

Exploring of Inquiry Skills of Teacher Students: Biology, Physics, and Elementary School Teacher Education

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ABSTRACT

Inquiry skills are needed by a teacher to create effective learning experiences so that the overall quality of education can improve. This becomes even more important for distance education students, whose characteristics include being independent and active learners. This research aims to determine the level of inquiry abilities of students in the biology education, physics education, and elementary school teacher education programs at the Open University. The subjects of this research were 96 students from various regions. The survey method was implemented by providing an instrument in the form of questions to measure inquiry skills, which were distributed via Google Forms. The research results show that students' inquiry skills vary. Students in the Biology Education and Physics Education study programs are at an intermediate level, but students in the Elementary School Teacher Education study program are at a low level of inquiry skills. Inquiry skills for each dimension also vary. Based on these results, efforts are needed to improve the inquiry skills of distance education students in the form of training or other habits so that they can implement them.

Keywords: Biology teachers, inquiry skills, physics teachers, primary teachers.

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1. INTRODUCTION

Science is knowledge gained from a systematic set of activities used to understand natural phenomena. Science has an important role in human life. Science is essentially built on the basis of scientific processes, scientific products, scientific attitudes, and applications (Kurniawan *et al.*, 2019). Over the past few decades, science learning has been synonymous with inquiry (Cairns & Areepattamannil, 2019; Fitzgerald *et al.*, 2019; Liu *et al.*, 2020). Inquiry-based learning is a method that should empower the skills that students need to master (Ghaemi & Mirsaeed, 2017). Learning of science will be optimal if 1) teachers understand inquiry (St. Pierre, 2019); 2) students practice their skills (Marshall *et al.*, 2017); and 3) students understand their progress in achieving these skills (Cairns & Areepattamannil, 2019; Cartwright & Hallar, 2018). Research conducted by previous researchers has shown that inquiry-based learning can increase creativity and contribute positively to student learning outcomes (Rodríguez *et al.*, 2019).

Skills supporting the inquiry process are called inquiry skills (Pedaste *et al.*, 2015). Many experts express inquiry skills as skills built into the process of science (Dilek *et al.*, 2020; Dobber *et al.*, 2017; Ekici & Erdem, 2020). Inquiry skills include observing and hypothesizing, designing experimental procedures, experimenting, interpreting data, concluding, and communicating. Another expert explains inquiry skills as basic skills such as observing, inference, and classification based on data predicting based on relationship patterns; intermediate skills, such as explaining models based on concepts, recording measurement results, using mathematical model formulations, describing relationships between variables, using evidence and logic, designing investigations, making measurements accurately, using technology during investigations related higher skills: synthesizing hypotheses, analyzing arguments, revising hypotheses, and solving problems (Darling-Hammond *et al.*, 2020). Some experts define Taxonomy inquiry skills in experiments and then adapted by Ješková *et al.* (2018), which can be revealed in Table I.



TABLE I: TAXONOMY OF INQUIRY

Indicators of inquiry skills	Sub-indicators of inquiry
Conception and planning design	- Defining problems - Formulating hypothesis - Designing variables and the relationship between variables and the experimental process
Implementation	- Predicting experimental results - Determining which tools to use - Determining what is measured, observed, and recorded
Analysis and interpretation	- Change the data representation in the form of graphs/diagrams and tables - Making generalizations from experimental results - Making conclusions
Communicating	Outlining a formal report on the results obtained

Every teacher needs these inquiry skills to create an effective learning experience. The low inquiry skills of prospective teachers can have a domino effect on students in their classes. They are ill-prepared to face the integration of various fields with the field of education (van Allen & Zygouris-Coe, 2019). Based on this, it is important to ensure that prospective teachers or even senior teachers have adequate inquiry skills. Many studies analyze these skills but tend to focus on student subjects (Elisanti et al., 2020; Kireš & Jurková, 2021), so research is needed that focuses on prospective or senior teachers.

Faculty of Teacher Training and Education, known as FKIP (in Indonesia) of Universitas Terbuka (UT; Open University), students are students who have a teaching background or experience at either the elementary, middle, or high school level. They really need inquiry skills to upgrade the quality of their learning. Like the vision and mission promoted by FKIP UT, namely, to provide opportunities for teachers to improve their qualifications and competencies without leaving their teaching schools or duties, research that aims to determine the level of students' abilities is really needed.

FKIP UT has 11 study programs, including elementary school teacher education, physics education, biology education, mathematics education, chemistry education, early childhood teacher education, Indonesian language education, English education, economics education, civics education, and educational technology. This paper will focus on the three study programs, namely elementary school teacher education, physics education, and biology education, which will analyze the level of inquiry ability so that it can be used as a consideration for future policies.

2. RESEARCH METHOD

2.1. Research Design

A quantitative approach was used in this research, where the method chosen was a purpose-designed survey method (Braun et al., 2021). This method is used to determine the level of student inquiry skills. The steps in this survey start

with problem analysis, developing inquiry skills instruments, conducting research on Open University's teacher students, data analysis, and making reports.

2.2. Participants

The participants in this research were Open University's teacher students from the biology education, physics education, and elementary school teacher education study programs, all of whom have become teachers, who are spread out from various cities in Indonesia. The selection of research subjects used random sampling where there were no specific criteria. A total of 96 students were willing to fill out the survey with the characteristics shown in Table II.

2.3. Instruments

The instrument used in this research was a Google Form questionnaire containing 30 multiple-choice questions. Two experts with doctoral degrees in science education have validated the instrument used in this research. Based on the results of expert validation through Kendall's Tau calculations, it has a value of 0.853 or is included in the "very high" category, while for the reliability of this instrument based on Cronbach's Alpha calculations, a value of 0.739 is obtained or is included in the "high" category. This question refers to indicators of inquiry skills, namely: 1) conceptualizing and planning design; 2) implementation; 3) analyzing and interpreting; and 4) communication skills.

TABLE II: PARTICIPANT CHARACTERISTICS

	Variable	N	Percentage
Gender	Male	26	27.08
	Female	70	72.92
Residence	Bandung	17	17.7
	Jakarta	35	36.45
	Purwokerto	4	4.17
	Palembang	2	2.08
	Medan	8	8.33
	Bandar lampung	2	2.08
	Jember	2	2.08
	Semarang	2	2.08
	Surabaya	2	2.08
	Yogyakarta	1	1.04
	Jayapura	1	1.04
	Malang	2	2.08
	Denpasar	1	1.04
	Pontianak	7	7.29
	Samarinda	2	2.08
	Surakarta	1	1.04
	Bogor	2	2.08
Term	Jambi	1	1.04
	Bengkulu	1	1.04
	Pekanbaru	1	1.04
	Mataram	1	1.04
	Semarang	2	2.08
	Manado	1	1.04
	1-4	10	10.4
	5-8	34	35.4
	>8	52	54.2

TABLE III: INSTRUMENTS OF INQUIRY SKILLS

Components of inquiry skills	Questions
Conceptualizing and planning design	A child conducts an experiment with three springs hanging in the same position, and all three are given the same load of 250 grams, as shown in the picture below. What do you think is the correct problem formulation for the practical activities carried out by the child?
Implementation	Alea plants bean seeds in clay, sand, and humus soil in pots of the same size. All plants received the same amount of sunlight and water for ten days. The growth of the bean seedlings in each pot was continuously observed and recorded by Alea. What factors do you think make the difference between the three pots?
Analyzing and interpreting	Ari conducted an experiment on a series of electric circuits to find out what the voltage and electric current were at each point. The voltage used in this experiment was 9 volts with three identical lights. Based on the results of this experiment, the following data was obtained: Based on this data, what conclusions can you draw?
Communication skills	Rif'at is writing an article based on the results of his research. What components should be written sequentially in the article?

Several examples of questions used to measure student inquiry skills are shown in Table III.

2.4. Data Analysis

In this study, quantitative data analysis was carried out by considering the number of correct scores and the length of time to answer the questions asked. Groups of students from the three study programs were analyzed for their level of inquiry skills through 30 multiple-choice questions derived from indicators of inquiry skills, which can be seen in Table II.

3. RESULT AND DISCUSSION

Inquiry skills can influence the development of the level of critical thinking because they can develop skills in interpreting, analyzing, turning, and concluding, all of which are the essence of critical thinking skills (Wale & Bishaw, 2020). This is another reason why a teacher must have and master this skill. Teachers who have inquiry skills are able to encourage students to become active researchers in their learning process. They can design assignments that encourage students to ask questions, seek answers, and develop a deep understanding of a particular topic. In addition, teachers with inquiry skills are able to create a learning environment that supports exploration, collaboration, and reflection so that students can develop

critical skills and the ability to think independently and be independent in their learning. Teacher inquiry skills also play an important role in helping students understand the world around them, developing information literacy, and preparing them to face the complex challenges of the 21st century (Bores-García et al., 2020).

The inquiry skills of students from the three study programs showed mixed results. They show different tendencies. The data can be seen in Table IV. In general, the average score for inquiry skills of Biology Education students is the highest, at 65.55. It is categorized at the medium level. The average inquiry skill of Physics Education students is 62.78, which is at a medium level. However, the average inquiry skill of primary teacher education students is 41.83, in the low category. The time completed to work on this inquiry ability varies, where the Physics Education students had completed tasks of the instrument of inquiry skills for 31 minutes 50 seconds, continued by primary teacher students for 38 minutes 32 seconds, and continued by Biology Education students for 44 minutes 11 seconds. The average Biology teacher student does it in a longer time. This shows that there is caution from the teachers in doing the problem compared to physics teachers and elementary school teachers. Biology teachers are unfamiliar with material characterized by quantitative measurements and repeatable experiments to test hypotheses. They are familiar with experiments and observations in the laboratory and field, although there remains room for descriptive-based approaches (Hartanti, 2021). Elementary school teachers also require a longer time to solve this inquiry ability problem than physics teachers. This is because the question of inquiry ability is considered difficult for elementary school teachers. Elementary school teachers are responsible for teaching students in many subject areas. This makes them not focus too much on one subject, such as science, which is the object of the instrument questions (Akin-Sabuncu & Ok, 2021).

Inquiry skills include four (4) indicators, namely, 1) conception and planning design, 2) implementation, 3) analyzing and interpretation, and 4) communication skills. There are three (3) scores of indicators of inquiry skills of primary teacher education that are less than 50, namely skill of implementation, skill of analysis and interpretation, and skill of communication. In Biology Education students, the score for skill implementation is

TABLE IV: STATISTICS OF DATA SAMPLE

Subject	PrTE	BiTE	PhTE
Sample size (n)	62	21	12
Male	19	3	4
Female	43	18	8
Average inquiry skills (x)	41.83	65.55	62.78
x min	16.67	30	40
x max	76.67	90	80
Average time completion	38 min 32 s	44 min 11 s	31 min 50 s
t min	1 min	7 min	16 min
t max	100 min	120 min	65 min

Note: PrTE = Primary Teacher Education Program; BiTE = Biology Teacher Education Program; PhTE = Physics Teacher Education Program.

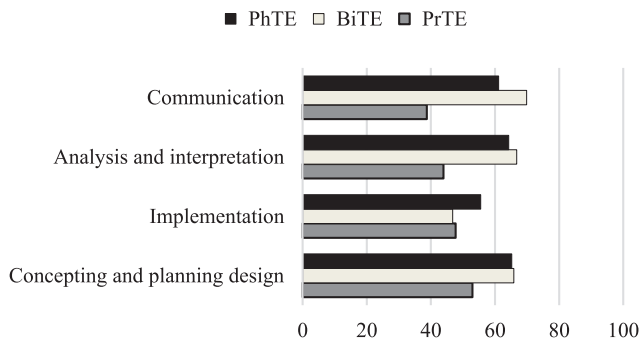


Fig. 1. Inquiry skills levels by indicators.

less than 50. However, all the scores of inquiry skills of physics education students are more than 50. These can be seen in Fig. 1.

The difference in the level of inquiry skills possessed by biology teachers, physics teachers, and elementary school teachers may be due to the habituation carried out by these teachers during teaching (Jannah *et al.*, 2022; Setiono *et al.*, 2021). Biology teachers and Physics teachers, as science teachers, teach only natural science in their daily duties of teachers. In recent decades, inquiry has been identified with science learning (Constantinou *et al.*, 2018). This means that science teachers are accustomed to applying the inquiry approach in their learning process. On the other hand, elementary school teachers are class teachers who must also master social science, civics, and mathematics subject matters in addition to science subject matter. This means that inquiry identified with science subjects is most likely only applied when they are teaching science subjects.

If this inquiry skill is broken down into inquiry sub-skills, then there are four sub-skills of inquiry of Primary

Teacher Education at a low level, namely the skills to predict experimental results, process and analyze data, change data representations in the form of graphs and tables, make conclusions, and make formal reports about the results obtained. In contrast, other sub-skills are in the medium category. In Biology Education students, there are two sub-skills of inquiry in the low category, namely the skills to process and analyze data and change data representations in the form of graphs and tables. The other six sub-skills are in the medium category. These are defining problems, formulating hypotheses, designing variables and relationships between variables and experimental processes, predicting experimental results, determining what is measured, observed, and recorded, and making formal reports. There are two sub-skills in the high category, namely, making generalizations from experimental results and making conclusions. In Physics teaching students, there is one sub-indicator in the low category, namely the skill of processing and analyzing data and changing data representations in the form of graphs and tables. There is one sub-skill of inquiry in the good category, that is, making conclusions, and eight other sub-skills of inquiry in the medium category.

Referring to Table V, the inquiry skills of primary teacher students, biology teacher students, and physics teacher students are varied. The inquiry skill of Biology teacher students is not significantly higher than that of Physics teacher students, but it is significantly higher than that of primary teacher students. Fifty percent of the inquiry skills possessed by primary teacher students are in the low category, and the other 50% of skills are in the medium category. In biology teacher students, 20% of inquiry skills are in the low category, 60% are sub-skills in the medium category, and 20% are other skills in the high category. Ten percent of inquiry sub-skills of

TABLE V: INQUIRY SKILLS OF STUDENTS OF PRIMARY, BIOLOGY, AND PHYSICS TEACHER EDUCATION PROGRAM

Skills	Sub-skills	PrTE	BiTE	PhTE
Concepting and planning design	Defining problems	50.54	74.62	72.2
	Formulating hypothesis	68.28	65.1	69.4
	Designing variables and relationships between variables and the experimental process	53.22	60.33	58.3
Implementation	Predicting experimental results	39.8	63.48	61
	Determining tools is used	51.08	63.48	58.3
	Determining what is measured, observed, and recorded	44.30	30.09	52.8
Analysis and interpretation	Changing the data representation in the form of graphs/diagrams and tables	28.5	30.9	40
	Making generalizations from experimental result	55.91	82.3	72.2
	Making conclusions	47.31	87.14	80.56
Communication	Outlining a formal report on the results obtained	38.71	69.86	61.1
Average		41.83	65.55	62.78

Physics Education teacher students are in the low category, ten percent in the high category, and the other 80% in the medium category. There are several sub-indicators of inquiry ability that still need to be improved in elementary school teachers, biology teachers, and physics teachers, namely sub-indicators of inquiry ability in changing data representations in the form of graphs/diagrams and tables. It is relevant to the PISA result. Based on PISA assessments, the science ability of students at fourteen ages is also low, ranking 71 of 80 participant countries (Schleicher, 2018). The weaknesses in this skill should be solved. We should give more tasks to teacher students, particularly Biology, Physics, and Primary teacher students, that are relevant to the ability to change data representations in the form of graphs/diagrams and tables. The sub-skills in data processing and analyzing are in the low category for elementary teachers and biology teachers. Data processing and analysis need other skills, namely numeracy and statistics (Megawati & Sutarto, 2021). Based on observations, biology teachers and elementary school teachers do not really like counting/numeracy. Therefore, it is necessary to give more tasks and practice in processing and analyzing data. In Table V, we can see that 50% of primary teacher students still have low ability in the inquiry approach. Therefore, this encourages UT to practice inquiry skills with its students not only through practicum courses, but also other courses.

4. CONCLUSION

The level of student inquiry skills in the three study programs, biology education, physics education, and primary school teacher education, tends to be at a low-medium level. This requires special attention from the relevant parties to overcome it. In conclusion, it seems that the cultivation and improvement of inquiry skills through distance education is still a challenge. Efforts are needed to improve inquiry skills for distance education students in the form of training or other habituation, particularly for primary teacher students, in almost all sub-indicators of inquiry skills. Some indicators of inquiry skills for Biology and Physics teacher students of Universitas Terbuka still need to be improved.

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CONFLICT OF INTEREST

The authors declare that they do not have any conflict of interest.

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