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Measuring the Effect of Subject-Specific Pedagogy on TPACK through Flipped Learning in E-Learning Classroom

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Technological pedagogical and content knowledge (TPACK) is an essential framework for chemistry teachers. Teachers are required to be able to integrate technology into learning so that TPACK must be acquired by pre-service chemistry teachers. TPACK can be integrated with a modified form of subject-specific pedagogy (SSP) as SSP has the same concept as PCK. In accordance, this study aims to measure the effect of using SSP through flipped learning on the pre-service chemistry teachers' TPACK. This research was conducted in Creswell's mixed-method. The subjects were 34 pre-service chemistry teachers from the chemistry education department in Indonesia. The data obtained from the pre-test and post-test were then analyzed by using Rasch's stacking-racking method. The result of this study indicated that pre-service chemistry teachers' ability (stacking method) from pre-test to post-test increased after being given the intervention. Then, the item analysis (racking method) showed that pre-service chemistry teachers found it easier to work on post-test items after being given the intervention. Based on the qualitative data, it was known that pre-service chemistry teachers could integrate technology with pedagogy and content in chemistry learning. It revealed that the intervention given during learning effectively affected the pre-service chemistry teachers' TPACK both in terms of personal ability and item difficulty level. Thus, strengthening TPACK since an early stage, as pre-service chemistry teachers, with specific treatments, could help them teach in real classrooms.

Keywords: SSP, Flipped learning, e-learning, PCK, rasch's stacking-racking, learning

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INTRODUCTION

One of the uses of technology in learning is the e-learning system. E-learning makes students get information and establishes effortless communication between students or lecturers, especially in higher education. The advantage of e-learning is that it is flexible in time and place, where students can choose the time and place accordingly (Arkorful & Abaidoo, 2014). E-learning provides information about the previous material and makes the learning process different (Al Soub et al., 2021). However, e-learning has weaknesses, one of which is limited communication between students and teachers. With the e-learning system, students feel they communicate less with teachers (Alawamleh et al., 2020). Online learning will make students lose concentration if it is done for too long (Perera et al., 2021). Thus, a combination learning of online and offline is needed. Students can be involved in online and face-to-face learning arrangements (Olsen et al., 2020). One of the e-learning based learning strategies is flipped learning. Using flipped learning allows educators to make learning changes that were once teacher-centered into student-centered learning (Hamdan et al., 2013). In flipped learning, students can communicate in one direction about new theories and repeat the learning materials packaged in the form of films or videos according to their needs (Østerlie, 2016). In flipped learning activities, the teacher can provide material that students can access anywhere and anytime according to their convenience (Brewer & Movahedazarhouligh, 2018). Besides, learning using flipped learning makes classroom activities into learning that forms collaboration, exploration, and engaging students (Burke & Fedorek, 2017). Flipped learning can be applied in various learning activities and various subjects, such as social science, computer science, engineering, health, art and humanities, mathematics, and more (Hwang et al., 2019). In chemistry learning activities, flipped learning can be applied, such as in organic courses, analytic chemistry courses, general chemistry courses, and advanced chemistry courses, where the subject matter is given outside the classroom (online) and followed by collaborative problem-solving activities in class (Bokosmaty et al., 2019; Broman & Johnels, 2019; Hairida, 2019; Ponikwer & Patel, 2018; Reid, 2016). At the university level, learning activities in chemistry education using the flipped learning approach uncovered students' good performance (Seery, 2015). Yet, a study from Goradia (2018) showed that flipped learning received minimum attention compared to inquiry or constructivist learning among academics. For this reason, flipped learning needs to get attention. Researchers must be aware of this learning model for 21st-century learning because it is one of the ICT-based learning models.

On the other hand, flipped learning is a set of lessons designed by teachers. This set is also known as subject-specific pedagogy (SSP). SSP is a set of comprehensive learning materials arranged after analyzing the overall materials, student characteristics, school infrastructure, and concepts used (Rahayu & Suparwoto, 2019; Ubaidillah & Wilujeng, 2019). SSP includes learning plans, learning media, teaching materials, and evaluation instruments. It is a complete set with the learning model used (Riyadi et al., 2018). Several studies in chemistry learning activities had conducted the SSP development with various learning models. SSP developed employing problem-based learning, guided inquiry, and guided discovery to improve students' abilities (Rahayu & Suparwoto, 2019; Riyadi et al., 2018; Sastradika & Jumadi, 2018). It signifies that SSP can also be developed with other learning models utilizing ICT in the learning process, such as flipped learning. Currently, there is no study on SSP development with flipped learning. Therefore, this research develops SSP through flipped learning.

SSP is closely related to pedagogical and content knowledge (PCK) as it has the same concept as PCK, a representative form of the teacher's knowledge and thought processes. SSP involves knowledge of subject matter description, student understanding, implications of teaching and learning, teaching strategies, curriculum knowledge, and knowledge of the context and goals of education, just the same as PCK (Handayani & Wilujeng, 2017). PCK is a representative combination of content and pedagogy, covering specific topics, problems, issues, and representations. It goes with students' various interests and abilities (Shulman, 1987). Besides, PCK is an idea to teach material not only through understanding concepts but also by developing strategies that are appropriate to the character of students (Koehler et al., 2014). PCK is also a teacher's interpretation of where the subject matter is packaged into learning activities to be well-accepted by students (Mishra & Koehler, 2006). PCK relies on both content and pedagogical knowledge, balanced with teaching experience, to become a unitary PCK (Aziz et al., 2020).

In learning activities, PCK relates to ICT. Implementing ICT-based media in teaching PCK can make learning interactive (Maryani & Martaningsih, 2015). Above all, PCK is vital for teachers. Yet, Shulman's PCK theory does not discuss technology despite its urgency in education. Thus, content (C), pedagogy (P), and technology (T) become the center of teacher teaching development (Mishra & Koehler, 2006). T and C describe teachers' knowledge about learning materials that are changed with technology implementation, while T and P explain the application of technology to support teachers' pedagogical goals. These three components belong to TPACK knowledge (Koehler & Mishra, 2005). TPACK represents classroom knowledge, which is crucial for teachers to teach with technology (Mishra & Koehler, 2006). The TPACK framework is built on the concept of PCK, integrated with the technological knowledge component (Graham, 2011). The relationship between PCK and TPACK is supported by integrating technology into student learning problems (Koh & Chai, 2016). Hence, SSP can be interpreted as the representative of TPACK because SSP results from teachers' pedagogical and content knowledge in the classroom integrated with technology.

Further, the TPACK framework is essential knowledge for pre-service teachers as TPACK components include teacher competencies, such as mastery of material content, pedagogy, technology, and their combination to make engaging learning (Naziri et al., 2019). On the other hand, it turns out that many teachers still do not utilize technology-based media integrated with pedagogy in the classroom (Utami & Muhtadi, 2020). If teachers do not know the relationship between technology and content, it will be hard to determine the technology used in the classroom (Harris & Hofer, 2011). It shows that TPACK training is essential for pre-service chemistry teachers. Pre-service chemistry teachers who study the TPACK framework can increase their knowledge and develop learning plans integrated with ICT in chemistry learning (Anci et al., 2021; Cetin-Dindar et al., 2018). Pre-service teachers must also receive guidance on effectively integrating technology into their learning activities (Pamuk, 2012). The effectiveness of using computers in pre-service teachers affects the increased knowledge of technology, content, and pedagogy (Kartal & Afacan, 2017). Technology education training, methods, and field experiences contribute to TPACK to pre-service teachers for direct learning and training activities in the classroom (Mouza et al., 2014). In addition, the application of ICT in learning activities provides pre-service teachers opportunities to develop their TPACK (Baran et al., 2019). Furthermore, improving technology skills possessed by pre-service teachers can help them develop their pedagogy in the classroom (Gao et al., 2009). Besides, university students are shown to be able to integrate technology with pedagogy quite well (Ching et al., 2016). In the end, learning using the TPACK approach can affect students' learning abilities in class (Irmita & Atun, 2018).

Based on a study, pre-service chemistry teachers must know the TPACK framework. In this case, TPACK for pre-service chemistry teachers can be conveyed with designed learning through the SSP integration with the TPACK components. The SSP used must also be integrated with the ICT-based learning model to align with the TPACK framework. One suitable learning model used is flipped learning. Flipped learning activities can help pre-service teachers build their knowledge of the TPACK framework through technology in their class (Piotrowski & Witte, 2016). In addition, the application of ICT in the flipped learning process can overcome time constraints (Syakdiyah et al., 2018). Therefore, this study develops SSP used through flipped learning to determine the pre-service chemistry teachers' TPACK ability.

An analysis is needed to discover the TPACK ability level of pre-service chemistry teachers obtained from the test results. These results can be analyzed using the Rasch model. Rasch model analysis places the person and item on a scale, where the placement reflects the individual ability and item difficulty (Forster et al., 2005). The Rasch modeling jointly uses score data based on each person and each item score, where the score is employed as the basis for estimating the pure score to show student's ability level and questions' difficulty level (Sumintono & Widhiarso, 2015). This study employed Rasch's stacking-racking model to measure the pre-service chemistry teachers' TPACK ability as this analysis can determine changes over time (two different conditions). Stacking racking analysis is a measurement from the same person, often obtained at two points in time or two conditions (time 1 vs. time 2) to investigate changes (Wright, 1996). In addition, research using Rasch's stacking-racking model to measure the pre-service chemistry teachers' TPACK has not been found. Therefore, this study analyzes how the intervention influences using SSP through flipped learning on the pre-service chemistry teachers' TPACK with Rasch's stacking-racking model measurement. This measurement was used to determine the extent of pre-service chemistry teachers' TPACK with the intervention. According to the Indonesian curriculum, TPACK is essential because teachers must integrate technology into their learning activities. The analysis carried out with Rasch's stacking-racking method can be used to see changes in each individual's response pattern from pre-test to post-test. It shows how each pre-service chemistry teacher possesses TPACK.

METHOD

General Background

This study aims to measure the effect of SSP through flipped learning on the pre-service chemistry teachers' TPACK with the Rasch model's stacking-racking analysis. This study used a mix-method design, especially with embedded design (Creswell, 2006). In embedded design, qualitative data is employed to support quantitative research data.

Sample

This study involved 34 pre-service chemistry teachers as research subjects. The research subjects involved in this research were 4th-semester students who took the Chemistry Learning Program Planning and Development course. In the Chemistry Learning Program Planning and Development course, pre-service chemistry teachers learned lesson plan principles and procedures. Prior to taking this course, they studied basic chemistry, inorganic chemistry, analytical chemistry, physical chemistry, organic chemistry, and learning technology. In previous lectures, pre-service chemistry teachers were accustomed to using various learning models. Besides, the ICT facilities had always been utilized to support the classroom's learning model. Using SSP through flipped learning was very suitable for this university, especially in the Chemistry Education Department.

Classroom Environment

This research used flipped learning which included virtual (online) and face-to-face (offline) learning activities. In the online class, the lecturer asked the pre-service chemistry teachers to studied the development of SPP based on TPACK through the SPADA e-learning platform. SPADA is an e-learning platform used by campuses to support online learning activities in the campus environment. This platform is equipped with various supporting features: administrative features, delivery of teaching materials, discussion and communication rooms, testing, and assessment. The SPADA platform used can be seen in Figure 1.

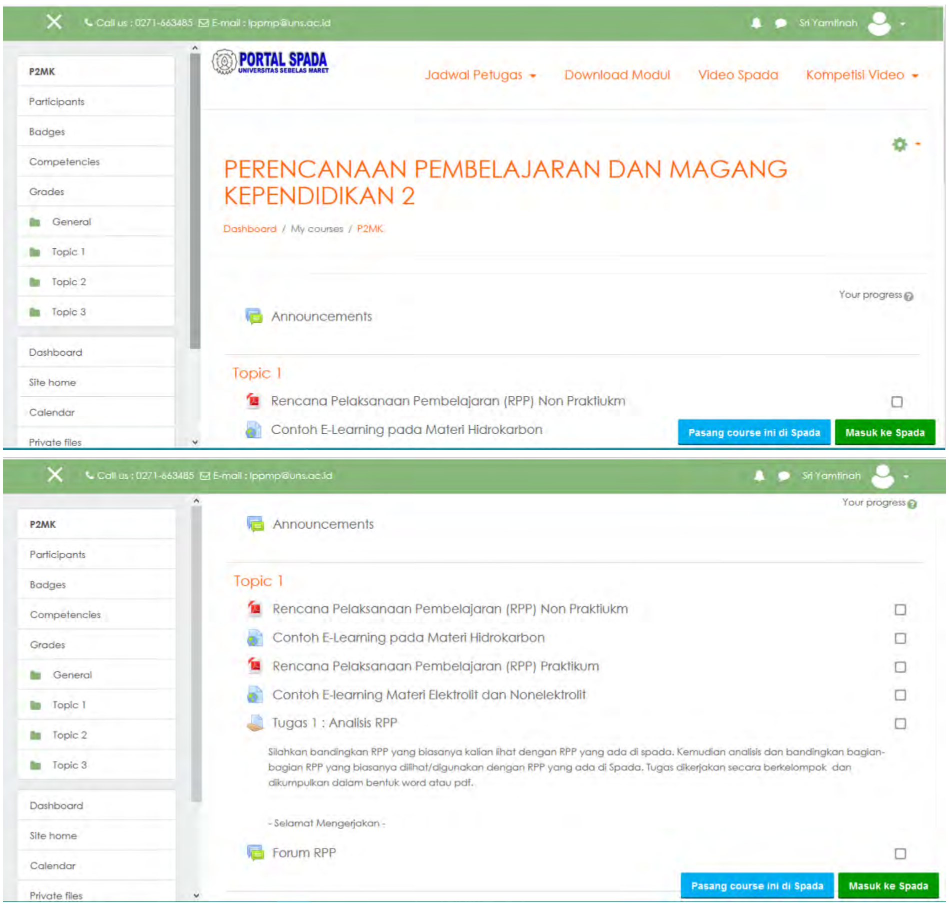


Figure 1
The SPADA platform used in this research

At SPADA, the pre-service chemistry teachers could access material and discuss with other fellow teachers through the discussion feature provided by the lecturer. In this activity, the pre-service chemistry teachers were asked to analyze the contents of the developed SSP. After that, the pre-service chemistry teachers conducted offline class activities. In the offline class, the lecturer conducted collaborative discussion activities with the pre-service chemistry teachers. In this activity, the lecturer asked about the difference between the TPACK-based SSP and the SSP commonly used by teachers in schools. Then, the pre-service chemistry teachers were asked to analyze the material about lesson planning and provide feedback through the discussion feature. After that, they carried out learning activities in class and discussed the material with the lecturer. Discussions were conducted collaboratively with the group to create a lesson plan produced by the TPACK framework. After that, an evaluation was carried out to determine the TPACK ability after the intervention. The assessment instrument was also adjusted to the TPACK framework. This assessment instrument was prepared by formulating the assessment objectives, determining material specifications, determining question indicators, and making evaluation items.

SSP Descriptions

SSP is a set of lessons designed by educators. The SSP used in this study was a form of the SSP through flipped learning. The SSP used was based on the curriculum currently being used in Indonesia. The SSP was also developed through flipped learning, where each activity reflected the seven TPACK components. The developed SSP was a lesson plan, which comprised learning media and assessment sheets. The lesson plan used was adjusted to the TPACK framework and flipped learning. Learning activities are carried out synchronously and asynchronously written in the SSP. Each learning activity contained in the SSP reflects the seven components of TPACK. In the first step, the pre-service teachers learned the material through SPADA from the lecturer. This activity was carried out synchronously anywhere and anytime. After that, the pre-service teachers carried out asynchronous activities with collaborative discussions with their fellow teachers.

Design Study

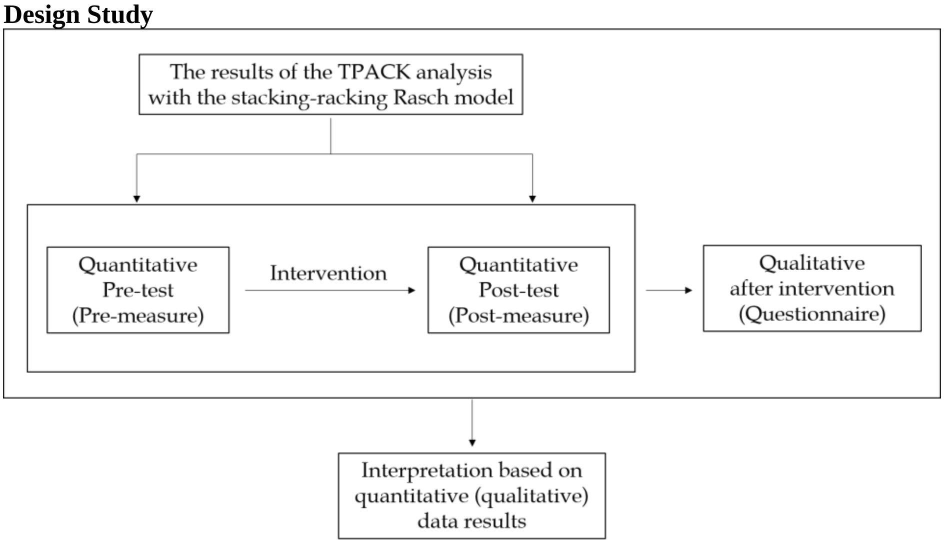


Figure 2
The embedded design used in this research

This study used a mix-method design, especially the embedded design by Creswell (2006). Data collection was carried out quantitatively in this embedded design, supported by secondary qualitative data. Quantitative data were obtained using pre-test (before intervention) and post-test (after intervention) data. Before conducting the research, pre-service chemistry teachers were asked to conduct the pre-test of the

TPACK instrument in the first week. After the pre-test was carried out, the class was given treatment according to the study objectives in the second week. During the learning activities, pre-service chemistry teachers were given treatment using SSP through flipped learning. After being given treatment, they were asked to respond to the TPACK instrument again as a post-test form in the third week. After that, they were given the questionnaire to follow up on the experimental results. Meanwhile, the questionnaire was analyzed qualitatively as secondary data. It was used to determine the TPACK possessed by the pre-service chemistry teachers and the effect of the intervention given on their TPACK abilities. This research design can be seen in Figure 2.

Instruments

The assessment instrument used in this study consisted of 20 questions in form of multiple choices. The questions contained in the instrument covered the seven TPACK components. It included Pedagogical Knowledge (PK), Content Knowledge (CK), Pedagogical Content Knowledge (PCK), Technology Knowledge (TK), Technological Content Knowledge (TCK), Technological Pedagogical Knowledge (TPK), and Technological Pedagogical Content Knowledge (TPACK). The assessment instrument indicator employed in this study was a modification of the TPACK instrument indicators by Schmidt et al. (2009), which was adjusted to the teacher competency qualification standards in the Regulation of the Minister of National Education of Indonesia (Kemendikbud, 2007). The indicators created were then utilized as a reference for making questions on the TPACK assessment instrument. The indicators for each TPACK component used in this study are presented in Table 1.

Table 1
Assessment instrument indicators based on TPACK components

TPACK Components	Indicators
PK	Implementing student-centered learning
	Understanding the principles of educational lesson planning
	Applying learning methods according to the material being taught
CK	Analyzing students' initial abilities before learning the following material
	Mastering basic competencies and learning objectives according to learning materials
	Understanding the material according to the representation of chemistry education (macro, sub-micro, symbol)
	Applying chemistry in daily life
PCK	Combining content with learning models according to the content being taught
	Evaluating student learning outcomes
TK	Understanding technology functions
TCK	Applying various technologies that can be used to help students understand chemical concepts
TPK	Using technology in accordance with the approaches, methods, and learning models used
	Using technology that can increase student learning motivation
TPACK	Integrating technology with content and pedagogy in the classroom

The questionnaire in this study employed indicators from the TPACK components, presented in Table 1. These indicators were used to make ten-item questionnaires, including two PK component items, two CK component items, one PCK component item, two TK component items, one TCK component item, one TPK component item, and one TPACK component item. This questionnaire was then given to the pre-service chemistry teachers in the fourth week. The items in the TPACK questionnaire are displayed in Table 2.

Table 2
TPACK questionnaire items

Number of Items	TPACK Components	Statements
1	PK	I know activities that can be student-centered.
2	PK	I know different approaches, methods, and learning models in learning activities.
3	CK	I have understood the concept of chemistry in depth.
4	CK	I know the application of chemical concepts to everyday life.
5	PCK	I can determine the learning approach/method/model according to the material to be taught.
6	TK	I can learn technology easily.
7	TK	I know the current technology developments.
8	TCK	I know various technologies that can be used to help students understand chemistry.
9	TPK	I know the technology that can increase student motivation.
10	TPACK	I can integrate technology into learning activities and chemistry content.

Data Analysis

Before being tested, the TPACK instrument had gone through a validation process by ten instrument validators. This study's validators were one subject material expert, one media expert, one evaluation and assessment expert, and seven education experts or teachers who had worked for more than 15 years. The expert validation results were gauged using Aiken's validation calculations. V value ranges from 0 - 1, and the criteria used to declare an item valid in the content on the number of raters (assessors) of 10 people is 0.73 (Aiken, 1985). The validation results by raters were obtained more than 0.73. It signified that the instrument was valid to use.

Table 3
TPACK instrument reliability

	Separation		Reliability		Cronbach's alpha
	Person	Item	Person	Item	
Real	2.08	4.01	0.81	0.94	0.85
Model	2.19	4.31	0.83	0.95	

After the validation, the instrument was tested for reliability using the Rasch model. The analysis results produced output in the form of item reliability, person reliability, and Cronbach's alpha. The reliability results of the TPACK instrument can be seen in Table 3. Table 3 exhibits that the person's reliability in the TPACK instrument used valued 0.81. It indicated that pre-service chemistry teachers' consistency in answering questions on the TPACK instrument was good. Then, the item reliability in the TPACK instrument used was 0.94. It denoted that the items' quality in the TPACK instrument was very good. Besides, Cronbach's alpha value was 0.85, indicating that the interaction between person and item as a whole was very good.

Additionally, the quantitative data from the pre-test and post-test results were then analyzed through Rasch's stacking-racking model. Stacking analysis provided change information at the individual level, indicating that an individual's ability had been increased, degraded, or maintained due to a fixed item's difficulty, which was unchanged from time to time. Measuring change at the individual level enabled the researcher to identify competent and problematic individuals with the intervention (Ling et al., 2018). Meanwhile, racking analysis was used to investigate the intervention's impact on each item's difficulty from a sample perspective. It was not possible to evenly affect all items' responses; some items may become more difficult due to intervention or time passing (Wright, 1996, 2003a). The intervention did not influence responses for all items equally but had a more substantial effect on items that were directly related (Anselmi et al., 2015). This stacking-racking analysis came from the pre-test and post-test data that each pre-service chemistry teacher had. This analysis resulted in two measures, namely the pre-test scale score and the post-test scale score. The differences between these scale scores represented the students' understanding changes due to the learning (Herrmann-Abell et al., 2016).

The pre-test and post-test scores were obtained in the form of dichotomous data. The dichotomous data were from the 'right' and 'wrong' answers, coded with the numbers '1' and '0' (Sumintono & Widhiarso, 2015). Then, the data were analyzed by utilizing the Ministep software to obtain the measure values of pre-test and post-test. The pre-test and post-test measure values were then analyzed by using the stacking-racking method, and the difference in measures was seen. The TPACK ability results before and after being given treatment were analyzed using stacking-racking derived from the response patterns possessed by each individual so that they could produce different measure values. The placement of time 1 vs. time 2 data in Rasch's stacking-racking model analysis based on Wright (2003) is presented in Figure 3.

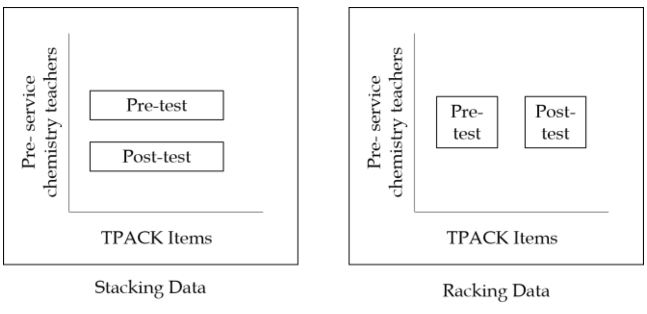


Figure 3
Placement of the stacking-racking analysis data used in this research

Meanwhile, the qualitative data were analyzed employing qualitative analysis from Miles & Huberman (1994), where the data collected were then performed data reduction, data presentation, and conclusion drawing. The data were obtained from the questionnaire results given to pre-service chemistry teachers who had been given the intervention. These qualitative data were used to follow up the experiment results (intervention). The data reduction process was employed to avoid data that was not following the research objectives to be presented systematically. Then, the conclusion drawn was to display appropriate data to support primary data.

FINDINGS

Item Fit

Item fit on the TPACK instrument was seen from the results of Outfit mean square (MNSQ), Outfit Z-standard (ZSTD), and Point Measure Correlation (Pt Measure Corr) on each item using the Rasch model analysis. The criteria for an item were in accordance with the requirements, namely 0.5 <MNSQ <1.5, -2.0 <ZSTD <+2.0, and 0.4 <Pt Measure Corr <0.85 (Boone et al., 2014). The TPACK fit item results can be seen in Table 4.

Table 4
Item fit on TPACK

Entry Number	MNSQ	ZSTD	Pt Measure Corr	Entry Number	MNSQ	ZSTD	Pt Measure Corr
4	1.60	1.39	-0.12	17	0.77	-0.11	0.21
15	0.95	-0.27	0.36	11	0.96	0.26	0.22
10	0.86	-0.90	0.46	12	0.63	-0.16	0.31
5	0.99	-0.30	0.28	13	1.06	0.37	0.12
8	0.79	-0.54	0.40	18	1.32	0.62	-0.01
14	0.83	-0.25	0.26	19	0.99	0.30	0.08
7	0.81	-0.23	0.26	20	0.99	0.30	0.08
6	0.82	-0.13	0.21	1	1.01	0.46	0.05
2	1.40	0.74	-0.04	3	0.46	-0.06	0.23
9	0.47	-0.70	0.45	16	0.46	-0.06	0.23

Table 4 displays that several items were not fit in the MNSQ and PT Measure Corr outfits. Even though these items did not meet the requirements in one of the MNSQ outfits, PT Measure Corr, or both, the items contained in the instrument in the ZSTD outfit were still within the permitted limits. Therefore, these items were retained and did not need to be replaced or reduced. It could be concluded that the 20 items contained in the TPACK instrument had all the questions retained and did not need to be replaced.

Stacking Analysis

In this stacking analysis, information about the person measure pre-test and post-test was obtained. Then, the person measure was combined to get the person measure difference value of each pre-service chemistry teacher. This difference result of person measure could determine the extent of each pre-service chemistry teacher's ability level.

The person measure results of pre-service chemistry teachers' TPACK analysis are depicted in Table 5.

Table 5
Person measure pre-test and post-test of pre-service chemistry teachers

Label Name	Person Measure		Difference of Person Measure	Label Name	Person Measure		Difference of Person Measure
	Pre-test	Post-test			Pre-test	Post-test	
E01	-1.67	2.00	3.67	E18	-1.33	1.58	2.91
E02	-1.33	1.21	2.54	E19	0.54	3.13	2.59
E03	-1.67	2.00	3.67	E20	-1.33	2.00	3.33
E04	-2.03	1.58	3.61	E21	0.23	4.10	3.87
E05	-0.70	2.49	3.19	E22	-0.70	1.58	2.28
E06	-0.70	2.49	3.19	E23	-0.40	2.00	2.40
E07	-1.01	2.00	3.01	E24	-1.01	1.21	2.22
E08	0.23	4.10	3.87	E25	-0.70	2.49	3.19
E09	-0.40	2.49	2.89	E26	-0.40	2.00	2.40
E10	-1.33	2.00	3.33	E27	-1.01	0.54	1.55
E11	-0.40	2.00	2.40	E28	0.54	4.10	3.56
E12	-0.09	2.49	2.58	E29	-1.01	2.00	3.01
E13	-1.67	2.00	3.67	E30	-1.01	2.00	3.01
E14	-0.70	2.00	2.70	E31	-1.01	2.49	3.50
E15	-0.09	1.58	1.67	E32	-0.40	2.49	2.89
E16	-1.01	2.00	3.01	E33	-0.40	2.00	2.40
E17	0.23	3.13	2.90	E34	0.23	2.49	2.26

Table 5 shows that the increases in the pre-service chemistry teachers' ability varied from the lowest increase in ability to the highest increase ability. In Table 5, it can be seen that the pre-service chemistry teachers who experienced the lowest increase in the ability had a person measure the difference of 1.55. Meanwhile, the pre-service chemistry teachers who experienced the highest increase in the ability had a person measure the difference of 3.87. The difference in the person measure values revealed that each pre-service chemistry teacher's ability varied. It depends on each pre-service chemistry teacher's ability level. It signifies that after being given the intervention, the pre-service chemistry teacher's ability to respond to post-test items was better than the pre-test.

Racking Analysis

Item analysis (racking) is an analysis that describes an item's difficulty level from pre-test to post-test. It can be seen from the measurement values of the pre-test and post-test items. In item analysis (racking), if an item has an increasingly positive item measure value, it is increasingly difficult to work. Otherwise, if an item has an increasingly negative item measure value, it is easier to work. The item analysis (racking) results of pre-service chemistry teachers can be seen in Table 6.

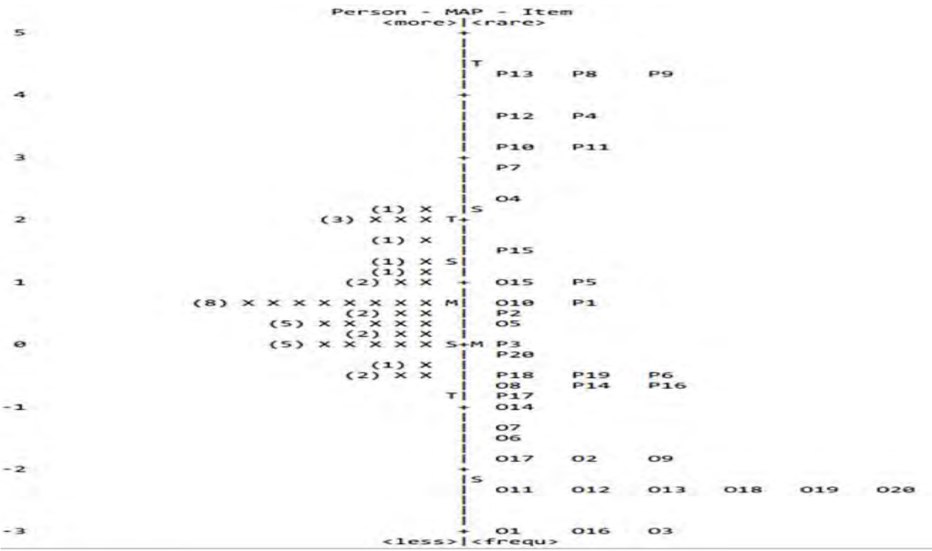
Table 6
Item measure pre-test and post-test of pre-service chemistry teachers

TPACK component	Items	Item Measure		Difference of Measure Items
		Pre-test	Post-test	
PK	1	0.73	-3.07	3.80
PK	2	0.47	-1.89	2.36
PK	3	0.08	-3.07	3.15
CK	4	3.62	2.31	1.31
CK	5	1.00	0.34	0.66
CK	6	-0.51	-1.56	1.05
CK	7	2.82	-1.29	4.11
CK	8	4.36	-0.68	5.04
CK	9	4.36	-1.89	6.25
CK	10	3.16	0.60	2.56
CK	11	3.16	-2.34	5.50
CK	12	3.62	-2.34	5.96
CK	13	4.36	-2.34	6.70
PCK	14	-0.68	-1.06	0.38
PCK	15	1.43	1.00	0.43
TK	16	-0.68	-3.07	2.39
TCK	17	-0.86	-1.89	1.03
TPK	18	-0.51	-2.34	1.83
TPK	19	-0.51	-2.34	1.83
TPACK	20	-0.21	-2.34	2.13

Table 6 presents that the pre-test measure item value for pre-service chemistry teachers was greater than the measure item value during the post-test. It shows that pre-service chemistry teachers found it easier to do post-test questions after being given treatment than when working on pre-test questions. It is in line with Pang et al.'s (2019) research that most respondents did better on the post-test. Then, to see the increase in pre-service chemistry teachers in answering each item in the instrument, it can be seen from the difference in their item measure. Based on Table 6, the item that experienced a slight increase in the measured value is item number 14 on the PCK component with a measure item difference of 0.38. Meanwhile, the item that increased the measured value the most is item number 13 in the CK component, with a measure item difference of 6.70.

Person-item map

Based on the measure item differences in Table 6, each item has a different change in response pattern. Changes in each item's response pattern from pre-test to post-test are displayed from the person-item map generated from the Rasch analysis in Figure 4. Figure 4 represents the changes to which items were difficult or easy to accomplish by pre-service chemistry teachers before and after the intervention. Eight items were difficult for all pre-service chemistry teachers to work on during the pre-test. These items came from the CK component. After the intervention, it was found that seven items became easier for all the pre-service chemistry teachers to work on during the post-test. However, there was one item, number 4, which was still difficult for the pre-service chemistry teachers to work on after the intervention. Pre-service chemistry teachers still had difficulty analyzing the initial concepts before moving on to new concepts. It was related to the depth of their concept. In fact, their understanding and depth of concept played an essential role in avoiding misconceptions when teaching in class. Teachers who do not understand the material being taught will affect student misconceptions (Kaya, 2013). Therefore, content knowledge plays a vital role in teaching success in the classroom (Nilsson, 2008).



Note
P : pre-test
O : post-test

Figure 4
TPACK person-item map for pre-service chemistry teachers

TPACK Questionnaire

Qualitative data were obtained from a questionnaire given to pre-service chemistry teachers after the intervention. These data were related to the TPACK they had after being given the intervention. They were asked to respond to a questionnaire about TPACK containing 25 questions. The questionnaire used a Likert scale of 1-4. Then the data collected was a percentage with indicators if 0% -24.99% = very poor, 25% - 49.99% = less, 50% - 74.99% = quite good, and 75% - 100% = good. After the data were collected, the data were reduced and presented in table 7. Table 7 shows the knowledge possessed by the pre-service chemistry teachers on each TPACK component.

Table 7
The results of the TPACK pre-service chemistry teacher questionnaire

Number of Items	TPACK Components	Percentage (%)	Number of Items	TPACK Components	Percentage (%)
1	PK	71.88	6	TK	75.00
2	PK	73.44	7	TK	76.56
3	CK	58.31	8	TCK	75.00
4	CK	73.44	9	TPK	76.56
5	PCK	71.88	10	TPACK	70.31

Table 7 exhibits that of the seven TPACK components, it was found that one of the items in the CK component had a low response. The item was about the depth of the concept they currently had. There were only 58.31% felt that their current chemical concept was good enough. Meanwhile, others were still doubtful whether they understood chemistry concepts well and in-depth. However, for the most part, the integration of technology into pedagogy or content was good.

DISCUSSION

Measurements in this study were used to analyze the effect of the interventions given using the SSP through flipped learning. The effect referred to was the effectiveness of using SSP through flipped learning on TPACK pre-service chemistry teachers. Based on the stacking analysis results, it could be seen how pre-service chemistry teachers influenced their TPACK after being given treatment (intervention). It could be used to see their TPACK ability increased, decreased, or remained.

This study used an e-learning system through a flipped learning strategy. During these learning activities, pre-service chemistry teachers were given intervention using SSP containing content knowledge and pedagogy to increase their TPACK knowledge. Based on Table 5, it was known that the difference between the person measure pre-test and post-test of 34 pre-service chemistry teachers as a whole was positive. It showed that each pre-service chemistry teacher had an increase in ability from pre-test to post-test after being given intervention in learning. Therefore, all pre-service chemistry teachers had a better TPACK ability, which increased than before the intervention. In this case, improving TPACK ability is crucial for pre-service chemistry teachers because they can provide meaningful learning to their students later. All components that make up TPACK are essential to provide optimal results in class (Mupita et al., 2018). The increase in pre-service chemistry teachers' TPACK ability revealed that the interventions given using SSP through flipped learning could affect their TPACK abilities. It was because SSP through flipped learning reflected the seven components in TPACK: PK, CK, PCK, TK, TCK, TPK, and TPACK, which pre-service chemistry teachers should have. Besides, the learning steps used in the SSP were by the characteristics and evaluation achievements that pre-service chemistry teachers should also have. It could help them increase their TPACK.

In the racking analysis, it was known that each item tested had a change in the pre-test and post-test measure item values. Based on the study results in Table 6 and Figure 4, the pre-service chemistry teachers' response pattern change was significant. The response pattern showed that each item in the PK, CK, PCK, TK, TCK, TPK, and TPACK components had a different response pattern after the intervention. This change in response patterns was due to the influence of the interventions given to pre-service chemistry teachers during learning activities. This intervention affected them, where they could work on items with an easier difficulty level than before the intervention was given. The application of the TPACK framework in the learning process (intervention) influenced their TPACK. It is supported by the research of Durdu & Dag (2017) that the learning process by implementing the TPACK framework positively impacted the development of pre-service teachers' TPACK. The intervention given was the use of SSP through flipped learning. This SSP could help pre-service chemistry teachers work more easily on most of the items contained in the instruments that covered the seven TPACK components.

During their learning activities, they used flipped learning. This learning activity could help them improve and understand the knowledge they had. Students involved in flipped classroom activities could improve their ability to relate concepts to one another and transfer their knowledge for further learning activities (Kozikoğlu, 2019; Shattuck, 2016; Sudarmika et al., 2020). Flipped learning is a learning strategy that utilizes an e-learning system. E-learning can increase pre-service chemistry teachers' motivation to learn. Also, e-learning plays a role in increasing learning motivation; when student learning motivation increases, it will generate curiosity and encourage them to seek the information they need (Rahayu & Suparwoto, 2019). Hsu et al. (2017) state ICT involvement can increase self-confidence in TPACK. Besides, pre-service chemistry teachers conducted learning in two stages in flipped learning activities: virtual and face-to-face carried out collaboratively. In virtual, pre-service chemistry teachers studied the material and dug up the information in e-learning and other sources. This virtual learning could be done by pre-service chemistry teachers anywhere and anytime. Then, after they had done virtual learning, pre-service chemistry teachers would do face-to-face learning in class collaboratively. This collaborative activity helped pre-service chemistry teachers improve their abilities and knowledge about TPACK with the provision of knowledge or material that had been previously learned through virtual. During the collaboration, they would share the knowledge they had with their friends. Through collaborative activities and sharing ideas in class, they would feel satisfied (Rodphotong, 2018).

Based on Rasch's stacking-racking analysis results, learning activities using SSP through flipped learning were effectively used to increase TPACK. This effectiveness affected pre-service chemistry teachers' response patterns. Besides, it could help deepen and strengthen their TPACK knowledge as the SSP is an interpretation of learning activities in the classroom that includes content knowledge and pedagogy. Knowledge of pedagogy and content contained in the SSP is related to technology in the e-learning learning system through flipped learning. The SSP contains how the strategies and teaching methods are used in explaining the concept of chemistry. It is effective in helping pre-service chemistry teachers to understand how to describe the subject matter and teaching strategies in a class by utilizing technology so that it is easier to understand the TPACK framework. Technology courses in the previous semester could also affect their technology knowledge. It could help them integrate technology into pedagogy and content. In this regard, technology can be used to assist scientific investigations and improve students' knowledge in the classroom (Tanak, 2020). Besides technology, pre-service chemistry teachers’ content knowledge should also be realized. Based on this study results, many pre-service chemistry teachers found it difficult to understand the chemistry concept (CK). Therefore, through this research, it is expected that authorities (universities) can provide interventions in learning activities through SSP based on the TPACK framework. It is a concern because it is one factor that influences pre-service chemistry teachers’ TPACK. Thus, it can help them to integrate technology into their learning activities while in the actual class. Furthermore, educators must pay attention to the SSP they use in class, whether in accordance with the TPACK framework. Besides, learning models in line with the TPACK framework, such as flipped learning or other models, also need to be considered. Further research on the pre-service chemistry teachers’ background can also be considered for the TPACK’s effect, apart from classroom intervention.

CONCLUSION

SSP is important for pre-service chemistry teachers because it has the same concept as PCK that contains knowledge of content and pedagogy. This knowledge prepares them before teaching in a real class. Teaching SSP can be done by learning with an e-learning system through flipped learning. Combined with the use of ICT, it helps pre-service chemistry teachers understand the TPACK framework contained in the SSP. The stacking-racking results revealed that the use of SSP through flipped learning could positively affect pre-service chemistry teachers’ TPACK. After giving the intervention, it was known that each pre-service chemistry teacher’s ability increased, and the item’s difficulty level decreased or was easier to work on during the post-test than the pre-test. The difference in each pre-service chemistry teacher's ability depended on the response pattern given by each of them to the pre-test and post-test instruments. The different response patterns of pre-service chemistry teachers for each item indicated that each pre-service chemistry teacher had different abilities for each TPACK component. It suggested that the change from time 1 vs. time 2 was due to the intervention. Interventions can be in form of learning activities or other treatments, which can impact individual abilities. Therefore, pre-service chemistry teachers need intensive guidance or treatment regarding TPACK to prepare them facing the actual class better.

Nevertheless, this study has several limitations. The research sample was limited to only 34 pre-service chemistry teachers so that the ability diversity analyzed was also limited. The subject used in this study was still limited, they were the second-year pre-service chemistry teachers. Further research can use pre-service teachers from the third year and in-service teachers. It can also analyze based on the gender of the subject used. It is recommended for further research to use more samples in different areas so that the capabilities analyzed are more significant and diverse. In addition, SSP through flipped learning can be combined with other ICT-based learning models and adapted to the latest rules of the lesson plan used by schools.

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REFERENCES

Aiken, L. R. (1985). Three Coefficients for Analyzing the Reliability and Validity of Ratings. *Educational and Psychological Measurement, 45*(1), 131–142. https://doi.org/10.1177/0013164485451012

Al Soub, T. F., Alsarayreh, R. S., & Amarin, N. Z. (2021). Students ‘satisfaction with using e-learning to learn chemistry in light of the COVID-19 Pandemic in Jordanian Universities. *International Journal of Instruction*, *14*(3), 1011–1024. https://doi.org/10.29333/iji.2021.14359a

Alawamleh, M., Al-Twait, L. M., & Al-Saht, G. R. (2020). The effect of online learning on communication between instructors and students during Covid-19 pandemic. *Asian Education and Development Studies*. https://doi.org/10.1108/AEDS-06-2020-0131

Anci, F. F., Paristiowati, M., Budi, S., Tritiyatma, H., & Fitriani, E. (2021). Development of TPACK of Chemistry Teacher on Electrolyte and Non-Electrolyte Topic through Lesson Study. *AIP Conference Proceedings*, *2331*, 1–7. https://doi.org/10.1063/5.0041804

Anselmi, P., Vidotto, G., Bettinardi, O., & Bertolotti, G. (2015). Measurement of change in health status with Rasch models. *Health and Quality of Life Outcomes, 13*(16), 1–7. https://doi.org/10.1186/s12955-014-0197-x

Arkorful, V., & Abaidoo, N. (2014). The role of e-learning, advantages and disadvantages of its adoption in Higher Education. *International Journal of Education and Research, 12*(2), 397–410.

Aziz, F., Haryani, S., & Sumarti, S. S. (2020). Analysis of Pedagogical Content Knowledge Topic Specific PCK Model for Chemistry Teachers at the Vocational School of Semarang in Stoichiometry. *Journal of Innovative Science Education, 9*(2), 159–166. https://doi.org/10.15294/jise.v8i3.33773

Baran, E., Canbazoglu Bilici, S., Albayrak Sari, A., & Tondeur, J. (2019). Investigating the impact of teacher education strategies on preservice teachers’ TPACK. British *Journal of Educational Technology, 50*(1), 357–370. https://doi.org/10.1111/bjet.12565

Bokosmaty, R., Bridgeman, A., & Muir, M. (2019). Using a Partially Flipped Learning Model to Teach First Year Undergraduate Chemistry. *Journal of Chemical Education*, *96*(4), 629–639. https://doi.org/10.1021/acs.jchemed.8b00414

Boone, W. J., Staver, J. R., & Yale, M. S. (2014). *Rasch analysis in the human sciences*. Springer. https://doi.org/10.1007/978-94-007-6857-4

Brewer, R., & Movahedazarhouligh, S. (2018). Successful stories and conflicts: A literature review on the effectiveness of flipped learning in higher education. *Journal of Computer Assisted Learning, 34*(4), 409–416. https://doi.org/10.1111/jcal.12250

Broman, K., & Johnels, D. (2019). Flipping the Class–University Chemistry Students' Experiences from a New Teaching and Learning Approach. *Chemistry Teacher International*, 1–8. https://doi.org/10.1515/cti-2018-0004

Burke, A. S., & Fedorek, B. (2017). Does "flipping" promote engagement?: A comparison of a traditional, online, and flipped class. *Active Learning in Higher Education, 18*(1), 11–24. https://doi.org/10.1177/1469787417693487

Cetin-Dindar, A., Boz, Y., Yildiran Sonmez, D., & Demirci Celep, N. (2018). Development of pre-service chemistry teachers' technological pedagogical content knowledge. *Chemistry Education Research and Practice*, *19*, 167–183. https://doi.org/10.1039/C7RP00175D

Ching, Y. H., Yang, D., Baek, Y. K., & Baldwin, S. (2016). Enhancing graduate students' reflection in e-portfolios using the TPACK framework. *Australasian Journal of Educational Technology, 32*(5), 108–122. https://doi.org/10.14742/ajet.2830

Creswell, John W. (2006). Choosing a Mixed Method Design. In J. W. Creswell & V. L. P. Clark (Eds.), *Designing and Conducting Mixed Methods Research* (pp. 58–89). Thousand Oaks, CA: Sage Publications.

Durdu, L., & Dag, F. (2017). Pre-Service Teachers' TPACK Development and Conceptions through a TPACK-Based Course. *Australian Journal of Teacher Education, 42*(11), 150–171. https://doi.org/10.14221/ajte.2017v42n11.10

Forster, P. A., Dawson, V. M., & Reid, D. (2005). Measuring preparedness to teach with ICT. *Australasian Journal of Educational Technology, 21*(1), 1–18. https://doi.org/10.14742/ajet.1340

Gao, P., Choy, D., Wong, A. F. L., & Wu, J. (2009). Developing a better understanding of technology based pedagogy. *Australasian Journal of Educational Technology, 25*(5), 714–730. https://doi.org/10.14742/ajet.1117

Goradia, T. (2018). Role of Educational Technologies Utilizing the TPACK Framework and 21st Century Pedagogies: Academics' Perspectives. *IAFOR Journal of Education*, *6*(3), 43–61. https://doi.org/10.22492/ije.6.3.03

Graham, C. R. (2011). Theoretical considerations for understanding technological pedagogical content knowledge (TPACK). *Computers and Education, 57*, 1953–1960. https://doi.org/10.1016/j.compedu.2011.04.010

Hairida, H. (2019). The Development of Blended Learning Media for Flipped Classroom Model on Direct Learning in Process Evaluation Courses and Chemistry Learning Outcomes. *1st International Conference on Educational Sciences and Teacher Profession (ICETeP 2018)*, *295*, 211–217. https://doi.org/10.2991/icetep-18.2019.52

Hamdan, N., McKnight, P., McKnight, K., & Arfstrom, K. M. (2013). *A Review of Flipped Learning*. Flipped Learning Network, 1–20.

Handayani, S., & Wilujeng, I. (2017). The Development of Inquiry-Based Subject Specific Pedagogy to Improve Process Skills and Science Learning Motivation. *Jurnal Pendidikan Matematika dan Sains, V*(1), 22–35. https://doi.org/10.21831/jpms.v5i1.13537

Harris, J. B., & Hofer, M. J. (2011). Technological Pedagogical Content Knowledge (TPACK) in Action: A Descriptive Study of Secondary Teachers' Curriculum-Based, Technology-Related lnstructional Planning. *Journal of Research on Technology in Education*, *43*(3), 211–229. https://doi.org/10.1080/15391523.2011.10782570

Herrmann-Abell, C. F., Koppal, M., & Roseman, J. E. (2016). Toward high school biology: Helping middle school students understand chemical reactions and conservation of mass in nonliving and living systems. *CBE Life Sciences Education, 15*(4), 1–21. https://doi.org/10.1187/cbe.16-03-0112

Hsu, C.-Y., Tsai, M.-J., Chang, Y.-H., & Liang, J.-C. (2017). Surveying In-Service Teachers' Beliefs about Game-Based Learning and Perceptions of Technological Pedagogical and Content Knowledge of Games. *Educational Technology and Society, 20*(1), 134–143.

Hwang, G., Yin, C., & Chu, H. (2019). The era of flipped learning : promoting active learning and higher order thinking with innovative flipped learning strategies and supporting systems. *Interactive Learning Environments, 27*(8), 991–994. https://doi.org/10.1080/10494820.2019.1667150

Irmita, L., & Atun, S. (2018). The influence of Technological Pedagogical and Content Knowledge (TPACK) approach on science literacy and social skills. *Journal of Turkish Science Education, 15*(3), 27–40. https://doi.org/10.12973/tused.10235a

Kartal, T., & Afacan, Ö. (2017). Examining Turkish pre-service science teachers' technological pedagogical content knowledge (TPACK) based on demographic variables. *Journal of Turkish Science Education, 14*(1), 1–22. https://doi.org/10.12973/tused.10187a

Kaya, E. (2013). Argumentation Practices in Classroom: Pre-service teachers' conceptual understanding of chemical equilibrium. *International Journal of Science Education, 35*(7), 1139–1158. https://doi.org/10.1080/09500693.2013.770935

Kemendikbud. (2007). Peraturan Menteri Pendidikan Nasional Nomor 16 Tahun 2007 tentang Standar Kualifikasi Akademik dan Kompetensi Guru. In *Kementrian Pendidikan dan Kebudayaan Republik Indonesia* (pp. 1–32).

Koehler, M. J., & Mishra, P. (2005). What happens when teachers design educational technology? The development of Technological Pedagogical Content Knowledge. *Journal of Educational Computing Research, 32*(2), 131–152. https://doi.org/10.2190/0EW7-01WB-BKHL-QDYV

Koehler, M. J., Mishra, P., Kereluik, K., Shin, T. S., & Graham, C. R. (2014). The Technological Pedagogical Content Knowledge Framework. In J. M. Spector, M. D. Merrill, J. Elen, & M. J. Bishop (Eds.), *Handbook of Research on Educational Communications and Technology* (pp. 102–103). Springer Science + Business Media.

Koh, J. H. L., & Chai, C. S. (2016). Seven design frames that teachers use when considering technological pedagogical content knowledge (TPACK). *Computers and Education, 102*, 244–257. https://doi.org/10.1016/j.compedu.2016.09.003

Kozikoğlu, İ. (2019). Analysis of the Studies Concerning Flipped Learning Model: A Comparative Meta-Synthesis Study. *International Journal of Instruction*, *12*(1), 851–868. https://doi.org/https://doi.org/10.29333/iji.2019.12155a

Ling, M.-T., Pang, V., & Ompok, C. (2018). Measuring Change in Early Mathematics Ability of Children Who Learn Using Games: Stacked Analysis in Rasch Measurement. *In Pacific Rim Objective Measurement Symposium (PROMS) 2016 Conference Proceedings* (Q. Zhang, pp. 215–226). https://doi.org/10.1007/978-981-10-8138-5_17

Maryani, I., & Martaningsih, S. T. (2015). Correlation between Teacher's PCK (Pedagogical Content Knowledge) and Student's Motivation in Primary School in Indonesia. *International Journal of Evaluation and Research in Education (IJERE)*, *4*(1), 38–44. https://doi.org/10.11591/ijere.v4i1.4490

Miles, M. B., & Huberman, A. M. (1994). *An Expanded Sourcebook Qualitative Data Analysis* (2nd Ed). Sage Publications, Inc.

Mishra, P., & Koehler, M. J. (2006). Technological pedagogical content knowledge: A framework for teacher knowledge. *Teachers College Record, 108*(6), 1017–1054. https://doi.org/10.1111/j.1467-9620.2006.00684.x

Mouza, C., Karchmer-Klein, R., Nandakumar, R., Yilmaz Ozden, S., & Hu, L. (2014). Investigating the impact of an integrated approach to the development of preservice teachers' technological pedagogical content knowledge (TPACK). *Computers and Education, 71*, 206–221. https://doi.org/10.1016/j.compedu.2013.09.020

Mupita, J., Widiaty, I., & Abdullah, A. G. (2018). How important is technological, pedagogical, content knowledge? A literature reviews. *IOP Conference Series: Materials Science and Engineering, 434*, 1–5. https://doi.org/10.1088/1757-899X/434/1/012285

Naziri, F., Rasul, M. S., & Affandi, H. M. (2019). Importance of Technological Pedagogical and Content Knowledge (TPACK) in Design and Technology Subject. *International Journal of Academic Research in Business and Social Sciences*, *9*(1), 99–108. https://doi.org/10.6007/ijarbss/v9-i1/5366

Nilsson, P. (2008). Teaching for understanding: The complex nature of pedagogical content knowledge in pre-service education. *International Journal of Science Education, 30*(10), 1281–1299. https://doi.org/10.1080/09500690802186993

Olsen, J. K., Faucon, L., & Dillenbourg, P. (2020). Transferring interactive activities in large lectures from face-to-face to online settings. *Information and Learning Science*, *121*(7–8), 559–567. https://doi.org/10.1108/ILS-04-2020-0109

Østerlie, O. (2016). Flipped Learning in Physical Education: Why and how? In D. Novak, B. Antala, & D. Knjaz (Eds.), *physical Education and New technologies* (pp. 166–176). Croatian Kinesiology Association. https://doi.org/10.13140/RG.2.2.19758.31048

Pamuk, S. (2012). Understanding preservice teachers' technology use through TPACK framework. *Journal of Computer Assisted Learning, 28*(5), 425–439. https://doi.org/10.1111/j.1365-2729.2011.00447.x

Pang, V., Ling, M., & Tibok, R. P. (2019). Achievement of Children in an Alternative Education Programme for Refugee, Stateless and Undocumented Children in Sabah, Malaysia. *Journal of Nusantara Studies, 4*(2), 335–361. https://doi.org/10.24200/jonus.vol4iss2pp335-361 J

Perera, A., Rainsbury, L., & Bandara, S. (2021). Face-to-face delivery this week; online the next: a reflection. *Accounting Research Journal*, *34*(3), 270–278. https://doi.org/10.1108/ARJ-09-2020-0294

Piotrowski, A., & Witte, S. (2016). Flipped Learning and TPACK Construction in English Education. *International Journal of Technology in Teaching and Learning*, *12*(1), 33–46.

Ponikwer, F., & Patel, B. A. (2018). Implementation and evaluation of flipped learning for delivery of analytical chemistry topics. *Analytical and Bioanalytical Chemistry*, *410*, 2263–2269. https://doi.org/10.1007/s00216-018-0892-2

Rahayu, B., & Suparwoto. (2019). The Effectiveness of Subject Specific Pedagogy based on Guided Discovery with E-learning to Improve Students' Problem Solving Skills. *Journal of Physics: Conference Series, 1233*, 1–8. https://doi.org/10.1088/1742-6596/1233/1/012065

Reid, S. A. (2016). A flipped classroom redesign in general chemistry. *Chemistry Education Research and Practice*, *17*, 914–922. https://doi.org/10.1039/c6rp00129g

Riyadi, I. P., Prayitno, B. A., & Karyanto, P. (2018). The Effectiveness of Subject Specific Pedagogy Based on Problem-Based Learning to Empower Student's Ecological Literacy. *Cakrawala Pendidikan, 2*, 212–222. https://doi.org/10.21831/cp.v37i2.15809

Rodphotong, S. (2018). The Effectiveness of Collaborative Learning to Enhance English Communicative Competence: A Case Study of the First-Year Students at Thepsatri Rajabhat University. *International Journal of Pedagogy and Teacher Education (IJPTE), 2*, 137–144. https://doi.org/10.20961/ijpte.v2i0.25174

Sastradika, D., & Jumadi. (2018). Development of subject-specific pedagogy based on guided inquiry about newton's law to improve senior high school students' scientific literacy ability. *Journal of Physics: Conference Series*, *1097*, 1–9. https://doi.org/10.1088/1742-6596/1097/1/012017

Schmidt, D. A., Baran, E., Thompson, A. D., Mishra, P., Koehler, M. J., & Shin, T. S. (2009). Technological Pedagogical Content Knowledge (TPACK): The Development and Validation of an Assessment Instrument for Preservice Teachers. *Journal of Research on Technology in Education, 42*(2), 123–149. https://doi.org/10.1080/15391523.2009.10782544

Seery, M. K. (2015). Flipped learning in higher education chemistry: Emerging trends and potential directions. *Chemistry Education Research and Practice, 16*(4), 758–768. https://doi.org/10.1039/c5rp00136f

Shattuck, J. C. (2016). A Parallel Controlled Study of the Effectiveness of a Partially Flipped Organic Chemistry Course on Student Performance, Perceptions, and Course Completion. *Journal of Chemical Education, 93*(12), 1984–1992. https://doi.org/10.1021/acs.jchemed.6b00393

Shulman, L. S. (1987). Knowledge and Teaching: Foundations of the New Reform. *Harvard Educational Review, 57*(1), 1–23. https://doi.org/10.17763/haer.57.1.j463w79r5645541

Sudarmika, P., Santyasa, I. W., & Divayana, D. G. H. (2020). Comparison between Group Discussion Flipped Classroom and Lecture on Student Achievement and Student Characters. *International Journal of Instruction*, *13*(3), 171–186. https://doi.org/10.29333/iji.2020.13312a

Sumintono, B., & Widhiarso, W. (2015). *Rasch modeling application in education assessment* [Aplikasi pemodelan Rasch pada assesment pendidikan]. Cimahi: Trim Komunikata.

Syakdiyah, H., Wibawa, B., & Muchtar, H. (2018). The effectiveness of flipped classroom in high school Chemistry Education. *IOP Conference Series: Materials Science and Engineering*, *434*, 1–5. https://doi.org/10.1088/1757-899X/434/1/012098

Tanak, A. (2020). Designing TPACK-based course for preparing student teachers to teach science with technological pedagogical content knowledge. *Kasetsart Journal of Social Sciences, 41*, 53–59. https://doi.org/10.1016/j.kjss.2018.07.012

Ubaidillah, M., & Wilujeng, I. (2019). Developing Physics SSP Based on the Problem Solving to Improve the Process Skills and Problem-Solving Ability. *Journal of Science Education Research, 3*(1), 30–42. https://doi.org/10.21831/jser.v3i1.27325

Utami, R. A., & Muhtadi, A. (2020). TPACK-Based E-Book for Learning Chemistry in Senior High School. *International Conference on Online and Blended Learning 2019 (ICOBL 2019)*, *440*, 166–168. https://doi.org/10.2991/assehr.k.200521.036

Wright, B. D. (1996). Time 1 to Time 2 (Pre-test to Post-test) Comparasion: Racking and Stacking. *Rasch Measurement Transactions, 10*(1), 478. https://www.rasch.org/rmt/rmt101f.htm

Wright, B. D. (2003). Rack and stack: Time 1 vs. time 2 or pre-test vs. post-test. *Rasch Measurement Transactions, 17*, 905–906. http://www.rasch.org/rmt/rmt171a.htm