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Research Article

21st Century chemistry teacher: Analysis of TPACK of pre-service chemistry teachers in teachers college

Friska Juliana Purba, Kelly Sinaga, Debora Sitinjak, Candra Y. Tahya

Departement of Chemistry Education, Faculty of Teachers College, Universitas Pelita Harapan, Tangerang 15811, Indonesia

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Keywords

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Corresponding author:
E-mail: friskajulianapurba@gmail.com
(Friska J. Purba)

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Abstract

This research is aimed to analyze chemistry pre-service teachers' profile of the TPACK (Technology Pedagogy and Content Knowledge) competencies in Teachers College. The method used in this study was a mixed method using TPACK's questionnaire and interview. This study revealed that Content Knowledge (CK), Technology Knowledge (TK), Pedagogy Knowledge (PK), Pedagogy Content Knowledge (PCK), and Technology Pedagogy Knowledge (TPK) components of TPACK of pre-service teachers are excellent. The Technology Content Knowledge (TCK) component needs to be improved throughout training courses that enabled the pre-service teacher to utilize, design, and apply various chemistry-based computer applications. The component of TPACK will continue to develop with the support of institutions and teaching experience. Strengthening the components of TPACK is important for a chemistry teacher to embrace 21st century learning.

Introduction

The direction of education in the 21st century is no longer just the transfer of knowledge from teacher to student but provides opportunities to use knowledge in order to help prepare students for a dynamic and unpredictable world, creative being, and room for the uniqueness of individual intelligence and build innovators. (Astuti et al. 2019). For this reason, the 21st century demands several competencies that must be possessed by a teacher to prepare students to face various challenges. Teachers must have the skills and qualifications so that their functions and roles can be carried out properly (Prayogi, 2019). Teachers must be able to stimulate students to be more creative and innovative so that the theories learned can be implemented in their daily lives (Dakhi et al. 2020).

Teachers in the 21st century must have competencies in carrying out teaching tasks, such as choosing appropriate approaches, teaching strategies, models, methods and learning media to be applied (Utomo, 2018; Paristiowati et al. 2019) as well as in identifying student needs and adept using technology in learning, so the students can learn from the learning experience (Rochintaniawati et al. 2019). In addition, teachers must also master technology and information literation. Environmentally friendly and community-friendly technology is a technology that needs to be developed in this 21st century digital era (Sonia, 2019).

Teachers are expected to continue to innovate in the learning process and keep up with education and curriculum development, as well as in-use technology. Competencies or skills that must be possessed in the 21st century is described in 4 competences namely critical thinking and problem solving, creativity and innovation, communication, and collaboration (Redhana, 2019). Teaching is a complex activity because it needs an understanding of content knowledge (CK), technology knowledge (TK), and pedagogical knowledge (PK) as to manage teaching-learning process. Connections between those components are drawn by Mishra and Koehler (Fig.-1).

TPACK is a wide integration of knowledge and skills regarding content and pedagogy combined with advanced technological developments. TPACK itself is built on 6 components, namely Technological Knowledge

(TK), Content Knowledge (CK), Pedagogical Knowledge (PK), Pedagogical Content Knowledge (PCK), Technological Content Knowledge (TCK), and Technological Pedagogy Knowledge (TPK). The components of the TPACK itself are also interrelated to assist a teacher in integrating their learning (Joharmawan et al. 2021). TPACK differs from individuals of content knowledge, pedagogy, and technology. TPACK is a form of professional knowledge of adept in pedagogy and technology, which is used by curriculum-oriented teachers when teaching (Harris et al. 2014).

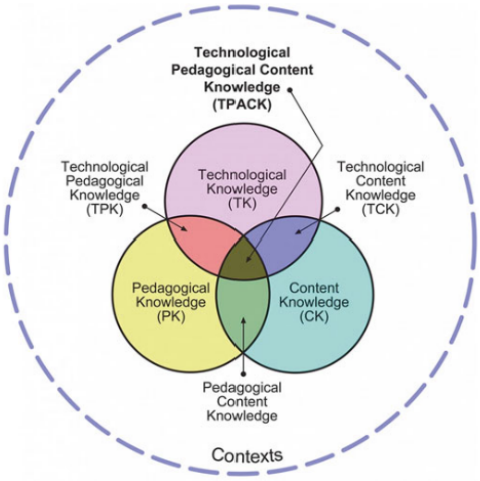

Fig.-1. Technological Pedagogical and Content Knowledge (Abbitt, 2011).

Table 1. Conversion of Correlation

Correlation coefficient	Description
0.0-0.19	Very weak
0.2-0.39	Weak
0.4-0.59	Middle
0.6-0.79	Strong
0.8-1	Very strong

Chemistry teachers need the TPACK to be able to overcome chemistry problems in an effective and efficient way (Utami and Muhtadi, 2019). Chemistry teachers need to understand and explain the macroscopic, sub-microscopic, and symbolic representation of chemistry that requires technology such as videos, animations, and simulations so that learning can take place creatively and innovatively (Liunokas et al. 2020). Chemistry teachers still need to master effective learning strategies in teaching chemistry content, especially the use of animation and demonstrations in describing the distance and motion of particles in solids, liquids, and gases (Maryati et al. 2019).

Chemistry teachers in the 21st century have more opportunities as well as challenges to create a better chemistry learning experience and be able to improve the quality of chemistry learning. Thus, the purpose of this study is to describe and analyze the TPACK competencies of chemistry pre-service teachers in Teachers College and to provide information on components that still need to be improved in the process of teaching and developing the Teachers College chemistry teacher program and curriculum.

Method

This research uses a mixed-method approach to describe the chemistry teachers' perception of TPACK components (Santos and Castro, 2021). The data is collected with a survey questionnaire, then analyzes the data to build up a second qualitative phase with interview. Analysis of the TPACK teacher profile with the help of the TPACK questionnaire. Overall, the questionnaire contained 33 reporting elements covering the 7 sub-areas of the TPACK. Status element distribution details, consisting of 6 TK elements, 4 CK elements, 7 PK elements, 3 PCK elements, 3 TCK elements, 9 TPK elements and 1 TPACK element (Schmidt et al. 2009). Respondents in this study were 16 chemistry pre-service teachers. The instrument uses 5 Likert scales consisting of: 1 (strongly

disagree); 2 (disagree); 3 (hesitated); 4 (agree), and 5 (strongly agree). In this table uses the correlation to provide an overview of the quality of the distribution of data in a sample so that can shown in category of description (Table 1).

Results and Discussion

In this research, the identification and description of the TPACK's chemistry teacher's profile was conducted. The result of this study can be shown in Table 2. Relationship in TPACK component with the correlation analysis is shown in Table 3. In this Table uses the standard deviation to provide an overview of the quality of the distribution of data in a sample (Zein et al. 2019). If the value of the standard deviation is smaller than the mean, then performance can be said to be good. As shown from the table and using a Likert scale category is seen that the value of the mean from TPACK component of pre-service chemistry teachers "agree" options on the scale in TK, CK, PK, PCK, TPK dan TPACK areas. This score means that pre-service teachers feel that they are in "Good" category in TPACK level.

Table 2. Mean score of components *of* TPACK

Component of TPACK	Mean	Standard Deviation	Category
TK	4.078	0.639	Good
CK	4.150	0.646	Good
PK	4.171	0.567	Good
PCK	4.356	0.527	Good
TCK	3.733	0.944	Good
TPK	4.104	0.635	Good
TPACK	4.000	0.756	Good

As shown from Table 3, the relationship of TPACK component. The strong positive correlation shown in CK-PCK, PK-PCK, PK-TCK, PCK-TCK, PCK-TPK, TCK-TPK, dan TPK-TPACK component. In every component, the relationship of TK-PK and TK-TPACK is in the middle category. The relationship is in line with the interview that technology in chemistry learning still need to be improved to used PPT, video, simulation, and other application such as Kahoot, Quizizz, Padlet, etc. These students do not know much and explore technology and other applications that can be used in chemistry learning. Technological knowledge within the framework of TPACK is an essential component that brings together content knowledge and pedagogy (Mouza and Karchmer-Klein, 2013; Harris et al. 2014). Technological knowledge within the framework of TPACK is quite different from just knowledge of technology but how the technology is utilized in teaching activities, especially in chemistry learning. From the interview, some of the student show that it's difficult to integration technology in chemistry learning because the limitation of the computer. For effective technology integration in instruction, knowledge about technology is not enough; teachers should have different knowledge types which are content, pedagogical, and technological (Cetin-Dindar and Geban, et al. 2018). From these problems, a special program on technological knowledge and its utilization in the process of teaching and learning chemistry needs to be provided to facilitate pre-service teacher to provide better chemistry learning in the future.

The relationship between CK component and other components based on questionnaire results is very strong, however, based on the results of the interview, there are still weaknesses in the knowledge of chemical content where one of the indicators is the ability to identify misconceptions. Some of student need more time to know about the chemistry. Studying chemistry has its own difficulties, like learning something abstract. Chemistry tends to learn something invisible, so learning Chemistry becomes difficult for visual learners. For visual learners, studying Chemistry is challenging because of its abstract nature. Chemistry is focused on the invincible such as the basic concepts of atoms, elemental reactivity, and molecular geometry which is related to molecular properties. In addition, the percentage of concepts that need to be memorized and the calculations are two, among others, reasons why Chemistry is a complex science to learn.

Most of the students are still lack of when asked to mention and identify misconceptions or still experience misconceptions on some topics. Knowledge of chemical content also urgently needs to be improved, because

understanding of content can affect the selection of appropriate teacher strategies/ pedagogy (Anwar, 2016). In the pedagogical component (PK) and its relationship with other components, pre-service teachers show a good understanding of classroom strategy and management and get to know the characteristics of students, however, this component will be better if directly applied when learning chemistry. Teachers sometimes fail to integrate technology effectively into their teaching because of a lack of pedagogical knowledge (Hew and Brush, 2007).

Table 3. Correlation analysis of components of TPACK

Component	TK	CK	PK	PCK	TCK	TPK	TPACK
TK		0.698	0.576	0.857	0.609	0.758	0.542
CK			0.809	0.938	0.811	0.752	0.694
PK				0.882	0.759	0.836	0.786
PCK					0.813	0.874	0.750
TCK						0.830	0.700
TPK							0.860
TPACK							1

In the framework of TPACK, content knowledge is very closely related to pedagogical knowledge which is manifested in the PCK component. To be able to teach content (chemistry) appropriately, it is necessary to choose and use the right learning strategy or method (Utami and Muhtadi, 2019). PCK is the component of a professional teacher formed from content knowledge and pedagogy that develops uniquely over time and teaching experience. Although the relationship between CK-PCK, PK-PCK and PCK-TPACK is strong, it takes teaching experience to be able to form the quality of professional teachers.

In integrating TPACK, teachers combine pedagogical, content, and technology skills in the classroom because they can be used in a variety of ways. Teachers can see students' ability to analyze content with support from technological media such as videos, animations, and images (Setiawan et al. 2019; Anci et al. 2021). Science issues, in particular chemistry concepts, deal with microscopic levels. Students often have difficulty in understanding and visualizing microscopic concepts such as atoms, molecules, or chemical reactions. Educational technologies such as animations and simulations are quite helpful in visualizing these concepts; chemistry teachers who integrate these educational technologies into the teaching and learning process may support effective learning (Moore et al. 2013). In line with (Bernardes and de Andrade Neto, 2021; Paristiowati et al. 2020) in explaining the chemical content, the concept of acid-base, the teacher applies the component of TPACK, students more easily understand the concept of acid-base both in theory and demonstration, in this case the teacher acts as a facilitator, however, still involved in learning, the advantages in using TPACK is also, teachers are easier to manage the classroom, the learning experience of both teachers and students is also increasing.

Conclusion

Based on the research results, the competence of TPACK of pre-service chemistry teacher is strong in aspects of content knowledge, pedagogy, and technology on several indicators such as understanding chemicals in general, understand effective strategies in chemical learning and be able to use technology although there are still weaknesses in indicators of understanding of chemical content and technology. To learn all components of TPACK must be balanced to create a more meaningful learning experience and students who are better prepared for a variety of real and work challenges. To know technology, especially the technology used in teaching must be learn by teachers, especially teachers of chemistry in the 21st century.

Conflict of Interests

The author (s) declares that there is no conflict of interest in this research and manuscript.

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