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The Influence of STEM Integrated Discovery Learning Model on Critical Thinking Skills, Motivation and Learning Outcomes of Grade X Students of Makassar State Senior High School.

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ABSTRACT
21st century skills help students adapt well to a changing world Based on the results of observations of students and the learning process at SMA Negeri 3 Makassar, it shows that the implementation of learning does not have active interaction between students. The use of learning models is not varied and there is a lack of a personal approach. This causes students not to be trained to identify a problem and are less brave in expressing ideas, less motivated to learn, their critical thinking skills do not develop and learning outcomes do not increase. The purpose of this study was to determine the effect of the STEM integrated discovery learning model on critical thinking skills, motivation and learning outcomes. This study is a quasi-experimental quantitative study. The population of the study was students of class X of SMAN 3 Makassar consisting of 10 classes, each class consisting of 36. The sample of the study was 72 selected people. The analysis of the research data was in the form of descriptive analysis and inferential analysis. Hypothesis testing used the ANACOVA test for critical thinking skills and learning outcomes then the ANOVA test for student learning motivation.Based on the data obtained, this study shows that the STEM integrated discovery learning model has an influence on students' critical thinking skills, motivation and learning outcomes which are very important for facing the challenges of the world of education.

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1. INTRODUCTION

Learning is a process when educators train students to acquire knowledge, skills and attitudes (Ariningtyas et al. 2018). 21st century skills help students adapt well to a changing world (Stehle, et al. 2019). 21st century thinking skills include critical thinking skills, creativity and innovation, communication and collaboration (Redhana, 2012). To fulfill all of that, there needs to be creativity in the learning process, one of which is that various learning models can be applied.

Based on the results of observations of students and the learning process at SMA Negeri 3 Makassar, the implementation of learning shows no active interaction between students. The implementation of learning activities during discussions is too passive, no one asks questions or provides objections from students who are presenting and the use of learning models is not varied and lacks a personal approach. This causes students not to be trained to identify a problem and are less brave in expressing ideas or concepts, less motivated to learn, their critical thinking skills do not develop and learning outcomes do not increase. The solution that will be done to train critical thinking skills is to apply the STEM integrated discovery learning model. The discovery learning model emphasizes the discovery of concepts or principles that students do not yet have.

The Discovery Learning model has an influence on critical thinking skills. Therefore, one of the efforts that educators can make to improve students' critical thinking skills and learning motivation is to apply the Science, Technology, Engineering, and Mathematics (STEM) approach in biology learning (Yusuf, et al. 2022). Therefore, one of the efforts that educators can make to improve students' critical thinking skills and learning motivation is to apply the Science, Technology, Engineering, and Mathematics (STEM) approach in biology learning.

Based on research conducted by (Fadlina et al. 2023) that using the STEM-based discovery learning model provides opportunities for students to explore the ability to identify problems from a case related to the material provided. STEM provides students with experience in solving real problems so that they can increase effectiveness, meaningful learning, and support future careers. The STEM-based discovery learning model is able to train the ability to ask and answer questions, which is the ability to find existing facts from a problem that can be used to help answer the problem.

The STEM integrated discovery learning model is able to train the ability to ask and answer questions, which is the ability to find existing facts from a problem that can be used to help answer the problem. Integrated STEM learning is effective in significantly improving students' scientific thinking skills, so that student learning outcomes increase and are better (Agustina et al. 2020).

This study aims to determine the effect of the STEM integrated discovery learning model on critical thinking skills, motivation and learning outcomes of students. In another educational journal by Hani & Suwarma (2018) it was stated that in STEM-based learning, overall students have high motivation to learn biology. Based on the research journal, the researcher considers that the STEM approach can be a solution to improve critical thinking skills, motivation and learning outcomes of students.

The application of the STEM approach to biology learning is still rarely applied. Therefore, the author will conduct a study with the title of the study The Effect of the STEM Integrated Discovery Learning Model on Critical Thinking Skills, Motivation and Learning Outcomes of Students of SMA Negeri 3 Makassar. To determine the relationship between the STEM approach and models in biology learning.

2. RESEARCH METHOD

This research is a quasi-experimental quantitative research. The research design used is Pretest-Postest Comparison Group Design.The population in this study was the entire study group of Class X IPA SMAN 3 Makassar which consisted of 10 class X IPA students.Each class consists of 36. The research sample was 72 selected people., for the experimental group 36 people in 1 class and the control group 36 people in 1 class. The sampling technique used is simple random sampling based on the study group.Data collection uses two types of research instruments, namely student learning motivation questionnaires and tests. The data collection procedures are, the preparation stage in the form of modules, LKPD, and other teaching materials, then the implementation stage (giving treatment to experimental and control learning groups) and the last stage of completion is processing research data. Data analysis techniques used in this study are descriptive statistical analysis and inferential analysis, this analysis technique is used to test the research hypothesis, hypothesis testing uses the ANOVA test for learning motivation and the ANACOVA test to measure critical thinking skills and learning outcomes.

3. RESULT AND DISCUSSION

1. Descriptive Statistical Analysis

Table 1. Descriptive Analysis of Critical Thinking Skills of Discovery Learning Group and PBL Group

Statistics	Discovery Learning Model		PBL Model	
	Pretest	***Posttest***	***Pretest***	***Posttest***
Average	41.94	87.57	38.75	73.06
Standard Deviation	5,641	4,371	7,872	4,516
Lowest Value	30	80	20	65
The highest score	50	95	50	80

The table shows that the average value of critical thinking skills of students in the STEM integrated discovery learning group with the PBL group has increased. In the table, the average posttest value in the discovery learning group is higher, which is 87.57 and the average posttest value of the PBL group is 73.06. However, when viewed from the two learning groups, the group that was taught with discovery learning had a higher increase value.

Table 2. Frequency Distribution and Percentage of Critical Thinking Skills Categories pretest-posttest Discovery Learning and PBL groups

Interval	Category	Discovery Learning				PBL			
		Pretest		Posttest		Pretest		Posttest	
		F	%	F	%	F	%	F	%
81-100	Very good	0	0	33	91.7	0	0	0	0
61-80	Good	0	0	3	8.3	0	0	36	100
41-60	Enough	16	44.4	0	0	10	27.8	0	0
21-40	Not enough	20	55.6	0	0	24	66.7	0	0
0-20	Very less	0	0	0	0	2	56	0	0

The pretest results obtained by the STEM integrated discovery learning group were dominated by the less category with a percentage of 55.6% and the posttest was dominated by the very good category with a presentation of 91.7%. While the pretest and PBL group were dominated by the less category with a percentage of 66.7% and the posttest was in the good category with a percentage of 100%. The results of the data indicate that students who are taught with the STEM integrated discovery learning model have higher critical thinking skills compared to students who are taught with the PBL model.

Table 3. Descriptive Analysis of Learning Motivation of Discovery Learning Group and PBL Group

Statistics	***Discovery Learning***	**PBL**
Average	89.69	66.22
Standard Deviation	0.668	4,043
Lowest Value	89	61
The highest score	92	75

Based on descriptive analysis, it shows that the average value of learning motivation in the discovery learning group is 89.69 and the average value of the PBL group is 66.22. However, when viewed from the two learning groups, the group that was taught with STEM-integrated discovery learning had a higher increase value than the PBL group.

Table 4.Frequency Distribution and Percentage of Learning Motivation Categories for Discovery Learning and PBL Groups

Interval	**Category**	***Discovery Learning***		***PBL***	
		F	**%**	**F**	**%**
81-100	Very good	36	100	0	0
61-80	Good	0	0	36	100
41-60	Enough	0	0	0	0
21-40	Not enough	0	0	0	0
0-20	Very less	0	0	0	0

Based on the results obtained, the STEM integrated discovery learning group is in the very good category with a presentation of 100%. While the PBL group is in the good category with a presentation of 100%. The results of the data show that students who are taught with the STEM integrated discovery learning model have higher learning motivation compared to students who are taught with the PBL model.

Table 5. Descriptive Analysis of Learning Outcomes of Discovery Learning Group and PBL Group

Statistics	**Discovery Learning Model**		**PBL Model**	
	Pretest	***Posttest***	***Pretest***	***Posttest***
Average	41.11	93.05	39.17	76.11
Standard Deviation	7,848	3,584	9,964	4,069
Lowest Value	30	87	20	65
The highest score	60	100	60	83

Table 5 shows that the average value of student learning outcomes in the STEM Integrated Discovery Learning group with the Problem Based Learning (PBL) group has increased. In the table, the average posttest value in the discovery learning group is higher, which is 93.05 and the average posttest value in the PBL group is 76.11. However, when viewed from the two learning groups, the group that was taught using the discovery learning approach model had a higher increase value.

Table 6 Frequency Distribution and Percentage of Learning Outcome Categories for Pretest-Posttest Discovery Learning and PBL Classes

Interval	**Category**	**Discovery Learning**				**PBL**			
		Pretest		**Posttest**		**Pretest**		**Posttest**	
		F	**%**	**F**	**%**	**F**	**%**	**F**	**%**
81-100	Very good	0	0	36	100	0	0	2	5.6
61-80	Good	0	0	0	0	0	0	34	94.4
41-60	Enough	9	75	0	0	11	30.6	0	0
21-40	Not enough	27	25	0	0	22	61.1	0	0
0-20	Very less	0	0	0	0	3	8.3	0	0

Based on table 8, the pretest results obtained by the Discovery Learning group were dominated by the sufficient category with a percentage of 75% and the posttest in the discovery learning group was in the very good

category with a percentage of 100%. While the pretest in the PBL group was dominated by the less category with a percentage of 61.1% and the posttest in the PBL group was dominated by the good category with a percentage of 94.4 percent. The results of these data indicate that students who are taught with the STEM trinity discovery learning learning model have higher learning outcomes compared to PBL.

2. Inferential Analysis

a. Normality Test

Table 7. Normality Test of Critical Thinking Skills

One Sample Kolmogorov Smirnov Test		
Critical Thinking Skills	**Significance**	**Information**
Discovery Learning Pretest	0.210	Normal
Posttest Discovery Learning	0.150	Normal
*Pretest*PBL	0.230	Normal
*Posttest*PBL	0.200	Normal

Based on the SPSS output, the Normality Test for critical thinking skills can be seen in the table based on the posttest in the discovery learning group is 0.150 and the posttest in the PBL group is 0.200. Normally distributed data has a significant value greater than 0.05 (α> 0.05) so it can be concluded that all data for critical thinking skills in the discovery learning and PBL groups are normally distributed.

Table 8. Normality Test of Learning Motivation

One Sample Kolmogorov Smirnov Test		
Learning outcomes	**Significance**	**Information**
Discovery Learning Class	0.083	Normal
PBL Class	0.132	Normal

The Normality Test for students' learning motivation in the discovery learning group is 0.083 and in the PBL group is 0.132. Normally distributed data has a significant value greater than 0.05 (α > 0.05) so it can be concluded that all data for the learning motivation of the discovery learning and PBL groups are normally distributed.

Table 9. Normality Test of Learning Outcomes

One Sample Kolmogorov Smirnov Test		
Learning outcomes	**Significance**	**Information**
Discovery Learning Pretest	0.120	Normal
Posttest Discovery Learning	0.149	Normal
*Pretest*PBL	0.071	Normal
*Posttest*PBL	0.160	Normal

In the SPSS output, the Normality Test for learning outcomes in the discovery learning group is 0.149 and in the PBL group is 0.160. Normally distributed data has a significant value greater than 0.05 (α > 0.05), so it can be concluded that all data for learning outcomes in the largest STEM and PBL integrated discovery learning groups are normally distributed.

b. Homogeneity Test

Table 10. Results of the Homogeneity Test of the Pretest and Posttest Critical Thinking of the Discovery Learning and PBL Groups

	Leaven Statistics	**df 1**	**df 2**	**Sig**
*Pretest*Critical Thinking Skills	2,026	1	70	0.159
Posttest Critical Thinking Skills	0.008	1	70	0.929

Levene's Test aims to determine whether the data variance is the same or different based on the results of data processing according to the test of homogeneity of variances table above, the pretest p-value of critical thinking skills is 2.026 and the posttest significance is 0.929 ≥ α = 0.05 so that it can be concluded that the data comes from groups that have the same variance (homogeneous).

Table 11. Results of the Homogeneity Test of Motivation of the Discovery Learning and PBL Groups

	Leaven Statistics	df 1	df 2	Sig
Motivation	46,860	1	70	0, 410

Based on data processing using SPSS 22.0 above, the significance of student learning motivation was obtained at 0.410.≥ α = 0.05 so it can be concluded that the data is from groups that have the same variation.

Table 12. Results of the Pretest-Posttest Homogeneity Test of Learning Outcomes of the Discovery Learning and PBL Groups

	Leaven Statistics	df 1	df 2	Sig
Learning Outcome Pretest	2,720	1	70	0.104
Posttest Learning Outcomes	0.768	1	70	0.384

Based on table 4.12 of the homogeneity test of pretest learning outcomes in the STEM and PBL integrated discovery learning group above, the sig of student learning outcomes was obtained as 0.104 ≥ α = 0.05 and the posttest of student learning outcomes obtained sig 0.384 ≥ α = 0.05 so that it can be concluded that the data is from a homogeneous group.

c. Hypothesis Testing

Table 13.Critical Thinking Skills Hypothesis Test

Source	Type III Sum of Squares	Df	Mean Square	F	Sig.
Corrected Model	4085.901(a)	2	2042,950	129,524	,000
Intercept	9132,961	1	9132,961	579,035	,000
Pretest	294,147	1	294,147	18,649	,000
Learning model	3133,256	1	3133,256	198,650	,000
Error	1088,318	69	15,773		
Total	469581,250	72			
Corrected Total	5174,219	71			

a R Squared = .790 (Adjusted R Squared = .784)

Based on the ancova test using SPSS 22.00 above, it can be seen that the corrected model shows a significance figure of 0.000 <0.05, meaning that the pretest and learning model simultaneously have different impacts on critical thinking skills. The intercept shows a constant value with a significance of 0.000 <0.05. The learning model shows a significance value of 0.000 <0.05, meaning that both learning models have significant differences on students' critical thinking skills.

Table 14**.** Learning Motivation Hypothesis Test

Source	Type III Sum of Squares	Df	Mean Square	F	Sig.
Corrected Model	9917.014(a)	1	9917,014	1180,876	,000
Intercept	437580,125	1	437580,125	52105,180	,000
Learning model	9917,014	1	9917,014	1180,876	,000
Error	587,861	70	8,398		
Total	448085,000	72			
Corrected Total	10504,875	71			

a R Squared = .944 (Adjusted R Squared = .943)

Based on table 14. anacova test using SPSS 22.00 above, it can be seen that the corrected model shows a significance figure of 0.000 <0.05, the learning model simultaneously has a different impact on learning motivation. Intercept shows a constant value with a significance of 0.000 <0.05. The learning model shows a significance value of 0.000 <0.05, meaning that the two learning models have a significant difference in students' learning motivation.

Table 4.15 Hypothesis Testing of Learning Outcomes

Source	Type III Sum of Squares	Df	Mean Square	F	Sig.
Corrected Model	5199,732(a)	2	2599,866	180,444	,000
Intercept	22091,424	1	22091,424	1533,261	,000
Pretest	35,064	1	35,064	2,434	,123
Learning model	5010,954	1	5010,954	347,786	,000
Error	994,161	69	14,408		
Source	**Type III Sum of Squares**	**Df**	**Mean Square**	**F**	**Sig.**
Total	521272,560	72			
Corrected Total	6193,893	71			

a R Squared = .839 (Adjusted R Squared = .835)

Based on the hypothesis test table using SPSS 22.00, it can be seen that the corrected model shows a significance figure of 0.000 <0.05, meaning that the pretest and learning model simultaneously have different impacts on learning outcomes. The intercept shows a constant value with a significance of 0.000 <0.05. The learning model shows a significance value of 0.000 <0.05, meaning that both learning models have significant differences on student learning outcomes. Decision making on the hypothesis test on critical thinking skills, motivation and learning outcomes of students tested using the anacova test that the significance value of the three variables is 0.000 <0.05, then the hypothesis is accepted. If the hypothesis is accepted, it means that there is an influence of the STEM integrated discovery learning model on critical thinking skills, motivation and learning outcomes of class X IPA students of SMAN 3 Makassar.

The Influence of the STEM Integrated Discovery Learning Model on Critical Thinking Skills of Students at SMAN 3 Makassar

The group taught with the STEM integrated discovery learning model (experimental group) obtained an average value of critical thinking skills in the sufficient and less category in the pretest and posttest, dominated by the very good category and some were in the good category. While in the group taught with the problem based learning (PBL) model (control group) for the pretest was dominated by the less category and some were in the sufficient category, the posttest was in the good category. It can be seen that the results of the research and the treatment that has been given to the sample have had an effect on critical thinking skills. This can be seen from the average value (mean) obtained by the STEM integrated discovery learning and PBL groups, it was found that there was a difference between the critical thinking skills of students taught using the STEM integrated discovery learning and PBL models.

Hypothesis testing was carried out using an anacova test showing a significance value of 0.000 which indicates a significant effect of the STEM integrated discovery learning model on students' critical thinking skills. This proves that the learning model is effective in improving students' critical thinking skills. In line with this, Nurfitra's research states that the STEM approach in learning can improve students' critical thinking skills (Yanto et al., 2024).

The Influence of STEM Integrated Discovery Learning Model on Learning Motivation of Students of SMAN 3 Makassar.

The average percentage of learning motivation of students in the control class using the PBL learning model is 100% with a good category. While in the experimental class that is taught with the STEM integrated discovery learning model is in the very good category, from the data it can be seen that the learning motivation of students in the STEM integrated discovery learning group is better than the PBL group. The main difference that can be seen in this study is that in the STEM integrated discovery learning model, students get the opportunity to be directly active in the learning process in the classroom, namely the process of discovering concepts through activities of searching, researching, and constructing their own knowledge. The use of the discovery learning

model can foster curiosity and meaningful learning experiences, so that students feel more motivated because students can be part of an active and challenging learning process.

Dewey's view that critical thinking is an active and persistent attitude resulting from careful reflection and showing the desire, drive, and desire to find solutions to the problems we face (Anisa, 2022). Therefore, learning must focus on developing critical thinking skills and learning outcomes. In line with this opinion, based on the results of the research that has been carried out, it shows that the STEM integrated discovery learning model can increase motivation better than the PBL learning model, because it can provide a more active, enjoyable, and relevant experience to real life. This has positive implications for the achievement of learning outcomes and the development of other skills such as critical thinking which are reinforced by high learning motivation.

The Influence of the STEM Integrated Discovery Learning Model on Learning Outcomes

Based on the results of the data analysis obtained from the calculations above, it can be seen that the results of the research and the treatment that has been given to the sample have influenced the learning outcomes of students. This is evidenced by the difference in the average value (mean) of learning outcomes between the two which shows a significant increase in the experimental learning group, which is 93.05 in the posttest, while the PBL learning group obtained an average of 76.11. The difference in the average between the two shows that the application of the STEM integrated discovery learning model produces a greater increase in learning outcomes than PBL. In addition, the statistical test (ANOVA) shows a sig value of 0.000 indicating that the STEM integrated discovery learning model on student learning outcomes is very statistically significant. This means that the variation in learning outcomes obtained is not solely due to chance factors but there is a real influence factor from the learning strategy. STEM integrated discovery learning has a stronger effect on improving student learning outcomes compared to PBL.

Discovery learning model through the STEM approach to provide improved student outcomes. STEM does not just help students remember material in general, but also deepens their understanding of science concepts that are relevant to everyday life (Herak, 2021). allows them to find learning concepts independently. Similar research conducted by Hapizoh (2019) showed that the implementation of a discovery learning model integrated with STEM can improve student learning outcomes. STEM includes interrelated disciplines, where science is used to collect data, mathematics to process it, and technology and engineering for its application (Hapizoh, 2019).

4. CONCLUSION

Based on the results of the research that has been conducted, it can be concluded that the STEM-integrated Discovery Learning model can significantly improve critical thinking skills, motivation and learning outcomes of participants and there is an influence of the STEM-integrated Discovery Learning model on critical thinking skills, motivation and learning outcomes of class X students of SMAN 3 Makassar.

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