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Improving critical thinking and metacognitive skills through the discovery learning model assisted by practicum for high school students

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ABSTRACT

Metacognitive abilities and critical thinking support the success of learning biology, so these skills need to be empowered. The purpose of this study is to determine the effectiveness of the practicum-based discovery learning model to improve critical and metacognitive thinking skills in digestive system material. The research method is a quasi-experimental research with a one-grub pretest-posttest design. The research was conducted from November to December 2022 at SMA Negeri 9. The research was carried out from November to December 2022 at one of the high schools in Mataram City. The research population was 98 students of class XI Science. The research sampling technique is a purposive sampling technique. The data collection technique used a test technique, namely 9 critical thinking essay questions and MAI. The instruments used in this study were the ability to think critically about the digestive system with several questions and the MAI instrument. The data analysis technique uses inferential statistics using the Paired Sample T-Test Assisted by SPSS IBM 27 software. The results of the study show that with an alpha of 5%, the practicum-based discovery learning model is effective for increasing critical thinking skills and metacognitive abilities. The average pre-test of critical thinking skills on the digestive system material was 54.0333 and the post-test was 75.8667. While the average pre-test of metacognitive abilities is 73.37 and the post-test of metacognitive abilities is 76.93 The application of the practicum-based discovery learning model effectively improves students' critical thinking and metacognitive skills with an alpha significance level of 5%.

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INTRODUCTION

Biology learning is learning related to the process of solving problems and deep thinking skills to understand them. Biology learning provides meaningful learning to students and is oriented towards science processes. To support this, various capital and student skills are needed, one of which is critical thinking skills (Palennari, 2012). In addition, there are several competencies that must be possessed by students such as higher thinking skills, critical thinking, creative thinking, metacognitive, collaborative skills, communication, and being a reliable problem solver (Listiana, Daesusi, & Soemantri, 2019).

Metacognitive is the ability to think, which is related to the process of thinking on oneself (Jaleel & Premachandran, 2016; Siagan, Saragih, & Sinaga, 2019). Metacognitive knowledge, awareness, and control over the cognitive processes that occur in oneself (Rizkiani & Septian, 2019). Metacognitive ability is an important factor in cognitive processes (Sudirtha, Widiana, & Adijaya, 2022). Empowering metacognitive abilities not only makes students more reflective, but students can understand each individual's learning strategies (Jaleel & Premachandran, 2016). Learning with a metacognitive ability approach is learning that instills awareness of how to design, monitor, and control what students do (Triana, Azis, & Irvan, 2021). Students who have good metacognition development will be better able to solve problems, make decisions and think critically, be more motivated to learn, be better able to regulate emotions, and be better able to overcome difficulties (Malahayati, Corebima, & Zubaidah, 2015).

Improvement of critical thinking skills in the learning process is one way to improve student learning outcomes (Malahayati et al., 2015). Critical thinking in biology learning has a very large role in improving processes and learning outcomes for future provision (Rahman, 2018). Students who have critical thinking skills are able to ask the right questions, provide effective and efficient information, have reasonable, creative reasons, be able to solve problems, make decisions, and have consistent conclusions(Bustami, Syafruddin, & Afriani, 2018).

Research result Li (2022) shows that critical thinking skills are still low. In line with the research results Fikriyati, Agustini, & Suyatno (2022) that the relationship between critical thinking disposition and critical thinking skills of prospective science teachers is 0.735 or relatively low. Biology students' critical thinking is low due to less-than-optimal strategies, models, methods, and learning processes (Bustami et al., 2018). Research result Agnafia (2019) shows that students' critical thinking abilities in the explanation indicator are 72%, the interpretation indicator is 63%, the analysis indicator is 31%, the self-regulation indicator is 51%, the evaluation indicator is 46%, and the inference indicator is 62%. Several previous research results show that students' critical thinking abilities in Indonesia are still relatively low. Apart from that, critical thinking skills are related to abilities

Metacognitive ability is one of the main contributors to students' academic success, because this ability is related to a person's cognitive activities regarding thought processes so that learning is more effective and efficient and improves student learning outcomes (Panggayuh, 2017; Sukarelawan, Jumadi, Kuswanto, & Thohir, 2021; Sukarelawan, Jumadi, Kuswanto, Soeharto, & Hikmah, 2021; Zakiah, 2020). Research conducted by Rumahlatu & Sangur (2019) in high school students shows that metacognitive skills are still relatively low. Research by Suryaningtyas & Setyaningrum (2020) shows that high school students in science learning do not use metacognitive abilities optimally when solving problems. The results of other research also show that metacognitive skills in university students are relatively low (Adiansyah, Corebima, Zubaidah, & Rohman, 2021).

Several previous research results show that the critical thinking and metacognitive abilities of middle school to university students are still relatively low. However, critical thinking and metacognitive skills are important abilities in 21st Century learning because they support the learning process. According to Dari & Ahmad (2020) and Nurfadillah, Cahyana, & Putra (2022) that learning methods and approaches can be one of the causes for optimizing students' critical thinking and metacognitive abilities. The low critical thinking and metacognitive abilities of students can be caused by a lack of teacher variation in using learning methods. The learning process tends to be monotonous, causing students to get bored easily and not focus on learning, especially since learning requires more concentration (Dari & Ahmad, 2020; Taufik, 2021). In this case, the teaching and learning process needs to implement a learning model that can attract students' interest and curiosity about the subject. The teacher's role is very important to determine the most appropriate method with systematic steps to arouse students' enthusiasm for learning (Nurfadillah et al., 2022).

In line with the results of observations in one of the high schools in Mataram City of class Biology

teachers have tried to create varied learning so that learning is not centered on the teacher. Even though the teacher has provided variations in learning, students are still less active and tend to be passive and even lack enthusiasm. Of the various variations of learning provided by teachers, students tend to be enthusiastic when learning is carried out outside the classroom, for example practicum. Practicum on human system material can be carried out on several materials, for example if in the 2013 class XI curriculum the digestive system material is basic competency 3.7 and 4.7. According to Umar, Baturante, Rahman, & Ahmar (2023) Practical activities are an important part of learning to provide concrete understanding and proof of the theory being studied. However, in schools the use of laboratories as practical places is not optimal, because schools have only had laboratories since the last 2 years. Several facts found from observations and interviews with teachers show that students are still less interested in learning so students tend to be passive. The results of previous research show that several causes of low critical thinking and metacognitive abilities, one of which is the use of learning methods and models. Empowering metacognitive skills and critical thinking abilities from an early age is a challenge for teaching staff, an understanding of the importance of metacognitive skills and critical thinking is needed (Nurfadillah et al., 2022). Empowering students' critical thinking and metacognitive abilities can be done by implementing learning models that can stimulate higher level thinking abilities, one of which is the Discovery Learning learning model.

The application of practicum-based Discovery Learning develops students actively by finding out for themselves and solving the problems they face by providing direct experience. Practical methods can be used so that students have the opportunity to test the theories they obtain with experimental activities (Amazida, Rahmi, & Azzarkasyi, 2021). Implementation of this learning model makes students learn to think analytically and try to solve their own problems (Susanti et al., 2020). Syamsu (2020) said that this model can help students develop critical thinking skills and discover concepts and principles from material. This learning model refers to mastering knowledge for oneself that is obtained through the process of searching, processing, tracing and investigating (Masitoh, Suganda, & Widiantie, 2019). In the research learning scenario the process through the process of searching, processing, tracing and investigating is designed through practicum activities. Through practical activities, it is hoped that students will gain an understanding of a concept that is initially abstract to concrete (Umar et al., 2023). In a learning scenario like this, students will also learn to think critically, analyze and try to solve the problems they face. This fact is also in line with the results of research on the application of effective discovery learning models to improve critical thinking skills (Safitri & Mediatati, 2021; Setyawan & Kristanti, 2021) and metacognitive skills (Rangkuti, Albina, & Masito, 2022).

Metacognitive abilities and critical thinking support the success of learning biology, so these skills need to be empowered. It is necessary to implement an appropriate model that can and as needed increase the efficiency and effectiveness of the learning process (Kusumaningtias, Zubaidah, & Indriwati, 2013). Improving the quality of learning biology can be done by improving the learning model used by teachers in teaching (Kusumaningtias et al., 2013). Based on the descriptions presented, research is needed that can empower high school students critical thinking and metacognitive abilities in biology learning. So that the purpose of this study is to the effectiveness of the discovery learning model based on practicum activities to improve critical thinking and metacognitive abilities of class XI students in the digestive system material.

METHODS

Research Design

The research method is a quasi-experimental study with a one group pretest-posttest design (Table 1). The research was carried out at one of the State High Schools in Mataram City, West Nusa Tenggara, Indonesia.

Table 1.
Experimental Research Design

Pre-test	Treatment	Post-test
Y1	V	Y2

Information
Y1 : Pre-test critical thinking skills and metacognitive abilities
V : Application of practicum-based discovery learning
Y2 : Post-test of critical thinking skills and metacognitive abilities

Population and Samples

The study population was 98 students of class XI IPA which were divided into 3 classes at SMAN 9 Mataram. The research sample was 30 students of class XI IPA 1. The research sampling technique was purposive sampling technique. The research population was 98 class XI Science students divided into 3 classes in one of the State High Schools in Mataram City. The research sample was 30 students of class XI Science 1. The research sampling technique was purposive sampling technique. The criteria for sampling were classes that had an average score below the minimum criteria completeness score, namely 75 and classes that had relatively little enthusiasm for learning or the majority of students were passive based on the results of interviews and recommendations with teachers. So, apart from research, determining the classes included in this sample is also based on recommendations from teachers.

Instrument

The instrument used in this research was a critical thinking ability instrument on digestive system material with a total of 9 questions (Table 1). The critical thinking question instrument was developed by researchers and a limited trial of the research instrument has been carried out. Test the validity of the critical thinking instrument using Pearson product moment correlation and reliability with Crobach's alpha because it is in the form of essay questions assisted by IBM SPSS 27 software. Of the 10 questions prepared, there were 9 valid items. Valid questions have a degree of reliability of 0.906 or a high degree of reliability (Yusup, 2018). Furthermore, to measure students' metacognitive abilities using the MAI instrument which was adapted by Schraw & Dennison (1994) totaling 40 question items (Table 2).

Table 2.
Indicators of the human digestive system critical thinking instrument

No	Critical thinking indicator	Number of questions
1.	Answer questions that require explanation	2
2.	argument	2
3.	Evaluate	1
4.	Defining an Action	1
5.	Think induction	1
6.	Think deduction	1
7.	Analyze the results of observations	1

Table 3.
MAI instrument indicator

No	MAI indicator	Number of questions
1.	Declarative knowledge	3 questions
2.	Procedural knowledge	4 questions
3.	Conditional knowledge	4 questions
4.	Planing	8 questions
5.	Information management strategies	8 questions
6.	Monitoring	6 questions
7.	Debugging strategies	3 questions
8.	Evaluating	4 questions

Procedure

The research procedure begins with observing the target school, preparing learning materials for the digestive system using the discovery learning model, preparing research instruments to measure critical and metacognitive thinking skills, pre-testing, applying a learning model that integrates practicum activities on nutrition and post-test, finally processing the data according to the method used. Learning with a practicum-based discovery learning model is carried out in one learning competency, namely the digestive system material. Digestive system material is carried out in 4 meetings with food substance practicum activities (Figure 1).

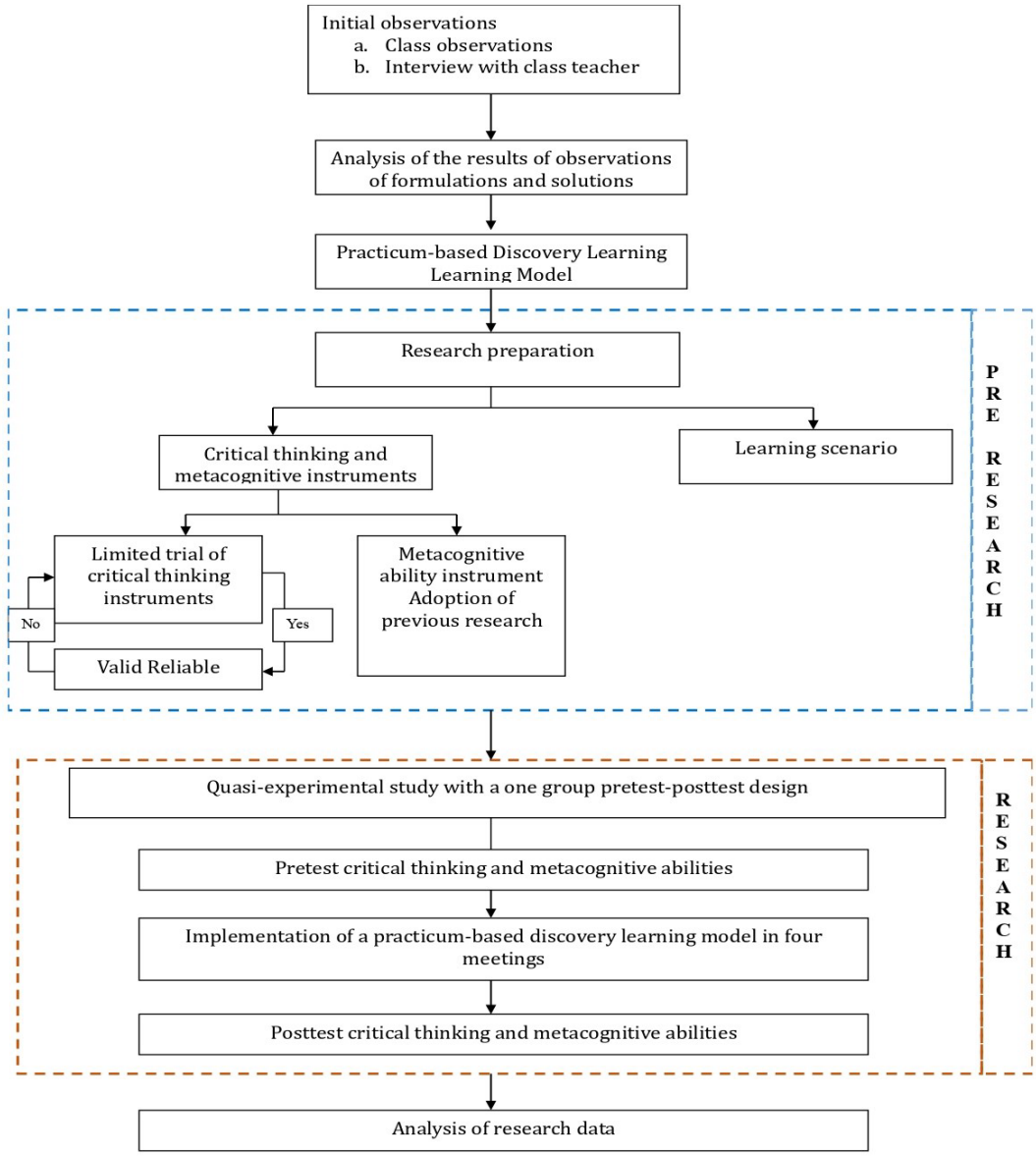

Figure 1.Research procedure

Data Analysis Techniques

Data analysis techniques using inferential statistics using the Paired Sample T-Test Assisted by IBM SPSS 27 software for windows. The basis for decision-making on the T-test sig. (2-tailed) < 0.05 means that H0 is rejected or Ha is accepted and the sig. (2-tailed) > 0.05 means that H0 is accepted or Ha is rejected. Test the validity of the items using the Pearson product-moment correlation test, the basis for making a decision is the sig value. (2-tailed) < 0.05 items question items declared valid while the sig. (2-tailed) > 0.05 question items declared invalid. Lastly, the reliability test used alpha cronbach with the help of IBM SPSS 27 software for windows.

RESULTS AND DISCUSSION

The learning scenario used in this research is applying a practicum-based discovery learning model in class XI on digestive system material. Learning is carried out over four meetings to complete one learning scenario. The first meeting is the syntax of the discovery learning model 1) providing stimulus to students and 2) identifying problems. Next, the second meeting was the syntax of the discovery learning model, namely data collection. The third meeting is 1) data processing and 2) verification. Lastly is generalization. Discovery learning is carried out in classrooms and laboratories to carry out practical activities, namely data collection.

Critical Thinking Ability

The research results in Table 4 show that the average pretest critical thinking ability of the class Furthermore, the average posttest score for students' critical thinking abilities after implementing the practicum-based discovery learning model on the digestive system material was 75.8667. This shows that there is a difference in the average value of students' critical thinking abilities before and after implementing the practicum-based discovery learning model on the digestive system material.

Table 4.
Paired samples statistics critical thinking

		Mean	N	Std. Deviation	Std. Error Mean
Pair 1	Results pre-test	54.0333	30	24.06813	4.39422
	Results post-test	75.8667	30	6.67333	1.21838

In line with the pretest and post-test averages in Table 4, the results of the T-test for critical thinking abilities have a sig value (2-tailed) for critical thinking abilities of 0.000 < 0.05 (Table 5). This shows that there is a significant influence of the application of the practicum-based discovery learning model on the digestive system material on the critical thinking abilities of the class on the digestive system.

Table 5.
Paired samples test critical thinking

	Paired Differences					t	df	Sig. (2-tailed)
	Mean	Std. Deviation	Std. Error Mean	95% Confidence Interval of the Difference				
				Lower	Upper			
Pre-post test critical thinking	-2.183.333	2.709.890	494.756	-3.195.223	-1.171.444	-4.413	29	.000

Metacognitive Ability

The research results in Table 6 show that the average pretest metacognitive ability of students on the digestive system material is 73.37. Furthermore, the average posttest score for students' metacognitive abilities after implementing the practicum-based discovery learning model on digestive system material was 76.93. This shows that there is a difference in the average value of students' metacognitive abilities before and after implementing the practicum-based discovery learning model on the digestive system material.

Table 6.
Paired samples statistics metacognition

		Mean	N	Std. Deviation	Std. Error Mean
Pair 1	Pre Test metacognition	73.37	30	5.951	1.086
	Post Test metacognition	76.93	30	6.011	1.097

In line with the pretest and posttest averages in Table 5, the results of the T test for students' metacognitive abilities have a sig value (2-tailed) for metacognitive abilities of 0.002 < 0.05 (Table 6). This shows that there is a significant influence of the application of the practicum-based discovery learning model on the digestive system material on the metacognitive abilities of class digestive system.

Critical Thinking Ability

Critical thinking skills include scientific thinking processes such as recognizing and describing a problem, gathering information to better understand the problem, assessing scenarios related to the problem, providing feasible solutions to the problem at hand, and evaluating recommended solutions. (Alharbi, Elfeky, & Ahmed, 2022). The research results in Table 4 and Table 5 show that the application of the practicum-based discovery learning model is effective in improving students' critical thinking skills. This shows that the practicum-based discovery learning model is effective for improving critical thinking skills on digestive system material. The discovery learning learning model can help improve critical thinking skills, this learning model helps students strengthen their self-concept, encourages student involvement in learning, and trains students to learn independently (Dari & Ahmad, 2020). The

application of practicum-based discovery learning guides students to build their knowledge independently. This learning model prioritizes student activities to develop knowledge integrally through teacher guidance and peer groups (Ristanto, Ahmad, & Komala, 2022). The application of the discovery learning model involves the process of observing, explaining, grouping and making conclusions (Nurrohmi, Utaya, & Utomo, 2017)

The findings in this research are in line with research results that the application of the Discovery Learning learning model can improve students' critical thinking abilities (Nugrahaeni, Wayan Redhana, & Made Arya Kartawan, 2017). Similar research by Rini, Sa'diyah, & Muhid (2021) that this learning model makes conditions in the classroom more interactive because students are required to actively find answers to the questions they encounter. The discovery learning model takes a big role in the concept of discovery which is the basis of the method for training students' critical thinking skills (Setiadi & Elmawati, 2019). This model encourages students to work independently or in groups to authentically construct information that originates from concrete problems in everyday life. This learning focuses on finding problems that originate from individual concrete experiences (Ananda, Haryanto, & Atmojo, 2022). This learning model provides students with the opportunity to be actively involved in learning (Simanjuntak & Silalahi, 2022)

Table 7.
Paired Samples Test Metacognition

	Paired Differences					T	Df	Sig. (2-Tailed)
	Mean	Std. Deviation	Std. Error Mean	95% Confidence Interval Of The Difference				
				Lower	Upper			
Pre test - post test metacognition	-3.567	5.716	1.044	-5.701	-1.432	-3.418	29	.002

Metacognitive Ability

Metacognitive abilities are important to support student learning processes (Wardana, Prihatini, & Hidayat, 2020). Jaafar & Ayub (2010) convey metacognitive abilities related to knowledge about abilities and strategies so that they have the potential to improve learning and student learning outcomes in class. The research results in Table 6 and Table 7 show that the application of the practicum-based discovery learning model is effective in improving metacognitive abilities. Someone who has high metacognitive skills becomes an independent person and can self-regulate in learning (Andriani et al., 2017). Several things cause this learning model to be able to train students' metacognitive abilities. The learning syntax using the discovery learning model prioritizes students to find their solutions. This fact is by the character of metacognitive abilities, namely students independently find a solution to a problem (Amanda, Haryani, Mahatmanti, & Marsini, 2020). Through practicum-based discovery learning, students can discover these concepts independently and strengthen biological concepts because they gain students' confidence to work together with others, thereby strengthening students' memories and training metacognitive abilities (Erianti & Miranda, 2020)

The findings of this research are in line with several previous studies. The results of research by Kuswara, Ekaningtias, Lume, & Nurmiati (2023) learning with discovery learning with learning activities such as conducting experiments, observing, designing, and analyzing as well as studying literature can improve students' learning activities and metacognitive skills. The discovery learning model has a positive effect on students' metacognitive skills (Triana et al., 2021). The Discovery learning model has a greater influence compared to conventional learning on students' metacognitive abilities (Saptarini, Dewi, Sukirman, & Santoso, 2022).

Apart from the research results which show that the application of the practicum-based discovery learning model is effective in improving critical thinking and metacognitive skills with an alpha of 5%, there are several limitations in this research. This research was carried out without a control class or used a quasi-experimental one-group pretest-posttest design. This is due to limited research time so that for further research we can carry out research with the control class so that we can see the effectiveness of implementing the learning model between the experimental and control

classes on students' critical thinking and metacognitive abilities. Even though this research was implemented without a control class, the application of the discovery learning model in research was based on practical activities. The control class for further research must apply a learning model that has the same potential to train students' critical thinking and metacognitive skills, but the learning model used has the same weight as discovery learning so that the control class is not left without treatment or is conventional. Lastly, this research is still being carried out in the 2013 curriculum, because at the time of the research in 2022 class IX is still using the 2013 curriculum so for research you can use the new curriculum, namely the independent curriculum.

CONCLUSION

In general, the research results show that the application of the discovery learning model assisted by practical activities on the human digestive system material is effective in improving students' critical thinking and metacognitive abilities with an alpha significance level of 5%. Regardless of the research results, this research was still carried out without a control class so that future researchers can carry out similar research with a control class. Finally, research on the application of the discovery learning model assisted by practical activities was carried out on the digestive system material, so that for further research or learning other material can be applied but it must be adapted to the characteristics of the material.

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