Effectiveness of Online Learning with the Web-based TPACK Scaffolding for Enhancement TPACK Ability of Pre-service Chemistry Teachers

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Received: December 4, 2022 Accepted: December 28, 2022 Online Published: February 16, 2023

doi:10.5430/jct.v12n1p183 URL: https://doi.org/10.5430/jct.v12n1p183

Abstract

This study investigates the effectiveness of web-based TPACK scaffolding to enhance the TPACK ability of pre-service chemistry teachers through online learning. Participants in this study were 74 pre-service chemistry teachers in Chemistry Education program who took a chemistry learning planning course. This study used the quantitative research method approach. The experimental study with pre-and post-test design examined the more significant increase in TPACK ability between the experimental and control classes. The research instrument consisted of 20 multiple-choice questions containing the TPACK components. Analysis of pre-and post-test data used the stacking and racking method in the Rasch model. The stacking analysis result indicated that the pre-service chemistry teachers' ability increased from pre-test to post-test. The racking analysis result indicated that the pre-service chemistry teachers could answer TPACK items easier in the post-test conditions after being given intervention. The various types of scaffolding available in web-based TPACK online learning effectively support pre-service chemistry teacher TPACK ability enhancement. Online learning with web-based TPACK scaffolding is advisable to develop pre-service chemistry teachers' TPACK to prepare them better to use various types of technology in classroom learning.

Keywords: web-based TPACK learning, online learning, scaffolding, technology-enhanced learning, pre-service chemistry teachers

1. Introduction

In the 21st century, the growth of Information and Communication Technology (ICT) adopted in developing global economies motivates the exploration of innovative designs for the learning environment to ensure a better quality of education (Lazem, 2019). These changes create new challenges for today's schools and teachers (Valtonen et al., 2017). Schools and teachers must use technologies creatively to collect and process information to solve problems and innovate to create better services in the real world (Teo et al., 2021). Technology is essential in improving education quality to provide a more innovative and relevant curriculum (Lambert & Gong, 2010). Technologies are expected to be an alternative for students in connecting the subject matter to their previous knowledge, arousing their motivation to learn, supporting high-order thinking processes, and facilitating collaboration in discovering ideas and solving problems (Valtonen et al., 2017; van Laar et al., 2017). Today's students must be equipped with skills appropriate to technological developments called twenty-first-century skills (Valtonen et al., 2017). 21st-century skills emphasize ICT literacy, collaboration, communication, social competence, creativity, critical thinking, and problem-solving (Voogt et al., 2012, 2013). To prepare students with 21st-century skills, teachers need the specific skills to apply appropriate ICT tools through various pedagogical approaches (Valtonen et al., 2018).

Teachers must understand how and when to best use technology to enhance teaching and learning (Lambert & Gong, 2010). Studies by Teo et al. (2021) described that integrating different technologies into learning can help pre-service teachers to consider how these technologies support a particular curriculum (Teo et al., 2021). They also pointed out a lack of research that has an essential role as a reference for teachers in understanding the potential of ICT to support teaching and learning processes. This lack shows the subject-specific needs that pre-service teachers face when using technology to connect subject matter with phenomena in everyday life (Otrel-Cass, 2012). Teachers should be able to transform the subject matter and design ICT-integrated learning into subject-specific pedagogy (SSP).

Teacher education should provide pre-service teachers with the readiness to integrate ICT tools into learning processes (Valtonen et al., 2018). However, there is a gap between the teachers' competencies and the use of ICT in teaching and learning (Hatlevik, 2017). Today's pre-service teachers actively use ICT applications in everyday life but still lack the knowledge to implement ICT for student learning (Lei, 2009). Pre-service teachers have difficulties understanding the pedagogical potential of different technologies and the use of ICT to develop students' 21st-century skills (Lei, 2009; Valtonen et al., 2011). Without a clear idea of the ICT skills that pre-service teachers need and frameworks to guide meaningful learning in technology integration, this leaves severe gaps in knowledge (Teo et al., 2021). To overcome this gap, one of the frameworks that can use flexibly in integrating technology into the learning process is Technological Pedagogical Content Knowledge (TPACK) (Koehler & Mishra, 2006). TPACK includes complex and mutually influencing interactions among the three main components of the learning environment: technology, content, and pedagogy (Koehler et al., 2013). Technology-enhanced learning environment designs are an efficient way to develop pre-service teachers' TPACK skills (Koehler et al., 2007).

Much research has focused on TPACK development programs that aim to develop teachers' TPACK skills to integrate ICT into student-centered learning (Angeli & Valanides, 2009; Hofer & Grandgenett, 2012; Kapici & Akcay, 2020; Koh, 2018; Koh & Divaharan, 2011; Kramarski & Michalsky, 2010). Various courses and field experiences can facilitate pre-service teachers to develop their TPACK skills (Hofer & Grandgenett, 2012). TPACK development attempts to help pre-service teachers improve their TPACK competencies. The three primary focuses of TPACK development are an educational technology course, content-specific teaching methods, and the coursework in a teacher preparation program (Hofer & Grandgenett, 2012). TPACK development programs that provide knowledge and practice integrating technology into learning can be more effective using multiple TPACK scaffolds (Koh, 2018).

Scaffolding is an instructional process that helps novices to carry out a task that they cannot accomplish independently (Wood et al., 1976). Scaffolding may include software programs, curriculum structures, conversational features, and physical structures that promote classroom learning (Pea, 2004). Learning designs without specific scaffolds may not be effective for pre-service teachers with inadequate teaching skills (Chai & Koh, 2017). Larkin & Ellis (1998) describes the scaffolding process in four stages: (1) the teacher/facilitator does it; the teacher introduces and models the task for students, (2) the class does it; the teacher and class work together to perform the task, (3) the group does it; allows students to work with a partner or in a small cooperative group; (4) the individual does it, students accomplish the tasks independently (Larkin & Ellis, 1998). The TPACK learning design models recently indicated the need to (1) engage pre-service teachers in learning by design; (2) provide scaffolding to create relevant TPACK; and (3) support the creation of the technology-integrated lesson design (Chai & Koh, 2017; Koh, 2018).

Due to the development of high-speed Internet, the transition of many activities from the offline to the online environment, and the digitalization of didactic processes, teacher education need to improve the quality of academic training for pre-service teachers (Tomczyk, 2020). Scaffolding pre-service teachers to develop their competencies related to technology integration in learning should concern professional development and teacher education (Poitras et al., 2019; Tomczyk, 2020). Implementing new digital technologies, websites, and software as scaffolds for pre-service teachers is the sustainable and methodologically correct application of ICT in teacher education (Poitras et al., 2019; Tomczyk, 2020). In this way, teachers can design effective learning in a digital environment with Web 2.0 tools (Kul et al., 2019). Examples of Web 2.0 applications are SkyDrive, Wikis, Flickr, WordPress, and Google Apps (Lin & Jou, 2012, 2013). Web 2.0 applications in the learning environment present various opportunities to facilitate more accessible access to information, communication, collaboration, interaction, and feedback (Kul et al., 2019). Web-based TPACK is integrating web technology into the learning process in teacher training programs to improve their TPACK skills (M. H. Lee & Tsai, 2008).

Research in recent years has shown that teachers often lack the skills needed to teach effectively through technology to support student learning (Angeli & Valanides, 2009; Cetin-Dindar et al., 2018; Kramarski & Michalsky, 2010; Rodríguez-Becerra et al., 2020). Pre-service teachers feel they are not adequately prepared to implement effective and meaningful use of technology in learning (Angeli & Valanides, 2009; Kay, 2006; Polly et al., 2010). Pre-service teachers still lack experience in designing learning in a digital environment (Kapici & Akcay, 2020). Teacher education must facilitate how pre-service teachers are being prepared to integrate instructional technology into their lesson design and develop valuable and applicable methods for better embedding technology (Angeli & Valanides, 2009; Tondeur et al., 2017). Therefore, the current study tried to develop the ability of pre-service chemistry teachers to integrate technology in learning through Web-based TPACK scaffolding.

2. Method

2.1 Design of the Study

The purpose of the study was to investigate the effectiveness of Web-based TPACK scaffolding to enhance the TPACK ability of pre-service chemistry teachers. This study applied the Google Classroom and Google site Web applications to propose a web-based learning environment to support TPACK learning. This study used a quantitative method with experimental designs (Creswell, 2012). The pretest-posttest control group design was used to obtain the data (Fraenkel et al., 2012). The experimental class and control class are measured in the pre-test and post-test. The symbolic appearance of the research design is given in Table 1.

Table 1. The Symbolic Appearance of the Research Design

Experimental Class	R	$O_{1.1}$	X	$O_{1.2}$
Control Class	R	$O_{2.1}$	C	$O_{2.2}$

R: random assignment, X: experimental class, C: control class, $O_{1.1}$: pre-test in the experimental class, $O_{1.2}$: post-test in the experimental class, $O_{2.1}$: pre-test in the control class, $O_{2.2}$: post-test in the control class

2.2 Participant

The research was conducted on Chemistry Education students in the second semester of the 2020/2021 academic year. The study uses a random sampling technique. This study involved 74 pre-service chemistry teachers who were divided into a control class and an experimental class. The characteristic of the participant is presented in Table 2.

Table 2. The Demographic of the Participant

Variable		Control class	Experimental class
Year of Study		2^{nd}	2^{nd}
Range age		18-20	18-20
Gender	Female	33/ 89.19%	33/ 89.19%
	Male	4/ 10.81%	4/ 10.81%
Total = 74		37	37

2.3 Instrumentation

The assessment instrument consists of 20 questions in the form of multiple choices. The question consists of 7 components of TPACK. It includes Content Knowledge (two items), Pedagogical Knowledge (three items), Technology Knowledge (two items), Pedagogical Content Knowledge (four items), Technological Content Knowledge (three items), Technological Pedagogical Knowledge (three items), and Technological Pedagogical Content Knowledge (three items). The indicator was adopted and modified from the TPACK instrument indicator by Schmidt et al. (2009) (Schmidt et al., 2009). The indicators for the TPACK instrument are presented in Table 3.

Table 3. Indicators of TPACK Assessment Instrument

TPACK components	Indicators
CK	Understanding the material to be learned or taught
PK	Applying teaching approaches in the classroom setting
	Understanding the principles of developing the lesson plan
TK	Understanding a lot of different learning technology
PCK	Combining content with learning models by considering the characteristics of the material, students, and learning environment
TCK	Determining the appropriate technology that can be used to understand the content
TPK	Using technology that fits the teaching approach
	Using technology that can enhance the student learning process
TPACK	Using various technologies to facilitate knowledge creation of specific subject content

A Focus group discussion was held to validate the TPACK assessment instrument. Validation was carried out by experts (N = 8) in learning media, TPACK, evaluation, and language. Validation in this study was used in Aiken's formula, which is determined by the number of raters and the criteria used (Aiken, 1980). For example, the v value criteria for the number of raters, eight people with four category choices, is 0,75. Therefore, the instrument is valid based on the result of Aiken's validation, given a value of 0.875.

The reliability of the TPACK assessment instrument was analyzed using the Rasch model. The unidimensionality of the instrument is considered very good if the Raw variance is more than 40%; as shown in Table 4, the result is 47.8%; in addition, the criteria for ideal unexplained variance value is below 15%. The value of person reliability is 0.80, and the item reliability is 0.83. This result showed that the consistency of the pre-service chemistry teacher in answering the questions is good, and the quality of the items on the TPACK instrument has a good reliability aspect. In addition, the value of Cronbach's alpha is 0.85, indicating that the overall interaction between persons and items is in the very good category. The TPACK instrument can be relied upon to distinguish a person's abilities well. The person separation index is 2.02, and the item separation index is 2.23; this value indicates the overall quality of the instrument is good because it can identify groups of respondents and groups of item difficulty. The psychometric attributes of the instrument are presented in Table 4.

Table 4. Instrument's Psychometric Attributes

Psychometric attribute	Value
Raw variance explained by measures	47.8 %
Unexplained variance	<10%
Cronbach's alpha	0.85
Person reliability	0.80
Person separation	2.02
Item reliability	0.83
Item separation	2.23

2.4 Data Analysis

The quantitative data on the pre-test and post-test were analyzed using the Stacking-racking method on the Rasch model. Stacking is placing pre-test and post-test data together vertically. It investigates the intervention's impact on each person's ability from a test perspective. Racking refers to the horizontal placement of the data in the pre-test and post-test. It investigates the impact the intervention had on each item's difficulty from the sample's perspective (Wright, 1996). The data placement in the stacking-racking analysis method is presented in Figure 1 and Figure 2.

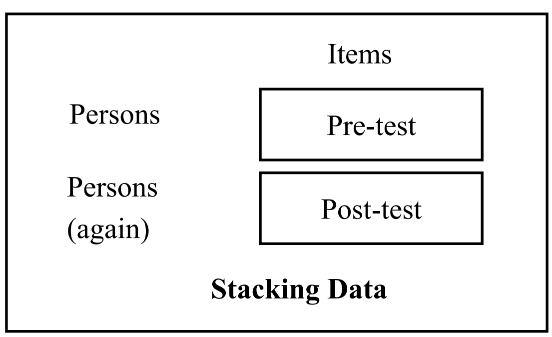


Figure 1. Placement of the Pre-test and Post-test Data in the Stacking Analysis

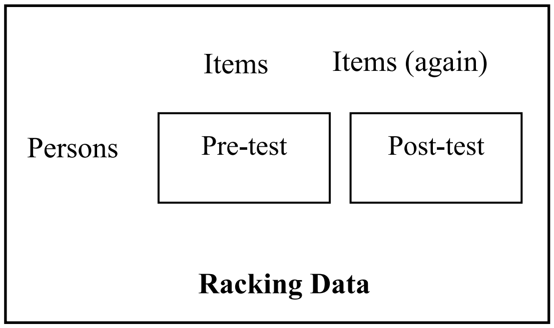


Figure 2. Placement of the Pre-Test and Post-Test Data in the Racking Analysis

2.5 Procedure for Integration of Web-based TPACK Scaffolding

The Web-based TPACK Scaffolding was implemented in the second semester of the 2020/2021 academic year. The intervention was only carried out in the experimental class. In contrast, the learning method used in the control class was the traditional method of delivering theoretical lectures about TPACK by the lecturer. Pre-service chemistry teachers are enrolled in TPACK online learning using Google classroom. The classroom environment with Google Classroom and the Web-based TPACK as Scaffolding are presented in Figure 3 and Figure 4.

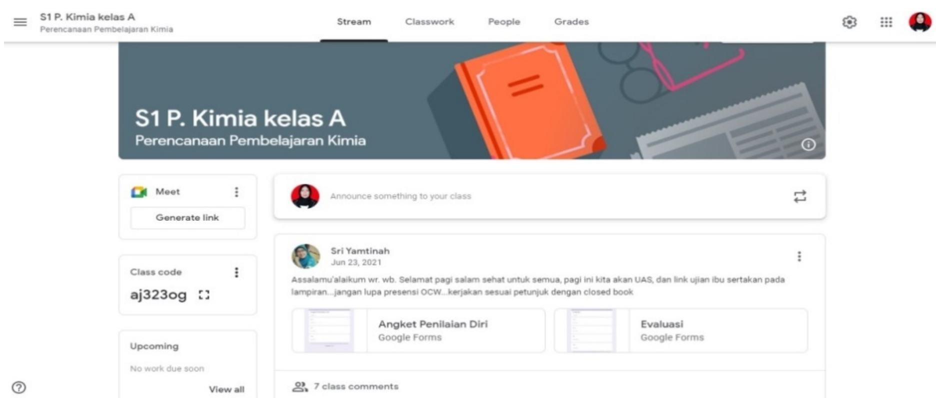


Figure 3. Classroom Environment Using Google Classroom

Figure 4. The Interface of the Web-Based TPACK Module as Scaffolding

The TPACK activity in the web-based TPACK module provides activities using the steps in the scaffolding strategy combined with the in-service learning – on-the-job learning (In1- On - In2) scheme. The step consists of the facilitator does it; the class does it; the group does it; and the individual does it (Larkin & Ellis, 1998). Pre-service chemistry teachers are enrolled in TPACK online learning using Google classroom. They will participate in TPACK learning with the support of Web-based TPACK scaffolding for six weeks. The time distribution of the TPACK-Scaffolding activity in the Web-based TPACK Scaffolding can be seen in Table 5.

Table 5. TPACK-scaffolding Activity on Web-Based TPACK Scaffolding

Scheme	Scaffolding Stage	Activities	Scaffolding	Time
Service-learning 1	Facilitator does it	Introducing TPACK and providing guidelines for TPACK integration	Facilitator, learning guidelines, online materials, and TPACK activity on the web-based module	Week 1
	Class does it	Discussion about the TPACK component	Facilitator, collaboration guidelines, online materials, and TPACK activity on the web-based module	Week 2
	Group does it	Discussion about appropriate technology to teach chemistry	Collaboration guidelines, online materials, and TPACK activity on the Web-based module	Week 3
On the job learning	Individual does it	Creating TPACK integrated syllabus for chemistry learning	Exemplary lessons and TPACK activity on the web-based module	Week 4
	Individual does it	Creating TPACK integrated lesson plan for chemistry learning	Exemplary lessons and TPACK activity on the web-based module	Week 5
Service-learning 2	Facilitator does it	Reflection and evaluation	Facilitator, TPACK assessment on the web-based module	Week 6

3. Results

3.1 Item Fit

The criteria used to see the items fit 0.5 < MNSQ < 1.5, -2.0< ZSTD < +2.0, and 0.4 < Pt Measure Corr < 0.85 (Boone et al., 2014). The item fit of the TPACK instrument is presented in Table 6.

Table 6. Item Fit of TPACK Instrument

Item	MNSQ	ZSTD	Pt Measure Corr	Item	MNSQ	ZSTD	Pt Measure Corr
1	1.74	1.29	0.32	11	0.40	-0.20	0.58
2	0.50	-0.54	0.69	12	0.78	-0.22	0.56
3	0.21	-0.39	0.41	13	2.12	1.10	0.21
4	1.39	0.80	0.31	14	0.59	-0.86	0.69
5	0.21	-0.54	0.73	15	0.70	0.16	0.55
6	0.31	-0.21	0.53	16	0.40	-0.33	0.60
7	0.48	-0.76	0.68	17	1.63	1.05	0.43
8	0.87	0.08	0.52	18	0.66	-0.12	0.54
9	1.02	0.43	0.46	19	0.95	0.05	0.61
10	0.21	-0.39	0.41	20	1.20	0.50	0.35

In Table 5. it can be seen that several items were not meet the requirements for Outfit MNSQ and Pt Measure Corr, but for Outfit ZSTD, the value is still within the allowed criteria. In addition, there is no item does not meet all three criteria at once. Therefore, these items do not need to be changed and can be used for TPACK measurements.

3.2 Stacking Analysis

Person measure data pre-test and post-test of the experimental class and control class are presented in Table 7 and Table 8.

Table 7. The Logit Value Person in the Pre-Test and Post-Test of the Experimental Class

Label name	Logit value person		Difference of logit value person	Label name	Logit value person		Difference of logit value person
	Pre-test	Post-test			Pre-test	Post-test	
A01	0.51	1.63	1.12	A21	1.31	2.50	1.19
A02	-0.45	0.76	1.21	A22	0.03	0.51	0.48
A03	-0.45	0.76	1.21	A23	0.51	1.63	1.12
A04	-0.21	1.31	1.52	A24	-0.99	0.76	1.75
A05	0.27	1.31	1.04	A25	1.31	2.50	1.19
A06	1.31	2.50	1.19	A26	0.03	1.31	1.28
A07	-0.71	1.02	1.73	A27	0.27	1.31	1.04
A08	0.76	2.01	1.25	A28	0.76	2.01	1.25
A09	-0.45	0.51	0.96	A29	0.03	1.31	1.28
A10	1.02	2.01	0.99	A30	0.51	1.31	0.80
A11	0.03	1.02	0.99	A31	1.02	2.50	1.48
A12	0.27	1.63	1.36	A32	0.51	1.63	1.12
A13	0.51	1.63	1.12	A33	-0.21	1.31	1.52
A14	0.03	1.02	0.99	A34	0.03	1.31	1.28
A15	0.76	1.63	0.87	A35	-0.21	0.51	0.72
A16	1.02	2.01	0.99	A36	1.02	2.01	0.99
A17	0.03	1.31	1.28	A37	1.31	2.01	0.70
A18	1.31	2.01	0.70				
A19	-0.21	1.31	1.52				
A20	0.76	2.01	1.25				

Table 8. The Logit Value Person in the Pre-Test And Post-Test of the Control Class

Label Name	Logit Value Person		Difference of Logit Value Person	Label Name	Logit Value Person		Difference of Logit Value Person
	Pre-test	Post-test			Pre-test	Post-test	
B01	0.77	1.31	0.54	B21	1.03	1.63	0.60
B02	-0.45	0.77	1.22	B22	1.31	2.01	0.70
B03	0.28	1.31	1.03	B23	-0.2	0.52	0.72
B04	0.04	1.03	0.99	B24	0.52	1.03	0.51
B05	0.52	1.03	0.51	B25	-1.29	-0.20	1.09
B06	0.04	1.03	0.99	B26	1.31	2.01	0.70
B07	0.77	1.31	0.54	B27	0.04	0.52	0.48
B08	1.03	1.31	0.28	B28	0.77	1.03	0.26
B09	1.31	2.01	0.70	B29	0.04	0.77	0.73
B10	-0.71	0.28	0.99	B30	0.52	1.31	0.79
B11	0.52	1.31	0.79	B31	-0.71	0.04	0.75
B12	0.77	1.63	0.86	B32	0.52	0.77	0.25
B13	1.31	1.63	0.32	B33	-0.45	0.52	0.97
B14	0.52	1.63	1.11	B34	0.52	0.77	0.25
B15	-0.2	0.52	0.72	B35	0.28	1.03	0.75
B16	-0.45	0.77	1.22	B36	1.03	1.63	0.60
B17	0.28	1.31	1.03	B37	-0.20	0.52	0.72
B18	-0.45	0.28	0.73				
B19	-0.20	1.03	1.23				
B20	1.03	1.63	0.60				

In the stacking analysis, two datasets on the pre-test and post-test are combined. Then, through the Rasch model, the logit value person is obtained, indicating a person's ability level. The analysis results describe changes in the level of TPACK ability of pre-service chemistry teachers after the intervention.

Table 7 and Table 8 show that the TPACK ability of pre-service chemistry teachers after TPACK learning has increased. There is a change in the logit value of the person's ability measurement between the pre-test and post-test. The average difference in logit value person in the pre-test and post-test in the experimental class was 1.15, while in the control class, it was 0.73. The comparison of the difference between the logit value person pre-test and post-test in the experimental and control class can be seen in Figure 5.

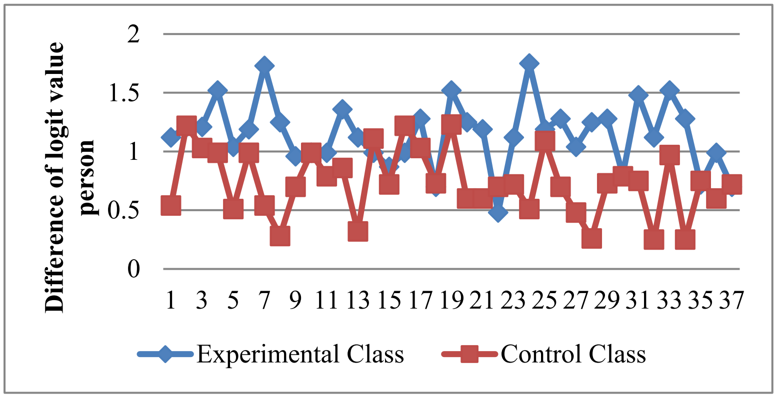


Figure 5. The Comparison of the Difference of Logit Value Person in the Experimental Class and the Control Class

3.3 Racking Analysis

The racking data analysis method is used to determine changes in the level of item difficulty and can also be used to determine differences in ability after the intervention. The positive difference in the logit value indicates that an item is easier to answer. On the other hand, the difference in logit value items is negative, indicating that the items are more difficult in post-test conditions. The difference in logit value items for the control and experimental class are presented in Table 9.

Table 9. The Differences in Logit Value Items for the Control Class and the Experimental Class

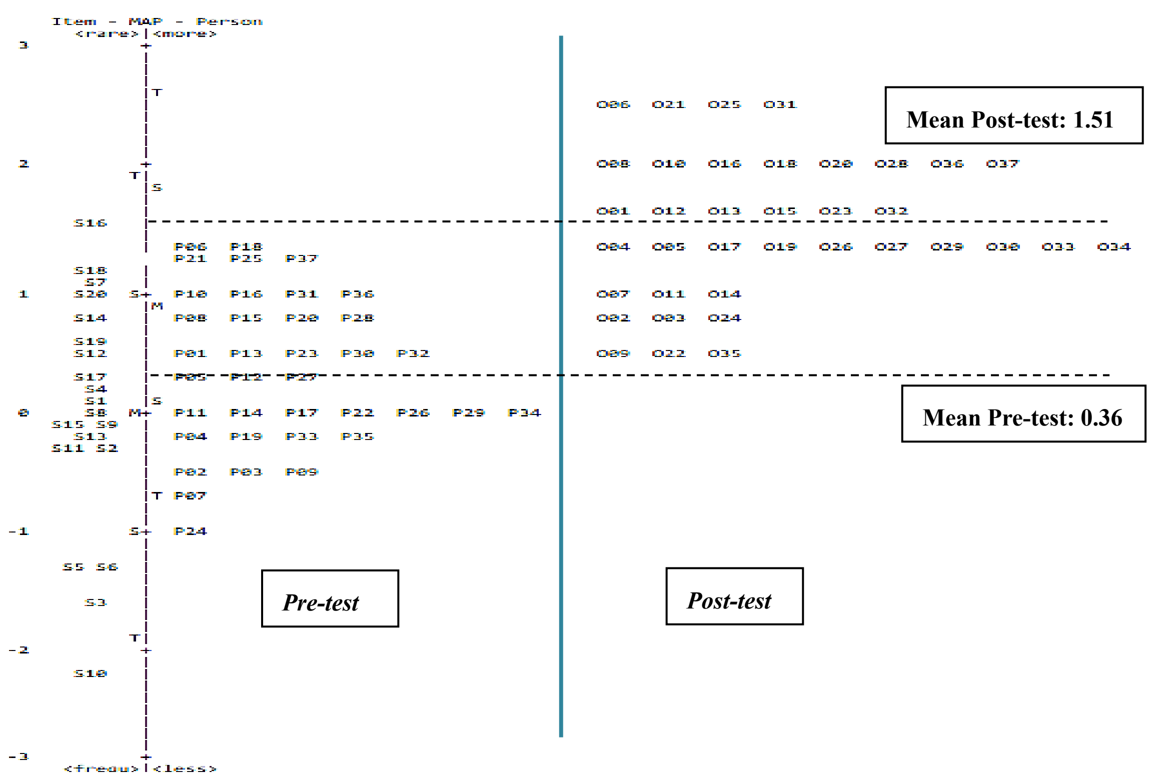
TPACK Component	Item	Difference of Logit Value Item	
		Control Class	Experimental Class
CK	1	1.04	1.08
CK	2	0.84	1.08
PK	3	1.77	1.99
PK	4	0.60	0.51
PK	5	1.19	2.36
PCK	6	1.46	2.36
PCK	7	0.59	1.08
PCK	8	0.73	1.26
PCK	9	0.49	0.71
TK	10	0.45	2.72
TK	11	0.56	0.45
TCK	12	0.95	0.98
TCK	13	0.66	1.56
TCK	14	0.83	1.08
TPK	15	0.38	1.02
TPK	16	0.85	1.55
TPK	17	0.50	0.63
TPACK	18	0.84	1.34
TPACK	19	0.47	1.22
TPACK	20	0.75	1.46

Based on Table 9, the differences in logit value items are more positive in the experimental class than in the control class. After the intervention, the pre-service chemistry teachers in the experimental class tended to be able to answer the post-test questions better than the control class. In the experimental class, the item that has the lowest difference in logit value item is item number 4 in the PK component, with a logit value of 0.51. There was no significant change in the difficulty level of the items between the pre-test and post-test. At the same time, the item with the highest difference in logit value item in the experimental class has a logit value of 2.72, namely item number 10, which contains the TK component. This item can be done easily on the pre-test and post-test.

3.4 Person-Item Map

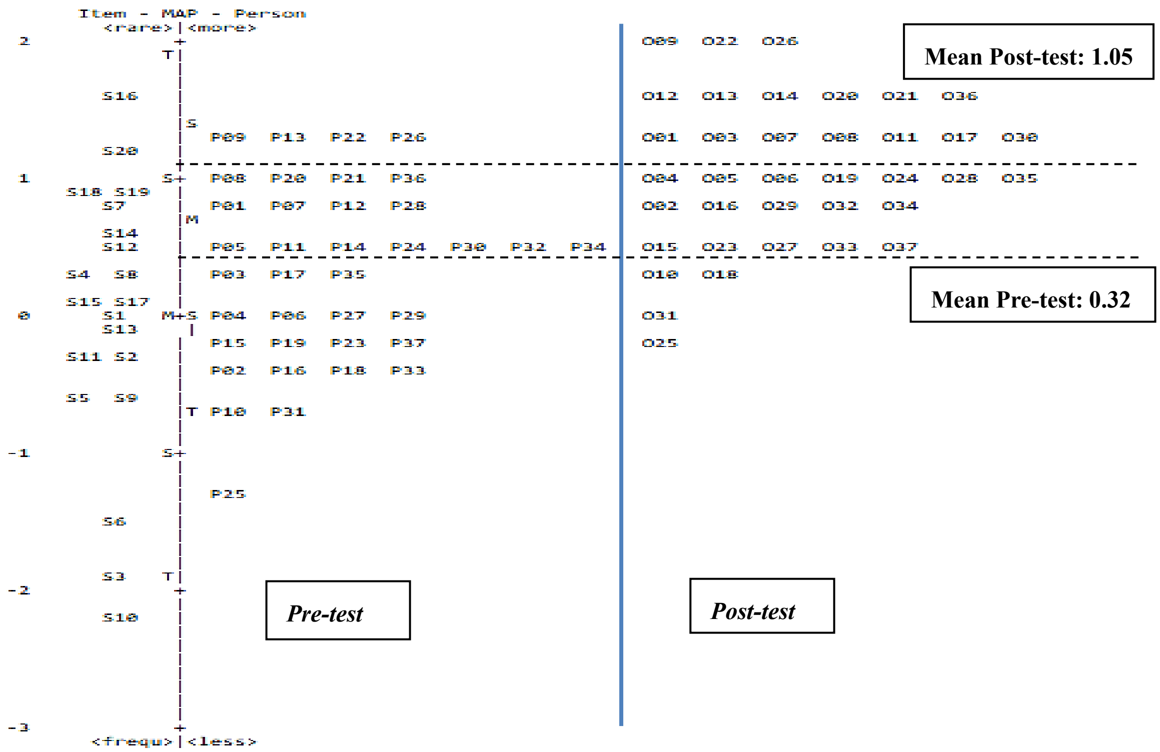
The person-item map describes the distribution of respondents' abilities and item difficulty levels with the same scale on the pre-test and post-test. The distribution of pre-service chemistry teacher abilities at the pre-test and post-test can be seen in the person-item map of the stacking data in Figure 6 and Figure 7. Changes in item difficulty level can be seen from the pattern of a person's response to the items in the racking analysis. The person-item map of data racking is presented in Figure 8 and Figure 9.

Based on Figure 6 and Figure 7, in the post-test, pre-service chemistry teachers in the experimental class with the lowest person ability have a logit value of 0.51, and the highest ability has a logit value of 2.50. Meanwhile, for the control class, the respondent with the lowest ability has a logit value of -0.20, and the highest ability has a logit value of 2.01. In the experimental class, the average logit value in the pre-test was 0.36 and 1.51 in the post-test. Meanwhile, in the control class, the average logit value person on the pre-test was 0.32 and 1.05 on the post-test. The experimental class had a higher increase in the TPACK ability of pre-service chemistry teachers than the control class.



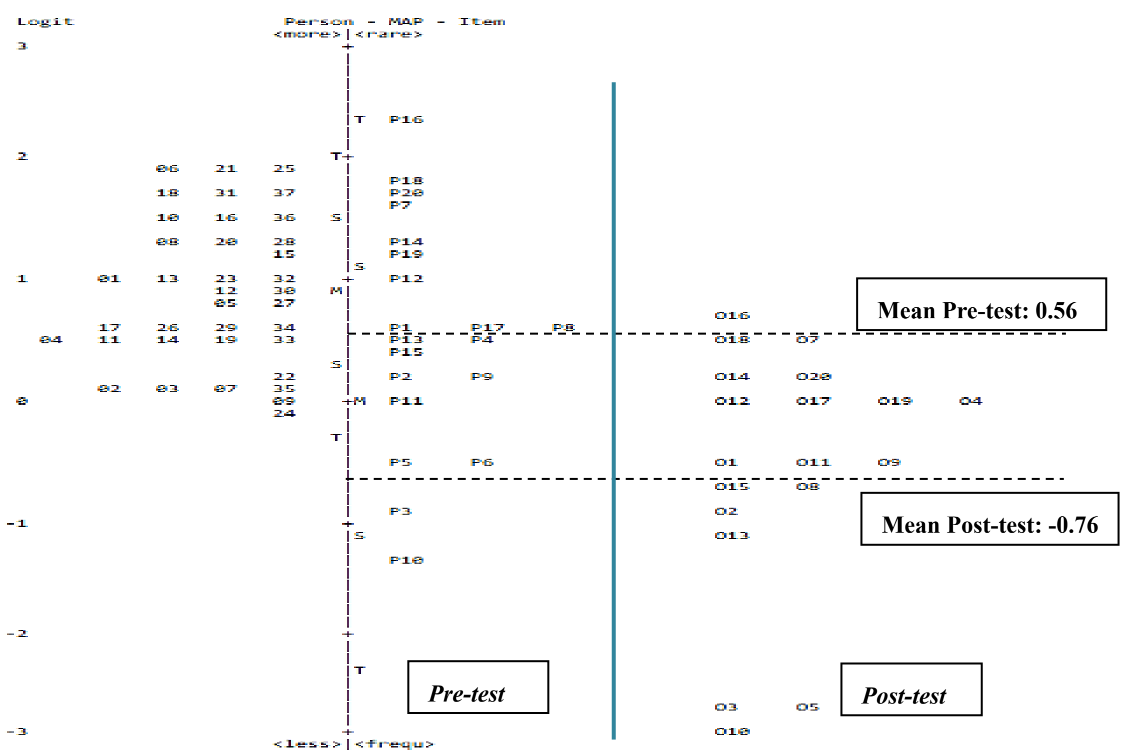
Note. P: Pre-test O: Post-test

Figure 6. Person-item Map of the Stacking Data of Pre-Service Chemistry Teachers in the Experimental Class



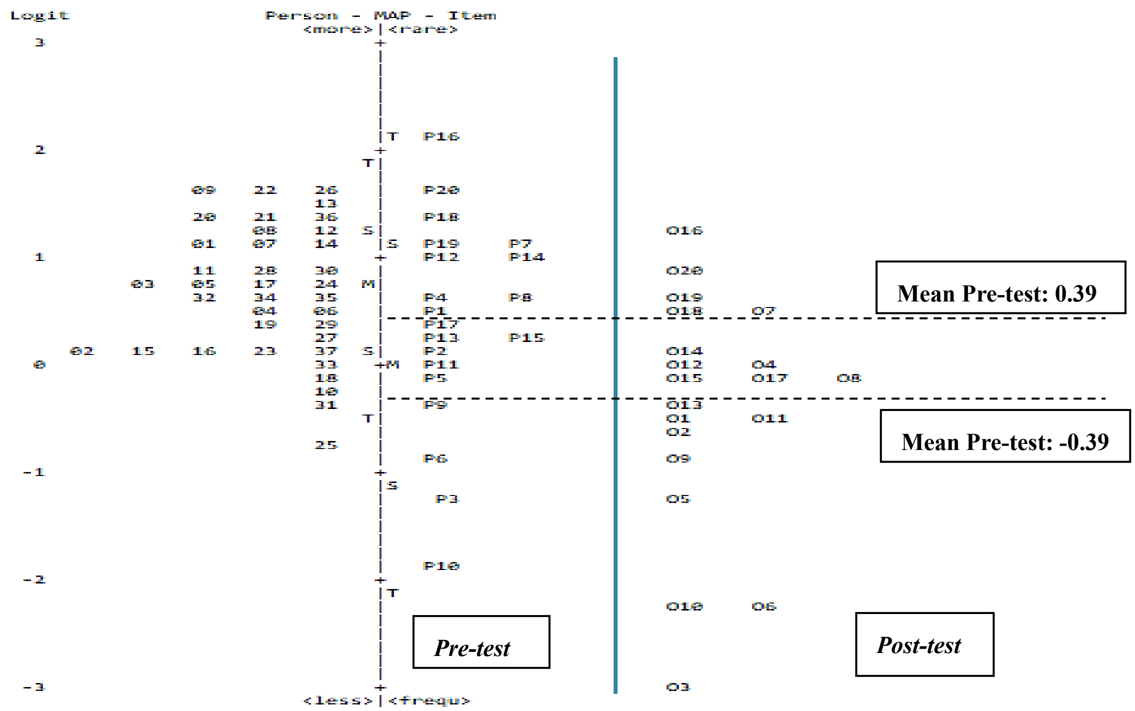
Note. P: Pre-testO: Post-test

Figure 7. Person-item Map of the Stacking Data of Pre-Service Chemistry Teachers in the Control Class



Note. P: Pre-testO: Post-test

Figure 8. Person-item Map of the Racking Data of Pre-Service Chemistry Teachers in the Experimental Class



Note. P: Pre-test O: Post-test

Figure 9. Person-item Map of the Racking Data of Pre-Service Chemistry Teachers in the Control Class

Figure 8 and Figure 9 describe the changes in the response pattern of the item in the pre-test and post-test in the experimental and control classes. For example, suppose the logit value item is increasingly positive. In that case, that means the item is more difficult, while the logit value item is increasingly negative means the difficulty level of the item is easier in the post-test.

Figure 8 shows the change in item difficulty level from the pre-test to the post-test in the experimental class. In the pre-test, logit value items ranged from 2.27 to -1.34, while in the post-test, logit value items ranged from 0.72 to -4.06. Logit value items in the post-test are more negative than in the pre-test. The item's difficulty level becomes easier in the post-test condition. This result showed that pre-service chemistry teachers' ability to answer TPACK items has increased. Figure 9 shows that in the pre-test, the logit value item ranged from 2.09 to -1.86, while in the post-test logit value item ranged from 1.24 to -3.04. The item difficulty level in the control class did not change significantly from the pre-test to the post-test.

4. Discussion

This study investigates the effect of the intervention provided by using the Web-based TPACK scaffolding through online learning for TPACK pre-service chemistry teachers. The results of Rasch's stacking-racking analysis showed an increase in the TPACK ability of pre-service chemistry teachers between pre-and post-intervention results. Furthermore, the stacking analysis result showed that the experimental class had an average difference of logit value person higher than the control class. The increase in the level of ability in the experimental class is more significant than in the control class. This result showed that the intervention applied to the experimental class significantly affected changes in pre-service chemistry teachers' TPACK abilities.

The results of the racking analysis showed that in the experimental class, the level of item difficulty has a logit value that is increasingly negative in the post-test condition. A significant change is in the items that contain the TCK, TPK, and TPACK components. Pre-service chemistry teachers in the experimental class could answer these items easier in the post-test. The item difficulty level changed in the pre-test and post-test, along with the increasing ability of the pre-service chemistry teachers to answer items. This condition is due to the pre-service chemistry teacher's extensive exposure to integrating technology into teaching environments (Kapici & Akcay, 2020). The online learning with

Web-based TPACK scaffolding reflected seven components of TPACK: PK, CK, PCK, TK, TCK, TPK, and TPACK in the lesson design and process. After the course, pre-service chemistry teachers enhance their skills and knowledge to interplay technology, pedagogy, and content in teaching.

This finding confirms that scaffolding pre-service teachers use a web-based TPACK module integrated with the stages of the scaffolding strategy in a collaborative online learning classroom to enhance the TPACK ability of pre-service chemistry teachers. Similarly, Kul, Aksu, and Birisci (2019) concluded that Web-based TPACK learning has a significant and positive effect on TPACK competence and self-efficacy beliefs of pre-service teachers to be better prepared in implementing technology-based learning (Kul et al., 2019). In the experimental class, overall, the pre-service teachers' enhancement of the TPACK ability and knowledge in integrating technology in chemistry learning resulted from using various types of scaffolding in TPACK learning. In collaborative learning design, pre-service chemistry teachers are facilitated with scaffolding through collaboration guidelines, experts, exemplary lessons, online materials, and TPACK activities in the Web-based TPACK module. Several studies concluded that various types of scaffold designs show positive results in the development of TPACK for pre-service teachers (Cetin-Dindar et al., 2018; Chai & Koh, 2017; Kapici & Akcay, 2020; Koh, 2018; Poitras et al., 2019; Wilujeng et al., 2020). Scaffolding provides help, guidance, direction, and various relevant resources in considering digital tools' technological and pedagogical characteristics to enhance teaching (Doukakis & Papalaskari, 2019). Scaffolding when provided to support teaching processes, can help teachers better consider the fit between technologies, pedagogy, content, practice, and context (Koh, 2018).

The Web-based TPACK module as scaffolding provides a pedagogy-based reading relevant to learning activities to help pre-service teachers connect technology and pedagogy and as a material for discussion (Bustamante, 2019). Web applications provide friendly user interfaces and various functionalities (Lin & Jou, 2012). Based on the features, the Web application could be a potential new way to engage students in meaningful teaching and learning activities (Schneckenberg et al., 2011). Teacher education programs have used Web 2.0 tools to provide an online learning environment for pre-service teachers (Zhang et al., 2019). Such environments provide facilities for discussing teaching problems and sharing educational resources and experiences online (Chen et al., 2009; Ching & Hursh, 2014). Web-based learning is collaborative, eliminates platform conflicts, and provides storage for shareable online content (Kul et al., 2019). During the online collaborative discourse process, pre-service teachers integrate technology and pedagogical practices (Barak, 2017; Poitras et al., 2019). Integrating Web 2.0 into learning is in line with the development of TPACK competencies (Bustamante, 2019). That is why the Web-based TPACK module as scaffolding can provide meaningful learning for pre-service chemistry teachers regarding technology integration. Web-based TPACK module provides references related to TPACK and TPACK activities that pre-service teachers can use as scaffolds to synthesize their knowledge and skills for integrating TPACK in chemistry learning.

In the teaching materials section, there are various types of scaffolding to enhance their TPACK ability. The TPACK-integrated lesson plan provides examples of lesson designs on some chemistry subject matter that integrate each component of TPACK appropriately. Lee and Lee (2014) concluded that lesson planning effectively improved pre-service teachers' self-efficacy toward technology integration (Y. Lee & Lee, 2014). Lesson plans provide important information about teaching decisions and the organization of teachers' TPACK knowledge into lesson design (Canbazoglu Bilici et al., 2016). TPACK-integrated lesson plans provide valuable information that enables pre-service teachers' purposeful in selecting appropriate technologies and pedagogical approaches to teach specific content. In addition, teaching materials are also equipped with videos about technology-integrated chemistry learning. It provides an overview of the ideal interaction of technology, pedagogy, and content in the classroom environment. Digital videos can support pre-service teachers' skills and knowledge to capture, analyze, process, and present information and can even promote critical reflection on examples of classroom teaching (Rosaen et al., 2008).

The TPACK activity section on Web-based TPACK Scaffolding contains some TPACK learning activities for pre-service teachers that provide experience, practice skills, and improve understanding of the integration of TPACK in chemistry learning. The TPACK activity type is one of the designed scaffolds that can help teachers create technology-integrated lesson designs (Harris et al., 2012; Koh, 2018). The use of activity types provides pre-service teachers with various activities according to their subject areas so that curriculum contexts can be considered concerning the pedagogical change (Harris & Hofer, 2011). The TPACK activity as scaffolding to develop TPACK skills consists of activities for pre-service chemistry learning with scaffolding strategy steps (facilitator does it - class does it - group does it - the individual does it) by Larkin & Ellis (1998) (Larkin & Ellis, 1998). They were combined with the In1-On-In2 scheme (In service learning 1-On the job learning-In service learning 2).

During In service-learning, pre-service chemistry teachers were involved in various TPACK activities, which included the facilitator does it, the class does it, and the group does it. TPACK learning activities are carried out in a collaborative learning design, where they will collaborate with the facilitator, class, and teams to discuss TPACK and complete each task given. In the collaborative lesson design, they share knowledge and reflect on their pedagogy (Jimoyiannis, 2010). The scaffolding provided includes collaboration guidelines, suitable lesson materials, online materials, and the expert as the facilitator. Collaboration guidelines guide pre-service chemistry teachers in managing the learning process in teams and discussing how to integrate technology into chemistry learning. The exemplary lesson provides an overview of technology-enhanced lessons and clarifies the tasks expected of the team. The online materials available in the Web-based TPACK module include materials on TPACK, technology-enhanced 21st-century learning, and TPACK learning videos in the classroom. The availability of relevant online materials simplifies the design process (Kafyulilo et al., 2015). Experts act as facilitators who provide direction on the TPACK learning process. The facilitator supports the pre-service chemistry teacher on technical and pedagogical problems. This way, pre-service chemistry teachers can expand their TPACK knowledge by getting guidance and discussion with a facilitator. In this stage, there are many questions and discussions, helping pre-service teachers to have sufficient preparation for the lessons, technologically, pedagogically, and content-wise (Kafyulilo et al., 2015).

On-the-job learning of TPACK activities focuses on individual activities in designing technology-integrated chemistry learning. In the scaffolding strategy, mentoring is carried out in the early stages of learning, reducing assistance and providing opportunities for individuals to take over responsibility after being able to do it themselves (Fani & Ghaemi, 2011). Designing technology-based learning involved the knowledge and experience gained by pre-service chemistry teachers in previous TPACK learning activities. This condition helps them to develop knowledge and skills dealing with technology in the classroom (Jimoyiannis, 2010). The role of the expert is to reflect on the overall TPACK learning activity and provide advice on how to overcome the problems encountered during the lesson design process.

Improving TPACK skills is essential for pre-service chemistry teachers as they become better equipped to provide meaningful learning using technology in their classrooms (Kapici & Akcay, 2020). The scaffolding provided in online learning through the Web-based TPACK supports pre-service chemistry teachers in developing their TPACK skills. The positive changes and enhancement of the TPACK ability of pre-service chemistry teachers indicate that scaffolding has an essential role in developing TPACK.

5. Conclusion

The stacking-racking analysis results show that using Web-based TPACK scaffolding through online learning effectively enhances the TPACK ability of pre-service chemistry teachers. The difference in their responses to the pre-test and post-test instruments indicated a positive change in TPACK ability after the intervention. After being given the intervention, the TPACK ability of the pre-service chemistry teacher increased, and the level of item difficulty decreased. The exemplary lesson, online materials, collaborative guidelines, and TPACK activities on the Web-based TPACK scaffolding provide learning experiences and practices for pre-service teachers to improve their skills and knowledge to integrate technology into chemistry learning. Scaffolding is provided during the TPACK learning to provide them with various forms of support for understanding different technologies that potentially improve the teaching of specific content. Through the scaffolding stage in TPACK online learning activities, pre-service chemistry teachers can receive support in the early stages of completing their work. After they can be independent individuals, they will use their ability to solve the problems they face. It provides a learning experience that helps them improve their knowledge and skills in collaboration with the facilitator, class, group, and individually. Technology-enhanced lesson designs help pre-service chemistry teachers understand the TPACK framework and how to decide which technology to use in teaching. As a result, they learned pedagogy and content in the teaching preparation process and digital technology well. In line with the result of this research, areas for the professional development of pre-service chemistry teachers are integrating technology into chemistry learning, improving online structures, and increasing interaction in online learning materials.

This study's main limitation is that the Web-based TPACK is only designed for pre-service teachers in chemistry education programs, not for other disciplines. In addition, this study was examined in a small sample, so the result in this research are less general and may only be possible to generalize in a similar context. To generalize the study result, we recommend implementing Web-based TPACK Scaffolding to enhance the TPACK ability of pre-service teachers in other disciplines of teacher education programs. This research also can be continued with the design of larger pre-service teacher groups in chemistry education programs. This study focused on the TPACK online learning scaffolding to help pre-service chemistry teachers learn about technology integration. It seems necessary to investigate the TPACK scaffolding for pre-service teachers to develop their skills in blended learning or other

TPACK development program.

Acknowledgment

The authors would like to thank the Ministry of Research, Technology, & Higher Education of Indonesia for giving the grant to support this research with grant number 113/UN27.21/HK/2020.

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