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INQUIRY-BASED SCIENCE TEACHING: KNOWLEDGE AND SKILLS AMONG SCIENCE TEACHERS

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Abstract

Purpose of the study: The purpose of this study is to investigate the relationship between teachers' knowledge and perceived skills in implementing inquiry-based science teaching at the secondary level.

Methodology: This quantitative research involved 63 science teachers from nine secondary schools in Putrajaya. Respondents were selected using a random sampling technique. The data were analyzed using descriptive and inferential statistics methods.

Main Findings: The analysis showed that the level of teachers' knowledge of inquiry-based science teaching and the level of teachers' perceived skills in implementing inquiry-based science teaching which was divided into four phases (conceptualization, investigation, conclusion, and discussion) were high. The Pearson correlation test found that there was a strong and significant relationship between teachers' knowledge in inquiry-based science teaching and teachers' skills in four phases of inquiry.

Applications of this study: This study implies that teachers' knowledge and skills are essential aspects to be emphasized in implementing inquiry-based science teaching and teachers should be trained in both of these aspects as they are interrelated to each other.

Novelty/Originality of this study: This study explores deeper on teachers' skills in implementing inquiry approach by dividing it into four phases to determine which phases of the inquiry that educators and scholars need to emphasize and give the training to improve teachers' implementation skills and determine whether the phases are interrelated to knowledge.

Keywords: *Knowledge, Skills, Level, Inquiry-Based Science Teaching, Science Teachers, Science Education.*

INTRODUCTION

Developing students' skills in science and technology are one of the important factors for Malaysia to become a progressive and prosperous country (Ministry of Science, Technology, & Environment, 2016). Therefore, to produce more experts in the science and technology generation in the future, science education must be accessible and equitable for everyone (Ishak & Iksan, 2015). For science teachers, there are challenges in implementing and delivering holistic teaching to students where teachers need to master the pedagogical content knowledge extensively, develop a conducive and effective learning environment, and motivate students to learn (Krijan et al., 2017). Meanwhile, teachers need to ensure the teaching approach applied is able to capture students' interest, curiosity, and inquiry. To achieve this requires a creative and innovative approach which can lead to an effective science education (Trna et al., 2012).

To date, science educators practice varieties in teaching and learning approaches to increase students' interest in science learning as an initiative to accomplish the 21st-century teaching including inquiry-based science teaching (Hakim & Ikhsan, 2018). An inquiry-based approach is a student-centred learning that actively engages students (Sikas, 2017; Silm et al., 2017) in learning activities about nature and the human world (Pedaste et al., 2015) and also responsible for exploring new knowledge through their investigation by taking ownership of the process (Maithri & Suresh, 2020). In other words, an inquiry-based approach is the process of finding the problems and solving the problems (Yu & Li, 2018). Students need to solve the problems, conduct self-investigations, and work in groups with the guidance from the teachers (Trna et al., 2012). This approach is a constructivist approach that is different from the didactic approach. In inquiry-based science teaching, teachers act as facilitators and guide the students in the investigation (Trna et al., 2012). Inquiry-based science teaching aims to stimulate critical thinking and problem-solving skills among students (Silm et al., 2017) in a way to emphasize the Four C elements of communication, collaboration, critical thinking, and creativity in this 21st-century learning.

Recent literature reported many positive impacts of inquiry-based science teaching such as helping students to gain direct experience in scientific knowledge (Teig et al., 2018), encouraging students to build their own conceptual understanding through exploration which will become their long-term memory (Jeanpierre, 2006; Marshall, 2013; Nawastheen, 2014; Uum et al., 2016), building students' scientific literacy and problem-solving skills (Sikas, 2017; Yuliati et al. 2018), enhancing students' critical thinking (Kitot et al., 2010), as well as improving students' understanding of science and engaging students in science more practically (Capps & Crawford, 2013). Nevertheless, the problem arose when teachers preferred using the traditional and teacher-centered approach in their teaching process (Mahalingam & Hamzah 2016; Saad & Boujaoude, 2012) even though they said they were inquiry-oriented. Silm et al. (2016) stated that teachers did not apply an inquiry-based approach in their teaching due to the lack of understanding and

knowledge of the inquiry-based approach. According to Capss & Crawford (2013), teachers' perception of their teaching practices was not aligned with their actual teaching practices. Teachers thought they have implemented inquiry-based in their teaching and learning process, but in reality, their teaching practice focused on traditional learning (Capss & Crawford, 2013; Saad & Boujaoude, 2012). This indicates that teachers still lack knowledge about inquiry-based science teaching.

Teachers with a low level of knowledge in the inquiry-based science teaching approach indirectly become unconfident to implement this approach in their classroom (Gillies & Nichols, 2014). They do not dare to take the risk in implementing an inquiry-based approach and more comfortable to stay with the traditional approach (Mahalingam & Hamzah, 2016). Jeanpierre (2006) reported that although teachers were positive about implementing an inquiry approach, they did not positively evaluate themselves in implementing it in their own classroom because of the confidence, skills, and knowledge. According to Mahalingam and Hamzah (2016), teachers were found to have a low level of skills in implementing inquiry-based science teaching. They used lower-order questions that did not encourage students' critical and creative thinking skills (Mahamod & Lim, 2011). Hence, this reflects that teachers' skill in implementing inquiry approaches was low.

Previous studies mostly highlighted the effectiveness and attitude of teachers in an inquiry-based approach (Silm et al., 2017), the relationship of inquiry-based approaches and achievement (Teig et al., 2018), scientific literacy through learning-based science learning (Sikas, 2017), implementation of inquiry model among geography teachers (Nawastheen et al., 2014), inquiry-based learning approach practice among teachers (Dai et al., 2011), the relationship between content knowledge of science subjects, attitudes, and practices of inquiry-based learning among teachers (Xie et al., 2014), as well as knowledge, attitudes, and skills in inquiry-based learning of history subject (Mahalingam & Hamzah, 2016). There is still a lack of research that focuses on the relationship between teachers' knowledge of the inquiry-based science teaching and the teachers' skills of four phases of inquiry in implementing the approach. Thus, this study will explore deeper on teachers' skills in implementing inquiry by dividing it into four phases to determine which phases of the inquiry that educators and scholars need to emphasize and give the training to improve teachers' implementation skills, and then determine whether the phases are interrelated to the knowledge of the inquiry. This enables teachers to improve their methods and approaches for a better and conducive teaching.

The purpose of this study is to examine the relationship between knowledge and perceived skills among science teachers in implementing inquiry-based science teaching in the process of teaching and learning at the secondary level. Specifically, this study has three objectives:

1. Identify the level of teachers' knowledge of inquiry-based science teaching.
2. Identify the level of teachers' skills in implementing inquiry-based science teaching.
3. To examine the relationship between teacher knowledge and teachers' skills in implementing inquiry-based science teaching.

In order to promote effective implementation of inquiry-based science teaching, science teachers should always improve themselves by developing their knowledge and practising a positive attitude toward this approach as inquiry requires sophisticated knowledge and skills (Capps et al., 2016; Latir et al., 2014). Teachers play an important role in creating an effective learning environment to foster students' critical and creative thinking as well as providing guidance on problem-solving in science subjects (Hakim & Ikhsan, 2018). As a result, it becomes imperative for teachers to have the knowledge and skills in every approach that has been used to make science learning more meaningful and to nurture students' interest in science learning.

LITERATURE REVIEW

Background of Inquiry-Based Science Teaching

The idea of inquiry-based teaching was first introduced in the school sector around 1962 by John Dewey and Joseph from John Dewey's observation of children's active involvement in developing their ideas and understandings (Jeanpierre, 2006; Harlen, 2013). Dewey (1910) and Wu and Hsieh (2006) argued that learning science was more effective through exploration and active involvement in nature and scientific phenomena rather than memorizing definitions and facts from the books. From that point, John Dewey, a science teacher, encouraged other science teachers to use inquiry techniques as one of the teaching strategies by encouraging active participation of students in developing their understanding (Barrow, 2003). Nowadays, the implementation of inquiry-based science teaching whether in primary school or secondary school has become a worldwide phenomenon including in Malaysia, especially in preparing students for the 21st-century learning and become an effective approach in teaching scientific process and concepts (Khalik et al., 2018; Martina et al., 2016).

In the Malaysia Education Development Plan or *Pelan Pembangunan Pendidikan Malaysia* (PPPM) 2013-2025, inquiry skill is one of the essential skills that has been emphasized in today's era of globalization. Every student should have the skill to relate their existing knowledge with the learning activities that have been carried out in the class. Inquiry-based science learning can help students to master a broader range of high-order thinking skills such as scientific skills, soft

skills, information technology skills, problem-solving skills, and decision-making skills. The mastery of each of these skills is capable of providing students to become an excellent 21st-century global player (Ministry of Education Malaysia, 2016) and help students to understand science concepts, enhance scientific development, as well as improve students' attitude and achievement in science.

There are various teaching methods based on inquiry-based approaches such as project-based learning (Ministry of Education Malaysia, 2016; Sikas, 2017), scientific investigation (Ministry of Education Malaysia, 2016; Sikas, 2017), problem-based learning (Ministry of Education Malaysia, 2016; Sikas, 2017), collaborative learning (Ministry of Education Malaysia, 2016), lesson study (Iksan et al., 2018), and case study (Sikas, 2017). Thus, it is clear that the inquiry-based science learning approach does not just involve experimentation (investigation in the laboratory), but it can also be conducted through various methods depending on teachers' creativity and suitability according to students' backgrounds.

Teachers' Knowledge of Inquiry-Based Teaching

Teachers' pedagogical knowledge is a crucial prerequisite for teachers in every teaching approach they are using (Xie et al., 2014). Teachers' pedagogical knowledge is strongly associated with the way teachers implement the approach in the classroom where teachers with a high level of pedagogical knowledge are likely to implement student-centered learning and inquiry-based learning more frequently (Park et al., 2011). The study conducted by Hakim and Ikhsan (2018) showed that teachers had a high level of knowledge about the characteristics of the inquiry approach and its implementation. This speculated that teachers had been well exposed to inquiry-based approaches.

However, there were also contrary findings showing that teachers had limited (Capps et al., 2016; Demir & Abell, 2010; Krijan et al., 2017; Ozel & Luft, 2013; Saad & Boujaoude, 2012; Senari & Osman, 2018) and misunderstandings of inquiry-based science teaching (Capps & Crawford 2013; Capps et al. 2016; Llewellyn 2001). Besides, teachers were unable to explain the concept of inquiry in a correct way (Ozel & Luft, 2013). They only knew that inquiry-based science teaching involved questioning and data collection but did not know that it also involved explanation, evidence, justification, and communication (Demir & Abell, 2010). Meanwhile, Ozel and Luft (2013) who conducted qualitative research on the conceptualization and enactment of beginning secondary science teachers in inquiry-based instruction, found that teachers' inquiry knowledge only involved questioning and explanation evidence. They were unclear that inquiry-based teaching also included communication aspects in the process of teaching and learning science. Apparently, these previous studies showed that teachers were still unclear about inquiry-based teaching.

Teachers' Skill in Implementing Inquiry-Based Teaching

Aside from knowledge, teachers' skills also serve as an important aspect in determining the effectiveness of implementing inquiry-based science teaching. Basically, skill means efficiency (Zakaria, 2015). Teachers' efficiency is needed to make sure students are able to engage actively in a meaningful learning environment by exploring and constructing their own scientific understanding (Hogan & Berkowitz, 2000). The inquiry approach generally has different aspects, models, phases, and criteria (Wu & Chou, 2006) according to the researcher's perspective. From the literature, researchers used a variety of aspects, phases, models, and criteria to investigate teachers' and students' knowledge, skills, and practices in getting the best results for the teaching and learning process in school.

According to Suchman's Inquiry model, skills in implementing an inquiry approach that had been emphasized in this model is the efficiency of teachers to provide objectives, ask questions, conduct experiments, guide students in making hypotheses, and analyze the inquiry processes during the learning process (Taridi, 2007). Meanwhile, teachers' skills in the phase of the inquiry approach, according to Pedaste et al. (2015) involved five phases, which are orientation, conceptualization, investigation, conclusion, and discussion. Then the inquiry phase was further developed by Uum et al. (2016) into seven phases: (a) introduction, (b) exploration, (c) investigation planning, (d) conducting investigation, (e) conclusion, (f) communication, and (g) deepening. In this research, teachers' skills in implementing inquiry-based science teaching focus on four phases, which are conceptualization, investigation, conclusion, and discussion that are in line with the study of Teig et al. (2018).

Findings from previous studies showed that teachers are less skilled in implementing inquiry-based science teaching, where teachers only teach science implicitly without proper explanation and guidance for their students (Taridi, 2007). Thus, students only learn indirectly without knowing the real characteristics of an inquiry-based science learning approach resulting in the ineffective implementation of inquiry in the process of teaching and learning (Capps et al., 2016). Teachers tend to use the traditional approach compared to the inquiry-based approach, which is more based on teacher-centered and memorization of the facts (Hanri, 2013) because teachers are less skilled at implementing them. Low level of teachers' skills to implement teaching pedagogy is one of the reasons for the failure of the process of teaching and learning (Ishak & Iksan, 2015; Razak et al., 2009). This is because the implementation of an inquiry approach needs sophisticated skills and critical thinking to facilitate students in problem-solving of their investigation and exploration (Mahalingam & Hamzah, 2016). According to Hakim and Iksan (2018), mastering a pedagogical approach is a must for all teachers to ensure that students gain knowledge and develop their interest toward science in achieving the country's goal of producing experts in science and technology.

Relationship between Teachers' Knowledge and Teachers' Skills in Implementing Inquiry-Based Science Teaching

Previous studies have further explored knowledge of the science concepts, attitude, and belief of inquiry (Xie et al. 2014), knowledge and belief of inquiry (Fazio, 2005), the relationship between teachers' efficacy and attitude (Silm et al., 2017), the relationship between inquiry and students' achievement in science (Teig et al., 2018), inquiry-based science learning strategies (Shamsudin et al., 2013), enactment and knowledge of inquiry-based science teaching (Capps et al., 2016), scientific literacy through inquiry-based science learning (Sikas, 2017), the relationship between knowledge, attitude, belief, and practices of primary school teachers in inquiry-based approach (Wilkins, 2008), teachers' belief and attitude in inquiry-based learning (Ramnarain & Hiatswayo, 2018), and teachers' understanding of scientific inquiry (Adisendjaja et al., 2017). Nevertheless, there is still a lack of research on the relationship between teachers' knowledge and skills in inquiry-based science learning. Teachers' knowledge and skills are two crucial aspects of teaching (Alkharusi et al., 2011). Walshaw (2012) stated that teachers' pedagogy knowledge affected their professional skills in the classroom. The way teachers lead their teaching in the classroom portrayed their understanding and belief in this approach (Anthony & Walshaw, 2007).

THEORETICAL FRAMEWORK

Teacher inquiry knowledge is measured using 21 items of inquiry enactments based on National Council Research (2000) and Capps et al. (2016). According to Pedaste et al. (2015), inquiry phases involve five phases, namely orientation, conceptualization, investigation, conclusion, and discussion. However, in this context of the study, teachers' skills are measured using four phases of inquiry that only involve conceptualization, investigation, conclusion, and discussion in line with the study of Teig et al. (2018) which emphasized the active involvement of students. In Value, Skills and Knowledge (VSK) framework (Chong & Cheah, 2009), pedagogical knowledge and pedagogical skills are interdependent and interconnected in developing education professionals. Based on the VSK framework, this study only emphasizes Skills and Knowledge (SK). When the level of teachers' knowledge in inquiry-based science teaching is high, the level of teachers' skills in implementing them in the process of teaching and learning is also high.

METHODOLOGY

Research Design

This study was quantitative research to identify teachers' level of knowledge of inquiry-based science teaching and teachers' perceived skills in implementing inquiry-based science teaching. Najid (2003) stated that the survey method is an appropriate method in obtaining current information, so it is suitable to identify the teachers' knowledge and skills of inquiry-based science teaching wherein Malaysia this approach has been revised and currently re-implemented in the science teaching. In this study, the data were collected using questionnaires and were analyzed descriptively and inferentially.

Population and sample

The population of this study was secondary science teachers in Putrajaya which were approximately 75 teachers. Putrajaya was selected as the site of the study because it is an urban area. Researchers reasoned that teachers in the urban area were more exposed to the inquiry approach as Osisioma and Onyia (2008) reported that the majority (78%) of teachers in urban secondary schools were knowledgeable about the inquiry. The sampling method used was random sampling. The sample size was determined using Krejcie and Morgan's (1970) table. Out of 11 secondary schools involved, only nine secondary schools returned the questionnaire. A total of 63 science teachers from nine secondary schools in Putrajaya were involved in this study (Table 1). Respondents were 48 female teachers (76.2%) and 15 male teachers (23.8%). This reflects that the number of female teachers was greater than the number of male teachers as it is the scenario in Malaysia that the number of female teachers is greater than male teachers. Roughly, the majority of the respondents who participated had the experience of teaching science more than 10 years (79.4%) compared to teachers with 4 to 9 years of science teaching experience (17.5%) and below 3 years (3.2%). Findings showed that the secondary science teachers in Putrajaya were predominantly experienced in the science subject.

Table 1: Teachers' Demography

Teachers' demography	Frequency	Percentage (%)
Gender		
Female	48	76.2
Male	15	23.8
Years of science teaching experience		
≤ 3 years	2	3.2
4-9 years	11	17.5
≥ 10 years	50	79.4

Instrument

The instrument used in this study was a set of questionnaires distributed to science teachers for feedback. The use of questionnaires is suitable for survey-based research (Hakim & Ikhsan, 2018). The questionnaire was developed by the researchers based on 21 items of inquiry enactments (Capps et al., 2016) and four phases of inquiry (Pedaste et al., 2015). The questionnaire consisted of three sections. Section A contained the teachers' demographic information. Section B contained 21 items to evaluate teachers' knowledge of inquiry-based science teaching. Section C contained 20 items to evaluate teachers' perceived skills in implementing inquiry-based science teaching, which was divided into four phases: conceptualization, investigation, conclusion, and discussion. Every phase of the inquiry approach was measured with five items. All the items in sections B and C were constructed using the Likert Scale, from scale 1 (strongly disagree) to scale 5 (strongly agree) for section B and from scale 1 (very unskilled) to scale 5 (very skilled) for section C.

Pilot test

A pilot test was conducted involving 30 science teachers in the Hulu Langat district randomly. Data were analyzed using Statistical Package for the Social Sciences (SPSS) software version 22.0. Table 2 shows the reliability of data received from the pilot test based on Cronbach's alpha analysis for two variables; teachers' knowledge of inquiry-based science teaching is the independent variable, and teachers' skills in implementing inquiry-based science learning with four components are the dependent variable. Gender and years of science teaching experience are the moderate variables. The results found that the reliability index was at a high level between 0.800 and 0.968. Hence, the questionnaire was appropriate for use.

Table 2: Cronbach's Alpha

Variables	Number of items	Cronbach's Alpha
Teachers' knowledge of inquiry-based science teaching	21	0.968
Teachers' skills in implementing inquiry-based science teaching	20	0.919
(a) Conceptualization	5	0.895
(b) Investigation	5	0.926
(c) Conclusion	5	0.929
(d) Discussion	5	0.926

Statistical Analysis

Data obtained were analyzed using SPSS version 22.0. The analysis used included descriptive statistics such as frequency, mean, and standard deviation to test the teachers' level of knowledge and skills in inquiry-based science teaching and inferential statistics such as the Pearson correlation to test the relationship between teachers' knowledge of inquiry-based science teaching and teachers' skills to implement inquiry-based science teaching. The mean interpretation for this study is referred to in Table 3 while the interpretation of the correlation coefficient is referred to Table 4.

Table 3: Mean Interpretation for Teachers' Knowledge and Skills in Inquiry-Based Science Teaching

Mean Range	Interpretation
1.00 - 2.33	Low
2.34 - 3.66	Medium
3.67 - 5.00	High

Source: Jamil (2002)

Table 4: Interpretation of Correlation Coefficient for Relationship Teachers' Knowledge and Skills in Inquiry-Based Science Teaching

Size of correlation (r)	Interpretation
0.10-0.29	Weak
0.30-0.49	Medium
0.50-1.00	Strong

Source: Pallant (2011)

FINDINGS

Teachers' Knowledge of Inquiry-Based Science Teaching

Table 5 shows the analysis of teachers' knowledge level of inquiry-based science teaching. Overall findings indicate that teachers' knowledge level of inquiry-based science teaching was high with M = 4.26, SD = 0.59. This shows that

teachers were knowledgeable about seven-dimensional inquiry approaches that involved questioning, investigating, interpreting data, argumentation, communicating, and modelling. From the 21 items of inquiry enactments, "Uses of the table, chart, graph, and diagram to present data" recorded the highest mean values (M = 4.41, SD = 0.53) while "Discussion of limitations and precision of a model" recorded the lowest mean values (M = 4.02, SD = 0.61) compared to other items.

Table 5: Teachers' Knowledge Level of Inquiry-Based Science Teaching

Variable	Mean	SD	Interpretation
Teachers' Knowledge	4.26	0.45	High

Teachers' Skills in Implementing Inquiry-Based Science Teaching

Table 6 shows the analysis of teachers' perceived skill level in implementing inquiry-based science teaching. Teachers' perceived skills in this approach were divided into four constructs which included four phases of inquiry approach, namely conceptualization, investigation, conclusion, and discussion. Overall, the level of teachers' perceived skills in implementing inquiry-based science teaching was high. Teachers' skills in the discussion phase recorded the highest mean (M = 4.31, SD = 0.51) followed by teachers' skills in investigation phase (M = 4.22, SD = 0.47), conceptualization phase (M = 4.17, SD = 0.51), and conclusion phase (M = 4.14, SD = 0.52). In conclusion, secondary science teachers in Putrajaya were able to implement inquiry-based science teaching with good skills since the majority of science teachers involved in this study were experienced teachers who had science teaching experience for more than 10 years.

Table 6: Teachers' Skills in Implementing Inquiry-Based Teaching

Phases of Inquiry	Mean	SD	Level
Conceptualization	4.17	0.49	High
Investigation	4.22	0.47	High
Conclusion	4.14	0.52	High
Discussion	4.31	0.51	High

Relationship between Teachers' Knowledge and Skills of Inquiry-Based Teaching

The Pearson correlation was used to test the relationship between teachers' knowledge and skills of inquiry-based science teaching. The study found that the Pearson correlation test shows a strong and significant linear relationship between teachers' knowledge of inquiry-based science teaching and teachers' skills in four phases of inquiry where all r values were greater than 0.05 ($r > 0.05$) while p values were smaller than 0.05 ($p < 0.05$). The values shown were conceptualization ($r = 0.62$, $p = 0.001$), investigation ($r = 0.59$, $p = 0.001$), conclusion ($r = 0.69$, $p = 0.001$), and discussion ($r = 0.62$, $p = 0.001$). Therefore, there was a significant and strong relationship between knowledge and teachers' skills in conceptualization, investigation, conclusion, and discussion phases. This indicates that teachers' knowledge of inquiry-based science teaching influenced teachers' skills in implementing an inquiry approach in the process of teaching and learning. The findings are shown in Table 7.

Table 7: Relationship between Teacher Knowledge and Skills in Implementing Inquiry-Based Science Teaching

Teachers' Skills	Knowledge		Interpretation
	Pearson Correlation (r)	Significant (p)	
Conceptualization	0.62	0.001	Strong
Investigation	0.59	0.001	Strong
Conclusion	0.69	0.001	Strong
Discussion	0.62	0.001	Strong

N = 63 **significant at level p < 0.05

DISCUSSION

This study was conducted to examine the relationship between teachers' knowledge and perceived skills in inquiry-based science teaching. This study provides awareness to all science teachers on the importance of knowledge and skills before implementing an inquiry approach in the classroom so that there is no misunderstanding in science subject teaching. In addition, this study could be one of the alternative learning approaches that can be broadly applied in the process of teaching and engaging students' active participation.

The findings demonstrated that science teachers in this study had a high level of inquiry-based science teaching knowledge (M = 4.26, SD. = 0.59). This shows that teachers are knowledgeable in seven dimensions of inquiry involving questioning, investigating, interpreting data, argumentation, communicating, and modelling. Hakim and Ikhsan (2018) stated that teachers were highly knowledgeable about the basic characteristics of an inquiry approach and how to implement the approach in their teaching. This indicates that teachers had been exposed to inquiry-based science

teaching approach directly or indirectly as inquiry-based science teaching was introduced in the school sector in 1962 (Jeanpierre, 2006) and the school curriculum in Malaysia also highlighted the implementation of inquiry-based approaches in the learning process (Ministry of Education Malaysia, 2019). Therefore, teachers were exposed to the inquiry approach for a long time and already had a high level of knowledge about inquiry-based science teaching. In implementing this approach, teachers' knowledge plays an important role in ensuring the effectiveness of the teaching and learning process in the classroom (Ali & Madon, 2014).

The analysis found that teachers had high-level skills in implementing inquiry-based science teaching. The four phases of the inquiry approach involving conceptualization, investigation, conclusion, and discussion were at a high level. Teachers' skills in the discussion phase showed the highest mean (M = 4.31, SD = 0.51). According to Pedaste (2015), the discussion phase involving the dimension of argumentation and communication-enabled teachers to give the opportunity to students in presenting ideas and arguments in the discussion. This finding was in line with Chichekian et al. (2016) where teachers were skilled at encouraging students to communicate their findings through presentations in the classroom as well as encouraging students to argue about the findings when they are involved in group discussions. A meaningful learning environment existed when teachers had the skills to integrate students' knowledge with their existing experience and build students' understanding of the learning activities they engaged in (Johnson et al., 1996).

Teachers' skills in the conclusion phase scored the lowest mean compared to other phases (M = 4.14, SD = 0.52). According to Pedaste (2015), the conclusion phase involved teachers' ability to engage students using the model in order to explain their investigation and draw the conclusion. Although the mean score in the conclusion phase was quite low compared to others, this phase was still interpreted as a high level. This showed that teachers have a good understanding and ability to engage students with the model and draw conclusions in the process of science learning (Justi, 2009). Justi and Gilbert (2010) reported that teachers should have good practical and observation skills to develop students' logical and abstract thinking as students were able to relate the results of their investigations with the model and draw conclusions when teachers had the skills in facilitating the learning process. Modelling helps students to imagine and understand the phenomenon of investigation better (National Research Council, 2012) while making conclusions helps students to improve students' understanding by reflecting on the whole process of learning (Uum et al., 2016). Overall, despite the discussion phase scoring the highest meanwhile, the conclusion phase scored the lowest, the level of teachers' skills in all four phases of inquiry was still interpreted as high. This shows the science teachers in Putrajaya are perceived as able to implement inquiry-based science learning approaches with good skills.

This was contrary to Saputra et al. (2019) which stated that the level of teachers' skills in the conceptualization phase was moderate and the investigation phase was low. This study which was conducted on 85 preservice science teachers in Aceh showed that teachers lacked skill in encouraging students to identify problems and making hypotheses (conceptualization) as well as implementing investigation by conducting experiments and interpreting data. The contradiction was identified since the sample of the study involved preservice teachers while the sample of this study involved in-service teachers and the majority were teachers with over 10 years of experience. Preservice teachers had a low level of skills because they were not exposed to the planning in conducting investigations and intellectual skills (Alkharusi et al., 2011; Saputra et al., 2019; Susilawati et al., 2018) where preservice teachers were more exposed to theoretical skills. They lacked practical experience compared to the in-service teachers who were more practically experienced (Alkharusi et al., 2011).

In addition, the findings also showed a strong linear relationship between teachers' knowledge of inquiry-based science teaching and four phases of teachers' skills in implementing inquiry-based science teaching: conceptualization, investigation, conclusion, and discussion. This showed that the knowledge of science teachers in Putrajaya toward inquiry-based science teaching influences teachers' skills in implementing it in the process of teaching and learning. If teachers were exposed to inquiry-based science learning through workshops or training, then teachers' skills in implementing them in the process of teaching and learning increased (Silm et al., 2017). If teachers were not exposed to inquiry-based science teaching approaches, teachers' skills in implementing this approach in science learning will not improve and may decline, causing teachers not confident about implementing this approach.

This finding is aligned with the study of Xie et al. (2014), who reported a significant and strong relationship between knowledge and skills in implementing the inquiry approach among teachers. The exposure of the inquiry approach to teachers is important to enhance better skills and understanding (Hakim & Iksan, 2018) because effective teaching requires in-depth knowledge and skills of the pedagogy used (Hamdan et al., 2017). With that, teachers should have a high level of knowledge and master their teaching approach. This enables teachers to match the approach to the topic of the lesson to ensure that the learning process conducted is meaningful and interesting to the students (Tamuri & Azman, 2010). Therefore, it is clearly shown that teachers' knowledge of inquiry-based science teaching affected the teachers' skills in implementing inquiry-based science teaching.

CONCLUSION

In conclusion, the findings proved that teachers' knowledge of inquiry is important in improving teachers' skills in conceptualization, investigation, conclusion, and discussion. This study is urging the government to give both theoretical and practical exposure of inquiry-based science teaching to improve teachers' skills and knowledge because without

knowledge of the approaches used and skills in guiding students to explore science, the learning of 21st-century embedded of Four Cs which are communication, collaboration, critical thinking, and creativity could not happen. As we all know, the 21st-century requires skillful and knowledgeable facilitators who can involve students actively in the process of exploration and investigation of nature and the human world.

LIMITATION AND STUDY FORWARD

This study was limited to teachers' cognitive perception, which only relied on their self-assessment of their perceived knowledge and skills in the form of questionnaires. Other than that, the study was also limited to the population of teachers in Putrajaya, which involved only nine schools out of 11 schools where two schools did not return the questionnaire.

Further research is recommended to be carried out using mixed methods research to examine whether teachers' perceived perceptions through questionnaires and observations of teachers' teaching using inquiry-based science teaching approaches are parallel to each other. Capps et al. (2016) found that teachers' self-perceptions were higher than actual practice. So, further research is needed to determine whether teachers' perceptions and practices are compatible enough with each other. To obtain more accurate findings, further research is also recommended by making the comparison between teachers' knowledge and skills based on the students' and teachers' perspectives to measure whether the knowledge and skills of the inquiry-based science teaching are corresponding to each other. Furthermore, replication of the research is also needed to make use of a larger sample and populations so that the findings obtained can be generalized to larger populations.

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AUTHORS CONTRIBUTION

Author 1: Conceptualization and writing the original draft.

Author 2: Conceptualization and writing the original draft.

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