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EFFECTS OF BIOLOGY LEARNING MODELS ON METACOGNITIVE SKILLS OF SENIOR HIGH SCHOOL STUDENTS

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ABSTRACT

The main problem in this study is that many students still rely on memorisation without understanding the concepts deeply, so their ability to plan, monitor and evaluate learning is less developed. In addition, conventional learning models that are often applied in schools tend to provide less opportunity for students to develop metacognitive skills optimally. Therefore, innovation is needed in learning models that can encourage students to think critically and reflect on their learning process. The purpose of this study was to determine the effect of STAD, guided inquiry, and combined STAD and guided inquiry learning models on the metacognitive skills of high school students in Ternate, Indonesia. The research used a quantitative method with a quasi-experimental nonequivalent control group design. The sample consisted of 92 active students in the even semester, selected through purposive sampling. In addition, metacognitive skills were measured using rubrics integrated with test questions. The results showed that the STAD learning model, guided inquiry and a combination of STAD and guided inquiry learning models can improve students' metacognitive skills with a value of Fhitung = 9.317. In addition, the use of STAD learning model, guided inquiry, and the combination of both models showed better metacognitive skills compared to the use of conventional methods. The conclusion of this research is that the learning model applied affects metacognition skills. The combination of STAD and guided inquiry learning models showed the highest achievement of metacognition skills compared to guided inquiry, STAD, and conventional learning models. However, the STAD and guided inquiry learning models showed the effect of metacognition scores that were not significantly different.

Keywords: biology learning, guided inquiry, metacognitive

INTRODUCTION

The learning process in Indonesian schools is in accordance with the 2013 national curriculum guidelines, which expect students to play active role in the process while teachers only act as facilitators. The learning process is designed using scientific approach and its models emphasize active and creative training of students' metacognitive skills (Fauzi & Sa'diyah, 2019). According to Rahmat & Chanunan (2018) and Firman et al., (2018) this approach develops students' metacognitive skills through students' learning experiences through observation, questioning, experimenting, collection of information, and communication. The learning models used by teachers in Indonesia include Inquiry, Problem Based Learning (PBL), Project Based Learning (PjBL), Student Team Achievement Divisions (STAD), Jigsaw, Problem Solving, and Discovery Learning.

According to Palennari (2016) the use of learning models such as PBL, jigsaw, and both, in teaching biology classes, improved students' metacognitive skills. Also, metacognitive strategies have been found to help students in genetic and

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science education (Susantini et al., 2018; Discipulo & Bautista, 2022; Herlanti et al., 2017; Huvard et al., 2020) and Manishimwe et al., (2023) reported that biology learning with inquiry models trains students in the middle class to think through open questions. In addition, learning using the inquiry model enhances metacogitive skills (Naimnule & Corebima, 2018). Moreover, Coşkun (2018) reported that students possess high metacognitive abilities in problem solving using certain learning models. Furthermore, inquiry-based learning remains a key method of teaching science in 54 countries of the world (Cairns & Areepattamannil, 2019). Although there were improvements in this area the cognitive conflict technique was combined with inquiry and put into practice by eighteen pre-service physics instructors the pre-service physics teachers' critical thinking abilities did not perform up to par (Verawati et al., 2021).

The guided inquiry model supports students' collaborative learning in anatomy courses (Alghamdi & Alanazi, 2020; Kersting et al., 2023; Strat et al., 2023; Wen et al., 2023). Students spend more time in engaging study activities using guided inquiry models (Al Mamun & Lawrie, 2023; Palupi et al., 2020). According to Supratman et al., (2023); Fitriani et al., (2020; Pursitasari et al., 2020; Teo et al., 2023) this model trains students' skills and knowledge, as well as enhances their scientific literacy and critical thinking. The learning model helps students in performing laboratory procedures in groups, designing experiments and writing reports independently (Abdelmoneim et al., 2022; Bernhard, 2018; Castro & Morales, 2017; Lestari et al., 2023). Inquiry provides opportunities for students to create new knowledge based on experiences by exploring various information and surrounding phenomena. It follows the principles of constructivism (Verawati et al., 2021; Vogt & Schmiemann, 2020). Through inquiry-based learning, students become active learners (Verawati et al., 2021) with several benefits, including stimulating interest in science, understanding of the nature of science (Gaigher et al., 2014), increasing understanding of concepts (Laksana et al., 2019; Verawati et al., 2021).

The urgency of research on the effect of biology learning models on metacognitive skills of high school students is very important to discuss considering that metacognitive skills are one of the key factors in effective and sustainable learning. These skills enable students to not only understand the subject matter but also manage their learning process independently. In the context of biology education, which often requires a deep understanding of abstract and complex concepts, metacognitive skills can help students plan, monitor and evaluate their own learning strategies, thus improving their understanding and application of the material. In addition, the urgency of this research is also driven by the demands of 21st century education which emphasises the development of critical thinking skills, problem solving, and the ability to learn throughout life. Biology learning not only teaches scientific facts and concepts, but also requires students to engage in investigative processes, reflection, and inference, all of which require good metacognitive skills. Therefore, identifying learning models that can support the development of these skills is essential to improve the quality of biology education at the high school level.

Research on the effect of biology learning models on high school students' metacognitive skills is important because metacognition, or students' ability to realise and manage their own thinking processes, is an essential skill in modern learning. This skill not only improves understanding of the material, but also helps students develop critical and reflective thinking skills. In the context of biology learning, metacognition can play an important role in helping students understand complex concepts and solve scientific problems more effectively (Rivas et al., 2022; Stanton et al., 2021). In addition, this research is important because metacognitive skills are increasingly recognised as one of the key competencies needed in 21st century education. In high school, as students prepare to enter higher education or the world of work, having these skills is crucial to ensure long-term success in their learning and professional lives.

Based on a preliminary study conducted at SMA Ternate, most students tend to only memorise the material without understanding the concepts deeply, which results in suboptimal learning outcomes. This raises the need to implement learning models that not only encourage concept understanding but also improve students' critical and reflective thinking skills. Early research also shows that the application of the right learning model in teaching biology has the potential to significantly improve students' metacognitive skills. This is important to be further researched as metacognitive skills not only help students in understanding biology material, but also provide them with the tools to become independent and efficient learners in various disciplines. Based on these findings, further research is needed to examine the effectiveness of various learning models

in developing students' metacognitive skills and their impact on their learning outcomes in biology.According to the results of the gap analysis in this study, metacognitive skills are the ability of students to understand and control their own thinking processes during learning. These skills are very important in learning Biology, as the discipline demands deep understanding and reflection skills. Sutarto et al., (2022) and Setiawati & Corebima (2018) shows that certain learning models, such as problem-based learning have the potential to improve students' metacognitive skills. However, not many studies have specifically explored the effect of Biology learning models on metacognitive skills, especially in the high school context.

The problem limitation in this study focused on the effect of biology learning models on students' metacognitive skills. The research only covers students at a certain level of education, such as senior high school, so that the results of the research cannot be generalised to other levels of education. In addition, the metacognitive skills studied were limited to aspects of planning, monitoring, and self-evaluation in the context of biology learning. In addition, this study was limited by the relatively short implementation time, so the effect of the learning model on students' metacognitive skills was only observed in the short term. This study did not include a longitudinal analysis that could reveal the long-term impact of the implementation of the learning model on metacognitive skills. The scope of biological materials used in the study is also limited to certain topics, so the results of the study cannot be generalised to all biological materials.

Learning models in Indonesia are developed based on the characteristics of students, with the aim of achieving their learning objectives in each class. During biology class for example, students' metacognitive skills are trained in groups to solve various problems designed by the teacher (Adiansyah et al., 2021; Discipulo & Bautista, 2022; Wass et al., 2023). The combination of various learning models helps students in learning, however, it has some disadvantages as well. To design experiences-oriented learning procedure, there is need to combine guided inquiry with STAD learning models. However, students, especially in suburban areasare still behind in thinking at a high level, and lack of internet access, infrastructure, motivation, traditional learning methods and resources, are some of the problems facing both students and teachers in learning biology (Jeronen et al., 2017; Limniou et al., 2018). Similarly, some of the factors affecting the metacognitive skills of students in senior high schools at Ternate city include memorization-oriented learning approach, lack of discovery activities, inability to formulate hypotheses, lack of basic experiments involving data collection and inability to analyze data and test hypotheses.

STAD learning in practice requires a long time, students who cannot work together in groups will be left behind from other students (Zubaidillah et al., 2016). The same thing was revealed by Motwani et al., (2022) that team competition-oriented STAD learning has an impact on low student learning outcomes. The teacher in carrying out the STAD model must play a more active role in class management, the group leader must be able to resolve conflicts constructively, because otherwise it will have an impact on less effective group work and students will be less active during discussions (Elpisah & Bin-Tahir, 2019). The guided inquiry learning model has the weakness of low achieving students having difficulty following the learning process because of limited initial knowledge and lack of discipline (Cahaya et al., 2020; Palupi et al., 2020; Putra et al., 2018). In contrast to inquiry which has the advantage of being able to make up for the lack of STAD, for example when teachers and students are both carrying out the learning process it can show increased motivation; students are motivated to learn, increase curiosity and creativity, teachers are motivated to help students to develop themselves (Zubaidillah et al., 2016).

The integration of STAD and guided inquiry learning models is intended to complement each other, specifically benefiting high school students by promoting the development of critical thinking and scientific work skills (Putra et al., 2018). The inquiry model is learning that is able to facilitate students to be able to observe, formulate problems, trace information, plan experiments, conduct experiments, use tools to collect data, analyze and interpret data, explain, predict, and communicate learning outcomes. Research Barcelona et al., (2023); Fitzgerald et al., (2019); Wale & Bishaw (2020) also revealed that Inquiry learning is a learning method that in principle invites students to actively ask questions and experiment independently during the learning process. The inquiry learning model is a learning activity that emphasizes the development of inquiry skills and habits of mind that enable learners to continue the search for knowledge (Maknun et al., 2022; Verawati et al., 2021). The inquiry-based learning model is considered more appropriate because the argument is directly integrated with inquiry and scientific literacy activities (Cairns &

Areepattamannil, 2019; Probosari et al., 2022). Inquiry learning is a learning method that basically invites students to actively ask questions and experiment independently during the learning process. In the inquiry learning model, learners search for learning materials independently (Muvid et al., 2022; van Riesen et al., 2018).

The selection of high school students in Ternate as research objects in this research study is based on several reasons. First, metacognitive skills, which include the ability to think about the thinking process itself, are very important skills in 21st century learning. This ability helps students to better understand how to learn on their own, organise strategies in solving problems, and improve learning outcomes, especially in complex subjects such as biology in high schools in Ternate. Secondly, Ternate has cultural diversity and unique geographical conditions, which may influence educational approaches. These conditions allow the research to identify whether certain learning models, such as biology learning, can be adapted or customised to local characteristics to improve students' metacognitive skills. Given the importance of biology in the national curriculum, as well as its link to the development of science and technology, this research becomes even more relevant in the local context, where improving the quality of education is a priority.

Furthermore, there are not many studies that specifically review the effect of biology learning models on students' metacognitive skills in the Ternate region. This suggests a research gap that needs to be filled in order to gain a deeper understanding of how effective learning strategies can be implemented to maximise students' potential in the area. Therefore, this research is not only important in an academic context, but also has practical implications for the development of educational policies that can improve the quality of learning in Ternate and similar regions. Based on this background, the purpose of this study was to find out the effect combining the STAD and guided inquiry learning models on the metacognitive skills of Senior High School students at Ternate, Indonesia.

METHODS

The method used in this study was quasi-experimental (Campbell & Stanley, 1963). The quasi experimental design was employed in this study with the aim of comparing the effects different learing methods on students' metacognitive skills. The experimental class will be treated by giving a pre-test (test at the beginning of learning) and post-test (test at the end of learning) to test students› metacognitive skills.

This research design allows the researcher to observe and compare changes in metacognitive skills within the experimental group over time. The use of pre-tests and post-tests helps in assessing the effectiveness of the combined STAD and guided inquiry learning models in enhancing students› metacognitive abilities. It›s important to note that quasi-experimental designs have limitations, such as potential confounding variables and issues with internal validity. However, they are valuable when true randomization is not feasible or practical in educational research settings. The findings from this study could contribute valuable insights into the impact of instructional methods on metacognitive skills in the context of Senior High School education in Ternate, Indonesia. The research designs are presented in Table 1.

Table 1. Quasi Experiment Design for Pre-test, Post-test and Control Group

Pretest	Control Group	Posttest
O1	X1	O2
O3	X2	O4
O5	X3	O6
O7	X4	O8

The study sample were determined through purposive sampling technique, from Class XI students of State Senior High Schools 3, 6 and 10 in Ternate City, Indonesia, selected based on the results of the class equality test. In addition, the sample were active students in the even semester, which 92 in total. Among these students, 20 studied biology through the STAD learning model, 22 with guided inquiry, 25 students used a combination of both methods while another 25 used the conventional learning models. The metacognition skills were measured using rubrics integrated with test questions. The test questions used in this study are in the form of a description question test (easay). The data were recorded using a rubric which refers to the conversion of the metacognition skills scores.

The data analysis technique used in this study consists of data prerequisite tests and hypothesis tests. The data prerequisite test consists of data normality test and data homogeneity test. The hypothesis test used in this study is the ANACOVA test. This test is used to test differences between groups by taking into account the influence of other variables (covariates) that can affect the results of metacognitive

skills between treatment groups (STAD, guided inquiry, combination, and conventional). If the ANACOVA test analysis results show that there are significant differences between groups, it will be followed by the Least Significant Difference (LSD) test to help determine which groups are significantly different from each other. This was followed by the Least Significant Difference (LSD) test using the SPSS software version 23.

RESULTS AND DISCUSSION

Table 1. Data Normality Test

Data	Value	N	Kol-mogorov-Smirnov	De-scrip-tion
Meta-cognition skills	Pretest	92	0.075	Normal
	Post-test	92	0.077	Normal

Based on Table 1, it can be seen that the Kolmogorov-Smirnov value for the pretest class is 0.075 > 0.05, and for the post-test class is 0.077 > 0.05. Therefore, in accordance with the basis for decision making in the Kolmogorov-Smirnov normality test, it can be concluded that the data has a normal distribution.

Table 2. Data Homogenity Test

Data	Value	N	Levene Statis-tics	Description
Meta-cogni-tion skills	Pretest	92	2.627	Homoge-neous
	Post-tes	92	1.635	Homoge-neous

Based on Table 2, it is known that the Levene Statistics value for students' metacognition ability in the pretest class is 2.627 > 0.05 and in the post-test class it is 1.635 > 0.05. Therefore, in accordance with the basis for decision making in the data homogeneity test, it can be concluded that the variance of the pretest and post-test data is the same or homogeneous. Based on the ANACOVA test results, the STAD learning model, guided inquiry, as well as the combination of both, have an influence on students' metacognitive skills. This information is presented in Table 3. Considering the fact that the F count = 9.317, at 1% significance level, then Ho is rejected. This means that the STAD learning model, guided inquiry, as well as the combination of both influences the students' metacognitive skills. Then, the test of LSD follow-up test conducted to compare the potential of each learning model in empowering students' metacognitive skills, is shown in Table 4.

Based on the results in Table 4, the use of STAD, guided inquiry, and the combination of both models improved metacognitive skills of the students compared with the conventional methods. Among the three models applied, the combination of STAD with guided inquiry showed the highest potential in improving students' metacognitive skills. However, STAD and guided inquiry showed the same potential in improving students' metacognitive skills. In addition, the conventional learning methods increased the students' metacognitive skills, but with lower values compared to the three cooperative learning mo-

Table 3. ANACOVA summary on the influence of learning models towards metacognitive skills of students in Ternate Senior High School in biology learning

Sources of Diversity	JK	dB	KT	Fcount	Significance
Corrected Model	4406.705	4	1101.676	33.859	.000
Interception	5002.123	1	5002.123	153.736	.000
Metacognitive Skills	413.719	1	413.719	12.715	.001
Learning model	909.446	3	303.149	9.317	.000
Error	2570.438	79	32.537		
Total	540744.000	84			
Corrected Total	6977.143	83			

Table 4. A summary of LSD's follow up test on the influence of the learning model towards students' metacognitive skills

Learning strategies	MS Average (Pre-test = X)	MS Average (Post-test = Y)	Difference	MS Cor-rected	LSD No-tation
1 = STAD and Inquiry	44.1667	87.4167	43.2500	84.968	A
2 = Inquiry	40.9048	81.6190	40.7142	80.661	B
3 = STAD	38.1053	79.6316	41.5263	79.954	B
4 = Conventional	30.8500	68.5500	37.7000	72.189	C

dels applied. The general results are presented in Figure 1.

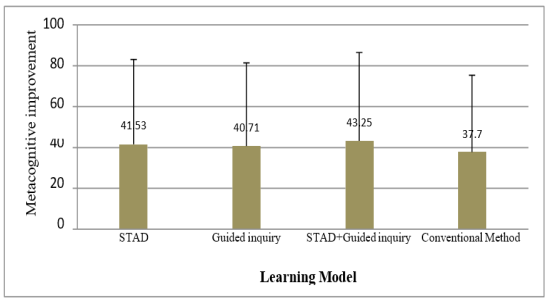

Figure 1. Difference in students' metacognitive skills improvement

Based on the results, the individual responsibilities within the group impacted on the performance of all team members. Students contribute to their team by improving their performances from previous investigative activities. This method ensure that students with high, medium and low achievements collaborate on problem solving, and the contribution of all team members rated according to their performance. With the collaborative activities in groups while studying biology using STAD and guided inquiry, the students' metacognitive skills improved. However, it does not improve to the maximum when teachers fail to guide the students' learning process well.

Considering the three cooperative learning models applied in teaching biology, STAD combined with guided inquiry showed the best potential in improving students' metacognitive skills. Thus, having the syntax of both models integrated in the worksheet, students could correctly understand the stages on how to formulate hypotheses, collaborate to find answers and analyze it, therefore empowering their metacognitive abilities. These findings are relevant to the results of the study by Sokołowska (2018); Palupi et al., (2020); Wen et al., (2023) guided inquiry-based learning produces excellent outcomes and metacognitive abilities in a short time. Also, teaching biology based on inquiry method, according to Frisch et al. (2018), Darmawan et al., (2020), Handayani et al., (2023) improved students' ability to think metacognitively. Additionally, this model indicated a strong positive predictor for students' achievement, and its influence is also positively related to their interests, as well as empowering the metacognitive abilities (In'am et al., 2021; Kang & Keinonen, 2018; Syahmani et al., 2023), positive accomplishment emotions should encourage the employment of innovative learning techniques, metacognitive thinking, and a greater desire to study (Chero, 2023; Feraco et al., 2023).

Other research findings related to cooperative learning influences students' level of interest and understanding in biology (Rabgay, 2018). The use of cooperative learning models, showed better metacognitive skills in students studying biology (Budiman & Marianti, 2020; Chang et al., 2020; Siswati & Corebima, 2017). Biology learning with a cooperative inquiry model empowers students in complex scientific practices in the laboratory (Hossain et al., 2018; Strat et al., 2023). According to Syahmani et al., (2023) and Yen et al. (2018), students with good basic skills rapidly develop metacognitive abilities. These skills are set of organized self-instruction for monitoring and controlling other cognitive activities in teaching and learning activities, with the use of cooperative learning models (Chero, 2023; Mahmoodi et al., 2014). Furthermore, children's metacognitive development in learning new concepts are rapidly developed through collaborative learning (Smortchkova & Shea, 2020; Werdiningsih et al., 2022).

In summary, STAD and inquiry guided cooperative learning, using worksheets, serve as a guideline for groups. The teacher guides the discussion to help students understand the biological concepts, thereby arriving at the desired results. All students in the group are given responsibility, then the teacher evaluates each individual to assess the progress of their learning. According to Darmuki et al., (2023) collaborative learning is a tool for achieving meaningful results in inquiry-based projects. Moreover, the use of cooperative learning models enhance students' metacoginitive abilities, which involved simple way of guiding students to read collaboratively through tutor-friendly means in their study groups (Feraco et al., 2023; Soodla et al., 2017; Matsuda et al., 2020; Werdiningsih et al., 2022).

The integration of these learning models is an important strategy teachers used to assist students in improving their cognitive, affective, psychomotor and reflective thinking (Chen et al., 2019; Van Velzen, 2015; Wu et al., 2022). Furthermore, students guided in this structured manner positively impact their metacognitive abilities (Çakiroğlu & Er, 2020; Chero, 2023; Feraco et al., 2023). Also, inquiry-based cooperative learning activates the participation mechanism in science and could be combined with other models in discussing the key topics of a subject (Darmuki et al., 2023).

The novelty of this study lies in the finding

that both the STAD learning model, guided inquiry, and the combination of the two significantly affect students' metacognitive skills. This research provides a new perspective by examining the effectiveness of combining two pedagogical approaches that are rarely discussed together in the context of improving metacognitive skills. The results suggest that the integration of a cooperative learning model such as STAD with a more exploratory approach such as guided inquiry can create a more optimal learning environment to develop students' ability to think reflectively and manage their learning process. In addition, this study offers empirical evidence that different learning methods can have complementary impacts, thus providing new guidance for the development of more effective learning strategies to improve higher cognitive skills such as metacognition. The findings expand insights in education, particularly in designing adaptive learning that focuses on students' critical and reflective thinking skills.

The results of the research by Yusnaeni et al. (2017) reported that the implementation of different learning treatments had a significant effect and had an effect size value with a high interpretation towards the achievement of students' conception of evolutionary learning material. Asiksoy & Özdamli (2016) also reported that student-centered learning approaches had a greater effect and size effect than the teacher-centered learning approaches on the improvement of students' understanding of science space concept. The research by Anwar et al. (2019), Supratman et al. (2021) reported that there was a difference in the effect size value of two different learning models on the achievement of temperature and heat concept mastery, critical thinking and creative thinking of senior high school students. Another research on character conducted by Jamaluddin et al. (2021) reports that student character development is influenced by local values of an area. Prayitno et al. (2017) which report that a combination of different learning models can improve students' critical thinking skills of biologi students.

The limitations of this study mainly lie in controlling variables that affect students' overall metacognitive skills. In some cases, external factors such as differences in students' academic background and learning motivation that were not adequately measured may affect the results of the study. In addition, the duration of implementation of the STAD learning model, guided inquiry, and the combination of both may not be sufficient to observe the full development of students' metacognitive skills. The use of more comprehensive measurement instruments and stronger validation of metacognitive measurement tools are also challenges in ensuring the accuracy of the results. For future directions, this research can be expanded by using a longer experimental design to provide more time for students to develop their metacognitive skills more deeply. Future research can also integrate technology-based learning techniques that can facilitate metacognition improvement through digital platforms. In addition, a triangulation approach, which combines quantitative and qualitative data to get a richer picture of students' learning process.

CONCLUSION

The conclusion of this study is that the learning model applied has an effect on metacognition skills. The combination of STAD and guided inquiry learning models showed the highest achievement of metacognition skills compared to guided inquiry, STAD, and conventional learning models. However, the STAD and guided inquiry learning models show the effect of metacognition values that are not significantly different. The conclusion that can be drawn from this research is that the right biology learning model has a significant influence on the development of metacognitive skills of high school students. Metacognitive skills, which include the ability to plan, monitor and evaluate thinking processes, are essential to help students become independent learners and more effective in understanding and applying biological concepts. Traditional learning models that focus more on memorisation tend to undermine the development of these skills. In contrast, the more innovative learning models in this study such as STAD, guided inquiry, and combined STAD and guided inquiry may be more effective in encouraging students to think critically and reflectively, so that they can better develop metacognitive skills. Thus, using the right learning model can improve the quality of students' learning process as well as more meaningful learning outcomes, especially in biology subjects.

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