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Guided inquiry laboratory to improve research skills of prospective biology teachers

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ABSTRACT

This study described guided-inquiry laboratory impact on increase in research skills of prospective biology teachers. Skill research indicators are designing, implementing, and reporting. This study was a non-equivalent control group design using experimental and control groups. Data were collected from 60 participants through observation of research skill indicators, namely designing, performing, and reporting then analyzed quantitatively-descriptively. The sample was selected using purposive sampling. The results confirmed that the guided-inquiry laboratory application has a more effective impact on improving research skills than ordinary learning. Each indicator of research skills (designing, performing, and reporting in the experimental class) meets the "Medium" category, while the "Low" category in the control class. This study concluded that the guided inquiry laboratory has a positive impact in improving the research skills of prospective biology teachers. This research provides a reference for teachers to explore the research abilities of their students.

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1. INTRODUCTION

Research skills are the demands of the Indonesian Curriculum (K-13). The essence of the curriculum states that learning should be research-based, discovery or inquiry learning [1]–[3], and problem solving to produce products [4]–[6]. In 2020, Maknun, Gloria, and Muzakki [7] stated that the mastery level of preservice biology teachers research skills in designing, implementing, and reporting is still low category. This finding is in line with the findings of Leonard [8] that about 90% of teachers did not conduct research and publications. Therefore, improving research skills is very important to solve learning problems, especially for prospective biology teachers. However, creative efforts are required to facilitate learning. As a result, the research abilities of preservice teachers have improved.

One of the learning facilities to stimulate research ability is the guided-inquiry laboratory. This learning type that maximally involves all students' abilities to look for and investigate something (objects, humans, and events) systematically, critically, logically, and analytically [9]–[11], therefore they can formulate their findings confidently [12], [13]. Inquiry lab can help students to solve problems because in learning they are easy to find answers [14], [15]. Meanwhile, the role of lecturers in the inquiry laboratory learning process according to Sitorus, Hasruddin, and Edi [16] and reinforced by Hester *et al*. [17] is to assist and guide students in finding answers to the problems being solved. This learning can train students to reduce

student dependence on lecturers to get the material being studied. Inquiry laboratory is used because in its implementation the lecturer provides detailed directions to students [18], [19]. The inquiry lab approach in learning activities is part of inquiry. Inquiry laboratory occupies a high level in terms of involving students' intellectual experiences in activities [20]–[22]. Inquiry laboratories generally consist of students who independently construct and carry out experimental plans and collect accurate data [23], [24].

Learning using inquiry labs can improve: Scientific understanding [25], [26], productivity of creative thinking [27]–[29], and being able to obtain and analyze information [30]. Meanwhile, the laboratory inquiries impact in research means asking questions and finding answers to scientific questions posed by lecturers to students [31]–[33]. Scientific questions are instructions that can lead students to investigative activities on the object of question [34], [35]. Thus, the inquiry laboratory according to Blumer and Beck [36] has been described as finding process, obtaining data and information through observation and scientific experiments using critical, systematic, and logical thinking skills. The implementation of inquiry laboratory learning can be carried out optimally by paying attention to several important things, including social aspects in the classroom environment and an open atmosphere that motivates students to discuss [37], [38]. This requires feeling relaxed and open in the classroom. Students do not feel pressure or obstacles to express their opinions. The student's division into study groups is also expected to be more active in learning by discussing with their members to solve problems and find concepts.

Previous researches have proven the positive effects of inquiry laboratories on various scientific skills. Some of them have been able to improve critical thinking skills [39]–[41], scientific knowledge [42], problem solving [43], [44], student concepts [45], maximize the learning process [46], explore attitudes [47], and develop experimental skills [48], [49]. Research related to the positive impacts of the role of inquiry laboratory is a reference in improving research skills of prospective biology teachers. Thus, it is necessary to carry out further research to see the inquiry laboratory impact on increasing research skills, especially for prospective biology teachers. The research skills are: Planning, implementing, and reporting the results of the research. In the future, the inquiry laboratory approach is expected to have an impact on creative and critical thinking skills to generate inspiration, ideas, or carry out the investigation and research processes.

2. RESEARCH METHOD

The right research steps are needed to achieve the expected goals. Ary *et al*. [50] stated that a research requires scientific stages to obtain data for certain uses. Therefore, this research has scientific stages from data analysis design to facilitate data interpretation. The stages are described in sub-sections.

2.1. Research design

This study employed a quantitative-descriptive method to explain the findings related to the improvement of the research skills of prospective biology teachers. A quasi-experimental design was used to compare the impact of the treatments applied. According to Handley [51], a quasi-experimental design is very appropriate for social research. The aim is to estimate true-experimental conditions when the researcher is not possible to control or manipulate all relevant variables. This study compared the effects of the treatment between the control and experimental groups, therefore a non-equivalent control group design was chosen [52]. This design view is shown in Table 1. The research design in the table illustrates that the experimental class is given treatment using inquiry laboratory-based learning to improve preservice teacher research skills, while the control class is not given special treatment, but uses traditional learning methods.

Table 1. Non-equivalent control group design

Group	Pre-test	Treatment	Pos-test
Experiment	O_1	X	O_2
Control	O_3	-	O_4

Note: O_1 - O_2; O_3 - O_4: Pre-test and post-test experimental and control classes; X: Treatment with inquiry laboratory

2.2. Participant

The sample was selected through purposive random sampling technique that in line with the previous research [53]. The study involved 60 students of the IAIN Syekh Nurjati Biology Tadris Study Program, Cirebon which were divided into two classes. This sample involvement is specifically for fifth semester students who have programmed Animal Physiology courses.

2.3. Data collection

Data collection is focused on three indicators of research skills adopted from Yanti [6] namely design, performing, and reporting. The descriptions of the indicators and sub-indicators of the research skill are shown in Table 2. The data was collected by observing the research activity indicators, namely designing (11 sub-indicators), performing (seven sub-indicators), and reporting (eight sub-indicators) as presented in Table 2.

Table 2. Research skills indicators

Research skills	
Indicators	Sub-indicators
Designing	Explaining research background
	Designing control variables confounding to be control variables
	Identifying relationship between independent and dependent variables
	Establishing research hypotheses
	Designing a series of research tools
	Identifying random variables
	Establishing research data collection procedures
	Designing sample size
	Designing data presentation
	Designing data analysis techniques
	Designing data analysis techniques
Performing	Arranging the treatment according to research design
	Developing research tools series
	Handling confounding variables
	Measuring data according to design
	Recording experimental data
	Maintaining stable environmental conditions when conducting experiments
	Observing any data deviations
Reporting	Presenting results in diagrams, tables or graphs
	Summing up the research data
	Discussing research results
	Writing results report, discussion, and conclusions
	Providing general conclusions on research results based on observations and generalizations of statistical analysis
	Disseminating research results through class presentations
	Determining the correctness of research results
	Disseminating research results through seminars

2.4. Data analysis

Describing the information obtained requires appropriate analysis to adapt it to the research objectives. This study aimed to determine the increase in research skills of prospective biology teacher students. However, normalized gain analysis (N-gain) was chosen as an alternative to facilitate the objective. The N-gain (1) analysis used refers to [54] and is shown in Table 3.

$$\text{N-gain } (g) = \frac{Posttest\ score - Pretest\ score}{Max.score - Pretest\ score} \quad (1)$$

Where, N-gain (g) represent research skills improvement score, Pretest-posttest represents research skill observation score before and after treatment was given, and Max. Score represent the maximum score for each research skills indicator.

Table 3. Criteria for improving research skills based on the n-gain score

N-gain scores (g)	Research skills improvement categories
g>0.7	High
$0.3 \leq g \leq 0.7$	Medium
$g<0.3$	Low

Source: Hake [54]

The N-gain scores obtained were then adjusted to the criteria for increasing research skills to be described. These criteria are shown in Table 3. It shows that if the student's N-gain score is less than 0.3, it is categorized that the increase in student research skills is still "Low". However, this study sought criteria with an N-gain score greater than 0.7 and a score between 0.3 and 0.7 as the minimum category to be considered.

3. RESULTS AND DISCUSSION

The data from the pretest and posttest observations in the experimental class found that there was an increase in research skills as an effect of the inquiry laboratory application. The enthusiasm and interest in students learning in the experimental class is higher than the control class. This is evidenced by the N-gain average score of the experimental class that has met the minimum criteria ($g \geq 0.3$) for all indicators of designing, performing, and reporting. Meanwhile, the control class is under the minimum criteria (Low category). The results of the N-gain analysis are shown in Table 4.

Table 4. Improvement (N-gain scores) and research skills categories for each indicator

Skill research indicators	Group			
	Experiment		Control	
	N-gain scores	Research skills categories	N-gain scores	Research skills categories
Designing	0.5	Medium	0.2	Low
Performing	0.8	High	0.1	Low
Reporting	0.6	Medium	0.3	Medium
Mean	0.6	Medium	0.2	Low

Table 4 shows that the N-gain analysis results in each indicator of student research skills of preservice biology teachers who program Animal Physiology courses. The application of the inquiry laboratory as a treatment in the experimental class showed an increase in research skills according to the considered criteria ($g > 0.3$). The research skill on indicator designing has increased with the "Medium" category (N-gain=0.5), then the performing indicators have the greatest increase in the "High" category (N-gain=0.8), and the reporting indicators have the same criteria as the designing indicators (N-gain=0.6). Overall, based on the N-gain score average of three indicators with "Medium" criteria (N-gain=0.6). These results can be concluded that the inquiry laboratory has a positive impact on increasing the research skills of prospective biology teachers

Different results are shown in the control class, there are two indicators (designing and performing) in the "Low" category (N-gain<0.3), while the students' skills on the reporting indicators meet the minimum criteria ($g \geq 0.3$). This means that, student motivation in reporting indicators is higher than designing and performing. This may be influenced by the reward factor in the form of an assessment report at the end of lecture. However, students have difficulty exploring designing and performing skills because they do not use a specialized laboratory to direct their research skills.

The data analysis results in Table 4 can also be described that the application of inquiry laboratory in the learning process has been proven to help improve student learning activities. The stages in the guided-inquiry laboratory learning model make students more active and creative. The increase in student learning activities with the application of guided-inquiry laboratory learning is because it has advantages in its presentation, namely designing curiosity, making students active to find out for themselves the material essence, train to solve problems and develop a cooperative attitude.

The results of inquiry laboratory application are supported by several previous research results that have shown positive effects. Several studies such as García-Carmona [55] found that the use of the inquiry laboratory can improve science understanding, creative thinking productivity, and skills in obtaining and analyzing information. In addition, Beck and Blumer [12] stated that an inquiry laboratory can increase the self-efficacy of students in completing a research. Thus, the inquiry laboratory is a process of seeking, finding and obtaining information through scientific observations and experiments using critical, systematic, and logical thinking skills. Inquiry laboratory learning involves a lot of student activities in learning, implementing constructivism learning principles, activating student participation to increase responsibility, making learning process-oriented and not product-oriented [56].

Inquiry laboratory learning can be maximally implemented by paying attention to several things, including social aspects in the classroom environment and an open atmosphere that invites students to discuss [57]. This requires a free atmosphere in the classroom, students do not feel any pressure or obstacles to express their opinions. The student's division into study groups is expected that students can be more active in learning by discussing between group members to solve problems and find concepts.

Inquiry laboratory learning in the Animal Physiology learning process can help students to actively participate in the learning process. Students learn while making their own observations in carrying out the concepts that are learned based on the problems that exist in the surrounding environment. Students will gain more meaningful experiences and will be more firmly attached to their minds. The strength of the information inherent in student memory will certainly have an impact on student learning outcomes. In addition, students can learn to solve problems fairly and objectively, critically, openly and cooperatively.

The findings of Madhuri, Kantamreddi, and Goteti [58] explained that the students learning activities who were taught by the inquiry laboratory had a higher percentage of thinking skills than non-inquiry labs. Students who taught using the application of the inquiry laboratory are more active in finding and solving problems. The research emphasized the importance of the learning process to find and solve problems so that they can find results independently.

The findings of this current study can be a reference for teachers to explore the research skills of prospective teacher students. In the future, the implications of this learning can produce prospective professional teachers as well as being able to carry out research after they become a teacher. All student problems in school can be researched through self-study to find solutions. Teachers who master research skills can also conduct research and publish the results as a reference for other teachers to apply.

4. CONCLUSION

The study proved a positive impact of inquiry laboratories application to improve student research skills, especially prospective biology teachers. The increasing of the average research skill (designing, performing, and reporting indicators) met the minimum criteria ($g \geq 0.3$) In the future, these results are expected to become a reference for teachers to conduct research in exploring students' learning abilities in schools.

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