

Meta-analysis The Effect of the Technological Pedagogical Content Knowledge (TPACK) Model Through Online Learning on Biology Learning Outcomes, Learning Effectiveness, and 21st Century Competencies of Post-Covid-19 Students and Teachers

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Abstract—This electronic do This study aims to analyze the effect of the Technological Pedagogical Content Knowledge (TPCK) learning model through online learning on the learning outcomes, effectiveness and competencies of 21st century students and teachers after Covid-19. This research is a type of meta-analysis research. This research sample comes from national and international journals that have been published from 2017-2022. Sample search through journal databases accessed through Google Scholar, Eric journal, Emerald, Elsevier, Sage Journal, Taylor and Francis and IEEE. The data selection technique in this study was through purposive sampling technique. The data that was sampled was in accordance with the criteria or related to TPCK in science learning on the variables of effectiveness and student learning outcomes. The data analysis used is quantitative data analysis with the help of SPSS version 16 application by looking at the value of N-gain and Effect size (ES). The results of this study concluded that the Technological Pedagogical Content Knowledge (TPCK) learning model through online learning had a significant effect on student learning outcomes with an average value of 70.5, student learning effectiveness with an average of 73 with an N-gain of 0.61, and 21st century competence of students and Teachers obtained an average of 77.33 with an effect size of 0.48 with moderate criteria.

Keywords— TPACK, Online Learning, Science Learning Outcomes, 21st Century Competence, Covid-19

I. INTRODUCTION

In the era of the 21st century, the world of education has made very significant progress [1]; [2]). This can be seen from the development of the field of education that has been based on digital technology. Every student and teacher has used technology in carrying out learning. In addition, this digital era learning pays attention to teachers and students in achieving effective learning [3]. Effective learning based on digital technology will make it easier for students to respond to subject matter. Not only that, teachers must be able to facilitate students to master technology in learning.

The learning carried out by the teacher provides learning effectiveness for students. students in the era of industrial revolution 5.0 society are expected to master Information and Communication Technology (ICT) in access to learning. In addition, teachers are able to master various kinds of the latest learning models [4];[5]. The expected learning model is to be able to integrate

technology with learning content. The TPACK model or Pedagogical Content Knowledge Technology is one of the learning models that has an influence on student learning activities. [6].

The TPACK learning model is a technology-based learning model that is able to make it easier for students to understand the material or concept. If you look at it now, teachers are still not effective in applying the Pedagogical Content Knowledge (TPACK) technology model properly (Perdani & Andayani, 2021), teachers are generally less able to collaborate on learning that uses technology [7];[8];[9]. Therefore, with the TPACK learning model, it will be able to increase the success and quality of education.

TPACK is a complex learning concept consisting of TK (Technology knowledge), PK (Paedagogical Knowledge), and CK (Content Knowledge) [10];[11][12]. The TPACK learning concept has an influence on the level of student knowledge [13]. In addition, a teacher is able to apply TPACK in the current independent curriculum. Teacher professionalism when used in applying the TPACK model in the curriculum. Teachers who have high professionalism will more easily integrate TPACK in the current learning curriculum. The process of integrating TPACK into the curriculum concept must be supported by the competencies possessed by students [14];[15].

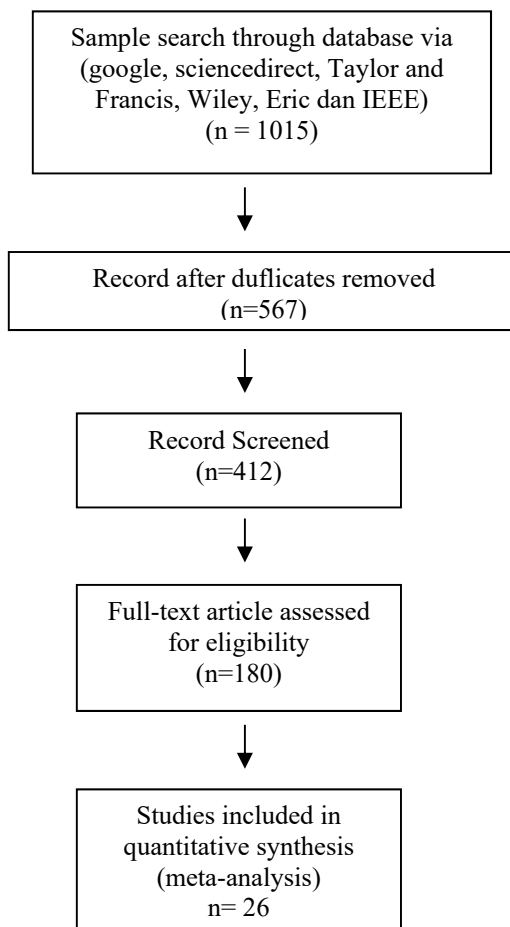
Competence is an ability that is needed by students to achieve learning objectives. In the TPACK learning model, there have not been many teachers who have calorated the TPACK concept in supporting 21st century competition to students [16]. So, the competencies needed today are critical thinking, creative, communication and collaboration or better known as 4C (Critical Thinking, Creative, Communication and Calaboration). Not only that, during the Covid-19 pandemic, the TPACK concept was generally carried out with teachers with online learning. Online learning is learning that is carried out with the help of the internet [17]. This online learning is very well implemented with a learning model based on TPACK [18], but the teacher is too heavy. Improving student competence through TPACK-based learning is very much needed during this Covid-19 pandemic [18];[19]. In addition, with teachers applying the TPACK concept in schools, students can easily improve their learning outcomes and competencies. Teachers and students at that time were indeed encouraged to have professionalism in improving their critical thinking, creative, communication and collaboration competencies. The spread of Covid-19 has adapted the learning process carried out by teachers and students [20].

TPACK is the biggest foundation for teachers in improving the quality of learning in Indonesia. With the Covid-19 disaster, teachers must be able to adjust the material presented to students. The learning process between teachers and students during the Covid-19 pandemic must be able to achieve the desired goals [21]. Therefore, with this TPACK model, teachers can easily and effectively transfer subject matter to students in this Covid-19 pandemic era.

Previous research on the TPACK concept affects the level of student proficiency in mastering learning technology [22]. According to [23], teachers who understand the TPACK concept well are able to apply learning models and strategies well, they will still be low in mastering technology. In addition, research by [24] teachers already have TPACK skills that positively affect the mastery of learning technology. In addition, research by [25] Online learning during the Covid-19 pandemic has made students accustomed to using learning technology. Research by [26] explained that TPCAK learning was able to encourage teacher performance in technology-based learning during this Covid-19 period. Research by [27] TPCK learning model has a significant influence on learning outcomes and student learning activities. Based on the background of the problem, this study aims to analyze the effect of the Technological Pedagogical Content Knowledge (TPCK) learning model through online learning on the learning outcomes, effectiveness and competencies of 21st century students after Covid-19.

II. RESEARCH METHOD

This research is a type of meta-analysis research. The sample in this study comes from the analysis of national journals indexed by SINTA or international journals indexed by Scopus, WOS and DOAJ which have been published in 2017-2022. Sampling was obtained through searching databases from Google scholar, Sciencedirect, Wiley, Taylor and Francis and Eric and IEEE. The sampling technique used purposive sampling technique. The data taken as a sample is related to the TPACK learning model in the learning process which has a relationship with learning outcomes, learning effectiveness and post-Covid-19 21st century competencies. Data analysis in this study is a quantitative analysis technique with amovi software and SPSS version 22. Data analysis in this study calculates N-Gain and Effect size (ES). The value of N-Gain and Effect Size (ES) can be seen in Table 2-3.



Pictures. 1 Journal Selection Process with Flowchart (Armero *et al.*, 2022)

Table. 1 Criterion N-Gain

Nilai	Criteria
$G > 0.7$	Hight
$0.3 \leq g \leq 0.7$	Medium
$G < 0.3$	Low

Table.2 Effect Size (ES) Criteria

Nilai	Criteria
$ES < 0.2$	Rendah
$0 \leq ES \leq 0.8$	Sedang
$ES > 0.8$	Tinggi

III. RESULT AND DISCUSSION

Result

From the results of the meta-analysis of national and international journals indexed by SINTA, Scopus, WOS and DOAJ published in 2017-2022, 26 journals met the sample criteria, which can be seen in Table 3.

Table.3 Meta-analysis by Journal Type & Journal Database

No	Author	Journal Type	Database	Terindex
1	[29]	Internationnal	Taylor and Francis	Scopus
2	[30]	International	Elsevier	Scopus
3	[15]	International	Elsevier	Scopus
4	[31]	International	Google Scholar	DOAJ
5	[32]	International	Google Scholar	DOAJ
6	[33]	International	MPDI	Scopus
7	[34]	International	MPDI	WOS
8	[31]	International	Eric Journal	DOAJ
9	[35]	International	Eric Journal	Scopus
10	[36]	International	Eric Journal	DOAJ
11	[7]	National	Google Scholar	SINTA
12	[37]	National	Google Scholar	SINTA
13	[38]	National	Google Scholar	SINTA
14	[39]	National	Google Scholar	SINTA
15	[40]	National	Google Scholar	SINTA
16	[41]	National	Google Scholar	SINTA
17	[42]	Internasional	Elsevier	Scopus
18	[2]	Internasional	Elsevier	Scopus
19	[43]	Internasional	Elsevier	Scopus
20	[44]	National	Google Scholar	SINTA
21	[45]	International	Taylor and Francis	Scopus
22	[46]	International	Taylor and Francis	Scopus
23	[47]	National	Google Scholar	SINTA
24	[48]	National	Google Scholar	SINTA
25	[49]	International	Elsevier	Scopus
26	[50]	International	Taylor and Francis	Scopus
		National = 9	Taylor and Francis = 4	
		International = 17	Google Scholar = 11	
			Elsevier = 6	
			MPDI = 2	
			Eric journal = 3	

Based on Table 4 above, there are 9 types of national journals indexed by SINTA and 17 international journals indexed by Scopus, WOS, and DOAJ. In addition, the journal database search contained 4 journals from Taylor and Francis, 11 Google Scholars, 6 Elsevier, 2 MPDI and 3 Eric journals. Not only did a meta-analysis based on the type of journal and database, but a meta-analysis was also carried out on the type of research which can be seen in Table 4.

Table. 4 Meta-Analysis Based on Research Type

No	Types of research	Amount	Persentase
1	Quantutative	17	65 %
2	R & D	6	23 %
3	Survey	3	12 %

Based on Table. 5 above explains the meta-analysis of the types of research obtained 65% quantitative research types, 23% R&D research and 12% survey research. Not only that, to see the influence of Technology Pedagogical Content Knowledge (TPACK) on learning outcomes, effectiveness and competence of the 21st century, the calculation of Effect Size (ES) can be seen from 5-7.

Table. 5 Effects of TPACK > Student Learning Outcomes after Covid-19

No	Class	Score	Means	ES
1	Experiment	81	70.5	0.52
2	Control	60		

Tabel. 6 Pengaruh TPACK > Efektivitas Belajar Siswa Pasca Covid-19

No	Kelas	Score	Means	N-Gain
1	Experiment	83	73	0.61
2	Control	63		

Table.7 Effect of TPACK > 21st Century Competence of Students & Teachers Post Covid-19

No	Competensy	Score	Means	Effect Size (ES)	Criteria
1	Critical Thinking	78			
2	Kreative	82.15	77.33	0.48	Sedang
3	Comunication	73.17			
4	Calaboration	76.02			

Based on Table. 5-7 above, it is known that the Technology Pedagogical Content Knowledge (TPACK) learning model has an effect on student learning outcomes after Covid-19 with an average of 70.5, student effectiveness of 0.61, and students' 21st century competency scores on average 77.33 with an Effect size of 0.48 with moderate criteria.

Discussion

The application of the Technology Pedagogical Content Knowledge (TPACK) learning model has a significant influence on student learning outcomes, effectiveness and 21st century competencies of post-Covid-19 students. This can be seen from the results of a meta-analysis of 26 reputable national and international journals. From the meta-analysis, TPACK has an effect on student learning outcomes of 70.5, student effectiveness of 73 and 21st century competence for students and teachers of 77.33 with an effect size (ES) of 0.48. This is in line with research by [28] The application of TPACK can improve student learning

outcomes. In addition, according to [29];[30] The TPACK learning model encourages a teacher to integrate technology in education. In addition, TPACK learning is effective in increasing the effectiveness of students in learning. This is in line with [31];[32] explained that the TPACK concept is effective in encouraging the effectiveness of technology-based student learning. This means that teachers and students are able to improve 21st century competencies.

In the 21st century competence, students and teachers are required to be able to have 4 basic competencies, namely critical thinking, creative, communication and collaboration. From the results of the research above, TPACK has an influence on 21st century competence [33]. This is in line with research by [34];[35] In the application of TPACK, it is able to improve the quality of critical thinking and student learning outcomes after the Covid-19 pandemic. In the learning of the Covid-19 era, learning technology is very important in supporting the teaching and learning process [36];[37];[38] In the TPACK concept, teachers must be able to apply subject matter easily and effectively to students through technology. Menurut [39] TPACK learning should be able to encourage the quality of a teacher in carrying out the learning process.

In the learning process during the Covid-19 period, everything is done online. Online learning requires the professionalism of teachers and students in mastering technology [40]). In the TPACK model the application of technology is also applied in the learning curriculum. Learning with the TPACK concept, the teacher applies the concept of learning by using technology, pedagogy, content and knowledge to students. Therefore, post-Covid-19 TPACK learning has an important effect on the quality level of student learning, although it does not directly have an effect on students. However, the TPACK model applied to students has been able to provide positive results for students and teachers [41];[42];[43];[44]. So, the application of Technology Pedagogical Content Knowledge (TPACK) is effectively used in various post-Covid-19 lessons [45];[46];[47].

In this post-Covid-19 learning era, students are able to understand subject matter through technology. Learning technology during the Covid-19 period is generally based on the use of technology [48];[49]. With its presence, the TPACK learning concept provides excellent student learning outcomes and 21st century competencies for students and teachers [50];[51];[52]. Furthermore, TPACK learning needs to be evaluated further so that this model is able to encourage the quality of teachers and students in the 4.0 revolution era. According to [53], TPACK learning encourages a teacher to improve the quality of learning. In addition, the TPACK model has been widely applied in various countries in Southeast Asia [54];[55]. The reason is that the TPACK model is able to develop the quality and potential of pedagogic technology and content for a student and teacher after Covid-19 [56];[57];[58];[59].

IV. CONCLUSION

From the results of the research above, it can be concluded that the Technological Pedagogical Content Knowledge (TPCK) learning model through online learning has a significant effect on student learning outcomes with an average value of 70.5, student learning effectiveness with an average of 73 with an N-gain of 0.61, and 21st century competence. students and teachers obtained an average of 77.33 with an Effect size (ES) of 0.48 moderate criteria. The application of the TPACK learning model is very well applied in post-Covid-19 learning.

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