



Effect of Structured and Think-Aloud Pair Problem-Solving Strategies on Students' Achievement and Retention in Machine Shop Practice in North-Central, Nigeria

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ABSTRACT

The study determined the Effect of Structured and Think-Aloud-Pair Problem-Solving instructional strategies on students' achievement and retention in Machine Shop Practice in North central Nigeria. Two research questions were raised and answered, while two null hypotheses were formulated and tested at a .05 level of significance. The study employed a quasi-experimental design of pre-test, post-test, and non-equivalent control groups. The study was carried out in North-Central Nigeria. This study's population comprised all 80 Nigerian Certificate in Education (N.C.E.) III metalwork technology education students. The study utilised the entire population as it is insignificant. The data collection instrument was Machine Shop Practice Cognitive Achievement and Retention Test (MSPCART). The MSPCART was subjected to content and face validation by three experts. The reliability index of MSPCART was determined using Kuder-Richardson 20 (K.R. 21) statistical technique and was found to be 0.77. The study employed descriptive statistics using mean and standard deviation to answer all the research questions and inferential statistics using Analysis of Covariance (ANCOVA) to test all the hypotheses at a significant level of 0.05 using Statistical Package for Social Science (SPSS) version 25. The study revealed that the students taught Machine Shop Practice using Structured Problem-Solving instructional strategy had higher mean cognitive achievement and retention scores than those taught using Think-Aloud Pair Problem-Solving instructional strategy. The study recommended that Machine Shop Practice lecturers adopt the Structured Problem-Solving instructional strategy to enhance students' cognitive achievement and retention.

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INTRODUCTION

Machine Shop Practice is a two-credit unit compulsory course of study with code TEM 321 offered by final year education students of metalwork technology in Colleges of Education, leading to the award of Nigeria Certificate in Education (N.C.E.) Technical certificate. The course deals with several machine operations in the fabrication of metallic components. According to the Federal Republic of Nigeria (F.R.N., 2020), Machine Shop Practice aims to equip metalwork technology education students with technical knowledge and skills in (i) Advanced machine shop process, (ii) Precision measurement and inspection, (iii) Advanced lathe work, (iv) Types of lathes and their applications, (v) Shaping machine and shaping

operations, (vi) Grinding machine and grinding operations, (vii) Computer-Assisted Machining (C.A.M.) and (viii) Computer Numerical Control (C.N.C.). However, dos-Santos (2019) noted that the aim of Machine Shop Practice is far from being achieved due to the persistently manifested low students' performance. The low performance of students in the course could be due to the non-utilisation of students-centred instructional strategies such as Structured and Think-Aloud-Pair problem-solving instructional strategies.

The Structured Problem-Solving instructional strategy helps students to evaluate big or small problems in a clearer and more structured way. According to Loes *et al.* (2018), the Structured Problem-Solving instructional



strategy ensures a problem is solved correctly with the right solution by dividing such problems into manageable steps for students to learn how to identify, analyse, and solve a problem in an organised manner.

Loes *et al.* further stated that when using the Structured Problem-Solving instructional strategy, all students must agree to a solution and be able to explain the answer and strategy used to solve the problem. In addition, the Structured Problem-Solving has characteristics such as fostering teamwork; (2) encouraging critical thinking; (3) enhancing new knowledge creation/construction. These characteristics help students such as Machine Shop Practice to work as a team and think critically about academic achievements, satisfaction, and interest (Madhu & Reddy, 2018). It also helps students construct new knowledge to achieve learning goals. Coskun and Eker (2018) stated that students performed and retained knowledge better when taught using a Structured Problem-Solving instructional strategy and other active techniques such as Think-Aloud-Pair Problem-Solving instructional strategy.

The Think-Aloud-Pair Problem-Solving instructional strategy emphasises how problem-solving can help students identify process errors. According to Tambunan (2018), Think-Aloud-Pair Problem-Solving instructional strategy has student pairs receive a series of problems and are assigned specific roles. The Think-Aloud-Pair Problem-Solving instructional strategy entails the problem-solver among the students to think aloud about their problem-solving process. Other students listen, try to understand the reasoning behind the steps, and offer suggestions if there are missteps. It improves students' analytical skills by helping them formulate ideas, understand the sequence of steps underlying their thinking, and identify errors in another's reasoning (Widuri *et al.*, 2018). It indicated that the Think-Aloud-Pair Problem-Solving instructional strategy might help address the poor performance of college of education students in Machine Shop Practice (Chang *et al.*, 2017). As ways to improve classroom activities, Machine Shop Practice lecturers may need to keep exploring more instructional strategies such as Structured and Think-Aloud Pair Problem-Solving to enhance students' cognitive achievement.

Cognitive achievement refers to students' ability to perform various mental activities most closely associated with learning and problem-solving. Eilks (2019) stated that cognitive achievement is a general mental capability involving reasoning, problem-solving, abstract thinking, complex idea comprehension and learning from experience. The mental ability of metalwork technology education students to display high-level knowledge after learning digital electronics as a course over the years is generally low. Oyetunde (2010) disclosed that the cognitive achievement of technical students, including Machine Shop Practice students, is declined due to the non-utilisation of effective teaching strategies among lecturers, such as Structured and Think-Aloud Pair Problem-Solving. Afolabi and Akinbobola (2019) confirmed that low cognitive achievement among students hinders the positive development of the overall learning outcomes. Thus, it implies that the low cognitive achievement of students in Machine Shop Practice largely affects students' knowledge retention.

Retention of knowledge is an individual's ability to reproduce valuable knowledge after some time. According to Adams (2017), retention of knowledge is the repeat performance by a learner of the behaviour earlier acquired, elicited after a while. Therefore, retention in this study refers to the extent to which Machine Shop Practice students repeat performance earlier acquired after some time. Green (2017) noted that knowledge retention is affected by the learner's memory capacity and the instructional strategies utilised by lecturers. Andriotis (2017) further stated that students' low retention of knowledge is due to the non-utilisation of active teaching strategies such as Structured and Think-Aloud Pair Problem-Solving. Hence, it implies that these active instructional strategies may enhance students' knowledge retention and possibly close the gap between students' ability levels. Hence, this study sought to investigate the Effect of Structured and Think-Aloud Pair Problem-Solving instructional strategies on students' achievement and retention in Machine Shop Practice in colleges of education in North-Central, Nigeria.



STATEMENT OF THE RESEARCH PROBLEM

Colleges of Education in Nigeria may have been experiencing multi-faceted challenges in the classroom instructional strategies, which are now affecting students' learning outcomes in Machine Shop Practice due to the experienced failure rate in the last five years. The rate of low academic learning outcomes among students in the Metalwork Technology Education programme at the N.C.E III level has been worrisome for the past five years. Furthermore, the poor learning outcome of students who graduated from the N.C.E. programmes at college, as revealed by the results obtained, was a reason for their teachers' uninteresting and non-stimulating instructional strategies.

It is part of the reason why research scholars are engaged in a series of studies looking for more instructional strategies that may improve classroom instruction, academic achievement, interest, and active learning in the classroom (Akiba & Liang, 2016; Coskun & Eker, 2018). The poor learning outcome could probably be due to the conventional instructional strategy employed, which has led to poor academic achievement of students in the Machine Shop Practice course during an examination. This failure rate could be avoided and improved by choosing and applying a more suitable instructional strategy in teaching colleges of education (Winarti *et al.*, 2019; Malik & Aswandi, 2019). Against this backdrop, there is a need to discover an appropriate instructional strategy that will improve learners' academic knowledge and skills, arouse learners' interest, and upsurge learners' academic achievement and retention for a better learning outcome are expected. To achieve this, the study investigated the Effect of Structured and Think-Aloud-Pair Problem-Solving instructional strategies on students' achievement and retention in Machine Shop Practice in North central Nigeria.

Aim and Objectives of the Study

The study aimed to determine the effects of Structured and Think-Aloud Pair Problem-solving instructional strategies on students' achievement and retention in Machine Shop Practice in North-Central, Nigeria. The specific objectives of the study are to determine the effects of:

1. Structured and Think-Aloud Pair problem-solving instructional strategies on students' cognitive achievement in Machine Shop Practice
2. Structured and Think-Aloud Pair problem-solving instructional strategies on students' retention in Machine Shop Practice

Research Questions

The study provided answers to the following research questions:

1. What is the Effect of Structured and Think-Aloud Pair Problem-Solving instructional strategies on students' cognitive achievement in Machine Shop Practice?
2. What is the Effect of Structured and Think-Aloud Pair Problem-Solving instructional strategies on students' retention in Machine Shop Practice?

Hypotheses

The following null hypotheses were postulated to guide the study and tested at a 0.05 level of significance:

HO₁: There is no significant difference between the mean cognitive achievement scores of students taught Machine Shop Practice using Structured and Think-Aloud Pair Problem-Solving instructional strategies

HO₂: There is no significant difference between the mean retention scores of students taught Machine Shop Practice using Structured and Think-Aloud Pair Problem-Solving instructional strategies

METHODOLOGY

The study employed a quasi-experimental design of pre-test, post-test, and non-equivalent control groups. The design was considered suitable for the study because cause-and-effect were easily established between Structured and Think-Aloud Pair Problem-Solving (independent variables) on students' cognitive achievements and retention (dependent variables) in Machine Shop Practice. The study was carried out in Nigeria's North-Central geo-political zone. This study's population comprised all the 80 Nigerian Certificate in Education (N.C.E.) III metalwork technology education students in all the Colleges of Education offering technical



education in the study area during the 2020/2021 academic session. The study utilised the entire population as it is insignificant. A Purposive Sampling Technique was used to choose the Colleges of Education offering Machine Shop Practice. They included the Federal College of Education, Pankshin, Nassarawa State College of Education, Akwanga, Kwara State College of Education, Lafiagi and Niger State College of Education, Minna and the Simple Random Sampling Technique was used to assign two Colleges of Education each to control and experimental groups.

The instrument for data collection was the Machine Shop Practice Cognitive Achievement and Retention Test (MSPCART), which consisted of 60 objective questions with four response options developed by the researcher using a table of specifications. The draft copies of the MSPCART were subjected to content and face validation by three experts from the Industrial and Technology Department, Federal University of Technology, Minna, Examination Development Department, National Examination Council, Minna, and Metalwork Technology Department, Niger State College of Education, Minna. The reliability index of MSPCART was determined using Kuder-Richardson 20 (K.R. 21) statistical technique and was found to be .77, which shows that the instrument's consistency is highly reliable. The researchers also developed two sets of lesson plans. Each of the seven lessons plans on the contents of the N.C.E curriculum of Machine Shop Practice to guide the lecturers in the class during the treatment procedure. The two lesson sets were based on Structured and Think-Aloud Pair Problem-Solving instructional strategies.

The study was conducted in 10 weeks, during which 7 topics in Machine Shop Practice were covered. The study involved four

stages: administration of pre-test, treatment, post-test and retention test. The pre-test was administered to all the students involved in the study. It was in the first week of the research exercise before both groups were subjected to treatment. After the administration of the pre-test, the students in the control group were taught using the Structured Problem-Solving instructional strategy, and the students in the experimental group were taught using Think-Aloud Pair Problem-Solving instructional strategy. All the groups were taught by their regular Machine Shop Practice lecturers. The treatment process lasted 8 weeks, after which the post-test was administered to the students on the 8th week. Finally, after the post-test administration, a retention test was administered to all the students on the 10th week to determine their mean retention scores in Machine Shop Practice.

The study used descriptive and inferential statistics to analyse the data. Descriptive statistics using mean and standard deviation were used to answer all the research questions, and inferential statistics using Analysis of Covariance (ANCOVA) to test all the hypotheses at a significant level of 0.05. The ANCOVA was considered suitable for this study because the effects of the second variable or covariate (pre-test) are removed or drastically reduced. A group with a higher mean value indicates to have performed better in cognitive performances or retention tests. All statistical calculations were conducted using Statistical Package for Social Science (SPSS) version 25.

RESULTS

RQ1: What is the Effect of Structured and Think-Aloud Pair Problem-Solving instructional strategies on students' cognitive achievement in Machine Shop Practice? The data for answering research question one is contained in Table 1.

Table 1: Pre-test and Post-test Mean Cognitive Achievement Scores of Students taught Machine Shop Practice using Structured and Think-Aloud Pair Problem-Solving Instructional Strategies

Groups		N	Pre-test		Post-test		Mean Gain
			Mean	SD	Mean	SD	
Structured Strategy	Problem-Solving	49	24.18	2.15	71.06	2.83	46.88
Think-Aloud Pair Problem-Solving Strategy		31	25.06	2.48	69.25	3.01	44.19



Table 1 shows that students taught Machine Shop Practice using Structured Problem-Solving instructional strategy had a pre-test mean cognitive achievement score of 24.18 with a standard deviation of 2.15 and a post-test score of 71.06 with a standard deviation of 2.83 and a mean gain of 46.88. On the other hand, the students taught Machine Shop Practice using Think-Aloud Pair Problem-Solving instructional strategy had a pre-test mean cognitive achievement score of 25.06 with a standard deviation of 2.48. In addition, a post-test score of 69.25 with a standard deviation of

3.01 and a mean of 44.19. thus, it indicated that students taught Machine Shop Practice using Structured Problem-Solving instructional strategy had higher mean cognitive achievement scores than students taught using Think-Aloud Pair Problem-Solving instructional strategy.

RQ2: What is the Effect of Structured and Think-Aloud Pair Problem-Solving instructional strategies on students' retention in Machine Shop Practice? The data for answering research question two is contained in Table 2.

Table 2: Pre-test and Retention Mean Scores of Students taught Machine Shop Practice using Structured and Think-Aloud Pair Problem-Solving Instructional Strategies

Groups		N	Pre-test		Retention test		Mean Gain
			Mean	SD	Mean	SD	
Structured Problem-Solving Strategy		49	24.18	2.15	65.55	1.17	41.37
Think-Aloud Pair Problem-Solving Strategy		31	25.06	2.48	64.58	.76	39.50

Table 2 shows that students taught Machine Shop Practice using Structured Problem-Solving instructional strategy had a pre-test mean cognitive achievement score of 24.18 with a standard deviation of 2.15 and retention score of 65.55 with a standard deviation of 1.17, and a mean gain of 41.37. On the other hand, the students taught Machine Shop Practice using Think-Aloud Pair Problem-Solving instructional strategy had a pre-test mean cognitive achievement score of 25.06 with a standard deviation of 2.48 and retention score of 64.58 with a standard deviation of .78 and the

mean gain of 39.50. hence, this indicated that students who taught Machine Shop Practice using Structured Problem-Solving instructional strategy had higher mean retention scores than students taught using Think-Aloud Pair Problem-Solving instructional strategy.

HO₁: There is no significant difference between the mean cognitive achievement scores of students taught Machine Shop Practice using Structured and Think-Aloud Pair Problem-Solving instructional strategies. The data for testing hypothesis one is contained in Table 3.

Table 3: Analysis of Covariance for the test of Significance Difference Between the Mean Cognitive Achievement Scores of Students Taught Machine Shop Practice Using Structured and Think-Aloud Pair Problem-Solving Instructional Strategies

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Corrected Model	470.384 ^a	2	235.192	72.409	.000
Intercept	1388.098	1	1388.098	427.357	.000
Pre-test	408.648	1	408.648	125.811	.000
Group	131.970	1	131.970	40.630	.000*
Error	250.104	77	3.248		
Total	396791.000	80			
Corrected Total	720.487	79			

a. R Squared = .653 (Adjusted R Squared = .644)

Table 3 shows the F-calculated value for testing the significant difference between the cognitive achievement scores of students taught Machine Shop Practice using Structured

and Think-Aloud Pair Problem-Solving instructional strategies. The F-calculated value of 40.630 was obtained with the associated exact Sig. 2 tailed value of 0.00. Since the



associated Sig. 2 tailed value of 0.00 is less than 0.05, the null hypothesis is rejected. Finally, it implied a significant difference between the mean cognitive achievement scores of students taught Machine Shop Practice using Structured and Think-Aloud Pair Problem-Solving instructional strategies.

HO₂: There is no significant difference between the mean retention scores of students taught Machine Shop Practice using Structured and Think-Aloud Pair Problem-Solving instructional strategies. The data for testing hypothesis one is contained in Table 4.

Table 4: Analysis of Covariance for the test of Significance Difference Between the Mean Retention Scores of Students Taught Machine Shop Practice Using Structured and Think-Aloud Pair Problem-Solving Instructional Strategies

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Corrected Model	49.711 ^a	2	24.855	35.990	.000
Intercept	2274.742	1	2274.742	3293.820	.000
Pre-test	30.623	1	30.623	44.342	.000
Group	28.344	1	28.344	41.042	.000*
Error	53.177	77	.691		
Total	339795.000	80			
Corrected Total	102.887	79			

a. R Squared = .483 (Adjusted R Squared = .470)

Table 4 shows the F-calculated value for testing the significant difference between the mean retention scores of students taught Machine Shop Practice using Structured and Think-Aloud Pair Problem-Solving instructional strategies. The F-calculated value of 41.042 was obtained with the associated Sig. 2 tailed value of 0.00. Since the associated Sig. 2 tailed value of 0.00 is less than 0.05, the null hypothesis is rejected. So, this implied that there is a significant difference between the mean retention scores of students taught Machine Shop Practice using Structured and Think-Aloud Pair Problem-Solving instructional strategies.

FINDINGS AND DISCUSSION

The findings on the effects of Structured and Think-Aloud Pair Problem-Solving instructional strategies on students' cognitive achievement in Machine Shop Practice revealed that the students taught Machine Shop Practice using Structured Problem-Solving instructional strategy had higher mean cognitive achievement scores than students taught using Think-Aloud Pair Problem-Solving instructional strategy. In addition, the finding showed that students' cognitive achievement in Machine Shop Practice is more enhanced using the Structured Problem-Solving instructional strategy than Think-Aloud Pair Problem-Solving instructional strategy.

The finding is similar to Tambunan's (2019) findings on the effectiveness of the problem-solving strategy and the scientific approach to students' Mathematical capabilities in High order thinking skills. His findings revealed that problem-solving strategies were more effective than scientific approaches to students' communication, creativity, problem-solving, and mathematical reasoning abilities. The effectiveness of the Structured Problem-Solving instructional strategy in improving students' cognitive achievement in Machine Shop Practice could be attributed to the unique phases of problem-solving that demand students to identify.

It also defines the problem to utilise the available resources needed for solving the problem. These two phases of Structured Problem-Solving instructional strategy are responsible for triggering the cognitive functions capable of enhancing students' cognitive achievement (Cherry, 2019). So, this implied that the problem identification and definition phases could be responsible for the effectiveness of the Structured Problem-Solving instructional strategy over the Think-Aloud Pair Problem-Solving instructional strategy in enhancing students' cognitive achievement in Machine Shop Practice.

Contrary to the stated null hypothesis on the significant difference between the mean cognitive achievement scores of students taught Machine Shop Practice using Structured

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and Think-Aloud Pair Problem-Solving instructional strategies, the test result revealed statistical significance. The statistical significance recorded indicates that there is a substantial difference between the mean cognitive achievement scores of students taught Machine Shop Practice using Structured Problem-Solving instructional strategy is much higher than that of students taught using Think-Aloud Pair Problem-Solving instructional strategy.

However, based on a related study by Siti et al. (2020), a similar finding revealed a statistically significant difference between the academic achievement scores of students taught Physics Concepts and Communication using Structured Problem-Solving instructional strategy in high schools in Indonesia. The finding implied that the Structured Problem-Solving instructional strategy clearly illustrated the capability of causing a major difference in the cognitive achievement scores of students in Machine Shop Practice.

Findings on the effects of Structured and Think-Aloud Pair Problem-Solving instructional strategies on the retention of students in Machine Shop Practice revealed that the students taught Machine Shop Practice using Structured Problem-Solving instructional strategy had higher mean retention scores than students taught using Think-Aloud Pair Problem-Solving instructional strategy. In addition, the finding showed that students' retention in Machine Shop Practice is more enhanced using the Structured Problem-Solving instructional strategy than Think-Aloud Pair Problem-Solving instructional strategy. The finding is similar to the findings of Treffers (2019) on the comparative Effect of two problem-solving instructional strategies on students' retention, which revealed that the Structured Problem-Solving instructional strategy is more effective in improving the retention of students.

The Structured Problem-Solving instructional strategy's effectiveness in improving students' retention in Machine Shop Practice could be attributed to the features of the Structured Problem-Solving instructional strategy that demand students to identify and define the problem and formulate a strategy for solving the problem. These activities could be responsible for triggering the cognitive and retentive functions capable of enhancing the

retention of students (Cherry, 2019). Thus, this implied that these features could be responsible for the effectiveness of the Structured Problem-Solving instructional strategy over the Think-Aloud Pair Problem-Solving instructional strategy in enhancing students' retention in Machine Shop Practice.

Contrary to the stated null hypothesis on the significant difference between the mean retention scores of students taught Machine Shop Practice using Structured and Think-Aloud Pair Problem-Solving instructional strategies, the test result revealed statistical significance. The statistical significance recorded indicates that there is a substantial difference between the mean retention scores of students taught Machine Shop Practice using Structured Problem-Solving instructional strategy is much higher than that of students taught using Think-Aloud Pair Problem-Solving instructional strategy. However, based on the findings of a related study by Mashuri *et al.* (2018), a similar finding revealed a statistically significant difference between the mean retention scores of students taught metal work using Reda and Rubult problem-solving models. The finding implied that the Structured Problem-Solving instructional strategy clearly illustrated the capability of causing a major difference in the retention scores of students in Machine Shop Practice.

CONCLUSION

Based on the study's findings, insights on the effects of Structured and Think-Aloud Pair Problem-Solving instructional strategies on students' cognitive achievement and retention in Machine Shop Practice in colleges of education are provided. The study found that students taught Machine Shop Practice using Structured Problem-Solving instructional strategy had higher mean cognitive achievement and retention scores. The educational implication of the findings is that adopting a Structured Problem-Solving instructional strategy can enhance students' cognitive achievement and retention in Machine Shop Practice. Nevertheless, the findings are limited to the contents of Machine Shop Practice at the college of education level in North-Central, Nigeria. Therefore, it is concluded that the Structured Problem-Solving instructional strategy positively affected students' cognition and retention in Machine Shop Practice.



RECOMMENDATIONS

Based on the findings from the study, the following recommendations were made:

1. Machine Shop Practice lecturers should adopt the Structured Problem-Solving instructional strategy to enhance students' cognitive achievement and retention.

REFERENCES

- Adams, N. E. (2017). Bloom's taxonomy of cognitive learning objectives. *Journal of the Med. Library Association*, 103, 152-153.
- Afolabi, F. & Akinbobola, O. A. (2019). Constructivist problem-based learning technique and the academic achievement of physics students with low ability level in Nigeria secondary school. *Eurasian Journal of Physics and Chemistry Education* 1(1). 45-51.
- Akiba, M. & Liang, G. (2016). Effect of teacher professional learning activities on students' Achievement growth. *Journal of Educational Research*, 21(1), 1-12.
- Andriotis, N. (2017). Make your eLearning stick: 8 tips and Techniques for learning retention. Retrieved from <https://www.talentlms.com/blog/8-tips-techniques-learning-retention/> date
- Chang, H., Wang, N., Ko, W., Yu, Y., Lin, L., & Tsai, H. (2017). The effectiveness of clinical problem-based learning model of medico-jurisprudence education on general law knowledge for Obstetrics/Gynaecological interns. *Taiwanese Journal of Obstetrics & Gynaecology*, 56(3), 325-330.
- Cherry, K. (2019). *Overview of the Problem-Solving Mental Process*. Retrieved from: <https://www.verywellmind.com/keandra-cherry-2794702>Verywell, Inc. (Dotdash) is part of the Dotdash publishing Family 2019.06.13
- Coskun, I. & Eker, C. (2018). The Effect of teaching activities done by activity-based posters on students' academic achievement and retention levels in their learning. *Universal Journal of Educational Research*, 6(4), 585-597.
- Dos-Santos, L.M. (2019). Pre-service teachers' professional development through four-step problem-solving model: A seminar method. *International Journal of Education and Practice*. 7(3), 146-157.
- Eilks, I. (2019). Learning at stations' in secondary level chemistry lessons. *Science Education International*, 12(1), 11-18
- Federal Republic of Nigeria (2020). *National Commission for College of Education Nigeria certificate in education minimum standards for vocational and technical education. (2020 Edition)*. Abuja: Government Publication.
- Green, M. (2017). Better, smarter, faster: Web 3.0 and the future of learning. *Development and Learning in Organisations*, 25(6), 70-72.
- Loes, C. N., Culver, K. C., & Trolan, T. L. (2018). How collaborative learning enhances students' openness to diversity. *Journal of Higher Education*, 5(2), 11-13.
- Madhu, S. & Reddy, G. P. (2018). Innovations in teaching methodologies to improve the results of core subjects at the first-year level: A study under the autonomous scheme. *Journal of Engineering Education Transformation*, 1(1), 2-7.
- Malik, A. & Aswandi, A. (2019). The application of reciprocal teaching to improve business text reading comprehension of business administration students of Bengkalis State Polytechnic. *INOVISH Journal*, 4(1) 2621-7295
- Mashuri, H. N. D. & Hendikawati, P. (2018). The mathematical problem-solving on learning with Thinking Aloud Pair Problem-solving (TAPPS) model in terms of



- student learning style. *Unnes Journal of Mathematics Education*, 7(1), 1-7. DOI: 10.15294/ujme.v7i1.18870
- Oyetunde, O. A. (2010). Effect of models on interest and academic achievement of auto mechanics students in technical colleges in Lagos-state. *Unpublished PhD thesis*, University of Nigeria, Nsukka.
- Siti, R., Widayanti., & Ahmad, R. (2020). Thinking Aloud Pair Problem-solving (TAPPS) Method: The Effect of understanding physics concepts and communication in high schools in Indonesia. *Journal of Physics: Conference Series*.
- Tambunan, H. (2018). The Dominant Factor of Teacher's Role as A Motivator of Students' Interest and Motivation in Mathematics Achievement. *International Education Studies*, 11(4), 114-151.
- Tambunan, H. (2019). The effectiveness of the problem-solving strategy and the scientific approach to students' mathematical capabilities in high-order thinking skills. *International electronic journal of mathematics education*, 14 (2) 293-302
- Treffers, A. (2019). *Direct instruction and problem-solving: Critical examination of cognitive load theory from the perspective of mathematics education*. Retrieved on 22nd January 2022 from: <https://scholarworks.umt.edu/tme/vol16/iss1/30>
- Widuri, S. Y. S., Almash, L., & Zuzano, F (2018) Application of Learning Engineering Techniques Thinking Aloud Pair Problem-solving in Learning Mathematics Students Class VII SMPN 15 Padang. *I.O.P. Conf. Ser.: Mater. Sci. Eng.* 335
- Winarti, E. R., Haryanti, M. D., & Asih, T. S. N. (2019). Students' problem-solving ability in thinking aloud pair problem-solving learning assisted by Schoology viewed from mathematical disposition. *Unnes Journal of Mathematics Education*, 8(1), 14-18.