

Implementation of Scientific Methods and Attitudes in Science Education

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Abstract

In scientific terms, the primary school represents the initial stage in formal education that imparts fundamental knowledge and skills to students. Therefore, primary school learning should emphasize the provision of meaningful learning experiences to develop the potential and abilities of students. One of the subjects at the primary school level is Natural Sciences (IPA - Ilmu Pengetahuan Alam). The teaching of Natural Sciences requires scientific methods and attitudes to ensure that students can develop a profound understanding of scientific concepts and apply them in daily life. The focus of this article is on scientific methods and attitudes. Based on this research, the researcher employed a literature review method. The results of the study indicate that employing Problem-Based Learning (PBL) as a model is an effective strategy for developing investigative skills and critical thinking within the framework of scientific methods and attitudes. This is because the learning model utilizes real-world problems as a context for students to learn problem-solving skills and critical thinking, enabling them to acquire essential knowledge and concepts.

Keyword: *Methodology, Scientific Attitudes, and Natural Science Education (IPA)*

Introduction

Natural Science (IPA - Ilmu Pengetahuan Alam) is a branch of scientific knowledge that investigates natural phenomena and systems in our environment, encompassing everything from plants and animals to celestial bodies. Primary school represents the initial stage of formal education, providing students with foundational knowledge and basic skills. Consequently, primary school learning should underscore the provision of meaningful learning experiences to foster the development of students' potential and abilities.

One of the subjects included in the primary school curriculum is Natural Science (IPA). Learning Natural Science requires the application of scientific methods and attitudes to ensure that students can cultivate a profound understanding of IPA concepts and apply them in their daily lives. Scientific methods and attitudes also aid students in developing crucial skills such as investigation, problem-solving, and critical thinking, essential for becoming independent and adept thinkers.

In primary school Natural Science education, there is an emphasis on providing direct learning experiences by actively involving students in the learning process. This necessitates the use of scientific methods and attitudes to ensure that students can develop a deep understanding of Natural Science concepts and apply them in everyday life. Through active student engagement, it is hoped that students can discover and construct their knowledge from the challenges encountered in both the learning process and daily life.¹

To provide students with direct learning experiences, various instructional activities can be employed, including discussions, question-and-answer sessions, group work, experiments, and observations. Scientific methods and attitudes are instrumental in helping students develop essential skills such as investigation, problem-solving, and critical thinking, which are crucial for fostering independent and skilled thinkers.

Scientific methods in Natural Science education involve several stages, namely observation, hypothesis formulation, hypothesis testing, data analysis, and drawing conclusions. These stages guide the systematic process of inquiry and discovery in the learning of Natural Science. Activities such as observation allow students to gather information, while formulating hypotheses encourages them to propose explanations for observed phenomena. Subsequently, hypothesis testing involves designing and conducting experiments, and data analysis helps students draw meaningful conclusions based on evidence. These scientific methods not only contribute to a deeper understanding of Natural Science concepts but also promote the development of analytical and critical-thinking skills necessary for students to become independent and adept thinkers.² These stages enable students to cultivate a deeper understanding of Natural Science concepts through practical experiences and experiments. Scientific attitudes are also crucial in Natural Science education.³ Students must exhibit an open attitude toward new knowledge, be capable of identifying and evaluating acquired information, and possess the ability to question assumptions underlying their existing knowledge. Scientific attitudes also encompass collaboration and creativity in problem-solving and making new discoveries. Scientific attitudes are essential for students to acquire knowledge, both existing knowledge and new knowledge discovered through a series of scientific learning processes. Scientific attitudes are not inherently ingrained in students; they need to be trained and accustomed to applying scientific methods and attitudes continuously in their daily behavior.

The cultivation of scientific methods and attitudes in students is crucial because with a

¹ Khoeruddin, dkk, Kurikulum Tingkat Satuan Pendidikan (KTSP) Konsep dan Implementasinya di Madrasah, (Semarang: Pilar Media, 2007), 182-183.

² Dra. Rella Turella, Lulu Ayuning Dyah, Modul Pengembangan Keprofesian Berkelanjutan (PKB) Kelompok Kompetensi E Materi dan Energi.

³ Patta Bundu, Penilaian Keterampilan Proses dan Sikap Ilmiah dalam Pembelajaran Sains Sekolah Dasar, (Jakarta: Depdiknas Dirjen Pendidikan Tinggi Direktorat Ketenagaan, 2006), 49.

scientific mindset, students can effectively address the challenges they encounter. However, in many cases within the context of Natural Science education, there are still students lacking a scientific attitude. In Natural Science education, teachers also play a role as facilitators and guides, assisting students in developing scientific methods and attitudes. Teachers should foster problem-based learning and enable students to take an active role in their learning process. In order to enhance effective Natural Science education, further research is needed on how scientific methods and attitudes can be applied in teaching Natural Science. This research can generate best practices and strategies to help students develop the investigative skills and critical thinking necessary for success in an increasingly complex and rapidly changing world.

Methods

The focal point of this article is on scientific methods and attitudes. According to this research, the method employed by the researcher is the literature review method ⁴. The literature review method refers to the approach used by the author to search, collect, explore, or examine various reference sources or literature relevant to the proposed topic. These collected materials are then analyzed using content analysis techniques with a historical and philosophical approach ⁵

Result And Discussion

Maskoeri Jasin further asserts that scientific attitude is a crucial attribute for scientists, encompassing the following traits: 1) Having a high curiosity and strong learning ability, 2) Not accepting truth without evidence, 3) Honesty, 4) Open-mindedness, 5) Tolerance, 6) Skepticism, 7) Optimism, 8) Courage and 9) Creativity or self-reliance. These traits are acquired through sincere efforts, and the experiments conducted by scientists contribute to the development of these scientific attitudes. Tini Gantini identifies eight characteristics of a scientific attitude: ⁶

1. Having a curiosity that drives the exploration of new facts
2. Being impartial and having a broad perspective on truth
3. Ensuring consistency between observations and reports
4. Being determined and diligent in the pursuit of truth
5. Maintaining a sense of doubt, continuously driving the effort to search for truth without being pessimistic
6. Being humble and tolerant of both known and unknown aspects
7. Having little fear
8. Maintaining an open mind toward new truths.

⁴ Mestika Zed, *Metode Peneletian Kepustakaan* (Yayasan Obor Indonesia, 2004).

⁵ David C Korten and Rudi Klauss, *People-Centered Development: Contributions toward Theory and Planning Frameworks* (Kumarian Press West Hartford, CT, 1984).

⁶ Maskoeri Jasin, *Ilmu Alamiah Dasar*, rev.ed., (Jakarta: Raja Grafindo Persada, 2010), 45-49.

From these eight characteristics of a scientific attitude, it is evident that key aspects of a scientific attitude include objectivity, openness, diligence, patience, humility, and avoiding dogmatism in scientific truths. This indicates that scientists need to continuously nurture these attitudes when dealing with science because there is always a possibility that what is considered true today (such as a theory) may be replaced by another theory demonstrating a new truth in the future.

Developing Investigation Skills and Critical Thinking in Scientific Methods and Attitudes Strategies

One strategy for developing investigation skills and critical thinking within scientific methods and attitudes is the utilization of Problem-Based Learning (PBL). PBL is a learning model based on real-world problems, generally defined as an instructional approach that employs real-world issues as a context for students to learn problem-solving skills and critical thinking to acquire essential knowledge and concepts.

Reasons for the Preferable Use of PBL Include: Stimulating Higher-Order Thinking Skills: PBL serves to stimulate students to engage in higher-order thinking skills, prompting them to analyze, synthesize, and evaluate information rather than mere memorization of facts, Fostering Lifelong Learning Skills: The approach initiates the development of lifelong learning skills, emphasizing the ability to independently acquire new knowledge and adapt to evolving situations, Enhancing Problem-Solving Abilities: PBL emphasizes problem-solving, enabling students to develop effective strategies for addressing real-world challenges., Promoting Communication Skills: Students engaged in PBL are encouraged to articulate their ideas and findings, both orally and in written form, fostering effective communication skills, Encouraging Collaborative Work: PBL involves collaborative group work, promoting teamwork and leadership skills as students work together to analyze and solve problems.

Implementing PBL in the educational setting aligns with the objectives of cultivating a scientific mindset and attitude. It offers a dynamic and engaging approach that not only imparts knowledge but also nurtures the skills and attitudes necessary for students to thrive in a rapidly changing and complex world.

In general, the teaching of Natural Science (IPA) is implemented using experimental methods. The instructional steps employed in this method are similar to those in Problem-Based Learning (PBL), involving activities such as problem formulation, hypothesis generation, and investigation. The design of PBL in Natural Science education focuses on creating authentic problems to stimulate students to work on solving complex problems as professionals. The creation of these problems involves the following steps: selecting the learning materials (content) and skills to be taught, determining learning resources, formulating the problem statement, establishing motivation, defining the focus of questions, and determining the evaluation methods.

In selecting learning materials (content) and skills to be taught, teachers should refer to the applicable curriculum. Similarly, in determining lesson objectives – what students should know and be able to do at the end of the lesson – teachers must design how students can achieve the specified learning objectives. For example, if the curriculum requires students to communicate verbally and orally, as well as possess interpersonal skills, the created problems should encompass tasks such as creating laboratory reports, conducting interviews, or working in teams.

After determining the learning objectives, content, and skills to be taught, the next step is for teachers to ensure the availability of learning resources needed by students to solve the problems they face. This is crucial because limitations in information and learning resources can hinder students from providing optimal solutions to the problems they encounter. Therefore, teachers are advised to create a list of required learning resources, such as books that need to be read and where they can be obtained, who needs to be interviewed, etc.

Once the teacher ensures that the necessary learning resources for students are available, the next step is to formulate the problems that will guide students in their learning process. Ideas for creating PBL problems can come from various sources, such as literature, news, articles, or events in everyday life. The problems used in PBL can be created by the teacher or adapted from problems created by others. For example, here is a problem adapted from Delisle.⁷:

"Some relatives and acquaintances you know are experiencing digestive disturbances in the stomach and have consulted a doctor. The doctor states that their digestive issues are caused by excessive stomach acid, and they have been prescribed antacids. However, they are confused because they do not know what acid and antacids are and which one they

⁷ Delisle, Robert, *How to Use Problem Based Learning in The Classroom*, 1997.

should use. You and your group are asked to help them understand what is happening with their stomachs and how to choose the right product to alleviate their pain."

The problem above is designed for grade 11-12 students on the topic of acids and bases. From the example problem above, it can be observed that the created problem must be developed in such a way that it can stimulate high-level thinking skills (critical thinking) and the socio-emotional abilities of students. Moreover, the created problem should also be rooted in students' experiences and be challenging enough. This is important because the more relevant the problem is to students' daily experiences, the higher their interest in learning and working to solve the problem. The created problem should also be based on the applicable curriculum and accommodate students' learning styles and strategies while being ill-structured. Problems in PBL should demand students to conduct investigations/research, seek necessary information, and integrate the knowledge they possess with the acquired information to provide various alternative solutions. Designing activities to motivate students to be interested in solving the problem is the next step that teachers need to take in designing PBL. This can be done by encouraging students to explore the connections between the problem and their daily lives. The higher the relevance of the problem, the higher their desire to work on solving it.

The next step is to determine the focus of the question. This step is beneficial for elementary or middle school teachers to help students focus on what they will learn. At a higher level (high school), this is not necessary because determining the focus of the question/problem becomes one of the students' responsibilities in implementing PBL.

The last step is to determine the strategy for evaluating student learning outcomes. Determining how student learning outcomes will be evaluated depends on the given problem and the predetermined learning objectives. Evaluation should assess the learning process and the knowledge and skills acquired by students. In Natural Science education, assessment can be done through reports, how students analyze the results of practical work, and checklists of students' skills in conducting practical work. Assessment can also be done through self and peer assessment, discussions, article writing, etc.

Steps of PBL in Natural Science Education

PBL is a student-centered learning method. When conducting investigations or research to find solutions to problems given by the teacher, students are assumed to play the role of a scientist. Students can work individually or in groups. Working in groups is preferably

implemented as students can learn and discuss with their peers. Moreover, students are also trained to develop their communication and interpersonal skills.

The implementation of PBL consists of several steps, and some of these steps can be repeated.⁸ The first step is for the teacher to provide stimulus/motivation to connect students with the problem to be given. Then, the teacher presents the problem and gives students the opportunity to read the presented problem. The next step is for students to discuss and take notes on the information/facts they can gather from the problem they have read. Subsequently, students express ideas, identify and determine the formulation/focus of the problem, and make hypotheses. The fifth step is for students to identify their learning needs in order to seek solutions to the presented problem. In this step, students identify what concepts/principles they need to learn, what learning resources they will use, and what tasks they need to perform. The next step is for students to inform their findings/solutions to their peers. This is done to test whether their findings are adequate or not. If their findings are satisfactory, students can draw conclusions and engage in self-assessment/reflection on what they have learned, such as "Do I understand and comprehend the material studied?" If students' findings have not provided a solution to the problem posed by the teacher, then students can repeat steps two through six.

In implementing PBL, the main role of the teacher is as a facilitator. In facilitating students, the teacher can ask metacognitive questions to transfer ownership of the problem formulations students have written, such as "What were you thinking when you wrote the problem formulation like this?" The teacher can also make reflective statements/questions to reinforce clarity and connect questions, such as "Can you explain which part you disagree with?" Furthermore, the teacher can express cognitive socialization by establishing norms or acting as a mediator in case of conflicts between students, for example, "I understand what you mean, but let's try to listen to the opinions of other groups."

In PBL, the evaluation to assess student success is conducted in an integrated manner. This means that it not only assesses what students have learned but also evaluates how students are engaged and their abilities in each step of problem-solving. Therefore, assessment begins when the problem is presented and continues until the assessment of the final results/products. Teachers assess students' thinking abilities, understanding, and success in carrying out each step of problem-solving. This includes how students guide themselves in their work and their involvement in teamwork. Thus, in PBL, teachers assess the extent of students' understanding of the material learned and the skills they have mastered. The assessment conducted should align

⁸ Nurdyansyah, Fitria Amalia. t.t, Model Pembelajaran Berbasis Masalah Pada Mata Pelajaran IPA Materi Komponen Ekosistem.

with the predetermined learning objectives. Therefore, to obtain information on the extent of student success in learning, teachers need to create assessment instruments that are suitable for the characteristics of the aspects to be evaluated. For example, if a teacher wants to assess the extent of students' involvement in problem-solving and the skills they have acquired, the teacher can create an observation sheet containing indicators/guidelines/questions for each aspect to be assessed.

Conclusion

The scientific process conducted in accordance with the stages of the scientific method provides a platform for the development of scientific skills and attitudes. Both are fundamental elements in achieving the goals of national education, namely to develop the potential of learners to become individuals who are faithful and devoted to the One Almighty God, have noble character, are healthy, knowledgeable, capable, creative, independent, and responsible citizens. The scientific method is a process employed by scientists to discover and acquire new knowledge through the identification and formulation of problems, formulation of hypotheses, experimental design, data collection, data analysis, and drawing conclusions. On the other hand, scientific attitudes are thought patterns that scientists must possess, including curiosity, openness, perseverance, skepticism, honesty, objectivity, deliberate decision-making, and respect for the opinions of others.

A strategy to develop investigative skills and critical thinking in the scientific method and attitude involves using the PBL model. PBL is a learning model that utilizes real-world problems as a context for students to learn problem-solving skills and critical thinking to acquire essential knowledge and concepts. The PBL learning model has been proven to enhance student participation, activity, motivation, and learning outcomes, as well as improve critical thinking/higher-order thinking skills.

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