriculum and strategy objectives), and "Fitness" (material, pedagogy, and technology together). The lesson plan documents were assessed by two researchers with equal academic competence. Inter-rater reliability using intraclass correlations was used to analyze the lesson plan assessment report from two researchers. The Cronbach's al-

Figure 4: Mode value from lesson plan analysis' results

pha for inter-rater reliability in four criteria were 0.747, 0.722, 0.751, and 0.707, respectively. The intraclass correlation showed that the reliability of a single judge level in four criteria were 0.596, 0.565, 0.601, and 0.547, and the average reliability for the two researchers was 0.747, 0.722, 0.751, and 0.707, respectively. This value of ICC is categorized as moderate [62].

The results of the TPVK evaluation from the lesson plan show that "the suitability of the curriculum and technology objectives" as the criterion that was rated the highest among the other criteria as shown in Figure 4. The mode value reached by these criteria was "3" which means "the technology used in the lesson plan is in accordance with one or more curriculum objectives". Meanwhile, the other criteria achieved the mode "2" which means "the use of technology slightly supports the learning strategy", "the technology chosen is not in accordance with the objectives of the curriculum and learning strategies" and "the materials, learning strategies, and technology together are quite suitable to be applied in the lesson plan".

3.3 The results of learning observations

Observations on the implementation of learning were carried out on four lessons from the 19 lesson plans analyzed

earlier. The results of the observation of the implementation of learning showed that TPVK still rarely implemented in all themes of learning being taught, according to those found in the lesson plan. The two teachers who were observed used the teacher center learning strategy. The first teacher delivered a mathematics-based subject matter, while the second teacher taught content in the area of the budget plan. Teachers explain the subject content directly using a blackboard in front of the class followed by individual exercises. There are no digital learning technologies used during the learning process. This method is of course less effective in terms of time and energy. For example, the teacher needs to repeat the making of pictures or written statements when there are questions from students about subject content that is no longer listed on the board. Further, this monotonous method makes students easily bored and diverts their attention to other things outside of the lesson, such as playing with gadgets, as found during observation. The availability of these gadgets should be used to support learning. When researchers confirm the situation with the teachers during the interview, they argue that they feel comfortable with the learning strategy that has been applied for so long. Lack of understanding of how technology can be integrated into learning strategies makes teachers feel reluctant to try it because they think it will be difficult to do.

In the third lesson observed, the teacher has implemented the use of technology in learning road construction. Students were asked to use their gadgets to dig up information related to the material being discussed in the class. Students search for information without any directions or keywords given by teachers. It was time-consuming and students often go into non-credible sources of information. There was no online learning platform used. From the interview, it was found that the teacher has given a stigma that students will be reluctant to access lessons outside school hours. Therefore, the teacher has the opinion that there is no need to prepare access for students to be able to study independently outside school hours, for example by utilizing information technology or online learning platform.

The fourth learning observed was drawing subjects with AutoCAD application. Even though these subjects directly related to technology, such as the technology used is solely the AutoCAD program for image creation. Not yet seen the use of other technology tools as learning aids. The learning strategy used in this subject is exercise-based learning. Based on the instruction given by the teacher, students practice using the AutoCAD application to draw a building design. According to the teacher statement which was given during the interview, using practical hours at

school to practice applying drawing software was enough to train students' drawing skills.

The little use of learning technology in vocational learning is very unfortunate. One of the characters of vocational content is to always follow the development of the workplace. The use of technology in learning is very supportive of such content characters.

This study indicates a significant difference between teachers' self-assessment and their practice in integrating technology during their lessons. The results of the self-assessment show that the majority of teachers already have knowledge related to technology integration in learning. However, the results of the analysis of the lesson plan and the learning implementation's observations show the low implementation of technology integration which fits with learning strategy and subject content. A previous study by Heitink, Voogt, Verplanken, Van Braak, and Fisser [63] reported the same circumstance, that there is a mismatch between teachers' assessment of their abilities and the performance they show in learning practice related to the integration of technology into learning. Teachers' knowledge about which technology is effective in realizing certain learning objectives will greatly influence the effectiveness of technology integration in learning. Hwee, Koh, Chai, & Hong [64] suggested that to enhance teachers' TPACK perceptions, they need guidance to develop lesson design practices iteratively based on their ideas.

3.4 Enhance TPVK skills through continuous professional development programs

Efforts to enhance teachers' ability to integrate technology into learning can be done through continuous professional development programs. As basic skills, the ICT application's training needs to be more conducted in teachers' professional development program to increase teachers ICT literacy [58]. As for the complete development of TPACK, several methods that have been used are through a design-based approach [65–68], the Learning Activity Types [50], utilization of open Access Repositories (OAR) and Digital Educational Resources (DER) [69] giving instructional scaffolding [54], and the use of class-based technology integration application examples [53].

A design-based approach could bring the situated perspective of learning into the TPACK framework. This approach designs a situation in which the teachers act and manifests their knowledge for knowledge development efforts. By addressing the concrete application of the knowledge manifested in a particular didactic design, this approach reduces the complexity of the TPACK framework.

A design-based approach that is carried out during the teachers' professional development program could encourage teachers to collaborate with other teachers and stakeholders to bring solutions to authentic problems and build artifacts for the certain subject matter and instructional goals [68]. A team-based design enabled teachers to draw upon the collective wisdom of a community to foster their TPACK. Through the design-implementation cycles, teachers develop their confidence as designers of pedagogical change [65].

The Learning Activity Types (LAT) approach [50] is used to assist teachers in connecting curriculum-based learning goals with content area-specific learning activities and complementary technology tools. The first step in the LAT approach is to determine different learning activities for each learning objective. Each activity type relates to what students do when engaged in that particular learning-related activity, such as collect data, doing the presentation, make a self-summary, etc. Selected learning activity types are combined to create a lesson plan, projects, and units. The next step is to choose technology that when combined with learning activities and learning objectives will work well. The next step is to introduce the teachers to the LAT taxonomies appropriate to their area of teaching, following with applying those taxonomies in Instructional Planning.

The development of Open Access Repositories (OAR) and easy access to Digital Educational Resources (DER) helps teachers design pedagogical and didactic approaches to learning in their field [69]. It supports teachers' TPACK by giving a better understanding of the potential of technologies in different approaches and representations of knowledge. Therefore, teachers could develop the ability to integrate technology in the teaching and learning process.

Doering *et al.* [54] reported that the provision of instructional scaffolding through teachers' professional development programs could help teachers to overcome barriers such as limited technology knowledge as well as limited understanding of pedagogical applications of content-specific technologies. Technology tools such as online learning environments, software programs, as well as mobile applications can scaffold teachers with pedagogical guidelines, content expertise, and technology support.

Best practices for class-based technology integration in certain contexts from other teachers can be a reference for other teachers in developing TPACK abilities. Of course, teachers need to be aware of the pedagogical reasoning to tailor practical examples from other teachers to their contexts [53]. During the learning process, technology can be used to stimulate students' critical thinking about authentic issues, to guide students in managing their learning, to help students develop diverse perspectives for factual

issues, to facilitate students in participating in collaboration with technology, and to guide students in constructing representations [70].

4 Conclusion

The results of a study to capture the extent of the TPVK 21st CL ability of vocational secondary school teachers in Indonesia through the self-assessment survey method showed that the TPVK among in-service teachers was at the intermediate level. The majority of teachers, $\geq 70\%$ ($n = 65$), stated that they had the ability in all the TPVK 21st CL forming components. The highest point achievement was PK with a mean of 4.10 and the lowest was VK with a mean of 3.85 (max point = 6). Meanwhile, the results of the lesson plan analysis show the low integration of technology into learning in accordance with the objectives and learning strategies, indicated by mode "2" on three of the four criteria observed. Teaching observations show a similar result, that was the low integration of technology into the learning process. Based on the results of this research, teachers' continuous professional development programs with several approaches were suggested to increase the ability to integrate technology into the learning process.

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