The Influence of Inquiry Models With a STEM Approach on Critical Thinking Ability in Low-Level Plant Structure Courses

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Abstract: The critical thinking ability of prospective biology teacher students still needs to be improved to support the implementation of 21st-century learning in schools. This study aims to determine the effectiveness of the STEM-based Inquiry learning model on critical thinking skills in the Low-Level Plant Structure course. This research is a type of pseudo-experimental research, using a control group Pretest-Posttest Design, involving 50 students who are divided into two classes, namely the control class and the experimental class. The data collection tools used in this study were student response questionnaires and critical thinking skills tests. For data analysis, researchers conducted testing using SPSS software. The results of data analysis obtained from the t-test of paired samples were obtained Sig. 0.00 < 0.005, which can be interpreted that there is a significant difference in effectiveness between critical thinking skills in experimental classes using STEM-based Inquiry and control classes using Inquiry in the Low-Level Plant Structure course. So it can be concluded that there is a positive and significant influence of the use of STEM-based inquiry on the critical thinking ability of prospective teacher students in the Biology Education Study Program.

Abstrak: Kemampuan berfikir kritis mahasiswa calon guru biologi masih perlu ditingkatkan untuk menunjang keterlaksanaan pembelajaran abad 21 di sekolah. Penelitian ini bertujuan untuk mengetahui efektivitas dari model pembelajaran Inkuiri berbasis STEM terhadap kemampuan berpikir kritis pada mata kuliah Struktur Tumbuhan Tingkat Rendah. Penelitian ini merupakan jenis penelitian eksperimen semu,menggunakan Control Group Pretest-Posttest Design, dengan melibatkan 50 orang mahasiswa yang terbagi menjadi dua kelas, yaitu kelas kontrol dan kelas eksperimen. Alat pengumpulan data yang digunakan dalam penelitian ini adalah angket respon siswa, tes kemampuan berpikir kritis. Analisis data, peneliti melakukan pengujian menggunakan software SPSS. Hasil analisis data yang didapatkan dari uji-t sampel berpasangan adalah diperoleh Sig. 0,00 < 0,005, yang dapat diartikan bahwa bahwa terdapat perbedaan efektifitas yang signifikan antara keterampilan berpikir kritis pada kelas eksperimen yang menggunakan Inquiry berbasis STEM dan kelas kontrol yang menggunakan Inquiry pada mata kuliah Struktur Tumbuhan Tingkat Rendah. Sehingga dapat disimpulkan bahwa terdapat pengaruh positif dan signifikan dari penggunaan inkuiri berbasis STEM terhadap kemampuan berfikir kritis mahasiswa calon guru di Prodi Pendidikan Biologi.

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A. Introduction

A teacher must create a learning process that is interactive, inspiring, fun, and challenging, and can motivate students to actively participate and provide sufficient space for student initiative and creativity. For this reason, students who will become teachers of biology education must have skills and quality in managing 21st-century learning activities in the classroom to increase the efficiency and effectiveness of student competency achievement. A similar opinion was conveyed (Insyasiska et al., 2015) where education in the 21st-century aims to build students' intelligence skills in learning to be able to solve problems around them. Teachers as facilitators of learning during learning are expected to have the ability to design and implement innovative learning and design and carry out various authentic assessments. 21st-century teachers are also required to be able to teach students by optimizing critical, collaborative, creative, and communication thinking skills or known as 4C.

The learning process in schools must prioritize student activity, interactivity, inspiration, fun, and challenge, and the ability to motivate students to actively participate in learning and can provide space for students to develop imagination, initiative, and creativity. For this reason, prospective biology education teachers at IKIP PGRI Pontianak must have skills and quality in managing learning activities in the classroom to increase the efficiency and effectiveness of student competency achievement. This opinion is reinforced by (Taryono et al., 2019) who state that the learning model that is seen as capable of facilitating students' 21st-century skills is; the project-based learning model (PjBL) and problem-based learning model (PBL), as both are innovative learning models. Meanwhile, according to (Handayani, 2020) 4C must always be built because these skills provide an important role in responding to the challenges of the Industrial Revolution 4.0 which has been marked by the transformation in all aspects of science by empowering the sophistication of digital-based technology.

Students that study biology not only master the collection of knowledge information in the form of concepts, principles, and facts but also relearned understand how knowledge is obtained through learning activities in the classroom and practical activities. Meanwhile (Agustina et al., 2016) stated that biology is a branch of Natural Sciences (IPA) that studies humans, animals, and plants. Based on the statement, the subject of biology is not only delivered theoretically. But it can also be proven through experimental or observational activities and communicating the knowledge gained through practicum reports or presentations.

Low-Level Plant Structure is one of the introductory courses for all students of the Biology Education study program IKIP PGRI Pontianak. This course consists of theory and practice. Low-level plant structure practicums practice several skills that can be categorized as basic Science Process Skills, such as; making preserved and newly preserved undergrowth preparations making transverse or longitudinal incisions, using a microscope, and making microscopic observations. Meanwhile, based on research conducted (Ariyansyah, 2018) the field trip method in the Low-Level Plant Structure course requires

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students to develop critical thinking skills in making discussion questions, and compiling, evaluating, and compiling reports from field lecture activities. Based on the results of the preliminary analysis, it is known that the ability of prospective Biology teacher students in the Biology Education Study Program IKIP PGRI Pontianak is still low in making low-level plant preserve preparations, students are still unable to identify plants correctly, and are still not careful in looking for supporting libraries for making practicum reports. Where these skills are skills that will later be taught by students as teachers of biology subjects in schools. Preliminary Observation Data can be seen in Figure 1.

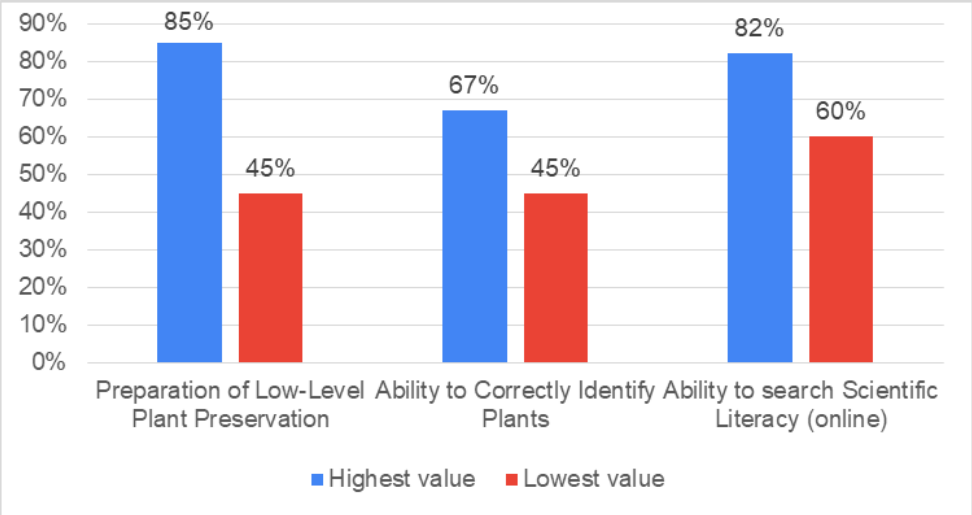

Figure 1.
Preliminary Observation Data in the Biology Education Study Program in the Low-Level Plant Structure course

Based on these problems, researchers use an inquiry learning model with a STEM approach which is expected to be able to improve student's critical thinking skills. Various studies have been carried out, such as research that has been carried out by (Islamyah et al., 2018) on the application of a STEM-based guided inquiry learning model that can improve the critical thinking skills of class X MIPA 4 students of SMAN 2 Singaraja. Meanwhile (Lestari & Rahmawati, 2020) stated that there is an influence of the interaction of integrated STEM learning models through Project-Based Learning and Guided Inquiry with the level of self-efficacy together on the science literacy ability of students of SD Negeri Cibatok 1. A similar study conducted (Fitriansyah et al., 2021) concluded that the STEM approach integrated into the guided inquiry model is superior in improving scientific attitudes and scientific work on science materials at SMP Negeri 4 Palu.

The Inquiry Learning Model is a series of learning activities that emphasize the process of critical thinking to find and find answers to the problems in question. Research that has been carried out (Sukini, 2019) states that the results of the application of a guided inquiry model based on a scientific approach at SMA Negeri 3 Dumai, have proven to have a significant influence on increasing student activity and learning outcomes. Another opinion states that inquiry learning is based on a science context in addition to being able to

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increase the achievement of science literacy and students' critical thinking skills when compared to guided inquiry learning (Pursitasari et al., 2020). Meanwhile, the research carried out focuses more on the use of inquiry learning models with a STEM approach where this research uses a digital microscope device that can be integrated with student smartphone devices, and this research focuses on the critical thinking ability of students of the biology education study program. So that the newness in this study is the use of an integrated digital microscope smartphone device which is used as part of the application of technology in incubation learning with a STEM approach.

Critical thinking in the era of the industrial revolution 4.0 has become a very important part for students to master as prospective biology teachers in schools. Where to develop critical thinking skills, researchers seek to build critical thinking skills through the application of inquiry learning models with a STEM approach. Students who are prospective biology teachers will later be responsible for the process of mastering and integrating technology, teaching research skills, and problem-solving in classroom learning activities, including students' critical thinking skills (Nainggolan et al., 2020). Meanwhile, a similar opinion was conveyed (Fahyuni et al., 2019) which stated that the use of guided inquiry worksheets can involve students in conducting investigations, training students to think critically, and thinking actively and purposefully through scientific investigation activities. So it is hoped that students who are prospective biology teachers will not only master the material but are also expected to have and master the critical thinking skills needed by teachers in classroom learning. So that this study aims to determine the influence of inquiry learning with a STEM approach on the critical thinking ability of prospective biology teacher students of IKIP PGRI Pontianak.

B. Method

This research is a quasi-experimental type of research. This study uses the Control Group Pretest-Posttest Design because this design involved two groups, namely the experimental and control groups. The experimental group is a class that is taught using a STEM-based inquiry learning model, while the control group is a class that is taught using an inquiry learning model.

Table 1. Research design

Group	Pre-Test	Treatment	Post-Test
Experiment Class	O1	X	O2
Control Class	O2	-	O2

This research was conducted at the Biology Education Study Program, IKIP PGRI Pontianak, in the Even Semester of the 2020/2021 Academic Year, involving 50 students. The assessment instrument uses observation sheets, questionnaires, and tests. Hypothesis testing is carried out using SPSS 25 software to answer the problem formulation, by conducting normality and homogeneity tests first before the t-Test. Where the data is declared to be normally distributed when obtaining a value of Sig. > 0.05, while

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homogeneous data was obtained the value of Sig. in Levene's Test Equality of Variances > 0.05. If the data obtained is normal and homogeneous, it is continued with the t-test of paired samples, where if the value of Sig. (2-tail) is obtained is < 0.05, then it can be concluded that there is a significant difference.

C. Result and Discussion

1) Result

The number of samples used in this study was 50 students, consisting of 25 students in the experimental class and 25 students in the control class. The normality test of the data in the research conducted can be seen in table 2.

Table 2.
The results of the calculation of the pre-test and post-test data normality test. Experiment class and control class

Tests of Normality				
Pre & Post Test	**Class**	**Kolmogorov-Smirnov[a]**		
		Statistic	**df**	**Sig.**
Pre_Test	Experiment Class	.166	25	**.075**
	Control Class	.130	25	**.200***
Post_Test	Experiment Class	.166	25	**.072**
	Control Class	.156	25	**.118**

The normality test results of the pre-test on the experimental class obtained the value of Sig. of 0.75, while for the control class, the value of Sig. of 0.200. Meanwhile, the normality test results of the pre-test on the experimental class obtained the value of Sig. of 0.72, while for the control class, the value of Sig. of 0.118. Because the Sig value > 0.05, the data is normally distributed.

Figure 2.
Activities in experimental classes using digital microscopes connected to Smartphone devices

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Table 3.
Calculation Results of Paired Sample T-test Data Pretest and Posttest Experiment Class and Control Class

Paired Samples Test									
		Paired Differences							
					95% Confidence Interval of the Difference				
		Mean	Std. Deviation	Std. Error Mean	Lower	Upper	t	df	Sig. (2-tailed)
Pair Experiment and Control	Pre_Test – Post_Test	-18.920	11.530	1.631	-22.197	-15.643	-11.604	49	.000

Table 3 above shows paired sample t-test data on learning outcomes in the experimental class and control class, Sig. 0.000. Meanwhile, The normality test results of the experimental class critical thinking data obtained the value of Sig. of 0.200. In contrast, for the control class (inquiry), the value of Sig. of 0.173 can be seen in Table 4.

Table 4.
Normality Test Results of Critical Thinking Data for Experiment Class and Control Class

Tests of Normality				
	Kelas	Kolmogorov-Smirnov[a]		
		Statistic	df	Sig.
Critical thinking	Experiment Class	.093	25	.200*
	Control Class	.147	25	.173

Table 5.
The results of the t-test of the critical thinking data sample for the experimental class and the control class

Independent Samples Test										
		Levene's Test for Equality of Variances		t-test for Equality of Means						
		F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	95% Confidence Interval of the Difference	
									Lower	Upper
Critical thinking	Equal variances assumed	.002	**.961**	6.106	48	**.000**	12.160	1.992	8.156	16.164
	Equal variances not assumed			6.106	47.84	.000	12.160	1.992	8.155	16.165

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Based on the t-test sample pair test of critical thinking data in the experimental and control classes, the Sig. result value was obtained. 0.000.

The normality test of pretest and post-test learning outcomes data between students taught using STEM-based Inquiry (Experimental Class) or Inquiry learning (Control Class) in the Low-Level Plant Structure course used the Kolmogorov-Smirnov Normality Test because the number of samples (N) used to both classes are 50 samples. Based on the results of the Normality Test using Kolmogorov Smirnov on SPSS 25, the results of Sig. Pretest data for the experimental class and control class, respectively; are 0.075 and 0.200, while the posttest data for the practical class and control class are; 0.072 and 0.118, so the value of Sig. Obtained is more significant than 0.05. Then the normality test results showed that the data were normally distributed, meanwhile based on the results of the Independent Sample t-Test test, it is known that the value of Sig. in Levene's Test Equality of Variances is 0.961 > 0.05, it can be concluded that the variance of the data for the experimental class and control class data is the same or homogeneous, so that it can be continued with the paired sample t-test.

Based on the results of the paired-sample t-test, it is known that Sig. (2-tails) is 0.00 < 0.005. Thus, it can conclude that there is a significant (significant) difference in effectiveness between critical thinking skills in the experimental class using STEM-based Inquiry and the control class using Inquiry in the Low-Level Plant Structure course.

2) Discussion

The application of STEM-based Inquiry in the experimental class showed better results than in the control class. This was possible because; 1) students in the experimental class are more active than the control class, 2) students in the experimental class can adapt to the learning methods used so that they can provide maximum results for student learning outcomes, 3) integration of STEM in plant structure practicum activities. Low like; the use of low-level plant species identification applications, a simple digital microscope, and the ability to search for literacy to support practicum reporting can help students master Low-level Plant Structure competencies. While in the control class, lecturers carry out practical activities using the inquiry method without maximizing the use of Science, Technology, Engineering, and Mathematics. The results obtained are in line with (Harahap, 2019)which states that the better the use of the inquiry method, the higher the learning outcomes of biology in Class XI Human Digestive System Material at SMA Negeri 4 Padangsidimpuan.

The results of the normality test conducted using Kolmogorov Smirnov on SPSS 25 on critical thinking ability data between students using STEM-based Inquiry learning (Experimental Class) and Inquiry Learning (Control Class) in the Low-Level Plant Structure course with some samples of as many as 50 students obtained Sig. 0.200 > 0.05 in the experimental class while in the control class Sig. 0.173>0.05. These results indicate that the data were normally distributed. Because the data were normally distributed, it continued with the homogeneity test and t-test. Based on the results of the Independent Sample t-Test,

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it is known that the value of Sig. on Levene's Test Equality of Variances of 0.961 > 0.05, it can conclude that the variance of the data for the experimental class and the data for the control class is the same or homogeneous. So, the Sig is known based on the independent sample t-test output table. (2-tails) is 0.000 < 0.005. Thus, it can be concluded that there is a significant (significant) difference in effectiveness between critical thinking skills in the experimental class using STEM-based Inquiry and the control class using Inquiry in the Low-Level Plant Structure course.

The research data analysis results showed a significant difference between students' critical thinking skills in the experimental class and the control class. Students' critical thinking ability with STEM-based inquiry learning was higher than those shown inquiry learning. Therefore, it can conclude that learning with STEM-based inquiry is more effective in improving critical thinking skills.

The results of research conducted on students of the Biology Education study program, IKIP PGRI Pontianak, showed that the results obtained as a result of students' active participation in learning through each stage of inquiry and student contributions in group discussions became a driving factor for the development of their critical thinking skills. Conversations increase participants' basic levels of thinking, help students improve their ability to make connections between claims and evidence, and improve critical thinking skills. These results are supported by the research findings conducted by (Apedoe et al., 2006), where inquiry-based learning strategies provide more opportunities for students to develop and use critical thinking skills, build scientific problem-solving skills, and develop scientific information. They have. Furthermore, DiPasquale (Duran & Dökme, 2016) found that during the experimental class practicum guided by inquiry-based learning, there was an increase in critical thinking skills and students' abilities to integrate information to combine data obtained theoretically in class. With the data obtained through experiments in the laboratory, able to make interpretations of data and be responsible for the work.

The results of this study are in line with what was found by (Sukmawati et al., 2016), where the engineering design process can improve students' critical thinking skills in the domains of organizing, asking questions, planning, developing, seeking opportunities, effective communication, and analytical thinking. Other research conducted (Musdar et al., 2015) shows that the interaction between scientific Inquiry and virtual laboratories can improve critical thinking skills and conceptual understanding. Meanwhile, the data from observations in the experimental class and control class can be seen in figure 3.

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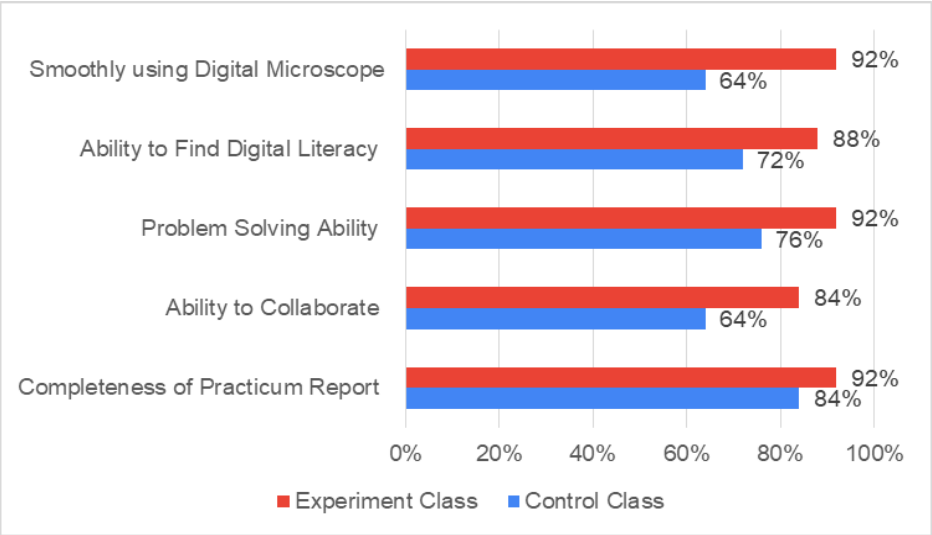

Figure 3. Observation results in experimental and control classes

The observational data obtained, which can be seen in figure 3, show that experimental class students are better at practical ability when compared to control classes, these results strengthen the observation carried out where based on observations obtained 92% of students in the experimental class have been able to use digital microscopes compared to control classes. Students in the experimental class also seem to be more active in discussing and collaborating in overcoming various problems that arise in the practicum observations carried out, where 84% have been active in collaborating when compared to the control class which is only 64%. The problems faced in the practicum carried out were able to be solved by conducting literacy studies online, this was strengthened by the results of observations where 88% of students were able to find supporting literacy online, while the control class was only 72%. The final result of the practicum is in the form of a report, it can be seen that the experimental class is more detailed in compiling the practicum report when compared to the control class. Based on the observation results, it can be seen that experimental class students have been able to apply and use digital microscope technology in practicum, where technology is part of STEM.

The integration of STEM in inquiry learning is also believed to affect the development of students' critical thinking skills positively. Through STEM-integrated inquiry learning, students are allowed to empower their scientific process skills and scientific information to sort and choose the most appropriate method or technology for solving problems that arise from the inquiry process. In the process, students train to identify problems, propose hypotheses, choose the right way with the help of technology to conduct investigations, and collect and analyze data as a basis for conclusions. The inquiry-based learning approach may be a new and uncomfortable experience for most students, so students need to be given greater responsibility (scaffolding) and guidance at the beginning of learning (Apedoe et al., 2006). Meanwhile, according to (Pow & Fu, 2012) The problems that are often experienced in finding the right literacy by students in learning are; 1) inaccuracies in gathering

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information, 2) difficulties in collecting, compiling, and analyzing information materials for investigations, 3) difficulties in synthesizing useful information into well-organized investigative reports.

D. Conclusion

Based on the data and analysis carried out, the research can be concluded that there is a positive and significant influence from the use of STEM-based inquiry on the critical thinking ability of prospective teacher students in the Biology Education Study Program in the Low-Level Plant Structure course. Meanwhile, the implications of this study are; 1) lecturers can use the right learning methods so that they can influence students' critical thinking ability, namely by using a STEM-based inquiry learning model. 2) Critical thinking skills, digital literacy, mastery of technology, and the ability to collaborate can be an important part of successfully studying Low-Level Plant Structure material.

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