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Experimental Discovery Learning Model and TPACK-based Problem-Based Learning Supported Media Moodle Reviewed from Student Process Science Skills

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Abstract: The research aims to find out whether or not there are: differences in the impact of the use of learning models discovery learning and problem-based learning supported by media Moodle on cognitive abilities; differences in the influence of students with high and low science process skills on cognitional capabilities; and interactions between learning models discovery learning and problem-based learning with the level of skills of science processes against cognitives on sound wave materials with the research subject being students of class XI SMAN 1 Surakarta teaching 2022–2023. The method used is the experimental method with a 2x2 factorial design. The data collection techniques used are the science process skills lift and the cognitive ability test of the learners. The data obtained was then analyzed using a two-way ANAVA test with cell frequencies not equal to the conclusion. It can be concluded that: there are differences in the impact of the use of discovery learning and problem-based learning supported by Moodle on cognitive abilities (F_{obs} = 18.606 > $F_{0.05;1;67}$ = 3.98); there is a difference in the influence of learners who have high science process skills and low science process abilities on cognition abilities (F_{obs} = 15.65 > $F_{0.05;1;67}$ = 3.98); and there is no interaction between the influences of learning models using discovery learning and problem-based learning in cognition (F_{obs} = 3.514 < $F_{0.05;1;67}$ = 3.98).

Keywords: Cognitive ability; Discovery learning; Moodle; Problem-based learning; Science process skills

Introduction

Education is defined as intentional activity and is planned to create a learning process that allows students to actively develop their own potential that will be useful later (Mutmainnah, 2019). In order to achieve this goal, a set of educational curricula should be prepared. Curriculum 2013 currently used is designed with the aim of improving the quality of learning and creating learners with good abilities through the learning process (Rochman & Hartoyo, 2018). Through the implementation of the Curriculum 2013, students are expected not only to obtain information or knowledge from teachers, but also to be able to structure what has been learned into a meaningful unity.

The results of the study at the event "Trends in Mathematics and Science Study" in 2015 on the trend or direction of development of science and mathematics, Indonesia ranks 44th out of 49 countries in the field of science with an average score of 397 out of an international average of 500 (Hadi & Novaliyosi, 2019). The fact shows that the cognitive abilities of Indonesian students are still low for science. One of the branches of this science is physics.

Physics learning should encourage students to actively engage in finding out and interacting with concrete objects. However, during the process of learning physics, not all teachers managed to include students to actively promote their cognitive abilities (Subekti & Ariswan, 2016). Suryawan et al. (2019) revealed that the learning center that is at a teacher

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causes low physics learning achievements. Continuing learning activities place the student as the recipient and educator as the source of information, so that the cognitive abilities of the student cannot be explored to the maximum.

External and internal factors are involved in creating learning outcomes of maximum cognitive abilities. One of the external factors that influence the cognitive abilities of the student is the learning model. There are various types of learning that can be practiced, including discovery learning and problem-based learning. Discovery learning is a learning model that invites students to actively engage in finding knowledge and constructing that knowledge by understanding its meaning (Fajri, 2019). Discovery learning focuses on the formation of knowledge of the student through experience during the learning process. Problem-based learning is a model in which teachers provide real and relevant problems to learners to be solved. Students conduct group discussions so that there is an exchange of information to be able to solve the problem with the teacher as a facilitator (Wulandari & Surjono, 2013).

Several studies have been conducted to find out the variation of cognitive learning outcomes of students with the discovery learning model and problem-based learning. Previous research by Satriani (2020) showed that the average grade in the class learned using the discovery learning model was superior to the class studied using the problem-based learning model. Other research by Siahaan (2020) showed different results, where the learning outcomes of students taught through a problem-based learning model are better than those taught via a discovery learning model.

Reviewed from internal factors, skills become factors that influence learners in building knowledge. One of the skills meant is the skills of science processes. On the one hand, teachers pay less attention to the fact that internal factors such as cognitive abilities can be enhanced through science process skills. Astari (2017) stated that in learning, the skills of the scientific process are important. If this skill is not developed, then the student can be prevented from interpreting his knowledge.

The learning process is also not independent of technological developments such as the use of interactive learning media (Lestari, 2015). One of the learning media that can be used in learning physics is the Moodle. E-learning Moodle helps teachers to observe the progress of students against a material because it gives access to interaction between teachers and students through assignments, quizzes, or exams (Effendi & Zhuang, 2005). Through this e-learning, the feedback provided can not only be done by the media alone, but also can be made by the teacher directly through features such as video conferences, discussions, and chats.

The use of technology such as e-learning Moodle as a medium in helping to convey information can improve the effectiveness of learning (Lestari, 2015). A teacher is expected to be able to combine technology with its teaching methods and teaching materials, so it is necessary to master three important aspects of effective teaching, namely knowledge of the teaching or pedagogical methods, mastery of the materials to be taught, and the use of technology (Durdu & Dag, 2017; Ammade et al., 2020; Esposito & Moroney, 2020; Armiyati & Habib, 2022). This concept is then known as Technological Pedagogical Content Knowlage (TPACK). Understanding of TPACK is necessary for a teacher to be able to master the pedagogics, technology, and material content that will be taught to the students (Swallow & Olofson, 2017; Supriyadi et al., 2018; De Rossi & Trevisan, 2018). This is in line with the view of Nofrion et al. (2018), Nuangchalerm (2020), and Yurinda et al. (2022) that teachers with good TPACK skills will be able to apply it to the learning process by using technology according to the content of materials, methods, as well as teaching strategies.

Based on the background description above, the authors are interested in conducting research to compare the discovery learning model and the problem-based learning model based on TPACK that supports media Moodle reviewed the science process skills on sound wave material.

Method

Place and Time

The research was carried out in Class XI MIPA SMAN 1 Surakarta in the semester of the academic year 2022/2023. The location of the research site is on Monginsidi Road, Banjarsari, Surakarta, Central Java. The study was conducted in February-March 2023.

Methods of Research

The research carried out was experimental research with a quantitative approach using two groups of treatments. Both treatment groups are experimental classes with TPACK-based discovery learning model supported media Moodle and control classes with problem-based learning model TPACK supported medium Moodle. Before taking the data, a preliminary state test is performed first for both classes. Students will be given an elevator to measure the skills of the scientific process so that it can be known the level of skill of the science process students are divided into two categories, namely high and low. The research design used is a 2x2

factorial design with the frequency of cell content not the same.

Table 1. Design of Research

Model of Learning (A)	Science Process Skills (B)	
	High (B_1)	Low (B_2)
Discovery Learning (A1)	$A_1 B_1$	$A_1 B_2$
Problem Based Learning (A2)	$A_2 B_1$	$A_2 B_2$

Sampling Techniques

The sampling technique is cluster random sampling, which takes two classes of nine classes in the population. Before being treated, the two groups of samples were tested for similarity in the initial condition using a two-tail test with a prior prerequisite analysis test, which is a statistical test to find out that the samples come from a normal and homogeneous distributed population through a test of normality and homogeneity. Based on the t-test, obtained both samples have the same initial condition.

Techniques of Data Collection

Questionnaire

The questionnaire used in this study aims to know the level of skills of the student's scientific process. The way of collecting data will be done directly by giving the elevator to the student as the subject of research. The scale in the lifting technique consists of four alternative answers, i.e. always (SL) with a value of 4, often (S) with the value of 3, sometimes (KD) with 2 and never (TP) with 1. This data was taken before both groups of samples were treated.

Test

The written test used in the study is an objective test of a total of 25 questions at the end of the study. Questions are structured according to the level of cognitive ability of students from C1 to C5 and each question consists of 5 alternative answers. Before submitting to the students, the question of the test is tested quantitatively and performed the test of the power of the different questions, the difficulty of the issues, the effectiveness of the distractor, and the reliability of the questions. This data is collected after the end of the treatment.

Validation of Learning Instruments

The learning instruments include the Lesson Plan (RPP) and the Student Activity Sheet (LKPD) that have been validated by expert lecturers.

Data Collection Instrument

Science Process Skills Questionnaire

The validity test technique of the instrument uses product-moment correlation, i.e. by correlating the score of each item with the total score of the item. The product-moment correlation is as follows.

$$r_{XY} = \frac{n\sum XY - (\sum X)(\sum Y)}{\sqrt{(n\sum X^2 - (\sum X)^2) + (n\sum Y^2 - (Y)^2)}} \quad (1)$$

(Sundayana, 2018)

Information

r_{XY} = Coefficient of correlation between variable X and Y

n = Number of respondents

X = Number of scores of the statement

Y = Total score of the statement

If an instrument element has a correlation coefficient value greater than or equal to 0.3($r_{XY} \geq 0.3$), then the instrument is declared valid. The results of the analysis showed that the entire process skill elevator had a $r_{XY} \geq 0.3$ value, so the entire declaration elevator was valid.

The reliability test of the study uses the Alpha-Cronbach method with the following equation.

$$r_i = \frac{k}{(k-1)}\left\{1 - \frac{\sum s_i}{s_t^2}\right\} \quad (2)$$

(Sundayana, 2018)

r_i = Alfa Cronbach reliability coefficient

k = number of items

$\sum s_i$ = the number of variants of each item

s_t = total variance

The size of the reliability value of the science process skill lift is 0.862 with high criteria so the lifting instrument deserves to be tested.

Cognitive Ability Assessment Instrument

Technical validation of instruments for evaluating the cognitive ability of students is carried out through quantitative analysis of questions that includes question differentiator power, problem difficulty level, distractor effectiveness, and question reliability.

Table 2. Results of Instrumental Decision

Category	Item Number	Total
Accepted	1, 5, 7, 17, 20, 21, 23, 25, 28, 29	10
Revised	4, 6, 8, 9, 10, 11, 12, 13, 14, 15, 19, 22, 26, 27, 30	15
Rejected	2, 3, 16, 18, 24	5

Result and Discussion

Two-way variance analysis is used to perform analysis tests. Variance analysis is carried out using data such as science process skills that differ in high and low categories as well as data values of physical cognitive abilities at the end of the treatment. The level of science

process skills of the student is obtained through the results of an assessment of 20 elements. Process science skills data of the student's experimental class and control class are presented in Table 3.

Table 3. Student Science Process Skills Data

Class	Amount of Data	Highest Score	Lowest Score
Experiment	35	79	35
Control	36	77	41

Data values of cognitive abilities of the students were obtained through the results of the test at the end of the treatment with a total of 25 questions. Cognitive ability data of the student's experimental and control classes are presented in Table 4.

Table 4. Student Cognitive Ability Data

Class	Number of Student	Average	Cognitive Ability Lowest Score	Highest Score
Experiment	35	70,29	44	92
Control	36	80,78	60	100

The results of the prerequisite analysis test showed that the experimental and control classes were normally and homogeneously distributed. The summary results of the two-way variance analysis with the content of uneven cells refers to statistical calculations with a significant (α) 5% scale presented in Table 5.

Table 5. Student Cognitive Ability Data

Source of Variation	F_{obs}	F_t Sig. ($\alpha = 0.05$)		Decision
Model of Learning (A)	18.606	3.98	0.000	H_{0A} rejected
Science Process Skills (B)	15.565	3.98	0.000	H_{0B} rejected
Interaction of the Two Methods	3.514	3.98	0.065	H_{0AB} accepted

The results of a two-way ANAVA test with uneven cell content showed that the first H_{0A} and the second H_{0B} hypotheses were rejected. Therefore, it is necessary to carry out further tests of variance analysis using a double comparison test with the Scheffe method.

Table 6. Summary of Double Comparison Test between Lines

Comparison	Average X_i	X_j	S	F_t
$\overline{X}_1$ vs $\overline{X}_2$	70.08	80.50	18.762	3.98

Based on Table 6, it can be concluded that the use of a problem-based learning model supported by a Moodle produces better cognitive abilities compared to using a discovery learning model with a marginal rate of 80.50.

Table 7. Summary of Double Comparison Test between Columns

Comparison	Average Xi	Xj	S	F_t
$\overline{X}_1$ vs $\overline{X}_2$	80.055	70.53	15.595	3.98

Based on Table 7, it can be concluded that learners who possess high-category science process skills yield better cognitive skills outcomes compared to learners that possess low-categories scientific process skills with a marginal rate of 80.055.

1st Hypothesis

Based on the results of the analysis, it is known that the value of $F_{obs} = 18.606 > F_t = F_{0.05;1;67} = 3.98$ so that H_{0A} is rejected and H_{1A} is accepted. The results of the test can be concluded that there is a difference in the impact between the use of the discovery learning model and problem-based learning supported by Moodle on the cognitive abilities of the learners.

Through the follow-up tests conducted by ANAVA, marginal average results were obtained in classes using a higher problem-based learning model compared to those using a discovery learning model. The problem-based learning model has a marginal average of 80.50, whereas the discovery learning model is a marginal of 70.08. The results showed that problem-based learning models produced better cognitive abilities compared to discovery learning models. The results of the study are consistent with the study of Dinnullah (2018) and Wabula et al. (2020) which stated that there are differences in the impact of the application of the problem-based learning model and discovery learning, where the learning outcomes of the class that uses the problem-based learning model are better compared to the class which uses the discovery Learning model.

The difference in average values in the two classes is due to the differences in the characteristics of each learning model. The application of a problem-based learning model supported by media Moodle can provide better results because this model encourages learners to think and question. Students not only conclude, but try to find the basis of arguments and supporting facts, so that students not only know but also think (Diani et al., 2017). The problem-based learning model focuses on the problems to be solved so that students are trained to think in finding a way out of the problems displayed on the media Moodle. The discovery learning model emphasizes the importance of understanding the structures and concepts of the materials to be studied (Pangastuti et al., 2019).

2nd Hypothesis

Based on the results of the analysis, it is known that the value of $F_{obs} = 15.565 > F_t = F_{0.05;1;67} = 3.98$ so that H_{0B}

is rejected and H_{1B} is accepted. The results of the test can be concluded that there is a difference in influence between the level of science process skills of the high and low categories on the cognitive abilities of students of high school grade XI in SMAN 1 Surakarta sound wave material. The average cognitive ability of students with high-category science process skills is 80.055, while the average cognitive ability of learners with low-categories science process abilities is 70.53. The results showed that students with high-grade science process skills produced better cognitive abilities compared to students with low-grade scientific process skills.

Process science skills are the scientific skills used to discover a new idea or theory or to develop an existing idea. The skills of the science process have a positive effect on the cognitive abilities of the learners. When the skills in the scientific process are high, then the student will have a clear perception, good memory, and a mature readiness for learning. Through this training, students will get better cognitive learning outcomes. This is in line with research by Sari et al. (2017) that shows the influence of science process skills on learning outcomes. Students with high science process skills will have high learning outcomes, while students with low science process skills will have low learning outcomes.

3rd Hypothesis

Based on the results of the analysis, it is known that the value of $F_{obs} = 3.514 < F_t = F_{0.05;1;67} = 3.98$ so H_{0AB} is accepted. The results of the test can be concluded that there is no interaction between the influence of the use of the learning model discovery learning and problem-based learning based on TPACK-supported media Moodle with the level of science process skills against the cognitive abilities of high school students XI grade in SMAN 1 Surakarta sound wave material. This study is consistent with research conducted by Hardiyanto et al. (2017) which also showed the absence of interaction between the skills of the scientific process as a moderator variable that can affect the relationship between the learning model as a free variable with the learning outcome as a bound variable.

Learning models and skills of scientific processes are known to influence the cognitive abilities of the student, but there are other factors also influencing the cognitive capabilities of students, namely internal and external factors. According to Marlina et al. (2021), internal factors originate from the student's self-such as interest and motivation, while external factors come from the outside of the student's environment. These two factors are interrelated, so cognitive abilities can be influenced by a variety of factors in addition to learning models and science process skills.

Conclusion

Based on the results of analysis and discussion, it can be concluded that: there is a difference in the influence between the use of discovery learning and problem-based learning based on TPACK-supported media Moodle on the cognitive abilities of high school students XI class material sound wave ($F_{observation} = 18.606 > F_{table} = F_{0.05;1;67} = 3.98$). Based on the results of the analysis, it was found that the problem-based learning model produces better cognitive abilities compared to the discovery learning model; there is a difference in the influence between the level of science process skills of the high and low categories on the cognitive abilities of high school students of class XI of sound wave material ($F_{observation} = 15.565 > F_{table} = F_{0.05;1;67} = 3.98$). Based on the results of the analysis, the result was obtained that students with high-grade science process skills produced better cognitive abilities compared to students with low-grade scientific process skills; there was no interaction between the influence of the use of discovery learning and problem-based learning models supported by TPACK media Moodle with the level of science process skills on the cognitive abilities of high school students of class XI material sound wave ($F_{observation} = 3.514 < F_{table} = F_{0.05;1;67} = 3.98$).

Author Contributions

All authors have read and agree to the published version of the manuscript.

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Conflicts of Interest

The authors declare no conflict of interest.

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