Bioedukasi
Jurnal Biologi dan Pembelajarannya
Vol. 23 No 2, June 2025, page 360-367
e-ISSN: 2580-0094; p-ISSN:1693-3931
DOI: 10.19184/bioedu.v23i2.53723
bioedukasi.jurnal.unej.ac.id/index.php/BIO

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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Article Info
Article history:
Received June 15, 2025
Revised June 26, 2025
Accepted June 27, 2025

Keywords: (AZ)
Critical Thinking Skills
Discovery Learning
Learning outcomes
Motivation
STEM

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

Source: Processed Primary Data

Table 1 shows that the average critical thinking skills scores of students in the STEM-integrated discovery learning group and the PBL group experienced improvement. The table shows that the average pre-test score for the discovery learning group was 41.94 and the post-test score was 87.57. Meanwhile, in the PBL group, the average pre-test score was 38.75 and the post-test score was 73.06. However, when comparing both learning groups, the group taught using discovery learning showed higher improvement in critical thinking skills compared to students who used the PBL model.

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

Source: Processed Primary Data

The pre-test results in Table 2 show that the STEM-integrated discovery learning group was dominated by the 'poor' category, with some in the 'adequate' category, while the post-test was dominated by the 'very good' category with some in the 'good' category. Meanwhile, the PBL group's pre-test was dominated by the 'poor' category with some in the 'adequate' category, and the post-test was in the 'good' category. These results indicate that students taught using the STEM-integrated discovery learning model have higher critical thinking skills compared to the critical thinking skills of students taught using 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

Source: Processed Primary Data

Based on Table 3, it shows that the average learning motivation score in the discovery learning group is 89.69, while the average score for the PBL group is 66.22. However, when comparing these two learning groups, the group taught using STEM-integrated discovery learning showed higher improvement compared to 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

Source: Processed Primary Data

Based on the results obtained in Table 4, the STEM-integrated discovery learning group was in the 'very good' category with 100% representation. Meanwhile, the PBL group was in the 'good' category with 100% representation. These results indicate that students taught using the STEM-integrated discovery learning model had higher learning motivation compared to students taught using 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

Source: Processed Primary Data

Table 5 shows that the average learning outcomes of students in the Discovery Learning Integrated STEM group and the Problem Based Learning (PBL) group both increased. The table shows that the average post-test score in the discovery learning group was higher at 93.05, while the average post-test score in the PBL

group was 76.11. However, when comparing both learning groups, the group taught using the discovery learning approach model showed a higher rate of improvement.

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	25	0	0	11	30.6	0	0
21-40	Not enough	27	75	0	0	22	61.1	0	0
0-20	Very less	0	0	0	0	3	8.3	0	0

Source: Processed Primary Data

Based on Table 4.6, the pre-test results obtained by the Discovery Learning group were dominated by the 'adequate' category, with some in the 'poor' category, while the post-test results were in the 'very good' category. Meanwhile, the pre-test results for the PBL group were dominated by the 'poor' category, with some in the 'adequate' and 'very poor' categories. The post-test results for the PBL group were then dominated by the 'good' category, with some in the 'very good' category. These results show that students taught using the STEM-integrated discovery learning model achieved higher learning outcomes compared to students taught using the PBL model.

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

Source: Processed Primary Data

Based on Table 7, critical thinking skills can be observed from the table showing that the posttest results for the discovery learning group were 0.150 and for the PBL group were 0.200. Data that are normally distributed have significance values greater than 0.05 ($\alpha > 0.05$), therefore it can be concluded that all data for critical thinking skills in both 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

Source: Processed Primary Data

Table 8 shows that the learning motivation of students in the discovery learning group was 0.083 and in the PBL group was 0.132. Data that are normally distributed have significance values greater than 0.05 ($\alpha > 0.05$), therefore it can be concluded that all data for learning motivation in both 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

Source: Processed Primary Data

In Table 9, the learning outcomes for the discovery learning group are 0.149 and for the PBL group are 0.160. Normally distributed data have a significance value greater than 0.05 ($\alpha > 0.05$), so it can be concluded that all data for learning outcomes in the STEM-integrated discovery learning and PBL 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

Source: Processed Primary Data

Table 10. Levene's test aims to determine whether data variances are the same or different. Based on the data processing results according to the test of homogeneity of variances table above, the p-value for the critical thinking skills pretest is 2.026 and the posttest significance is 0.929 ≥ α = 0.05, so it can be concluded that the data come from groups that have the same variances (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

Source: Processed Primary Data

Based on Table 11 above, the significance value obtained for students' learning motivation was 0.410 ≥ α = 0.05, so it can be concluded that the data are from groups with equal variance.

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

Source: Processed Primary Data

Based on Table 12. for the homogeneity test of pre-test learning outcomes in the STEM-integrated discovery learning and PBL groups above, the significance value for students' learning outcomes was 0.104 ≥ α = 0.05, and for the post-test learning outcomes of students, the significance value obtained was 0.384 ≥ α = 0.05. Therefore, it can be concluded that the data are from homogeneous groups.

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 in Table 13 above, it can be seen that the learning model shows a significance value of 0.000 < 0.05, meaning that the two learning models have significant differences in 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 the ANCOVA test in Table 14. above, it can be seen that the learning model shows a significance value of 0.000 < 0.05, meaning that the two learning models have significant differences in students' learning motivation.

Table 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		
Total	521272,560	72			
Corrected Total	6193,893	71			

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

Based on the test results in Table 15 above, it can be seen that the learning model shows a significance value of 0.000 < 0.05, meaning that the two learning models have significant differences in students' learning outcomes. Decision-making in hypothesis testing for critical thinking skills and students' learning outcomes was tested using ANCOVA, while motivation was tested using ANOVA. The significance values of all three variables were 0.000 < 0.05, so the hypothesis is accepted. If the hypothesis is accepted, it means there is an effect of the STEM-integrated discovery learning model on critical thinking skills, motivation, and learning outcomes of Grade X Science students at 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 results of this study indicate that the STEM-integrated discovery learning model has an effect on student learning motivation. The ANOVA test results showed a very low significance value (lower than the specified level of significance). This indicates that the implementation of the STEM-integrated discovery learning model and PBL significantly impacted student learning motivation.

Students who used the STEM-integrated discovery learning model had very high learning motivation. This is reflected in the average motivation score obtained by students in the very good category. Based on the frequency distribution, it can be seen that all students taught using the STEM-integrated discovery learning model were in the very good learning motivation category. This indicates that this learning model is able to effectively stimulate student curiosity, increase enthusiasm for learning, and encourage students to be more active and motivated in participating in learning.

The discovery learning model can stimulate student motivation due to its challenging and enjoyable process. This aligns with Rahmi et al.'s (2020) opinion, which states that in learning, students learn to identify problems, seek relevant information, develop solution strategies, and select the chosen strategy (Sholehah et al., 2022). The integration of STEM into the discovery learning model further strengthens student motivation because this approach connects science, technology, engineering, and mathematics in contexts relevant to real life. This is supported by Sanderayanti's (2021) opinion that enables students to understand the tangible benefits of the material being studied, ultimately leading to greater enthusiasm, passion, and motivation in learning. Therefore, the high motivation of students in STEM-integrated discovery learning is closely related to the classroom learning process.

Dewey's view holds that critical thinking is an active and persistent attitude resulting from careful reflection and demonstrating the desire, drive, and desire to find solutions to the problems we face (Anisa, 2022). In the context of learning, high motivation enhances mastery of material and ensures the development of critical thinking skills, which are complex skills requiring objective, analytical, and creative aspects. Therefore, learning should focus on developing critical thinking skills and learning outcomes.

In line with this opinion, research findings indicate that the use of a STEM-integrated discovery learning model significantly increases motivation because it provides a more active, enjoyable, and real-life experience. This impacts learning outcomes and the development of critical thinking skills, which are reinforced by high learning motivation.

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

The results of this study indicate that the STEM-integrated discovery learning model has an effect on student learning outcomes. The ANACOV test results showed a very low significance value (lower than the specified significance level). This indicates that the implementation of the STEM-integrated discovery learning model and PBL significantly impacted student learning outcomes.

Students' grades after learning using the STEM-integrated discovery learning model showed improvement. This was evident in the fact that students with the lowest grades improved significantly, while those with high initial abilities improved even more. After learning using the STEM-integrated discovery learning model, students were in the very good category, indicating that the use of the STEM-integrated discovery learning model had an impact on student learning outcomes.

STEM learning can strengthen students' motivation and active engagement, leading to greater enthusiasm and deeper understanding of the material. STEM guides students to apply scientific principles, utilize technological tools, and design simple engineering solutions in a unified process that ultimately significantly improves learning outcomes. Similar research by Hapizoh (2019) demonstrated that implementing a discovery learning model integrated with STEM can improve student learning outcomes.

The combination of discovery learning and STEM can significantly improve learning outcomes. Discovery learning encourages students to actively and consciously understand concepts and apply the knowledge they acquire. When combined with STEM, which integrates Science, Technology, Engineering, and Mathematics, the learning process becomes more relevant to everyday life. Satriana (2023) found that this increases student motivation to participate in the learning process. Integrating the discovery learning model with the STEM approach creates an interactive learning environment, thereby improving the quality of student learning outcomes. Furthermore, Utami (2018) stated that the discovery learning model through the STEM approach can improve student outcomes. STEM not only helps students remember material in general but also deepens their understanding of scientific concepts relevant to everyday life (Herak, 2021).

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.

5. ACKNOWLEDGEMENT

Thanks to the supervising lecturer for his direction and guidance during the research until compiling the article, the principal and biology teacher of SMA Negeri 3 Makassar who have given permission to conduct research at the school and the class X students who are the samples of this research.

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