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Research Article

Effect of the integrated science, technology, and society (STS) learning approach with *tecnological pedagogical content knowledge* (TPACK) to cognitive learning outcomes and metacognitive abilities on State Vocational School West Seram

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ABSTRACT

West Seram Regency is one of the areas that has quite low quality educationThere needs to be innovation in using several learning approaches. Learning approacheswhich can be used to solve problems in the surrounding environment and is technology-based, namely Science Technology and Society (STS) and*Technological Pedagogical Content Knowledge* (TPACK).This research aims to determine the effectlearning approachesTPACK integrated STS on cognitive learning outcomes and metacognitive abilities on ecosystem material in Class X students of West Seram Vocational School. This type of research isquasi-experiment. The research population was State Vocational School 2 West Seram, State Vocational School 9 West Seram and West Seram State Vocational School 12 with a total sample of 33 students. The research instruments used were metacognitive ability tests and questionnaires and analyzed using Ancova. The research results show thatthere is an influence of the TPACK integrated STS learning approach on cognitive learning outcomes, there is an influence of the TPACK integrated STS learning approach on metacognitive abilities, and there is an influence of the TPACK integrated STS learning approach on cognitive learning outcomes and metacognitive abilities.

Keywords: integration, STS, TPACK, cognitive learning outcomes, metacognitive ability

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INTRODUCTION

West Seram Regency is one of the areas that has a fairly low quality of education. Based on these conditions, there is a need for innovation in using several learning approaches. The learning approach chosen by a teacher is expected to be a learning approach that allows and emphasizes the process of student involvement to be able to discover material and improve students' metacognitive abilities which they learn independently (Agatha and Wuri, 2018).

Ferdiansyah (2015) research results explain that student learning outcomes on viral material applylearning approaches Science Technology and Society (STS) is higher than the learning outcomes of students who do not applylearning approaches STS. Apart from that, Badriyah (2014) research results explain that the science technology society learning approach can improve students' metacognitive abilities. Meanwhile, the research results of Elya, et al. (2022) explain that improving student learning outcomes through the Technological

Pedagogical Content Knowledge (TPACK) approach has a positive influence. Imam (2019) research concluded that the TPACK-based learning model has a significant influence on students' metacognitive abilities in high school science material. Based on several studies regarding the combination of learning models, one method used by teachers is to combine the STS learning approach with the TPACK learning approach which, when combined, can improve students' learning outcomes and metacognitive abilities.

Based on observations in West Seram Regency inFrom the interview results, teachers explained that in the learning process, students generally appear passive and this means that educators are the ones who are more active in learning which has an impact on grades. Students' semester test results are low, because the learning process is still carried out using conventional methods such as lectures. Lectures given by teachers in learning make students feel bored and give the impression of playing around in every learning process, this is because teachers do not use technology such as learning videos or PPT which is due to the lack of internet access in the area, especially teachers are less creative in using the environment as a instructional Media.Students tend to have difficulty understanding or remembering the ecosystem material provided by the teacher so that students' ability to process information from the learning outcomes provided by the teacher is still low. This is because the teacher has not used learning models and methods properly, the teacher only uses conventional lectures, discussions etc. So that students are not motivated to participate in learning well, it can be said that the learning objectives have not been achieved. Therefore, the STS learning approach and the TPACK learning approach can be alternatives that can increase student motivation and enthusiasm in the learning process.

METHODS

This type of research is a quasi-experimental which consists of three schools, namely each school is divided into 2 classes, namely the experimental class (treatment class) and the control class (comparison class). In the experimental class, treatment was given with STS learning approach integrated with TPACK and in the control class usinglearning approaches conventional.Tthe research was conducted in State Vocational School 2 West Seram, State Vocational School 9 West Seram, State Vocational School 12 West Seram. The sampling technique used was a saturated sample. Saturated sample techniqueis a sample selection technique when all members of the population are sampled. The reason for taking the saturated sampling technique is because West Seram Regency only has 3 Vocational High School (SMK) units that have agribusiness majors. The research instruments used were test instruments to measure students' cognitive learning outcomes and questionnaires to measure students' metacognitive abilities based on the indicators Declarative knowledge, Procedural knowledge, Conditional knowledge; Planning, Information Management Strategies, Comprehension Monitoring, and Evaluation from Schraw and Dennison (1994). The test of the research instrument for test questions used a validity test using product moment correlation, a reliability test using alpha cronbach and a test of the level of difficulty of the questions. Data analysis used Ancova and further tests were carried out using the LSD test using SPSS Version 27 software.

RESULTS AND DISCUSSION

The cognitive learning results in the control class and experimental class will be seen in the Table 1 and Table 2.

Table 1. Student cognitive learning results in the control class

Control Class							
State Vocational School 2 West Seram							
Pretest				Posttest			
Interval	F	%	Qualification	Interval	F	%	Qualification
90-100	0	0%	Very Good	90-100	1	8,33%	Very Good
80-89	0	0%	Good	80-89	6	50%	Good
71-79	0	0%	Enough	71-79	5	41,67%	Enough
<70	12	100%	Not Enough	<70	0	0%	Not Enough
State Vocational School 9 West Seram							
Pretest				Post Test			
Interval	F	%	Qualification	Interval	F	%	Qualification
90-100	0	0%	Very Good	90-100	1	10%	Very Good
80-89	0	0%	Good	80-89	2	20%	Good
71-79	0	0%	Enough	71-79	5	50%	Enough
<70	10	100%	Not Enough	<70	2	20%	Not Enough

State Vocational School 12 West Seram							
Pretest				Post Test			
Interval	F	%	Qualification	Interval	F	%	Qualification
90-100	0	0%	Very Good	90-100	0	0%	Very Good
80-89	0	0%	Good	80-89	1	9,10%	Good
71-79	0	0%	Enough	71-79	5	45,45%	Enough
<70	11	100%	Not Enough	<70	5	45,45%	Not Enough

Table 2. Student cognitive learning results in the experimental class

Experimental class							
State Vocational School 2 West Seram							
Pretest				Posttest			
Interval	F	%	Qualification	Interval	F	%	Qualification
90-100	0	0%	Very Good	90-100	8	66,67%	Very Good
80-89	0	0%	Good	80-89	4	33,33%	Good
71-79	0	0%	Enough	71-79	0	0%	Enough
<70	12	100%	Not Enough	<70	0	0%	Not Enough
State Vocational School 9 West Seram							
Pretest				Post Test			
Interval	F	%	Qualification	Interval	F	%	Qualification
90-100	0	0%	Very Good	90-100	4	40%	Very Good
80-89	0	0%	Good	80-89	6	60%	Good
71-79	0	0%	Enough	71-79	0	0%	Enough
<70	10	100%	Not Enough	<70	0	0%	Not Enough
State Vocational School 12 West Seram							
Pretest				Post Test			
Interval	F	%	Qualification	Interval	F	%	Qualification
90-100	0	0%	Very Good	90-100	2	18,18%	Very Good
80-89	0	0%	Good	80-89	6	54,54%	Good
71-79	0	0%	Enough	71-79	3	27,28%	Enough
<70	11	100%	Not Enough	<70	0	0%	Not Enough

Based on the Table 1 and Table 2, it is known that the distribution of scores on the pretest shows that students have a low level of mastery of ecosystem material concepts. Meanwhile, if we look at the posttest, it can be seen that almost all students experienced an increase in scores in both the control group and the control group. This means that there is an increase in scores between before and after students are taught with STS learning approach integrated TPACK learning approachand classes whose learning uses conventional models.

To find out the calculation of the average percentage results for each indicator of student metacognitive ability, see Appendix 5 which is summarized in Table 3.

Table 3. Results of Shiva's metacognitive abilities

School	Class	Percentage (%)	Category
State Vocational School 2 West Seram	Control Class	50.09	Enough
	Experimental Class	50.63	Enough
State Vocational School 9 West Seram	Control Class	50.31	Enough
	Experimental Class	50.42	Enough
State Vocational School 12 West Seram	Control Class	48.05	Not enough
	Experimental Class	48.40	Not enough

Based on the table above, it is known that the percentage score of metacognitive ability results for West Seram 2 Vocational School students in the control class is 50.09% and in the experimental class is 50.63%. Then for students at State Vocational School 9 West Seram in the control class it was 50.31% and in the experimental class it was 50.42% and for students at State Vocational School 12 West Seram in the control class it was 48.05% and in the experimental class it was 48.40%.

The results of validity, reliability and difficulty level of the questions test is performed in Table 4, Table 5 and Table 6. The results of the construct validity test using the product moment coefficient can be seen that all the items (items) of the cognitive learning outcome variables and metacognitive abilities are included in the valid category. This means that the ecosystem material test item instrument and metacognitive ability assessment questionnaire instrument are suitable for use.

Table 4. Construct validity test results

Question Items	R Count	R Table	Criteria
Cognitive Learning Outcomes			
Question 1	0.733	0.344	Valid
Question 2	0.766	0.344	Valid
Question 3	0.807	0.344	Valid
Question 4	0.820	0.344	Valid
Question 5	0.829	0.344	Valid
Question 6	0.707	0.344	Valid
Question 7	0.824	0.344	Valid
Question 8	0.685	0.344	Valid
Question 9	0.646	0.344	Valid
Question 10	0.594	0.344	Valid
Students' Metacognitive Abilities			
Item 1	0.841	0.344	Valid
Item 2	0.879	0.344	Valid
Item 3	0.948	0.344	Valid
Item 4	0.865	0.344	Valid
Item 5	0.815	0.344	Valid
Item 6	0.874	0.344	Valid
Item 7	0.810	0.344	Valid
Item 8	0.895	0.344	Valid
Item 9	0.810	0.344	Valid
Item 10	0.608	0.344	Valid
Item 11	0.919	0.344	Valid
Item 12	0.877	0.344	Valid
Item 13	0.883	0.344	Valid
Item 14	0.602	0.344	Valid
Item 15	0.490	0.344	Valid
Item 16	0.727	0.344	Valid
Item 17	0.874	0.344	Valid
Item 18	0.789	0.344	Valid
Item 19	0.820	0.344	Valid
Item 20	0.690	0.344	Valid

Table 5. Reliability test results

Variable	Cronbach Alpha	Criteria	Information
Cognitive Learning Outcomes	0.971	0.07	Reliable
Metacognitive Ability	0.910	0.07	Reliable

Based on the table above, it can be seen that the item instrument used in this research has very high reliability, for the cognitive learning outcome variable 0.971 > 0.07 and for the metacognitive ability variable 0.910 > 0.07 so it is very good to use for actual testing.

Table 6. Test results for the difficulty level of the questions

Difficulty index value range (P)	Category	Question number	Amount	Percentage (%)
0.71-1.0	Easy	1, 2	2	20
0.31-0.70	Medium	3,4,5,6, 7, 9,10	7	70
0.00-0.30	Difficult	8	1	10

Based on the data in the table above, it can be seen that as many as 70% of the questions tested in learning ecosystem material for X State Vocational School students in West Seram are in the medium category, while 20% are in the easy category, and 10% are in the difficult category.

Table 7. Normality Test Results

No	School	Variable	Class	Sig	Information
1	State Vocational School 2 West Seram	Cognitive Learning Outcomes	Control	0.200	Normally distributed
			Experiment	0.150	Normally distributed
		Metacognitive Ability	Control	0.200	Normally distributed
			Experiment	0.226	Normally distributed
2	State Vocational School 9 West Seram	Cognitive Learning Outcomes	Control	0.228	Normally distributed
			Experiment	0.224	Normally distributed
		Metacognitive Ability	Control	0.126	Normally distributed
			Experiment	0.200	Normally distributed
3	State Vocational School 12 West Seram	Cognitive Learning Outcomes	Control	0.241	Normally distributed
			Experiment	0.200	Normally distributed
		Metacognitive Ability	Control	0.200	Normally distributed
			Experiment	0.200	Normally distributed

Based on the table above, it is known that the significance value for the control class and experimental class at State Vocational School 2 West Seram, State Vocational School 9 West Seram and State Vocational School 12 West Seram is sig > 0.05, so this value can be said to be valid, which means all data normally distributed.

Table 8. Homogenity Test Results

No	School	Variable	Class	Sig	Information
1	State Vocational School 2 West Seram	Cognitive Learning Outcomes	Control	0.184	Homogeneous
			Experiment	0.172	Homogeneous
		Metacognitive Ability	Control	0.932	Homogeneous
			Experiment	0.918	Homogeneous
2	State Vocational School 9 West Seram	Cognitive Learning Outcomes	Control	0.174	Homogeneous
			Experiment	0.383	Homogeneous
		Metacognitive Ability	Control	0.833	Homogeneous
			Experiment	0.709	Homogeneous
3			Control	0.797	Homogeneous

State Vocational School 12 West Seram	Cognitive Learning Outcomes	Experiment	0.853	Homogeneous
	Metacognitive Ability	Control	0.230	Homogeneous
		Experiment	0.235	Homogeneous

Based on the table above, it is known that the significance value for the control class and experimental class at State Vocational School 2 West Seram , State Vocational School 9 West Seram, State Vocational School 12 West Seram is sig > 0.05, so this value can be said to be valid, which means all data valid or homogeneous.

Table 9.ANCOVA test results

No	Variable	Sig
1	Learning outcomes	0.001
2	Metacognitive Ability	0.002
3	Learning Outcomes*Metacognitive Ability	0,000

There is an influence of the integrated STS and TPACK learning approach on the cognitive learning outcomes of ecosystem material of class X students of State Vocational School West Seram with a sig value of 0.001 <0.05. Meanwhile, There is an influence of the integrated STS and TPACK learning approach on the metacognitive ability outcomes of ecosystem material of class X students of State Vocational School West Seram with a sig value of 0.002 <0.05. And, There is an influence of the integrated STS and TPACK learning approach on the cognitive learning and metacognitive ability outcomes of ecosystem material of class X students of State Vocational School West Seram with a sig value of 0.000 <0.05.

The LSD test or difference test was carried out to find out whether the control class and experimental class had significant differences in learning outcomes and metacognitive abilities. LSD Test Results can be seen in the following table10.

Table 10. LSD test results

No	Variable	School	Sig	Information
1	Cognitive Learning Outcomes	State Vocational School 2 West Seram	0.001	Really Different
		State Vocational School 9 West Seram	0.001	Really Different
		State Vocational School 12 West Seram	0.009	Really Different
2	Metacognitive Ability	State Vocational School 2 West Seram	0.006	Really Different
		State Vocational School 9 West Seram	0.006	Really Different
		State Vocational School 12 West Seram	0.003	Really Different

The results of the LSD further test show that the cognitive learning outcome variable at State Vocational School 2 West Seram is significantly different from the cognitive learning outcome at State Vocational School 9 West Seram AND is significantly different from the cognitive learning outcome

variable at State Vocational School 12 West Seram. And the that the metacognitive learning outcome variable at State Vocational School 2 West Seram is significantly different from the cognitive learning outcome at State Vocational School 9 West Seram and is significantly different from the cognitive learning outcome variable at State Vocational School 12 West Seram.

From the pre-test and post-test results given to control class students and experimental class students, it can be seen that there was an increase in cognitive learning outcomes after being given the approach treatment. Learning STS integrated TPACK. This increase occurs because teachers in schools rarely use learning models and approaches during the learning process in order to produce a good learning process. In the experimental class, students are given treatment according to syntax approach learning STS integrated TPACK which is useful for motivating and enhancing students' learning abilities which aims to improve cognitive learning outcomes.

Before starting learning, the researcher invited students to observe the surrounding environment and the researcher invited students to reveal what problems were occurring and continued with the researcher conveying the material points presented in the learning video and power point PPT. Judging from the looks on the students' faces during the learning process, students' attention seemed to increase as the researchers displayed videos and PPTs that were interesting to students during the learning process. This is possible because of the encouragement of students' curiosity about the media that researchers use, where students still seem unfamiliar with the use of learning videos and PPTs displayed. The increased attention from students encourages them to want to take part in the learning process more seriously, which will certainly improve students' cognitive learning outcomes. Students are more active in participating in learning and there is more interaction. Students want to ask questions about the material provided and students are able to solve problems related to the student worksheets provided. This makes them better understand the material being taught. When working on the student worksheet, the researcher provided opportunities and guided students to search for literature that was relevant to the material provided. The researcher invited students to use YouTube as a reference in the learning process. After students have finished working on the students' work sheet, the researcher invites students to discuss the results of processing the information obtained and students between groups conduct student questions and answers. If there is a wrong discussion, the researcher will act as an intermediary and provide solutions.

From the results of this explanation, it shows thatapproachLearning STS integrated TPACK can improve students' cognitive learning outcomes,which proven by the results of Ancova hypothesis testing with spss that hypothesis 1 is accepted, which means there is an influence of the STS learning approach integrated with TPACK on the cognitive learning outcomes of ecosystem material in Class X students of West Seram Vocational School withsig 0.001 < 0.05.

In line with research by Triwibowo et al. (2021) that the effectiveness of using learning media with technology has proven to be more effective, namely by achieving learning achievement in accordance with the established minimum completion criteria. Toyik and Nafiah (2020) stated that with the TPACK approach to learning, teachers can effectively practice pedagogy and understand concepts by integrating technology. The technology used can be laptops, LCD projectors, Microsoft Power Point as learning media, videos, YouTube, smart phones and the internet. Using the TPACK approach in learning trains and improves students' learning experiences in using technology. With this approach, it is hoped that students will be more motivated and more active in learning so that the learning outcomes obtained will increase and learning objectives can be achieved.

So it is concluded that there are differences in the learning outcomes of students who are taught using STS learning approach integrated with TPACK ecosystem material. Developing learning outcomes for learning is basically helping students see the relationship between the material being studied and themselves and if students see that the results of their learning experiences will bring progress to them, they will most likely be motivated in learning so that the results of their learning efforts can improve.

From the results of the student metacognitive ability questionnaire that was given to control class students and experimental class students, it was seen that there was an increase in metacognitive ability after being given the approach treatment. Learning STS integrated TPACK. The results of the students' metacognitive abilities were highest at State Vocational School 2 West Seram Section with the Control class 50.09% and the Experiment class 50.63%. Then followed by the State Vocational School 9 West Seram with the control class 50.31% and the experimental class 50.42% and the State Vocational School 12 West Seram with the control class 48.05% and the experimental class 48.4%. The difference in metacognitive abilities in the three schools is because students at State Vocational School 2 West Seram have quite good academic abilities when compared to students at State Vocational School 9 West Seram and State Vocational School 12 West Seram (Muhiddin, 2012).

Students' metacognitive abilities were measured using a questionnaire using 7 indicators consisting of declarative knowledge, procedural knowledge, conditional knowledge; planning, information management strategies, comprehension monitoring, and evaluation from Schraw and Dennison (1994) with a total of 20 questionnaire questions. Questionnaire questions are prepared based on students' understanding of the learning

process they receive. Giving students metacognitive ability questionnaires on the grounds that students are not used to working on lots of test questions and from several references such as Damayanti et al. (2021), Simamora (2021), Utari (2024). Therefore, researchers chose to measure metacognitive abilities by administering questionnaires based on a Likert scale to students. In the process of filling out the metacognitive ability questionnaire, the experimental class students looked enthusiastic compared to the control class students, because the treatment approach was given learning STS integrated TPACK helps students improve student academics so that students are able to think and increase student awareness in using declarative, procedural and conditional knowledge. Ideally, when students are faced with a problem, students consciously know what strategies can help them find a solution, how to apply these strategies, and the reasons for using or choosing these strategies. This awareness is related to how students can realize that the strategy used is appropriate.

In addition, it is possible that this occurs because students feel more confident about their planning abilities than what they actually do. Increased student self-confidence because students understand more about what must be done in learning and this is supported by teachers who explain more clearly the stages and learning processes. Before implementing the integration of the STS and TPACK approaches, students had low information management strategies and lacked strategies to process information more efficiently. After implementing the integration of the STS and TPACK approaches, students become better at seeing the important parts of the problem so they are more timely, as well as making notes and schemes in their own language so they understand better, are able to make their own examples even though they are not yet relevant, and show how previous knowledge plays a role in solving the problem. , and make clear work steps. This increase can occur because the instructions given on student worksheets are clearer. Apart from that, teachers encourage students to see real experiences in the field and the knowledge they gain. Therefore, the integration of STS and TPACK is able to support students in planning their learning and can improve students' metacognitive abilities.

Based on this explanation, it can be proven by hypothesis testing showing that the second hypothesis is accepted which is meaningful there is an influence of the STS learning approach integrated with TPACK on the metacognitive abilities of ecosystem material in Class sig 0.002 < 0.05.

In line with research Sufiantini et al. (2017), who stated that the STS approach can develop students' metacognitive abilities which are fully formed in individuals as students with the hope that they can be applied in everyday life. The material that will be given to students is designed in such a way that it combines explanations in the form of writing, images and videos and is made in Power Point form so that it can be understood by students. Nofrion et al. (2021) stated that TPACK is based on effective learning using technology, which can improve student problems regarding the concept of learning material and can improve students' metacognitive abilities.

So it is concluded that there are differences in the metacognitive abilities of students who are taught using STS learning approach integrated with TPACK ecosystem material. Developing students' metacognitive abilities regarding learning is basically helping students see the relationship between the material being studied and themselves and if students see that the results of their learning experiences will bring progress to them, they will most likely be motivated in learning so that the results of their learning efforts can be achieved.

Based on the results of hypothesis testing, it shows that hypothesis 3 is accepted which is significant There is an influence of the STS learning approach integrated with TPACK on cognitive learning outcomes and metacognitive abilities in ecosystem material in Class sig 0.000 < 0.05.The results of the LSD further test show that the cognitive learning outcome variable at State Vocational School 2 West Seram is significantly different from the cognitive learning outcome at State Vocational School 9 West Seram and is significantly different from the cognitive learning outcome variable at State Vocational School 12 West Seram. And the metacognitive ability variable at State Vocational School 2 West Seram is significantly different from the metacognitive ability variable at State Vocational School 9 West Seram and significantly different from the metacognitive ability variable at State Vocational School 12 West Seram.

Based on the analysis that has been carried out on research datathat has been obtained, it can be concluded that by implementinglearning approaches STS with TPACK can help students improve their learning outcomes and metacognitive abilities as indicated by an increase in scores from pre-test results to post-test results. Application learning approaches STS with TPACK able to encourage students to be more active in learning, so that the problem solving process can proceed well. Saridevi et al. (2017) shows that student learning outcomes increase with the use of discovery learning models and experiential learning. Student learning outcomes begin with understanding a concept. Through this understanding, students train basic thinking skills. Students who have a good basic way of thinking can empower higher level thinking, one of which is creative thinking and critical thinking.

An effective learning approach will be easy for students to understand and master in the learning process. Effective learning here occurs when students are actively involved in the learning process. Not only that, students can also solve problems that exist during the learning process. At the end of the learning process, the researcher

asked students to work on post-test questions. Using the right learning model can have a good impact on students and help students to develop students' metacognitive abilities (Kusnandar, 2019). With the explanation above, it can be concluded that even though the material to be taught is complicated, it can still be conveyed welllearning approaches STS with TPACK. Learning approaches STS with TPACK can be used as a solution in using learning models.

In line with research Ferdiansyah (2015) explained that student learning outcomes on viral material apply learning approaches STS is higher than the learning outcomes of students who do not apply learning approaches STS. Apart from that, Badriyah (2014) research results explain that the STS learning approach can improve students' metacognitive abilities. Meanwhile, the research results of Elya et al. (2022) explain that improving student learning outcomes through the TPACK approach has a positive influence. Imam (2019) concluded that the TPACK-based learning model has a significant influence on students' metacognitive abilities in high school science material. Based on several studies on the combination of learning models, one way teachers use this is to combine learning approaches STS with TPACK, which when combined then able to improve students' learning outcomes and metacognitive abilities

CONCLUSION

There is an influence of the STS learning approach integrated with TPACK on the cognitive learning outcomes, metacognitive abilities and cognitive learning outcomes of ecosystem material in Class X students of State Vocational School West Seram.

REFERENCES

Badriyah. 2024. Penerapan model pembelajaran Science Technology Society untuk meningkatkan kemampuan pemecahan masalah siswa pada muatan pelajaran Ilmu Pengetahuan Alam di kelas V SDN 4 Bathin Solapan Kabupaten Bengkalis. *Skripsi.* Universitas Islam Negeri Sultan Syarif Kasim Riau Pekanbaru.

Damayanti, P., Aini, A.N., Wulandari, N.K.F., & Primandiri, P.R. 2021. Pentingnya pengembangan kemampuan metakognitif siswa kelas XI MIPA pada pembelajaran biologi di SMAN 7 Kediri. *Esjar,* 156-168.

Elya, U. H., Dwiyanti, P., Emilia S., Hema, R.F., Maurin, P., & Reza, N. I. 2022. Integrasi pendekatan TPACK (Technological, Pedagogical, Content Knowledge) guru Sekolah Dasar SIKL dalam melaksanakan pembelajaran era digital. *Journal of Education Integration and Development*, 2(2), 15-27.

Ferdiansyah, I. 2015. Perbedaan hasil belajar peserta didik menggunakan pendekatan STS, SETS dan STEM pada pembelajaran konsep virus. *Skripsi*. Universitas Islam Negeri Syarif Hidayatullah Jakarta.

Imam, F. R. 2019. Technological Pedagogical Content Knowledge (TPACK): Kerangka pengetahuan guru abad 21. *Jurnal Pendidikan Kewarganegaraan*, 6(1), 1-10.

Muhiddin, P. 2012. Pengaruh integrasi PBL dengan pembelajaran kooperatif jigsaw dan kemampuan akademik terhadap metakognisi, berpikir kritis, pemahaman konsep, dan retensi mahasiswa pada perkuliahan Biologi Dasar di FMIPA Universitas Negeri Makassar. Disertasi Tidak Diterbitkan. Malang: Program Pascasarjana Universitas Negeri Malang.

Nofrion, Wijiyanto, B., Wilis, R., & Novio, R. (2021). Analisis Technological Pedagogical and Content Knowledge (TPACK) guru geografi di Kabupaten Solok, Sumatera Barat. *Geografi*, 10(2), 105–116.

Simamora, M.C., Siburian, J., & Gardjita. 2021. Analisis kemampuan metakognisi siswa dalam pembelajaran Biologi melalui assesmen pemecahan masalah di SMA Negeri 5 Kota Jambi. *FKIP Universitas Jambi*, 1-19.

Sufiantini, D., Rahayu, D., & Sri, R. 2017. Pengembangan perangkat pembelajaran fisika berbasis model pembelajaran Science Technology Society (STS) dalam peningkatan penguasaan materi dan pencapaian berpikir kritis pada peserta didik SMA. *Jurnal Pendidikan Fisika*, 6(1), 1-9.

Triwibowo, S., Abdurrahman., Nyeneng, I. D. P. 2021. Perbandingan hasil belajar kognitif siswa menggunakan media simulasi komputer dan media realia. *FKIP UNILA, 77-88.*

Utari, L. 2024. Identifikasi karakteristik metakognitif siswa dalam pemecahan masalah pada materi hidrokarbon Di MAN 4 Kampar. *Skripsi*. UIN Suska Riau.