Prospective Teachers' Understanding of Inquiry Constructs in Science Education

Soraya Ishak[1], Nur 'Adilah Husna Termizi[2] & Ahmad Muslihin Ahmad[*3]

[1]Department of Curriculum Development, Ministry of Education, Putrajaya, Malaysia

[2,3]Department of Biology, Faculty of Science and Mathematics, Sultan Idris Education University, Tanjong Malim, Malaysia

***Corresponding Author**

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ABSTRACT

This study tested prospective teachers' understanding of the inquiry construct in science education, as well as its differences in gender, field of specialization and level of study. A quantitative descriptive survey approach was used to obtain data to answer the questions and test the hypotheses in this study. A total of 128 study respondents based on Krejcie and Morgan were prospective teachers' students from Tanjong Malim in the fields of specialization Diploma, Bachelor's Degree and Master's Degree in the field of Science (Biology, Chemistry, Physics and Science). Descriptive analysis was used to see the frequency and percentage of three inquiry constructs (Questioning, Scientific Investigation and Data Collection) while inferential statistics using Mann-Whitney U Test and Kruskal-Wallis H Test were used to test the null hypothesis. Findings from the analysis of the Mann-Whitney U Test and the Kruskal-Wallis H Test found that there was no significant difference between teachers' understanding in terms of gender, field of specialization and level of study of the inquiry construct, thus accepting all the research hypotheses that were built. This study is expected to be the basis to give explicit attention and emphasis to the inquiry construct in the curriculum that is formulated in the future.

Keywords: pre-service teachers, inquiry-based learning, science education, undergraduate, postgraduate.

INTRODUCTION

The transformation of the model-based curriculum in the Secondary School Curriculum Standard (KSSM) introduced in the Malaysian education system emphasizes the integration of inquiry in the context of school education, as well as impacting the relevance of the teacher education curriculum. Othman and Mohamad (2014) agreed where transformation process should begin by providing prospective teachers with the right knowledge and skills. This statement is also supported by Sickel and Friedrichsen (2015) that teacher education programs need to have a background in scientific inquiry and adopt a constructivist approach to teaching.

According to Quigley et al. (2011), one of the challenges in implementing inquiry-based learning is correcting the perceptions of teachers and prospective teachers about the concept of inquiry-based learning where it can be done in various ways, not only in the laboratory or through group work. It can also be done in regular classes or lectures to help students develop thinking and questioning skills. It is very important for prospective teachers to fully understand the concept so that they can master how to use inquiry-based teaching effectively. Salbiah Mohd Som (2012) defined inquiry as the activity of seeking information, questioning and investigating phenomena that occur around us. Therefore, the inquiry teaching method becomes less effective if the teacher's teaching technique does not involve the higher-order thinking skills (HOTS) questioning process while at the same time limiting the development of critical thinking skills among students.

Tajularipin and Abdul Rahim (2010) claimed that despite the efforts of science teachers to adopt constructivist

teaching approaches such as inquiry and demonstration, many lack the knowledge and experience needed to do so effectively. This lack of knowledge and experience may restrict teachers' ability to plan and implement lessons that will help their students develop their science skills beyond the level of ordinary knowledge. The implementation of the inquiry approach requires educators to use critical and creative thinking skills, as shown by the HOTS. However, teachers' knowledge of HOTS in the teaching and learning process is said to be still low as supported by a report from Kestrel Education Consultants and 21st Century School in 2011. Chandran et al. (2023) stated that teachers were found to be lagging in questioning techniques and skills that promote HOTS (Yusoff & Seman, 2018), impedes the effective implementation of HOTS in schools due to educators' limited understanding of the needs for teaching critical thinking skills in classroom (Yusoff & Seman, 2018; Ling et al., 2024) and low self-efficacy (Ling et al., 2024) especially in the context of science education.

Several studies had discussed about inquiry construct among prospectives science teachers which includes teacher institutes and public universities (Misbah & Noordin, 2008; Embong et. al., 2017). The importance of this study underscores the fact that understanding inquiry construct is essential for effective inquiry-based learning. Teachers need to understand these constructs to successfully implemented inquiry-based learning strategies in their classrooms. Therefore, this study aims to identify prospective teachers' understanding of the inquiry construct in science education. It is hoped that the findings of this study can produce an analysis to identify the need and depth to integrate the inquiry construct in the teacher education curriculum based on the identified weaknesses and strengths of inquiry.

Research Objectives and Hypotheses

In general, this study was conducted to identify and analyze the understanding of prospective teachers towards the inquiry construct in science education. Therefore, the objectives of this study are specified as follows:

1. To examine the difference in the prospective science teachers' understanding of the inquiry construct in science education based on their field of specialization.

2. To examine the difference in the prospective science teachers' understanding of the inquiry construct in science education based on their level of education.

The null hypotheses for the study are as follows:

H_{O1}: There is no significant difference in the prospective science teachers' understanding of the inquiry construct in science education based on specialization.

H_{O2}: There is no significant difference in the prospective science teachers' understanding of the inquiry construct in science education based on education level.

METHODOLOGY

The research design for this study is quantitative method using a survey method. Data for this study were obtained through instruments adapted from several relevant reference sources based on the Science Inquiry Skills Framework (National Science Foundation, 2020), Inquiry-based learning framework and the 5E Inquiry Model.

Sampling Methods

The population in this study is students of the diploma, bachelor's and master's degree programs at Tanjong Malim institute with different specializations which includes Science, Physics, Chemistry and Biology. The total population of students following the education program is 192 people. Based on Krejcie & Morgan, (1970), the sample size needed for this study is 128 samples.

Normality Test

Before the researcher conducts inferential analysis, the researcher conducts a normality test to see the normal

distribution of the study data, where the study data will represent the entire study population.

The Kolmogrov-Sminov (KS) and Shapiro-Wilk (SW) normality tests also show a significant value, p is 0.00, where this significant value is less than the alpha value, which is 0.05 ($p \leq 0.05$). Therefore, the study data shows that the data is in a non-normal distribution. Therefore, non-parametric tests will be conducted next.

FINDINGS

The first hypothesis for this study is to test the difference in the prospective science teachers' understanding of the inquiry construct in science education based on their field of specialization. Therefore, a hypothesis was built, namely "There is no significant difference in the prospective science teachers' understanding of the inquiry construct in science education based on specialization."

To analyze this hypothesis, the Kruskal-Wallis H Test was used because the study data obtained had an informal distribution. Table 1 shows the results of the Kruskal-Wallis H Test which tested the level of understanding of the inquiry construct based on the field of specialization.

Table 1. Kruskal-Wallis H Test for Inquiry by Specialization

Inquiry Construct	**No.**	**Mean rank**	**Kruskal-Wallis H**	**p**
Questioning				
Science	44	67.48	1.98	0.58
Physics	28		57.86	
Chemistry	21		70.52	
Biology	35		62.46	
Scientific Investigation				
Science	44	55.47	11.33	0.01
Physics	28		57.95	
Chemistry	21		63.88	
Biology	35		81.47	
Data Collection				
Science	44	60.84	0.88	0.83
Physics	28		64.43	
Chemistry	21		69.07	
Biology	35		66.41	
Overall Construct				
Science	44	59.80	4.29	0.23
Physics	28		57.09	
Chemistry	21		69.10	
Biology	35		73.59	

The Kruskal-Wallis H test analyzed that there was no significant difference in the understanding of prospective teachers towards the questioning construct. The results of the analysis showed a difference in the mean level between prospective teachers in the field of Science (67.48), prospective teachers in the field of Physics (57.86), prospective teachers in the field of Chemistry (70.52) and prospective teachers in the field of Biology (62.46). However, the significant value showed a value of 0.58 and exceeded the alpha value, which is the alpha value of 0.05. Therefore, the researchers decided that there was no significant difference in the questioning construct between prospective teachers in the fields of Science, Physics, Chemistry and Biology.

Meanwhile, the results of the Kruskal-Wallis H test analysis towards the scientific investigation construct showed that there was a significant difference in the mean level between prospective teachers in the field of Science (55.47), prospective teachers in the field of Physics (57.95), prospective teachers in the field of Chemistry (63.88) and prospective teachers in the field of Biology (81.47). Meanwhile, the significant value showed a value of 0.01 for prospective teachers in these four specialization areas, where this value is less than the alpha value. Therefore, the researchers concluded that there is a significant difference in scientific inquiry between male and female prospective teachers.

In this regard, post-hoc tests need to be conducted to determine the relationship between the field of specialization and the scientific inquiry construct. Table 2 shows the results of the post-hoc test used to compare the differences in inquiry comprehension according to the field of specialization for the scientific inquiry construct.

Table 2. Comparison of Areas of Specialization on the Construct of Scientific Inquiry

Specialization	**Statistical test**	**Standard error**	**Standard statistical test**	**p**
Science – Physics	-2.481	8.763	-0.283	0.777
Science – Chemistry	-8.415	9.614	-0.875	0.381
Science – Biology	-26.006	8.210	-3.167	0.002
Physics – Chemistry	-5.935	10.464	-0.567	0.571
Physics – Biology	-23.525	9.191	-2.560	0.010
Chemistry - Biology	-17.590	10.006	-1.758	0.079

Based on the results of post-hoc analysis of comparisons between specialization fields on the scientific investigation construct. Specialization fields that do not show significant differences on the scientific investigation construct will produce a significant value exceeding the p value > 0.005. Therefore, specialization fields that do not show significant differences on the scientific investigation inquiry construct are between the comparison of specialization fields of Science and Physics (p=0.0777), Science and Chemistry (p=0.381), Physics and Chemistry (0.571), Physics and Biology (p=0.10) and Chemistry and Biology (p=0.079). While the specialization field of Science and Biology shows that there is a significant difference between these two specialization fields on the scientific investigation inquiry construct, because the comparison results between these two specialization fields produce a significant value of less than 0.005, which is a significant value of 0.002.

The Kruskal-Wallis H test further showed that there was a difference in the mean level value between prospective teachers in the field of specialization for the data collection construct. Prospective Chemistry teachers showed the highest mean level value, which was 69.07, followed by prospective Biology teachers (66.41), prospective Physics teachers (64.43). Prospective Science teachers showed the lowest mean level, which was 60.84. However, the significant value showed a value of 0.83, also exceeding the alpha value. Therefore, the researchers concluded that there was no significant difference between prospective teachers in the field of specialization in understanding the data collection construct. The Kruskal-Wallis H test also analyzed differences based on the field of specialization for all inquiry constructs built in the questionnaire.

The results of the analysis also showed that there was a significant difference between the fields of specialization, where prospective Biology teachers showed the highest mean level, which was 73.59, followed by prospective Chemistry teachers (69.10), prospective Physics teachers (57.09) and finally prospective Science teachers (59.80). However, the significant value still shows a value that exceeds the alpha value, which is 0.23, thus concluding that overall, there is no difference in understanding between the fields of specialization of prospective teachers towards the science education inquiry construct. Therefore, the first null hypothesis is failed to be rejected.

The second hypothesis for this study is to test the difference in the prospective science teachers' understanding of the inquiry construct in science education based on their level of education. Therefore, H_{02} is built, namely "There is no significant difference in the prospective science teachers' understanding of the inquiry construct in science education based on education level."

To analyze this hypothesis, the Kruskal-Wallis H Test test was also used again because the study data obtained had an informal distribution. Table 3 shows the results of the Kruskal-Wallis H Test which tested the level of understanding of the inquiry construct based on the level of education.

Table 3. Results of the Kruskal-Wallis H Test Which Tests the Level of Understanding of the Inquiry Construct Based on the Level of Education

Inquiry Construct	**No.**	**Mean rank**	**Kruskal-Wallis H**	**p**
Questioning				
Diploma	36	77.42	7.63	0.022
Bachelor	59		56.08	
Master	39		64.03	
Scientific Investigation				
Diploma	36	57.47	5.76	0.056
Bachelor	59		60.87	
Master	39		75.92	
Data Collection				
Diploma	36	69.92	1.12	0.57
Bachelor	59		62.16	
Master	39		62.68	
Overall Constructs				
Diploma	36	67.57	1.86	0.40
Bachelor	59		59.25	
Master	39		68.81	

The results of the Kruskal-Wallis H test showed a difference in the mean level between prospective teachers at the Diploma level (77.42), prospective teachers at the Bachelor's Degree level (56.08) and prospective teachers at the Master's level of study (64.03). Meanwhile, the significant value showed a value of 0.22, less than the alpha value, which is the alpha value of 0.05. Therefore, the analysis shows that there was a significant

difference in the prospective science teachers' understanding of the inquiry construct in science education based on their education level.

In this regard, a post-hoc test needs to be conducted to find out the relationship between the level of education and the inquiry construct. Table 4 shows the results of the post-hoc test used to compare the differences in the understanding of inquiry according to the level of education for the scientific investigation construct.

Table 4. Comparison of Study Levels on the Inquiry Construct of Questioning

Level of study	Statistical test	Standard error	Standard statistical test	p
Bachelor - Master	-7.950	7.553	-1.053	.293
Bachelor - Diploma	21.341	7.732	2.760	.004
Master - Diploma	13.391	8.275	1.618	.106

Based on the results of the post-hoc analysis of the comparison between the levels of study on the questioning construct. The level of study that does not show a significant difference on the scientific investigation construct will produce a significant value exceeding the p value > 0.005. Therefore, the level of study that does not show a significant difference on the questioning inquiry construct is between the comparison of the bachelor and Master's level of study (p=0.293) and Master's and Diploma (p=0.106). While the bachelor and Diploma levels of study show that there is a significant difference between these two fields of specialization on the questioning inquiry construct, with a significant value of 0.004.

Meanwhile, the results of the Kruskal-Wallis H Test analysis on the scientific investigation construct showed that there was a significant difference in mean levels between prospective teachers at the Diploma level of study (57.47), prospective teachers at the bachelor level of study (60.87) and prospective teachers at the Master's level (75.92). Meanwhile, the significant value showed a value of 0.056 for prospective teachers at the three levels of study, where this value was greater than the alpha value. Therefore, the researchers concluded that there was no significant difference in the understanding of scientific investigation between prospective teachers based on the level of study. The Kruskal-Wallis H Test further showed that there was a difference in mean levels between prospective teachers in the field of specialization for the data collection construct. Prospective Chemistry teachers showed the highest mean level value, which was 69.07, followed by prospective Biology teachers (66.41), prospective Physics teachers (64.43). Prospective Science teachers showed the lowest mean level, which was 60.84. However, the 2-tailed significant value showed a value of 0.83, also exceeding the alpha value. Therefore, the researchers concluded that there was no significant difference between prospective teachers in the field of specialization on the understanding of the data collection construct.

Kruskal-Wallis H Test also analyzed the differences based on the field of specialization on all inquiry constructs built in the questionnaire. The results of the analysis also showed that there was a significant difference between the levels of study, where prospective teachers at the Master's level of study had the highest mean, which was 68.81, followed by prospective teachers at the Diploma level (67.57) and finally prospective teachers at the bachelor level (59.25). However, the significant value still showed a value that exceeded the alpha value, which was 0.40, thus concluding that overall, there was no difference in understanding between prospective teachers' levels of study on the science education inquiry construct. Therefore, the null hypothesis (H03) was failed to be rejected.

DISCUSSION

Overall, the results of the study showed that there was no difference in the understanding of the inquiry construct between prospective teachers and their specialization (Science, Physics, Chemistry and Biology). However, it was found that prospective Biology teachers had a better understanding of the inquiry concept than prospective Science, Physics and Chemistry teachers based on the mean level analysed. The findings of this

study contradict the findings of a study by Misbah and Noordin (2008) conducted on second-year Physics Education students, where her study stated that there were differences in the level of understanding across study programs based on specialization. Several factors may have an impact on this situation. First, the findings of this study may be accurate in representing a sample of prospective teachers at Tanjong Malim and do not reflect the findings of the entire prospective teachers who are taking science education courses throughout Malaysia. Second, the sampling method can be expanded and improved to obtain more accurate data and to reflect the data to the entire population. Improvements to this study can be made to improve the quality of the study if it is continued in the future.

Based on the results of the study, the researcher concluded that there was no significant difference in the understanding of the inquiry construct with the level of study of prospective teachers. However, the mean level showed that prospective Diploma teachers' understanding of the inquiry construct was better than prospective bachelor and master's teachers. In general, the results of the study showed that the level of education did not affect the understanding of the inquiry approach of trainee teachers.

The results of the study by Embong et al. (2017) showed that the understanding and preparation of prospective primary school science teachers in the sixth semester from the Malaysia Teacher Education Institute (IPGM) were at a satisfactory level and did not exhibit inquiry-based teaching that was in line with their understanding during their teaching training in phase one. However, because of the guidance of the lecturers, their level of understanding increased after trainee teachers attended the Inquiry Approach Strengthening Workshop before teaching training in the second phase. Hands-on exposure and activities, especially questioning techniques and scientific investigation in the workshops attended, are a good implementation step to strengthen the mastery of inquiry among prospective teachers.

Therefore, the researcher also believes that the level of understanding of student teachers about inquiry does not depend on their background or level of education but depends on the experience of learning and understanding about inquiry. With the understanding that prospective teachers have after receiving maximum input regarding inquiry, it is hoped that the inquiry approach can be applied in the teaching and learning of science more effectively to their students in school.

CONCLUSION

As expected, teachers' understanding of inquiry-based education is an important issue, as teachers are the main drivers of inquiry-based education systems. The findings of this study have proven that the scenario that occurs at the school level also occurs at the higher education level, because many prospective teachers still do not understand the inquiry construct well, especially the questioning element that includes emphasizing the correlation of students' existing knowledge, identifying students' misconceptions and restructuring students' scientific ideas. Strengthening inquiry knowledge should be emphasized at the basic level of teacher education before the implementation and integration of the inquiry approach is implemented at the school level. Without a clear understanding of the inquiry construct, it is undeniable that the transformation to an inquiry-based form of teaching and learning cannot be implemented effectively.

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