*ELINVO (Electronics, Informatics, and Vocational Education)*, *November 2021; vol6 (2):183-193*
*ISSN 2580-6424 (printed), ISSN 2477-2399 (online,) DOI: https://doi.org/10.21831/elinvo.v6i2.44301*

# Development and Validation of a TPACK Instrument for Preservice Teachers in the Faculty of Engineering UNY

**Bonita Destiana[1*], Priyanto[1], Ponco Walipranoto[1], Rahmatul Irfan[1]**
Department of Electronics and Informatics Education, Faculty of Engineering, UNY
*Email: bonita@uny.ac.id

## ABSTRACT

It is crucial to assess teachers' competency using TPACK. Therefore, the objective of this study was to develop a TPACK instrument for preservice teachers in the Faculty of Engineering, Universitas Negeri Yogyakarta. This study designed the TPACK instrument through 4 stages, namely: (1) literature study to determine the construct and statement items, (2) expert judgment to meet content validity, (3) revision and refinement of items from the review results, (4 ) validity and reliability testing. The research sample consisted of 200 preservice teachers. Validity and reliability testing used Confirmatory Factor Analysis (CFA) with a SmartPLS software program. The results suggested that the instrument met convergent validity with a loading factor value > 0.4, which ranged from 0.802 to 0.932, and discriminant validity, which indicated that the factor loading value for each observed variable with each latent variable was higher than the factor loading value with other latent variables. Composite Reliability values ranged from 0.908 to 0.954, and Cronbach Alpha ranged from 0.867 to 0.936, indicating that the instrument was reliable. Thus this instrument was considered effective in measuring the TPACK of preservice teachers preparing to be productive teachers in vocational high schools.

**Keywords***:TPACK instrument, confirmatory factor analysis, preservice teachers, vocational high schools*

## INTRODUCTION

The Law of the Republic of Indonesia Number 14 of 2005 concerning Teachers and Lecturers, Article 10 paragraph (1) states that teacher competencies include pedagogic competence, personality competence, social competence, and professional competence that were obtained through professional education [1]. Teachers must not only comprehend learning materials but also be able to determine methods and strategies for effectively explaining the materials to students. The importance of this aspect then emerges a new concept, namely a combination of subject-matter expertise and instructional strategies. Shulman proposed "Pedagogical Content Knowledge (PCK)" to describe this conceptual framework. Shulman [2] and Fernandez [3] explained that PCK consists of two main aspects, namely Pedagogical Knowledge and Content Knowledge.

In addition to pedagogical and content knowledge, technological knowledge in education is equally significant. Science and technology advancements can be beneficial to increase teachers' ability to provide high-quality lessons. Mishra and Koehler presented a conceptual framework for educational technology, extending Shulman's PCK formulation to the phenomena of teachers integrating technology into their teaching. The wise use of pedagogical technology requires developing a complex form of knowledge called technological pedagogical content knowledge (TPACK) [4]. This framework consists of the complex and interplay of roles among the three main components of the learning environment: content, pedagogy, and technology. The TPACK framework is built on top of the PCK framework by synthesizing Pedagogical Knowledge, Content Knowledge, and Technological Knowledge. The addition of the technological knowledge aspect is based on the needs and role of technology in today's teaching. Figure 1 describes the TPACK framework.

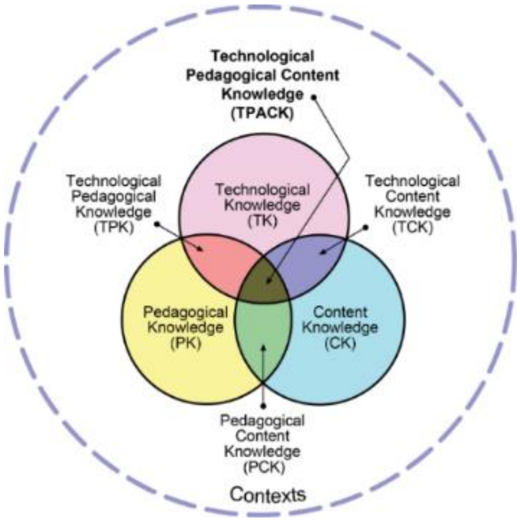


Figure 1. Technological Pedagogical Content Knowledge (TPACK)
(Retrieved from http://www.matt-koehler.com/tpack/using-the-tpack-image/ )

The TPACK framework (Figure 1) shows three primary forms of knowledge interacting to produce four derived forms. These forms include pedagogical content knowledge (PCK), technological content knowledge (TCK), technological pedagogical knowledge (TPK), and technological pedagogical content knowledge (TPCK). PCK refers to the unique form of teachers' professional knowledge in creating knowledge content that is accessible to students through several pedagogical methods. TCK focuses on content knowledge of content-specific software or hardware. TCK differs from TK in terms of specific content. TCK deals with specific software according to the required content, whereas TK deals with open software such as Microsoft Office, which is content-free software. In addition, TCK itself is not related to teaching. On the other hand, TPK refers to knowledge of the pedagogical use of related technologies without considering content knowledge. Meanwhile, TPCK is a synthesis of the six types of knowledge that have been mentioned [5].

One strategy to improve the quality of education is to improve teachers' understanding of their roles and responsibilities in the education system [6]. In other words, improving the quality of education starts with the teacher. One of the ways to increase teachers' competence is through Teacher Professional Education (*Pendidikan Profesi Guru*/PPG). PPG program is an educational program designed for graduates of Bachelor of Education and Non-Education majors who have a passion for teaching and want to become professional teachers who meet national education standards and earn educator certification. Teachers can increase their capacity to select and comprehend instructional materials, plan, develop, and implement effective teaching and learning processes by participating in PPG [7].

In 2020, the Faculty of Engineering UNY was assigned to hold a Collaborative Teacher Professional Education Program for Vocational Productive Teachers. After undergoing those program, all participants as preservice teachers are expected to be professional and innovative teachers so that the learning process in the classroom is no longer conventional. The use of technology in the learning process can certainly improve teachers' innovation and creativity in the classroom. Recently, there has been a shift in preservice teachers' attitudes toward technology. Previously, they would teach and learn about technology, but now they believe they will use technology to aid in learning [8].

Koehler, Mishra, & Cain state that teaching that utilizes technology requires changes in existing practices, both in pedagogy and content [9]. Therefore, teachers must be able to go beyond technological literacy to promote educational practices that innovatively need to use the interaction of technology, pedagogy, and content. Meanwhile, according to Schmidt et al. [10], TPACK refers to knowledge of how to use appropriate technology in the classroom to aid student learning and assist teachers in thinking creatively. TPACK will also reflect teachers' experiences to help them become more professional and add a new dimension to instructional technology. It demonstrates that TPACK is a crucial factor that can increase the quality of education. Considering the significance of TPACK for prospective teachers' performance, this study aims to develop and test the validity of a TPACK instrument for preservice teachers who are Teacher Professional Education Program participants in the Faculty of Engineering UNY.

## METHODS

### *A. Research type and stages*

This study was development research. Figure 2 presents the research procedure. The first step of the study was a literature review to identify constructs and indicators of the TPACK framework. FGD was used in the second step to evaluate the instrument items generated using previous studies' conceptual framework and adaptations. The third stage was revising and refining items based on expert reviews. The instrument was evaluated on a research sample in the fourth stage to ensure validity and reliability.

### *B. Population and Sample*

The population of this study consisted of all PPG participants in the FT UNY. This study implemented a non-probability sampling technique with purposive sampling. Purposive sampling is the determination of samples with specific considerations [11]. The sample size in this study was 200, which corresponded to Thompson's view that at least 200 respondents should be sampled to obtain factor analysis stability [12].

### *C. Data Collection Technique*

Data collection was through a closed questionnaire because the respondent provides answers by choosing an alternative that best suits him. On a five-point Likert scale, the responses ranged from Strongly Disagree to Strongly Agree. The Google Form was used to present the questionnaire.

| | **Activity** | **Product** |
|---|---|---|
| Item Construction | Literature study based on TPACK framework to define constructs and indicators | • TPACK constructs and instrument items<br>• Theoretical item validity |
| Expert Judgement | FGD with experts to evaluate the instruments | The instrument meets content validation |
| Revision | Instrument refinement and items refinement | Instruments that are ready to be tested for construct validity and reliability |
| Finalization | Validity and reliability testing used Confirmatory Factor Analysis (CFA) with a SmartPLS software program | • The instrument meets the requirements of validity and reliability.<br>• The instrument is ready to be used for further research. |

Figure 2. Instrument Development Stages

### *D. Data Analysis*

In required to address the aspects of validity and reliability, data analysis was conducted for instrument testing. The instrument validity used in this study was content and construct validity. The content validity test was conducted by compiling an instrument grid and asking for expert judgment. The outer model, which was a measurement model to verify the validity and reliability of the construct, was tested using confirmatory factor analysis (CFA) with the SmartPLS software tool. The criteria that demonstrate construct validity are as follows: (1) convergent validity, by looking at the loading factor score > 0.4 for a sample of 200 [13] ; (2) discriminant validity, by looking at the cross-loading score, if the observed variable correlation in each latent variable is more significant than in the other latent variables, then it shows that the latent variable predicts the size of their block better than the size of the other blocks. At the same time, the reliability test was measured by two criteria, namely Composite Reliability and Cronbach Alpha. Composite Reliability and Cronbach Alpha values for measurement items considered good and acceptable are at least 0.70 [13].

## RESULT AND DISCUSSION

### *A. Instrument Development*

Preparing the instrument started with a literature study based on the TPACK framework to determine constructs and indicators. The literature study was carried out in two stages. In the first stage, it focused on theoretical studies according to the conceptual framework of PCK [2], [14], and TPACK [15]. TPACK is determined by seven variables (Shulman [2]; Mishra & Koehler [4]; Cox & Graham [16]), namely: 1) Technological Knowledge (TK) is about knowledge of how to operate computers and relevant software; 2) Pedagogical Knowledge (PK) is about teacher's capability to manage student learning; 3) Content Knowledge (CK) is the discipline of knowledge such as knowledge of the language, Mathematics, and Natural Sciences; 4) Technological Content Knowledge (TCK) is knowledge of how content can be researched or represented by technology; 5) Pedagogical Content Knowledge (PCK) is the knowledge of how to represent and formulate a subject to demonstrates it; 6) Technological Pedagogical Knowledge (TPK) is knowledge of how to use technology as a pedagogical approach such as using online discussion forums to build of social knowledge; 7) Technological Pedagogical Content Knowledge (TPACK) is knowledge of how to support students in learning certain content with pedagogical and technological approaches.

Then in the second stage, a literature study was conducted to adapt the instrument items from previous studies [5], [10], [17]–[20]. Based on this two-stage process, a draft of the first instrument was compiled, referring to the operational definitions of seven aspects of TPACK, namely TK, PK, CK, TPK, TCK, PCK, and TPACK. Each operational definition was developed into 4 to 6 items; thus, the total statement items in the first draft instrument were 32 items. The instrument was on a five-point Likert scale, with responses ranging from Strongly Disagree to Strongly Agree.

Furthermore, a review of the instrument was carried out through Focus Group Discussion (FGD) involving four experts in the field of education and two students to fulfill the content validity. Experts evaluated the first draft of the instrument, such as adjusting items with indicators, arranging the wording of statement items, and removing items that were not appropriate. Meanwhile, the students read the instrument and expressed their opinion regarding the clarity and legibility of the items. Based on the FGD, the first draft of the instrument was revised to 31 items and translated into the Indonesian language for use in the next stage.

### *B. Instrument Validity and Reliability*

Instrument validity and reliability are two essential concepts for assessing the quality of an instrument. While reliability concerns internal consistency, validity mainly concerns how the instrument measures what it is supposed to measure [21]–[23]. Reliability and validity are also interrelated concepts, so researchers must be aware of this relationship and ensure that the instrument has reliability and validity. Without reliability, for example, it is impossible to adequately describe the instrument's validity [23], [24].

After the instrument was revised according to input from experts, further testing was carried out to assess validity and reliability. The test was conducted on 200 respondents. Validity testing used Partial Least Squares (PLS) method by looking at the value of convergent validity and discriminant validity. The validity test results (outer model evaluation) showed that the loading factor value had met > 0.4, as shown in Table 1. It indicated that all Observed Variables for each Latent Variable had met Convergent Validity.

The results of the next validity test were based on discriminant validity criteria which could be seen in the output cross-loading between the observed variables and the latent variable in Table 2. The output presented in Table 2 explained that the factor loading value of each observed variable with each latent variable was higher than the factor loading value with other latent variables. It indicated that the latent variable predicted the observed variable on its block better than the observed variable on the other latent variables. As a result, all items in each construct met the Discriminant Validity requirements.

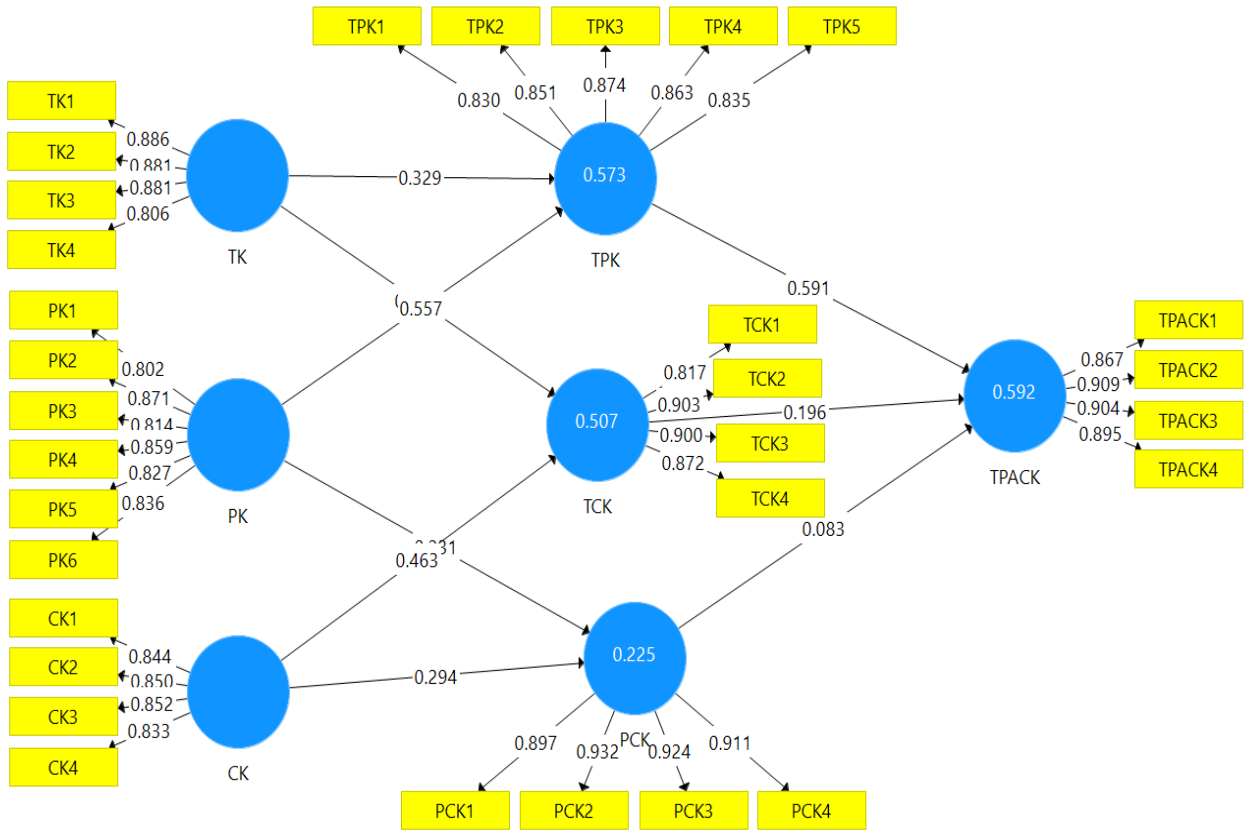

Figure 3. Outer Model Evalution

Table 1. Loading Factor Value

| | TK | PK | CK | TPK | TCK | PCK | TPACK |
|---|---|---|---|---|---|---|---|
| **TK1** | 0.886 | | | | | | |
| **TK2** | 0.881 | | | | | | |
| **TK3** | 0.881 | | | | | | |
| **TK4** | 0.806 | | | | | | |
| **PK1** | | 0.802 | | | | | |
| **PK2** | | 0.871 | | | | | |
| **PK3** | | 0.814 | | | | | |
| **PK4** | | 0.859 | | | | | |
| **PK5** | | 0.827 | | | | | |
| **PK6** | | 0.836 | | | | | |
| **CK1** | | | 0.844 | | | | |
| **CK2** | | | 0.850 | | | | |
| **CK3** | | | 0.852 | | | | |
| **CK4** | | | 0.833 | | | | |
| **TPK1** | | | | 0.830 | | | |
| **TPK2** | | | | 0.851 | | | |
| **TPK3** | | | | 0.874 | | | |
| **TPK4** | | | | 0.863 | | | |
| **TPK5** | | | | 0.835 | | | |
| **TCK1** | | | | | 0.817 | | |
| **TCK2** | | | | | 0.903 | | |
| **TCK3** | | | | | 0.900 | | |
| **TCK4** | | | | | 0.872 | | |
| **PCK1** | | | | | | 0.897 | |
| **PCK2** | | | | | | 0.932 | |
| **PCK3** | | | | | | 0.924 | |
| **PCK4** | | | | | | 0.911 | |
| **TPACK1** | | | | | | | 0.867 |
| **TPACK2** | | | | | | | 0.909 |
| **TPACK3** | | | | | | | 0.904 |
| **TPACK4** | | | | | | | 0.895 |

Table 2. Cross Loading Value

| | TK | PK | CK | TPK | TCK | PCK | TPACK |
|---|---|---|---|---|---|---|---|
| **TK1** | **0.886** | 0.354 | 0.579 | 0.502 | 0.521 | 0.209 | 0.493 |
| **TK2** | **0.881** | 0.327 | 0.524 | 0.485 | 0.542 | 0.181 | 0.471 |
| **TK3** | **0.881** | 0.341 | 0.505 | 0.473 | 0.529 | 0.258 | 0.479 |
| **TK4** | **0.806** | 0.434 | 0.536 | 0.486 | 0.526 | 0.219 | 0.468 |
| **PK1** | 0.412 | **0.802** | 0.522 | 0.583 | 0.490 | 0.339 | 0.620 |
| **PK2** | 0.387 | **0.871** | 0.591 | 0.635 | 0.496 | 0.338 | 0.627 |
| **PK3** | 0.350 | **0.814** | 0.486 | 0.552 | 0.452 | 0.341 | 0.534 |
| **PK4** | 0.384 | **0.859** | 0.538 | 0.601 | 0.489 | 0.373 | 0.594 |
| **PK5** | 0.304 | **0.827** | 0.514 | 0.575 | 0.455 | 0.343 | 0.491 |
| **PK6** | 0.264 | **0.836** | 0.462 | 0.532 | 0.327 | 0.343 | 0.534 |
| **CK1** | 0.524 | 0.517 | **0.844** | 0.486 | 0.489 | 0.375 | 0.515 |
| **CK2** | 0.563 | 0.516 | **0.850** | 0.504 | 0.550 | 0.338 | 0.536 |
| **CK3** | 0.470 | 0.514 | **0.852** | 0.456 | 0.554 | 0.425 | 0.583 |
| **CK4** | 0.542 | 0.555 | **0.833** | 0.568 | 0.641 | 0.342 | 0.581 |
| **TPK1** | 0.544 | 0.583 | 0.547 | **0.830** | 0.659 | 0.268 | 0.635 |
| **TPK2** | 0.522 | 0.570 | 0.535 | **0.851** | 0.587 | 0.253 | 0.585 |
| **TPK3** | 0.512 | 0.614 | 0.542 | **0.874** | 0.588 | 0.255 | 0.659 |
| **TPK4** | 0.431 | 0.614 | 0.486 | **0.863** | 0.572 | 0.227 | 0.670 |
| **TPK5** | 0.381 | 0.576 | 0.425 | **0.835** | 0.513 | 0.244 | 0.640 |
| **TCK1** | 0.491 | 0.332 | 0.505 | 0.550 | 0.817 | 0.212 | 0.455 |
| **TCK2** | 0.558 | 0.511 | 0.616 | 0.591 | 0.903 | 0.292 | 0.516 |
| **TCK3** | 0.502 | 0.510 | 0.583 | 0.623 | 0.900 | 0.227 | 0.561 |
| **TCK4** | 0.582 | 0.523 | 0.610 | 0.632 | 0.872 | 0.243 | 0.638 |
| **PCK1** | 0.273 | 0.432 | 0.453 | 0.313 | 0.307 | **0.897** | 0.294 |
| **PCK2** | 0.204 | 0.386 | 0.411 | 0.266 | 0.226 | **0.932** | 0.285 |
| **PCK3** | 0.223 | 0.349 | 0.395 | 0.251 | 0.260 | **0.924** | 0.293 |
| **PCK4** | 0.211 | 0.338 | 0.331 | 0.234 | 0.222 | **0.911** | 0.263 |
| **TPACK1** | 0.440 | 0.606 | 0.538 | 0.648 | 0.530 | 0.306 | **0.867** |
| **TPACK2** | 0.537 | 0.622 | 0.613 | 0.672 | 0.580 | 0.287 | **0.909** |
| **TPACK3** | 0.497 | 0.601 | 0.591 | 0.691 | 0.569 | 0.261 | **0.904** |
| **TPACK4** | 0.501 | 0.601 | 0.608 | 0.670 | 0.558 | 0.260 | **0.895** |

A reliability test was conducted in addition to the validity test. Cronbach's alpha coefficient, one of the numerous viable techniques for measuring instrument reliability, can verify the instrument's reliability and assure its internal consistency [23]. The reliability of this study was assessed using two criteria: Composite Reliability and Cronbach Alpha. Figure 3 shows that each Latent Variable's Composite Reliability and Cronbach Alpha values were above 0.70, suggesting that each Latent Variable in the tested model had high reliability.

Table 3. Composite Reliability and Cronbach's AlphaValues

| | Composite Reliability | Cronbach's Alpha |
|---|---|---|
| **TK** | 0.922 | 0.886 |
| **PK** | 0.933 | 0.913 |
| **CK** | 0.909 | 0.867 |
| **TPK** | 0.929 | 0.905 |
| **TCK** | 0.928 | 0.896 |
| **PCK** | 0.954 | 0.936 |
| **TPACK** | 0.941 | 0.916 |

The overall test results concluded that all items on the instrument were valid and reliable, indicating that the developed instrument could be used to assess preservice teachers' self-assessment in the TPACK knowledge domain. Table 4 lists the instrument items that have passed the validity and reliability tests and can be utilized in further study.

Table 4. The instrument items that meet the validity and reliability

| No | Construct | Items |
|---|---|---|
| **1** | Technological Knowledge (TK) | 1. *Saya memiliki keterampilan teknis untuk menggunakan komputer secara efektif.* |
| | | 2. *Saya bisa belajar menggunakan teknologi dengan mudah.* |
| | | 3. *Saya tahu bagaimana menyelesaikan masalah teknis saya sendiri ketika menggunakan teknologi.* |
| | | 4. *Saya mengikuti perkembangan teknologi baru yang penting.* |
| **2** | Content Knowledge (CK) | 1. *Saya memiliki pengetahuan yang cukup tentang subjek pengajaran saya.* |
| | | 2. *Saya dapat berpikir tentang isi mata pelajaran saya seperti ahli materi pelajaran.* |
| | | 3. *Saya bisa mendapatkan pemahaman yang lebih dalam tentang isi pelajaran saya sendiri.* |
| | | 4. *Saya yakin bisa mengajarkan materi pelajaran.* |
| **3** | Pedagogical Knowledge (PK) | 1. *Saya dapat mengembangkan pemikiran siswa saya dengan menciptakan tugas yang menantang bagi mereka.* |
| | | 2. *Saya dapat membimbing siswa saya untuk mengadopsi strategi pembelajaran yang tepat.* |
| | | 3. *Saya dapat membantu siswa saya untuk memantau pembelajaran mereka sendiri.* |
| | | 4. *Saya dapat membantu siswa saya untuk merefleksikan strategi pembelajaran mereka.* |
| | | 5. *Saya dapat merencanakan kegiatan kelompok untuk siswa saya.* |
| | | 6. *Saya dapat membimbing siswa saya untuk berdiskusi secara efektif selama kerja kelompok.* |
| **4** | Pedagogical Content Knowledge (PCK) | 1. *Tanpa menggunakan teknologi, saya dapat mengatasi kesalahpahaman umum yang dimiliki siswa saya untuk mata pelajaran mengajar pertama saya.* |
| | | 2. *Tanpa menggunakan teknologi, saya tahu bagaimana memilih pendekatan pengajaran yang efektif untuk membimbing pemikiran siswa dan pembelajaran materi pelajaran untuk subjek pengajaran pertama saya.* |
| | | 3. *Tanpa menggunakan teknologi, saya dapat membantu siswa saya untuk memahami konten pengetahuan dari subjek pengajaran pertama saya melalui berbagai cara.* |
| | | 4. *Tanpa menggunakan teknologi, saya dapat mengatasi kesulitan belajar umum yang dimiliki siswa saya untuk mata pelajaran pengajaran pertama saya.* |
| **5** | Technological content knowledge (TCK) | 1. *Saya dapat menggunakan perangkat lunak yang dibuat khusus untuk mata pelajaran pengajaran saya.* |
| | | 2. *Saya tahu tentang teknologi yang harus saya gunakan untuk mempelajari isi pelajaran saya.* |
| | | 3. *Saya dapat menggunakan teknologi yang tepat untuk mewakili konten dari mata pelajaran pengajaran saya.* |

| No | Construct | Items |
|---|---|---|
| | | 4. *Saya dapat menggunakan perangkat lunak khusus untuk melakukan penyelidikan tentang subjek pengajaran saya.* |
| **6** | Technological pedagogical knowledge (TPK) | 1. *Saya dapat menggunakan teknologi untuk memperkenalkan siswa saya ke skenario dunia nyata.* |
| | | 2. *Saya dapat memfasilitasi siswa saya untuk menggunakan teknologi untuk menemukan lebih banyak informasi sendiri.* |
| | | 3. *Saya dapat memfasilitasi siswa saya untuk menggunakan teknologi untuk merencanakan dan memantau pembelajaran mereka sendiri.* |
| | | 4. *Saya dapat memfasilitasi siswa saya untuk menggunakan teknologi untuk membangun berbagai bentuk representasi pengetahuan.* |
| | | 5. *Saya dapat memfasilitasi siswa saya untuk berkolaborasi satu sama lain menggunakan teknologi.* |
| **7** | Technological pedagogical content knowledge (TPACK) | 1. *Saya dapat merumuskan topik diskusi mendalam tentang pengetahuan konten dan memfasilitasi kolaborasi online siswa dengan alat yang sesuai.* |
| | | 2. *Saya dapat menyusun kegiatan untuk membantu siswa membangun representasi berbeda dari pengetahuan konten menggunakan alat TIK yang tepat.* |
| | | 3. *Saya dapat membuat kegiatan belajar mandiri dari pengetahuan konten dengan alat TIK yang tepat.* |
| | | 4. *Saya dapat merancang kegiatan inkuiri untuk membimbing siswa agar memahami isi pengetahuan dengan alat TIK yang tepat.* |

The instrument was developed with the specific objective of analyzing the development of TPACK for preservice teachers of the PPG program in the Faculty of Engineering, UNY; therefore, it was designed for preservice teachers who are prepared to be productive teachers in Vocational High Schools. In general, productive teachers in Vocational High Schools teach specific areas of expertise. A normative and adaptive instrument for teacher self-assessment is required in Vocational High Schools to specifically discuss teachers' fields, such as mathematics, science, social sciences, and languages. Based on these findings, it seems realistic that there will be instruments specifically designed for each subject area.

## CONCLUSION

Validity and reliability testing revealed that all 31 statement items passed the reliability and validity requirements. The instrument created in this study can assess and encourage the development of TPACK for preservice teachers preparing to teach in Vocational High Schools. Policymakers can apply this instrument to map teachers' competencies based on TPACK results. In the future, the researcher will conduct research with preservice teachers to see how TPACK improves once PPG participants have completed the entire training program.

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