

SCIENCE TEACHING AND LEARNING THROUGH KATH MURDOCH'S INQUIRY CYCLE: A CASE STUDY ON PRESERVICE PRIMARY TEACHERS

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Abstract

Many studies on inquiry focus on the effect of inquiry learning on students' learning abilities and science skills. However, research focusing on the learning experience and teaching skills of preservice teachers based on inquiry is still lacking. The practices that a preservice teacher undertakes in his/her teaching years are strongly influenced by his/her learning experience in teacher education. The inquiry learning experienced by preservice teachers while in college will later affect inquiry-based teaching practiced in schools. This qualitative research aims to describe inquiry practices conducted by pre-service teachers. The sample of the study was 33 preservice primary teachers who took the second-year science content course named Integrated Science for Primary. There are two questions that will be the focus of this research: 1) How does Kath Murdoch's Inquiry Cycle help preservice teachers experience significant learning? 2) How does an inquiry cycle help preservice teachers design Inquiry-based Science Lesson Plan? This study shows that learning through Kath Murdoch's inquiry cycle is found as an interesting and useful approach for preservice teachers to understand how scientific processes are integrated into their experiment designs. Also, an inquiry cycle used in guided practices (including metacognitive prompts, reflections, and group discussion) could provide preservice teachers with the necessary skills to develop an inquiry-based teaching plan. Yet, this does not guarantee that preservice teachers would successfully facilitate inquiry in a real classroom setting.

Keywords: Inquiry Learning; Kath Murdoch's Inquiry Cycle; Preservice Teacher

Abstrak

Banyak penelitian tentang inkuiri berfokus pada pengaruh pembelajaran inkuiri terhadap kemampuan belajar siswa dan keterampilan sains. Namun, penelitian yang berfokus pada pengalaman belajar dan keterampilan mengajar calon guru yang berbasis inkuiri masih sedikit. Praktik yang dilakukan seorang calon guru di tahun-tahun mengajarnya sangat dipengaruhi oleh pengalaman belajarnya selama di pendidikan keguruan. Pembelajaran inkuiri yang dialami oleh calon guru selama di bangku kuliah nantinya akan mempengaruhi pengajaran berbasis inkuiri yang dipraktikkan di sekolah. Penelitian kualitatif ini bertujuan untuk mendeskripsikan praktik inkuiri yang dilakukan oleh calon guru. Sampel penelitian adalah 33 calon guru SD yang mengambil mata kuliah konten sains tahun kedua yaitu IPA Terpadu untuk Sekolah Dasar. Ada dua pertanyaan yang akan menjadi fokus penelitian ini: 1) Bagaimana Siklus Inkuiri Kath Murdoch membantu calon guru mengalami pembelajaran yang signifikan?; 2) Bagaimana siklus inkuiri membantu calon guru merancang Rencana Pembelajaran IPA berbasis Inkuiri? Studi ini menunjukkan bahwa pembelajaran melalui siklus Kath Murdoch adalah pendekatan yang menarik dan berguna bagi calon guru untuk memahami bagaimana proses ilmiah diintegrasikan ke dalam rancangan eksperimen. Juga, siklus inkuiri yang digunakan dalam praktik terbimbing (termasuk petunjuk metakognitif, refleksi, dan diskusi kelompok) dapat memperlengkapi calon guru dengan keterampilan yang diperlukan untuk mengembangkan rencana pengajaran berbasis inkuiri. Namun, ini tidak menjamin bahwa kelak calon guru tersebut akan berhasil memfasilitasi praktik inkuiri di kelas nyata.

Kata Kunci: Pembelajaran Inkuiri; Siklus Inkuiri Kath Murdoch; Calon Guru

Introduction

The meaning of the word "inquiry" refers to the process of investigation carried out to obtain new knowledge or find answers to existing questions or problems. The inquiry process involves steps such as formulating questions, designing research methods or experiments, collecting data, analyzing results, and reaching conclusions based on existing evidence. It involves critical thinking, meticulous observation,

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and problem-solving skills (Perry & Richardson, 2001; Rais et al., 2018; Sari et al., 2020).

Teaching science subject is synonymous with building a learner's inquiry attitude. This is because the attitude of inquiry is very attached to the scientific method that underlies scientific activities. Many studies on inquiry focus on the effect of inquiry learning on students' learning abilities and science skills. However, research focusing on the learning experience and teaching skills of preservice teachers based on inquiry is still lacking.

The role of the teacher is the most influential in science learning (Qing et al., 2010) with one aim to focus inquiry as a central element of the curriculum, to promote students to actively develop their understanding of scientific concepts, along with reasoning and thinking abilities. Thus, the traditional top-down approach has gradually become an obstacle to science education today, therefore a preservice teacher is expected to use a more appropriate approach.

A teacher must experience inquiry learning before teaching it in the classroom. The practices that a preservice teacher undertakes in his or her teaching years are strongly influenced by the college learning experience. The inquiry learning learned and experienced by preservice teachers while in college will later affect inquiry-based teaching practiced in schools. How the learning experience process of preservice teachers is seen in the design of teaching actions is what will be the focus of this research. The inquiry learning model used in this study is Kath Murdoch's Inquiry Cycle.

The research was conducted at the Faculty of Education, Pelita Harapan University. The research method used is descriptive qualitative research. Thus, there are 2 research questions that will be discussed in this study:

1. How does Kath Murdoch's Inquiry Cycle help preservice teachers experience significant learning?
2. How does an inquiry cycle help preservice teachers design Inquiry-based Science Lesson Plan?

Inquiry-based Learning

In general, inquiry can also refer to a scientific approach in research, where a researcher adopts a skeptical attitude, asks questions, designs experiments or studies, and analyzes data to reach new understandings or answer research questions posed (Mugaloglu & Saribas, 2010; Qing et al., 2010). In addition, inquiry is often used in scientific methods that involve students in a process of self-investigation and exploration, where they are given the opportunity to ask questions, formulate hypotheses, conduct experiments, and make conclusions based on their findings (Mugaloglu & Saribas, 2010; Verawati et al., 2020). Thus, inquiry is at the core of the scientific process and can be applied in many different fields of knowledge and disciplines, especially in science subjects. This inquiry approach encourages students to actively participate in learning, develop critical thinking skills, and increase their understanding of the subject matter (Rais et al., 2018).

Many studies have revealed the reasons why inquiry learning is important:

1. Inquiry learning encourages deep understanding. Through inquiry learning, students are actively involved in the process of inquiry and discovery on their own. They are invited to think critically, analyze information, and make conclusions based on their findings. This helps students gain a deeper and conceptual understanding of the subject matter, compared to passive learning (King and Taba in Qing et al., (2010)).
2. Inquiry learning improves critical thinking skills. Inquiry learning encourages students to ask questions, formulate hypotheses, and conduct evidence-based analysis (Rais et al., 2018). This process involves critical thinking skills, where students learn to evaluate information, identify assumptions, and take decisions based on rational thinking (Sari et al., 2020). These critical thinking skills are important in everyday life and help students become more independent and analytical learners.
3. Inquiry learning encourages curiosity and learning motivation. In inquiry learning, students have an active role in exploring new knowledge. They are invited to explore the topic in depth and find answers to their own questions (Rais et al., 2018). This process stimulates students' curiosity and interest, as they feel in control of

their learning. This high motivation can increase academic engagement and achievement.

4. Inquiry learning develops problem-solving skills. In inquiry learning, students are faced with situations that require problem solving. They are invited to design and carry out experiments, collect data, and find solutions to complex problems. This process develops problem-solving skills that are essential in many aspects of life, in both academic and professional contexts (Puspitasari, et al., 2019)
5. Inquiry learning builds cooperation and social skills. Inquiry learning often involves group work or collaboration between students. In this process, students learn to work together, share ideas, and respect the views of others. They also learn to communicate their findings effectively and appreciate different perspectives. These social skills are important in preparing students to work in teams and interact with others in real life (Sudiantara & Artawan, 2014).

To provide better understanding on inquiry learning, several studies has shown two factors that may affect inquiry learning as listed below:

1. Teachers' attitudes towards inquiry learning. Teachers who are enthusiastic about inquiry learning and believe in its benefits are more likely to create a classroom environment conducive to inquiry (Ahokoski, 2017; Rahmi & Nari, 2022; Seneviratne et al., 2019; Unlu et al., 2015).
2. Resource availability. Inquiry learning can be resource-intensive, so it is important to have access to the necessary materials and equipment (Asmariani, 2016 in (Rahmi & Nari, 2022)).
3. Prior knowledge and experience of students. Students who have a solid foundation in the subject matter and who have experience with inquiry learning are more likely to succeed in inquiry-based activities (Priyanto (2016).
4. Class size. Inquiry learning can be difficult to implement in large classes, as it is more differentiated and requires more individual attention from the teacher (Jumaisa, 2020).

Science Teaching & Learning

Inquiry-based science learning brings significant benefits to students, including deep understanding, critical thinking skills, high learning motivation, problem-solving skills, and social skills. According to

Kath Murdoch (2015), powerful learning happens when we "know the why" of what we are learning. Thus, nine prompt questions of Content Representations were used to emphasize this "know the why" learning experiences.

In learning science students need to have the construction of proofs derived from applicable theories and principles, which can then lead to new principles (Ong et al., 2020). National Research Council (NRC) dalam Seneviratne et al. (2019) stated that this can begin with students understanding and mastering inquiry skills:

1. Students are actively involved in scientific questions.
2. Students use facts as evidence to answer questions.
3. Students construct evidence-based explanations to answer scientific questions.
4. Students evaluate explanations that are compared with alternative explanations that reflect scientific understanding.
5. Students communicate and correct their proposed explanations.

Science learning using an inquiry approach allows students to show their curiosity (Khalaf & Zin, 2018; Mugaloglu & Saribas, 2010; Qing et al., 2010) and make it a motivation (Gibson and Chase in Khalaf & Zin, (2018)). Hofstein and Walberg in Qing et al.(2010) affirmed that both of these things help learners to participate in understanding problems, formulating hypotheses, planning science experiments, analyzing data obtained, and providing conclusions from the science problems studied. This reflects students' expectations and confidence in science learning opportunities with inquiry. The stages involved in inquiry-based learning may vary, but several studies have shown that inquiry-based learning generally includes stages in the scientific process: (1) Ask questions; (2) Conduct research; (3) Analyze data; (4) Communicate findings; and (5) Reflect on the process.

Aligned with the scientific process abovementioned, Kath Murdoch (Murdoch, 2015) introduced an inquiry cycle consisting of six stages of inquiry as shown in the illustration below:



Figure 1. Kath Murdoch's Inquiry Cycle

Source: <https://blog.siliconvalleyinternational.org/the-inquiry-learning-cycle>

1. Tuning In
Tuning in is the initial stage of the inquiry process. It aims to engage learners and activate learners' prior knowledge and curiosity about the topic as well as goal setting. Some questions may emerge from learners at this stage. What theories do we have? How do we already understand this?
2. Finding Out
In this stage, learners gather information and investigate the questions generated during the Tuning-In stage. This stage is an active and inquiry-driven stage where learners gather information, conduct investigations, and deepen their understanding of the topic.
3. Sorting Out
This stage focuses on organizing and analyzing the information collected during the Finding Out stage. Learners categorize and sort the data, identify patterns, make connections, and develop new insights and understandings.
4. Going Further
In this stage, learners go beyond the initial information and delve deeper into the topic. They engage in further research, investigations, experiments, or activities to expand their

understanding and address any remaining questions or areas of interest.

5. Making Conclusions

Learners reflect on their learning journey and draw conclusions based on their research, analysis, and observations. They consolidate their findings, identify key concepts, and develop a deeper understanding of the topic.

6. Taking Action

This stage involves applying and sharing the knowledge and insights gained throughout the inquiry process. Learners take meaningful action based on their learning, such as creating projects, presentations, or products, sharing their findings with others, or applying their understanding to real-world contexts.

Besides the six stages above, the regular reflection stage is taking place in every stage to assess learners' progress, identify any gaps in their understanding, and determine their next steps. Reflection can take the form of journaling, group discussions, or individual consultation with the teacher. It helps learners consolidate their learning and refine their inquiries.

Research Method

This study is qualitative research with a descriptive design. This design was chosen because the research aims to describe inquiry practices conducted by pre-service teachers. The sample of the study was 33 preservice primary teachers who took the second-year science content course named Integrated Science for Primary. The 16-week program consisted of interactive lectures, discussions, assignments, group work, and individual practices related to process skills and designing inquiry activities. Table 1 shows the weekly focus of the program.

Table 1

An overview of weekly focus of the program

Week	Focus	Instrument Applied
1	What is inquiry in science	Observation Notes
2-5	Scope of Primary Science	-
5-7	Group Work	Experiment Design

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Week	Focus	Instrument Applied
9	Review week 1-8	Reflective Forms 1
10	How to Create an Inquiry-Based Teaching Plan	-
11-15	Individual Practices	Observation Notes Lesson Plan Design
16	Review week 10-15	Reflective Forms 2

In the first week of the program, a lecture followed by a discussion was given about inquiry in the context of science teaching and learning. In the next four weeks, primary science materials were discussed in the light of *Capaian Pembelajaran Kurikulum Merdeka* (Learning Outcomes in National Curriculum). Preservice teachers were expected to have a better understanding of science concepts for primary students. Moreover, during these four weeks, preservice teachers in group work were responsible for conducting an experiment based on a worksheet given every week as well as working on a design of a science experiment for a chosen topic. Through group work and discussion, preservice teachers were expected to be able to integrate scientific processes into their design. Following these group activities, reflective forms were filled to create metacognitive awareness about the cycle of inquiry learning.

During the individual practices (week 11 to 15) nine guiding questions in the Content Representation (CoRes) framework were used also as metacognitive prompts of inquiry to facilitate deep learning. During these weeks, each student's teaching plan was discussed in groups, and got regular feedback from their peers as well as the lecturer. In the end of the program, preservice teachers had a chance again to reflect on their learning experience, expectations, and belief regarding inquiry in science teaching and learning. Both reflective forms used in weeks 9 and 16 were developed by the researcher using

In this study, to answer the research questions several instruments were applied to gather data as shown in Table 2 below:

Table 2

An overview of research questions, instruments, and data sources

Research Qs	Observation Notes	Experiment Design	Reflective Forms 1	CoRes Lesson Plan	Reflective Forms 2
How does the cycle of inquiry help preservice teachers	√	√	√		

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Research Qs	Observation Notes	Experiment Design	Reflective Forms 1	CoRes Lesson Plan	Reflective Forms 2
experience deep learning through inquiry?					
How does an inquiry cycle help preservice teachers reframe the way they think about inquiry-based teaching?	√			√	√

As mentioned earlier, the study uses qualitative data. Validity in this study has been built since in the process of research designing, during data collection, and data analysis (Yin, 2003). The use of theory in this study (Kath Murdoch's inquiry cycle) during the process of research design is considered a way to maintain external validity. Triangulating data collected through observation, experiment design activities, and reflections was hopefully believed to amplify the internal validity of the research findings. Meanwhile, the reliability of data in this qualitative research can be assured through procedures of data collection that are appropriate and fully explained (Hittleman & Simon, 1997). All the collected data will be reviewed according to Kath Murdoch's inquiry cycle as a conceptual framework to develop concepts and theoretical propositions from the findings.

How does Kath Murdoch's Inquiry Cycle help preservice teachers experience significant learning?

In inquiry-based learning students not only develop their critical thinking and communication skills but also learn to work independently and collaboratively (Harlen, 2014; Short, 2009). In this way, significant learning is facilitated as students become part of a learning community and learn from each other through social interaction. Teachers contribute to building a community of inquirers within the classroom in many ways: activate small group work by encouraging learners to share with each other as well as by providing an equal opportunity to participate in the class discussion (Austin, 2019). Through the six stages of inquiry-based

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learning, preservice teachers have experienced significant learning in integrating scientific processes into their experiment design:

1. Tuning In

In this stage, most of the preservice teachers asked the similar questions: *"What do we already think, feel and know about this experiment topic?"* To bring preservice teachers to the next stage, later the lecturer asked preservice teachers: *"How could we find out more about this topic?"*

2. Finding Out

In group discussions, preservice teachers were encouraged to decide what information needed, how they might find out more, and how to deepen their understanding of the topic chosen for the experiment plan. After that, they will work together individually to gather the information.

3. Sorting Out

In this stage, preservice teachers organized and analyzed the information gathered in group works. This stage combined collaborative and individual work to express their inquiry learning on the experiment topics.

4. Going Further

This stage was where any group members raised new inquiries/questions. *What's another way to find out more about this? How can we organize for our own inquiry?* Some groups admitted that they followed personal inquiry into own group questions.

5. Making Conclusions

After series of collaborative and individual works, group work summed up the findings leading to culminating task. The most often question discussed in this stage was: *"How can we show what we understand/learn?"* Eventually, this question led the group to the final stage: taking action.

6. Taking Action

While stages are broadly sequential, it was common to see groups worked backward and forward to solidify the findings and making connections between scientific step the experiment design.

The high score (Mean = 89.66) achieved by the students has shown that experiencing learning through a cycle of inquiry of Kath Murdoch is found as an interesting and useful approach for preservice

teachers to understand how to integrate scientific processes into their experiment designs. In addition, though the experiment design was developed in group works, preservice teachers were also expected to always reflect on learning personally. Their notes in the first reflection have also shown their deep understanding of how scientific processes are integrated into their experiment designs.

How does Kath Murdoch's Inquiry Cycle help preservice teachers design Inquiry-based Science Lesson Plan?

Inquiry learning in designing science experiments has emphasized the construction of conceptual understandings of a topic and how scientific processes are integrated into their experiment designs. Yet, from the initial plan and brainstorming conducted, it is found that preservice teachers were having low competence to design inquiry-based science teaching. The traditional approach was most likely chosen regarding science teaching at the primary level. The pedagogy proposed during brainstorming lacked inquiry-based activities and missed scientific process steps.

Through group discussion and individual practices, preservice teachers were assigned to design their own science lessons. Both collaborative and individual work was used to allow preservice teachers to take ownership of their learning, encourage critical thinking, and promote collaboration among peers using Kath Murdoch's cycle of inquiry learning:

1. Tuning In

In this stage, preservice teachers refined their initial lesson plans. Many of them still required some early immersion or 'front loading' in the topic when little is known or experienced. Several key/essential questions were developed to drive their inquiry work.

2. Finding Out

Together with key questions predefined, preservice teachers used nine questions of CoRes as metacognitive prompts to help them design the lesson plan. These prompt questions (Bertram, 2014)

assisted them to know why they chose specific practices in their lesson plan.

- a. What are big science ideas/concepts of teaching the content?
 - b. Why is it important for the students to know this?
 - c. What do you intend the students to learn about this idea?
 - d. What else you might know about this idea (that you do not intend students to know yet)?
 - e. What are difficulties/limitations connected with teaching this idea?
 - f. What is your knowledge about students' thinking that influences your teaching of this idea?
 - g. Are there any other factors that influence your teaching of these ideas?
 - h. What is your particular teaching procedure (and reasons for using these to engage with this idea)?
 - i. What are specific ways of ascertaining students' understanding or confusion around this idea (include a likely range of responses)
3. Sorting Out

In this stage, preservice teachers organized, analyzed and discussed the information gathered using predefined key/essential questions. "*What meaning can we make of this? What are we learning*" were two big questions used during group discussion and individual practices guided by the lecturer.

4. Going Further

In individual practices, preservice teachers now developed their own questions. The emphasis here is on choice and differentiation made by their personal inquiry and reflections.

5. Making Conclusions

This stage allowed preservice teachers to revisit key/essential questions and state revised understanding, which was better, deeper, and more meaningful. To some extent, they could articulate explicit connections between prompt questions in the CoRes framework throughout the science lesson plan. In this stage, the lesson plans have shown how their competence has improved substantially.

6. Taking Action

This final stage was the stage where preservice teachers must finalize their science lesson plan in which inquiry was expected to be cultivated and impactful for students' science learning.

Eventually, the science lesson plans submitted have shown how preservice teachers' inquiry concepts have been improved and changed the way they developed science lesson plans. The nine prompt questions were answered in a very thoughtful way where preservice teachers expressed their belief in the power of inquiry. Also, it is found that in their lesson plan teaching strategies were selected purposefully to provide an inquiry journey. These findings were confirmed by the second reflection in which preservice teachers stated that they have learned a lot. Some notes in their reflections are quoted below:

"Designing an inquiry lesson plan makes me reflect more often..."

"This task makes me read a lot, the more I read the more unknown things are revealed."

"Group discussion, self-investigations, consultation with lecturer have developed my critical thinking."

"Collaborative work with friends has brought me unexpected ideas of inquiry. I became more confident in science teaching than I would have been in early meetings."

These findings have proved that the use of Kath Murdoch's Inquiry Cycle helps preservice teachers design Inquiry-based Science Lesson Plans. Eventually, preservice teachers could experience the inquiry discourse and develop their inquiry comprehension to improve its impact power to their journey of learning (Lee, 2011).

Conclusions

Learning how to learn is a central goal of an inquiry-based approach to learning. Cultivating inquiry in primary students begins with cultivating it in preservice teachers' selves. Experiencing learning through Kath Murdoch's inquiry cycle is found as an interesting and useful approach for preservice teachers to understand how scientific processes are integrated into their experiment designs. Yet, it is plausible to argue

that designing and implementing inquiry-based teaching requires an ability to implement scientific processes into the lesson plan. In this research, although preservice teachers got high scores for scientific process skills in science experiment designing, they were unable to design an inquiry-based teaching plan before the individual inquiry-guided practices were given.

After the individual practices with the lecturer's guidance, preservice science teachers' competence in designing an inquiry-based teaching plan has improved substantially. This implies that an inquiry cycle used in guided practices (including metacognitive prompts, reflections, and group discussion) could provide preservice teachers with the necessary skills to develop an inquiry-based teaching plan. Also, this shows us alternatives to how to cultivate inquiry through classroom practices. Yet, this does not guarantee that preservice teachers would successfully facilitate inquiry in a real classroom setting. For further studies, it is suggested that preservice teachers should be encouraged to implement their inquiry-based teaching plan in their next practicum courses. So, preservice teachers could experience the inquiry discourse and develop their inquiry comprehension to improve its impact power to their journey of learning as well as students learning.

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