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Analysis of Classroom Action Research Studies: The Effectiveness of Inquiry Learning Models on Biology Education Undergraduate Students Problem Solving Ability

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Abstract: The ability to solve problems is a skill that students should have in the 21st century to support better life activities. Observations on learning activities found that students were still relatively passive in learning activities, lacked confidence in conveying ideas, lacked the motivation to learn, and had no more interaction between students during learning, which affected low problem-solving abilities. It is in line with the evidence obtained through the acquisition of pre-research data where the results of problem-solving abilities include indicators of understanding problems with an average score of 55.63, indicators of preparing a settlement plan with an average value of 43.78, indicators of implementing a settlement plan with an average value of 50.37, and the indicator checks back with an average value of 46.53. Low problem-solving abilities can impact the quality of life of students who are less able to compete for jobs in the future. Increasing student solving needs to be considered so that from these problems, it is necessary to conduct classroom action research using the inquiry learning model to improve student problem-solving abilities, where this model has learning steps in guiding students to study in a directed manner and be able to solve problems. The research sample was 21 undergraduate students in Biology Education program. They obtained data through student activity questionnaires, student responses to learning models, model teacher activity questionnaires, and the results of problem-solving skills through giving test questions in the form of essays. This classroom action research was conducted in 3 learning cycles, with an average score between cycle I of 45.96%, cycle II of 94.78%, and cycle III of 95.26%. The acquisition of the average value shows an increase in problem-solving results between cycles I and II, cycles I and III. Testing the effectiveness of the learning model was carried out by the N-Gain test of 86.63% with the interpretation of "effective," and the distribution of the N-Gain score of 0.86 was greater than g > 0.7 with the "high" category. Obtaining these data can be concluded that the inquiry learning model effectively improves students' problem-solving abilities.

Keywords: Action Research; Inquiry; Learning Models; Problem-Solving; Skills

Introduction

Life skills are needed, including the ability to solve problems. This problem-solving ability is very useful in everyday life, especially for students in their learning process of obtaining information. Respective abilities or capabilities can determine a person's quality of life as they manage life when faced with problems (Hwang & Ng, 2013; Lent & Brown, 2013; Ledesma, 2014; Hees et al., 2015). The existence of problems that are present in life makes a person with his subconscious have to act and find solutions to be able to solve them so that he is free from thought disturbances caused by problems (Ampuero et al., 2015; Hannula, 2015; Llera & Newman,

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2020) . as well as in the learning process faced by students by giving problems in it, making them look for solutions to new answers or findings through thought processes (Kirschner & Merriënboer, 2013; Valentim et al., 2017; Borge et al., 2018). The 21st century is significant for students to have problem-solving skills that are useful in supporting very complex life processes, especially in natural sciences and technology (Häkkinen et al., 2017; Hadinugrahaningsih et al., 2017). High thinking skills make it easier for students to solve problems with a structured and accurate pattern (Stupple et al., 2017; Isnaini & Mulyono, 2019). Learning that familiarizes students with problem-solving activities makes them accustomed to thinking broadly, quickly finding reference materials for solving problems, and can be responsive in solving problems (García et al., 2016; Pitkänen et al., 2020). In line with this, the task of lecturers or educators must be to familiarize their learning by giving authentic problems in each learning topic so that there are exciting things or new facts that they get, which are then used as a source of new knowledge, which is beneficial both now and in the future. Anyone can face obstacles in solving problems. However, with these obstacles, students can think again to devise a replacement plan/strategy for solving this, so with these activities, students are trained and can easily solve problems in the future very easily and skillfully. (Čadež & Kolar, 2015 ; Graesser et al., 2018) . Trained problem-solving skills make it easier for students to deal with complex or complex work by presenting logical solutions/ideas through quick thinking skills that are acceptable with common sense (O'Shea & Leavy, 2013), ready to accept challenges, easy to deal with, completion time can be faster than usual, and able to determine the outline of the objectives of the problem easily (Mao et al., 2016). Problem-solving is a series of work activities or actions examining what problems are encountered through investigations to obtain answers acceptable to the truth (Kale & Akcaoglu, 2020). Problem-solving is based on the clarity of important information generated based on students' actions in searching for answers (Bagassi & Macchi, 2020). Students must have problem-solving abilities to facilitate thinking and learning activities more effectively (Yulindar et al., 2018). Solving problems can be done in various ways, including making initial observations, compiling guiding questions, conducting experiments and collecting data, clarifying, and conducting evaluations. On the findings (Pedaste et al., 2015; Altaftazani et al., 2020; Wola et al., 2023). Problem-solving skills that are continuously trained make students have good skills in analyzing and managing information (Permata et al., 2022; Sapriyadin et al. ., 2023). Graduate students can easily overcome the difficulties expected to be experienced in the future because they are used to and can solve problems easily (Sanggara et al., 2018; Damayanti et al., 2021). Problem-solving abilities can be trained and improved through learning by emphasizing finding information or answers based on the problems given (Scherer & Beckmann, 2014; Walker et al., 2016; Kärner, 2017).

Based on observations made for three face-to-face meetings before conducting further research, it was found that students tended to be less focused on paying attention to speakers in front of the class, there was a lack of interaction between speakers and the audience, the focus was diverted from discussions outside the topic of discussion, debriefing was only carried out by approximately three students for each discussion session, and there was no development of questions or debate activities during the discussion. After making direct observations, the researcher proceeded to obtain initial data where the researcher wanted to find out more about the extent of problem-solving abilities possessed by students by providing test questions in the form of descriptions. The average results of the acquisition of problem-solving abilities from pre-research results for each indicator include understanding the problem with a score of 32.44, preparing a settlement plan with a score of 31.22, implementing a settlement plan with a score of 28.68, and checking again with a score of 27.55. If it is averaged, the total score of students' problem-solving abilities is 29.97. The findings through observation and pre-research indicate that students' problem-solving abilities still need to improve. It is caused by learning activities that are less innovative, less flexible, and do not optimally empower students' thinking abilities in learning activities. Low problem-solving abilities can be corrected or overcome by carrying out meaningful, varied, and student-centered learning activities with a learning focus on the problem-solving process by providing authentic problems that are appropriate to the learning activities at the time (Mahanal et al., 2022). Indicators of problem-solving ability, based on Polya, include "understanding the problem, developing a settlement plan, carrying out the settlement plan, and checking again."

Getting used to problem-solving activities needs to be presented through a learning process that is carried out in and outside the classroom, which is assisted by methods and strategies packaged in the learning model. Effective learning, students are enthusiastic about learning, motivated, creative, and critical are found in learning innovations designed with strategies and methods packaged in learning models. The learning model helps improve the quality of learning so that the goals to be achieved can be implemented where learning can be carried out collaboratively and then produced

together ideas (Mamahit et al., 2020). Learning models can help improve abilities or skills in the 21st century (Van Laar et al., 2017; Kawuwung et al., 2023), including problem-solving abilities that are still very important today for students (Tösten et al., 2017). Various existing and inquiry learning models can be used to improve student problem-solving (Gunawan et al., 2020; Pujani, 2022). The inquiry learning model is a learning activity that emphasizes the process of searching for an answer carefully, systematically, accurately, critically, and analytically so that the truth can be trusted in producing new theories (Andrini, 2016; Kawuwung & Kaunang, 2017; Nisyah et al., 2020). The inquiry learning process can be carried out independently or in groups, outside the classroom, or in discussions with groups so that these activities can lead to direct student activities (student-centered) in their learning activities in seeking and finding answers. (Sahyar & Nst, 2017 ; Margunayasa et al., 2019; Kawuwung, 2019) . The significance of conducting classroom action research is to improve the quality of learning continuously, improve teaching methods in terms of strategies, learning methods, and evaluation to achieve learning objectives and increase professionalism in teaching. Based on the initial studies, classroom action research can be done regarding applying inquiry learning models to improve students' problem-solving abilities.

Method

The type of research being conducted was classroom action research (CAR) to see and find out how far the inquiry learning model can improve problem-solving abilities in the "Student Development" course, which was conducted on Undergraduate Students in Biology Education, Universitas Negeri Manado with a total of 21 students. The research was carried out in 3 learning cycles by applying the steps of the inquiry learning model. The design flow in classroom action research can be seen in Figure 1.

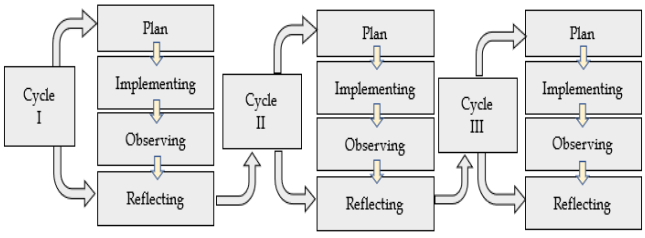

Figure 1 . Design Flow in Classroom Action Research

The implementation of the inquiry model learning syntax is carried out in all learning cycles (cycle I, cycle II, and cycle III) with pre- and post-learning activities consisting of initial planning before carrying out learning, implementing learning by applying the inquiry learning model syntax, and reflecting at the end. Learning instruments in this study included observation sheets of student learning activities using a Likert scale (equation I and Table 1), student response questionnaires using inquiry learning models, peer assessment sheets, essay questions, and scoring rubrics according to problem-solving indicators.

The results of this study are in the form of descriptive and statistical studies based on the instruments used in learning from cycles I, II, and III. Calculate the average value by calculating the total problem-solving ability and the average value of each problem-solving indicator in cycles I, II, and III. The acquisition data is continued through N-Gain calculations to determine the effectiveness of the inquiry model on problem-solving abilities. The formula for calculating the N-Gain value can be seen in equation (2), and the scoring of the N-Gain effectiveness test can be seen in Table 2.

$$= \frac{\sum Frequency\ of\ activity\ occurrence}{\sum total\ activity\ frequency} x100 \quad (1)$$

Table 1. Criteria for Scoring Student Learning Activities

Score (%)	Category
81–100	Very well
61–80	Good
41–60	Currently
21–40	Bad
0 – 20	Very bad

$$N - Gain \frac{posttest\ score - pretest\ score}{ideal\ score\ - pretest\ score} \quad (2)$$

Table 2. N-Gain Test Effectiveness Scoring Category

Category Interpretation of N-Gain Effectiveness	
Percentage %	Interpretation
< 40	Ineffective
40 – 50	Less effective
56-75	Effective enough
> 76	Effective
N-Gain Score Distribution	
N-Gain Value	Category
g > 0.7	Tall
0.3 ≤ g ≤ 0.7	Currently
g < 0.3	Low
g > 0.7	Tall

Results and Discussion

Data on Student Learning Activity Results

Student learning activities need to be considered so that there is a need to assess these activities to know the extent of the student learning process. The results of observations made by researchers showed an increase in

learning activities from cycle I to cycle II, cycle I to cycle III, and there was no significant increase in learning activity from cycle II to cycle III. The increase was insignificant between cycles II and III learning activities because the application of learning strategies, methods, and other supports was the same between cycles II and III and was different from the learning activities in cycle I. Assessment aspects of active learning cycle I 45.67, cycle II 90.75, cycle III 91.88, aspect of asking cycle I 48.78, cycle II 91.66, cycle III 92.26, aspect of responding to cycle I 37.66, cycle II 93.88, cycle III 94.76, aspect of confirmation cycle I 33.32, cycle II 93.76, cycle III 93.88, enthusiastic aspect of the cycle I 38.35, cycle II 94.76, cycle III 95.67, and reference aspects of the cycle I 45.55, cycle II 96.66, cycle III 96.78. The average student learning activity in cycle I for all aspects was 41.55 with the provisions of the Liker scale in the "moderate" category, while in cycle II, it was 93.47, cycle III was 94.20 with the conditions that the Liker scale was included in the "very good" category. Data on the results of student learning activities can be seen in Figure 2.

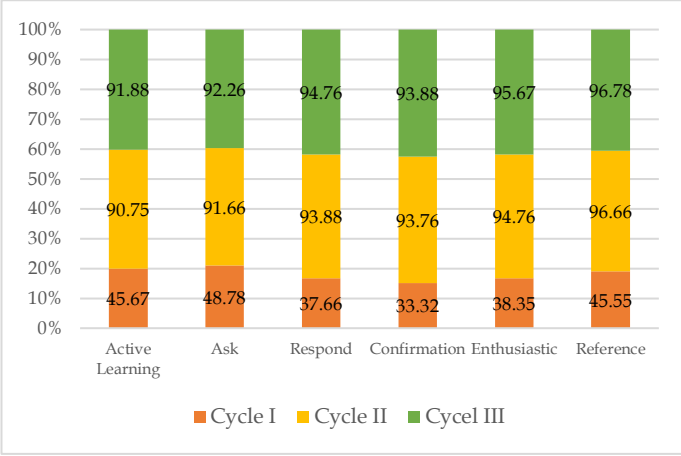

Figure 2 . Average Results of Student Learning Activities

Data on Student Response Results to the Learning Model

The inquiry learning model received a very positive response with the results through a student response questionnaire consisting of the main aspects and sub-aspects of the questionnaire, which were developed to describe learning activities. These aspects received a very good response, including with an average score, including aspects of Learning Innovation 4.83, aspects of learning materials, sources, and Media 4.66, aspects of time Management 4.33, aspects of learning Activities 4.83, aspects of class Management 4.83, aspects of giving task 4.16, and evaluation aspect 4.55. If the value of each aspect is averaged, a score of 4.59 is obtained, so it can be said that the student's response to the inquiry learning model is in the "very good" category. These results show that the inquiry learning model can be applied in subsequent lessons. Student response data can be seen in Figure 3.

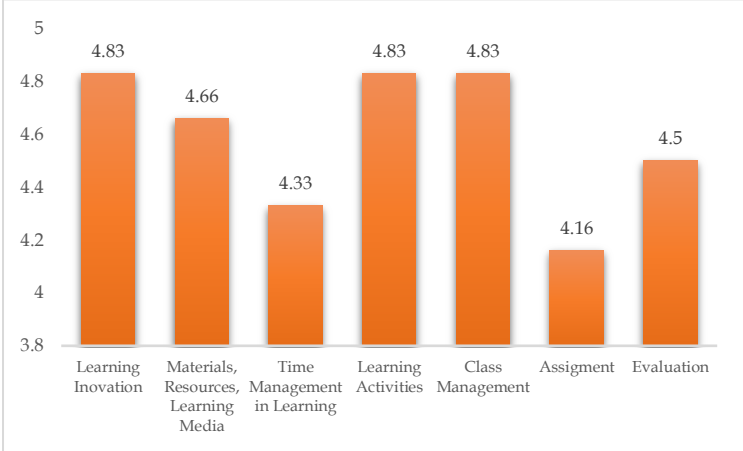

Figure 3. The Average Results of Student Responses to the Learning Model

Data on Student Problem-Solving Ability Results

Data results on students' problem-solving abilities with the average calculation in each cycle obtained: learning at cycle I at 45.96%, cycle II at 92.78%, and cycle III at 92.88%. The results of calculating the average need to be known for the number of differences between learning cycles. The differences obtained included cycle I to cycle II with a difference of 46.82%, cycle II to cycle III with a difference of 0.1%, and cycle I to cycle III with a difference of 46.92%. The overall average results of problem-solving abilities in cycles I, II, and III can be seen in Figure 4.

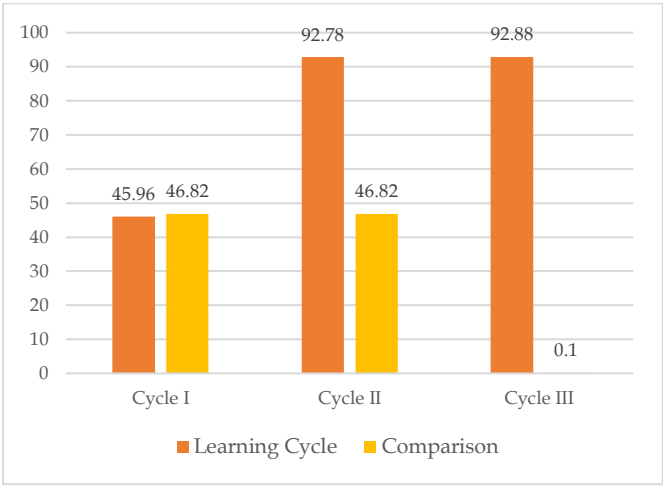

Figure 4. Average and Difference in Student Problem-Solving Ability

After testing the overall average of the problem-solving abilities of students in cycles I, II, and III, the researcher needs to describe each indicator of problem-solving ability to determine the extent to which students have improved in each indicator of problem-solving.

The average results per indicator include indicators of understanding the problem cycle I 49.95, cycle II 91.66, and cycle III 94.74, with the difference from cycle I to cycle II of 41.71, cycle II to cycle III 3.08, and cycle I to cycle III of 44.79. The indicators are planning the completion of Cycle I 42.95, cycle II 93.23, and Cycle III 95.44 with the difference from Cycle I to Cycle II 50.38, cycle II to Cycle III of 2.21, and Cycle I to Cycle III of 52.49. The indicator implementing the complete plan for the cycle I was 47.04, cycle II was 93.04, and cycle III was 94.84, with the difference from cycle I to cycle II of 46, cycle II to cycle III of 1.8, and cycle I to cycle III of 47.08. The indicators re-examine cycle I 43.9, cycle II 93.19, and cycle III 95.85 with the difference between cycle I to cycle II of 49.29, cycle II to cycle III of 2.66, and cycle I to cycle III of 51.95. Obtaining the average value per indicator of problem-solving ability in cycles I, II, and III experienced a significant increase between cycles I and II, cycles I and II, and not significantly between cycles II to cycle III, where this was due to the use of similarities Learning strategies in cycles II and III are different from cycle I, even though they apply the same learning model. The average results for each indicator of problem-solving in learning Cycle I, cycle II, and Cycle III can be seen in Figure 5.

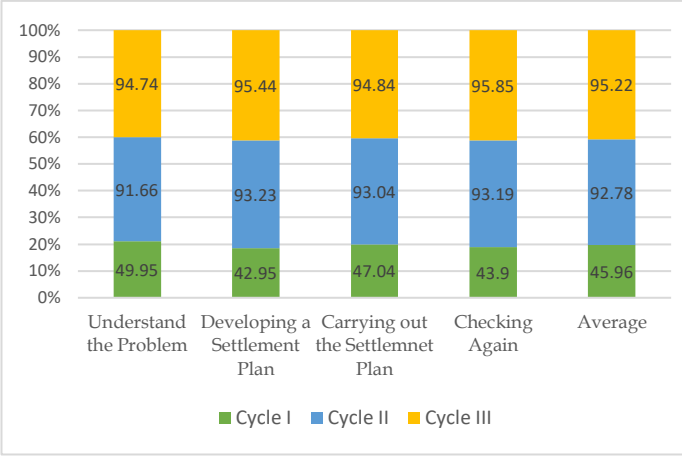

Figure 5. Average Student Problem-Solving Indicator

Inquiry Model Effectiveness Data with N-Gain Calculations

Obtaining data through N-Gain calculations shows the results, namely the effectiveness value of 86.63, with the interpretation of "effective" because the results of the acquisition value are above the provisioned value, namely> 76. The distribution of the N-Gain score obtained a score of 0.86 in the "high" category. The division value is more than the provision value, namely, g > 0.7. Through the results of these calculations, we concluded that the inquiry learning model is effective on students' problem-solving abilities. N-Gain calculation results data can be seen in Table 3.

Table 3. Category Effectiveness of N-Gain on Problem Solving

Category Effectiveness of N-Gain on Problem Solving		
Percentage (%)	Interpretation	Conclusion
< 40	Ineffective	86.6379% Category >76: "Effective"
40 – 50	Less effective	
56-75	Effective enough	
> 76	Effective	
Distribution of N-Gain Scores on Problem Solving		
N-Gain Value	Category	Conclusion
g > 0.7	Tall	0.86638% Category g > 0.7: "High"
0.3 ≤ g ≤ 0.7	Currently	
g < 0.3	Low	

Implementation of Learning Actions

Learning activities by applying the inquiry learning model are carried out in 3 learning cycles with learning stages using the inquiry model syntax. Before carrying out the learning, it is necessary to pay attention to the following matters, among other things, 1) Planning: preparing learning instruments to be used by lecturers and students, preparing learning scenarios, preparing learning resources and media, as well as evaluation tools used at the end of learning. Planning before learning activities are carried out is crucial for achieving learning steps, implementing learning activities, and effectively using media and learning resources (Nyoni, 2022). 2) Action: implementation of learning with the steps of the inquiry learning model. Learning activities need to apply learning models, especially the inquiry learning model, where this learning model has learning steps that can guide students to carry out learning activities well, directed, and motivated so that learning can take place according to the desired goals (Jalinus et al . al., 2019; Fathabadi, 2023). 3) Reflection: the activities of lecturers and students after learning is completed, where in this activity, the strengths and weaknesses will be identified in learning activities so that positive things can be maintained and deficiencies can be corrected in the next lesson. Reflection is critical at the end of learning to improve learning, see student potential, measure the extent to which learning models are applied, and evaluate all learning activities (Camus et al., 2021; Gani et al., 2022).

Learning activities in outline in 3 cycles are carried out with the same learning model, namely the inquiry model. Learning activities are different between cycle I and learning cycles II and III. The difference in the learning methods given results from carrying out reflection activities because the results of the acquisition of student problem-solving abilities are still low. These learning activities consist of the use of learning resources, presentation models carried out by students, as well as evaluation tools used by lecturers for students

to find out the final results of learning activities on students' problem-solving abilities.

The initial determination of cycle I learning is to use learning resources like teaching materials and the internet as a reference. After reflecting and conducting tests/exams with low results, it is known that in using internet learning resources, students only access information from Blogspot and Wikipedia, which are irrelevant as reference sources for learning. Hence, students experience misconceptions about theories that exist. Furthermore, information delivery activities are carried out by lecturing activities to small groups. The observation results show that students who receive information are less focused on the material being conveyed because the delivery process does not use the media as a tool. Evaluation activities are carried out by giving essay tests according to problem-solving indicators where the results obtained are still lacking and not following the learning objectives due to the factors previously described.

Based on the findings and results obtained in cycle I, remedial action was taken for subsequent learning, taking into account learning resources, presentation models, and evaluation tools. The improvements made to apply learning in cycles II and III are the same: learning resources in textbooks, reference books, renewable research articles, general references, and relevant sources that can be tested for validity. Learning activities are continued in cycle III to test the actions in the treatment of cycle II to determine whether the results of problem-solving abilities are the same or whether there are differences that increase or decrease. The addition of learning resources affects students' inquiry learning abilities and problem-solving abilities, and there are no misconceptions about the theories or concepts being studied. Furthermore, changes to the presentation model were carried out with lectures to small groups with the help of media in the form of posters. Conveying information using attractive posters made the group enthusiastic about discussing questions and answers. Observations on student discussion activities showed increased motivation in learning, being able to express opinions, and being more self-confident. There are additional forms of evaluation, including conducting 1) essay tests, by knowing how far the final results obtained by students on problem-solving abilities, 2) material resumes, making students study independently by recording essential things according to learning topics so that additional information they can increases and affects their learning outcomes, namely problem-solving abilities, and 3) peer assessment, assessment is carried out on students who make presentations so that it motivates them to study in depth the theory/concept of a learning topic and posters that are provided with an attractive display design. The results of these additions affect the increase in student problem-solving abilities.

Implementation of Inquiry Learning Model

Learning by applying the inquiry model is an activity/process/activity of independent or collaborative learning by seeking answers by observing, asking questions, and managing information to influence, develop, and enhance logical and systematic thinking abilities and activities (Nasir et al., 2015; Ulfa et al., 2022). Ideas, ideas, and motor skills in learning activities by applying the inquiry model can affect students' problem-solving abilities (Chen & Chen, 2021; Miftakhurrohmah et al., 2023). The stages of the inquiry learning model are orientation/observation, question/conceptualization, investigation, conclusion, and discussion. The implementation of the inquiry learning model is illustrated in the following learning stages.

1) The orientation/observation stage. Students determine or formulate problems based on group learning topics in this stage. Students are free to give their opinion regarding this matter. After obtaining the problem formulation, the group agrees to continue at the information search stage or find answers at the next learning stage. Training students to determine the formulation of the problem aims to motivate and empower minds at the beginning of learning, making it easier to carry out learning activities in the next phase (Milanto et al., 2023; Uludağ & Erkan, 2023). Formulating a problem is an attitude toward the ability to express reasonable ideas, ideas, and considerations (Pečiuliauskienė & Kaminskienė, 2022).

2) Question/conceptualize stage. The next stage is compiling guiding questions for the material to be studied, where this is done in group discussions. This stage is essential for students to explore to think in determining appropriate questions, and it is hoped that the questions will be prepared based on authentic problems of everyday life according to the learning topic. Arranging questions based on authentic problems can make it easier for students to explore their potential to develop problem-solving skills, making it easier to determine scenarios and how to get answers quickly and easily (Pérez-Álvarez et al., 2018; Steger & Kizilhan, 2022).

3) Investigation stage. This activity is carried out by investigating information based on questions previously made with the group. Investigative activities involve all aspects of thinking, providing ideas, using skills, and having a strategy to complete the investigative process correctly. Learning activities by relying on thoughts to solve problems and use skills can help students become

more skilled and accustomed to easy learning activities in obtaining information quickly and accurately (Hanafi et al., 2022). Significant authentic problems are given to students to practice thinking skills, provide ideas, ideas, and provide appropriate solutions (Shelton et al., 2021). The process of seeking answers is carried out in group discussions by combining various findings to form new information and is considered necessary in acceptance as a new learning resource. Information or answers obtained through investigative activities will be used as a source of knowledge to be conveyed to other groups.

4) Conclusion stage. The next stage is making overall conclusions related to the results of investigations related to problems that have obtained results or findings of answers to be used as new concepts that are acceptable and can be accounted for. This stage is carried out to avoid misconceptions about existing theories in building a new theory based on the investigation results. It is important to learn to verify before the information is forwarded to the recipient, where the information must be confirmed again to avoid misconceptions (Chavan & Patankar, 2018).

5) Discussion/sharing stage. After verifying the information's correctness, it is continued at the stage of conveying the findings to other groups through joint presentations and discussions. The findings are submitted through lectures and media assistance in the form of posters. Some differences can be seen during the presentation and discussion process, wherein the first cycle only conveys information in the form of lectures without the help of media presentations, reducing the attractiveness of new information. In contrast to cycles II and III, conveying information was carried out with the help of media posters developed by the entire group. Groups are freed in designing poster displays, making attractive displays, color designs, and layouts used as media for conveying information. Using posters in presentations makes students interested and highly motivated, influencing better learning activities (Khastini et al., 2021).

Dissimilarities in results on students' problem-solving abilities in cycles I, II, and III are influenced by the methods, styles, and learning innovations applied. Learning that is not optimal in the first cycle is highly considered for follow-up on the next cycle of learning to gain progress and increase student problem-solving abilities so that there is further or improved learning in scenarios and learning devices. Innovation in learning is very influential, so to be noted; hence the strategies, methods, and evaluation activities are prepared to achieve learning objectives very well (Moye et al., 2014; Rahman Ahmad et al., 2020).

Conclusion

The results of the study can be concluded that the calculation *of* the average comparison and calculation through N-Gain, the inquiry learning model is effective and can improve students' problem-solving abilities, where this can be seen from the learning outcomes from cycle I to cycle II, cycle II to cycle III and cycle I to cycle III. The use of inquiry learning models can be done in other learning to improve other skills possessed by students.

Author Contributions

Conceptualization, F.R.K. and J.A.M.; methodology, software, validation, F.R.K.; writing - original draft preparation, formal analysis, investigation, F.R.K and J.A.M; resources, F.R.K.; data curation, writing—review and editing, F.R.K and J.A.M.; visualization, J.A.M.; supervision, project administration, funding acquisition, F.R.K. All authors have read and agreed to the published version of the manuscript.

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Conflicts of Interest

The authors state no conflict of interest in conducting research and publishing this manuscript

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