



The Role of Laboratory-Based Inquiry in Correcting Science Misconceptions and Strengthening Students' Conceptual Understanding

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Abstract

Science misconceptions can hinder students from developing accurate and meaningful conceptual understanding. Laboratory-based inquiry provides students with opportunities to test their prior conceptions through observation, experimentation, evidence analysis, and reflection. This article examines the role of laboratory-based inquiry in correcting science misconceptions and strengthening students' conceptual understanding. This study uses a literature review method by analyzing relevant studies on misconceptions, conceptual change, inquiry-based learning, and laboratory activities. The findings indicate that laboratory-based inquiry can help students identify inconsistencies between their initial conceptions and experimental evidence, develop scientific reasoning, and construct stronger conceptual understanding. Therefore, laboratory activities should be designed as inquiry-based experiences that actively involve students in questioning, predicting, investigating, analyzing evidence, and reflecting on their initial conceptions.

Keywords: laboratory-based inquiry, science misconceptions, conceptual understanding, inquiry-based learning, science education

1. Introduction

Science education aims not only to provide students with scientific facts but also to develop their ability to understand concepts, investigate phenomena, interpret evidence, and construct scientifically appropriate explanations. However, students enter science classrooms with prior ideas that have developed through everyday experiences and previous learning. Some of these ideas may differ from accepted scientific explanations and can consequently become misconceptions that interfere with subsequent learning (Julianto et al., 2023).

Science misconceptions are particularly challenging because students may consider their initial explanations to be reasonable based on their own experiences. As a result, simply providing students with the scientifically correct answer may not be sufficient to change their existing understanding. Recent research indicates that instructional strategies specifically designed

to create opportunities for conceptual change can produce substantial improvements in science learning and help address persistent misconceptions (Pacaci et al., 2024).

Laboratory activities provide an important context for connecting scientific concepts with observable phenomena. Through experimentation, students can collect evidence, observe relationships, and evaluate explanations based on actual findings. Recent research on inquiry-based science laboratories has shown that students can benefit from engaging in scientific practices such as designing investigations, collecting and analyzing data, and constructing evidence-based arguments (Eymur & Çetin, 2024).

Nevertheless, laboratory work does not automatically guarantee conceptual learning. Students may experience difficulties at conceptual, procedural, and epistemic levels when conducting experiments, including difficulties in formulating research questions, interpreting evidence, and connecting experimental procedures with scientific ideas. These challenges demonstrate the importance of providing appropriate instructional support during laboratory investigations (Kalthoff et al., 2022).

Inquiry-based learning provides a framework that can make laboratory activities more meaningful by involving students in asking questions, developing investigations, collecting evidence, and constructing explanations. A recent systematic review found that inquiry approaches can positively influence students' conceptual understanding, motivation, scientific skills, and science literacy, although successful implementation requires appropriate teacher support and classroom management (Dah et al., 2024).

The connection between inquiry and misconceptions is particularly important because students can use evidence obtained from investigations to test their initial ideas. When an experimental result differs from what students expect, the discrepancy can encourage them to reconsider their existing explanations. Research involving an inquiry-based learning environment specifically designed to address misconceptions found that students exposed to misconception-focused inquiry demonstrated greater conceptual change than students participating in conventional inquiry activities (2023).

Laboratory-based inquiry can therefore provide a learning environment in which students are not merely asked to memorize scientific concepts but are encouraged to investigate, evaluate evidence, and reconstruct their understanding. Recent experimental research has also demonstrated that guided inquiry laboratory instruction can improve both procedural and conceptual understanding, highlighting the value of structured guidance during laboratory learning (Karal Eyüboğlu & Sağlam Arslan, 2024).

Based on these considerations, this article aims to examine the role of laboratory-based inquiry in correcting science misconceptions and strengthening students' conceptual understanding. The discussion focuses on how inquiry-oriented laboratory experiences can reveal students' initial conceptions, provide evidence for evaluating those conceptions, and support the development of scientifically accurate conceptual understanding (Johnston et al., 2022).

2. Research Method

This article uses a literature review method to examine recent research concerning laboratory-based inquiry, science misconceptions, conceptual change, and students' conceptual understanding. The review focuses primarily on publications from 2022 to 2026 to ensure that the discussion reflects current developments in science education research (Dah et al., 2024).

The literature was selected based on its relevance to the main themes of the study, particularly research investigating inquiry-based laboratory activities, misconception-oriented instruction, conceptual understanding, and scientific reasoning. Studies employing experimental, quasi-experimental, review, and literature-review approaches were considered to provide a broader understanding of the topic (Kara! Eyüboğlu & Sağlam Arslan, 2024).

The selected literature was analyzed thematically by identifying recurring findings related to the role of laboratory-based inquiry in exposing misconceptions, facilitating conceptual change, strengthening conceptual understanding, developing scientific practices, and supporting students during scientific investigations. The findings were then synthesized to identify the contribution and limitations of laboratory-based inquiry in science education (Kalthoff et al., 2022).

3. Results And Discussion

Students' prior conceptions play an important role in science learning because they influence how students interpret new information and scientific phenomena. When these conceptions conflict with scientific explanations, they may become misconceptions that interfere with the development of accurate conceptual understanding. Recent research emphasizes the importance of directly addressing misconceptions through instructional approaches that engage students in active reasoning and conceptual examination (Julianto et al., 2023).

Correcting misconceptions requires more than presenting students with correct scientific information. Students need opportunities to recognize inconsistencies between their existing explanations and evidence obtained from learning experiences. Recent meta-analytic evidence indicates that conceptual change strategies have substantial positive effects on science achievement, suggesting that instructional approaches designed around conceptual restructuring can be effective in improving students' scientific understanding (Pacaci et al., 2024).

Laboratory-based inquiry can provide an appropriate context for this process because students encounter scientific phenomena directly. Instead of receiving explanations before conducting an investigation, students can formulate questions, develop predictions, conduct experiments, and analyze the resulting evidence. Research on inquiry-based science laboratories has demonstrated that students can develop scientific literacy through active participation in scientific practices and evidence-based argumentation (Eymur & Çetin, 2024).

An important feature of laboratory-based inquiry is the opportunity for students to express their initial expectations before conducting an experiment. Predictions can reveal how students currently understand a phenomenon and provide a basis for comparison with subsequent observations. When students discover that their predictions do not correspond with the experimental evidence, they have an opportunity to reconsider their original explanations and seek more appropriate scientific interpretations (2023).

The comparison between predictions and experimental findings can become an important mechanism for conceptual change. Students may encounter evidence that challenges their existing explanations, creating an opportunity to examine why their initial ideas were unable to explain the observed phenomenon. Such experiences can be particularly valuable when laboratory activities are explicitly designed to address known misconceptions rather than simply demonstrate scientific principles (Johnston et al., 2022).

Laboratory-based inquiry also contributes to conceptual understanding by requiring students to connect theoretical ideas with empirical evidence. Students are encouraged to interpret observations, analyze data, and construct explanations rather than merely record

experimental results. Recent research on guided inquiry laboratory instruction has found positive effects on students' procedural and conceptual understanding, indicating that laboratory inquiry can support both what students know and how they conduct scientific investigations (Kara! Eyüboğlu & Sağlam Arslan, 2024).

The development of conceptual understanding is strengthened when students are able to apply scientific concepts to explain phenomena rather than simply recall definitions. Open inquiry has been reported to have positive effects on conceptual understanding as well as scientific and thinking skills. However, the effectiveness of inquiry depends on appropriate implementation, teacher-student interaction, and instructional support (Dah et al., 2024).

Teacher guidance is therefore an important component of laboratory-based inquiry. Although students should be given opportunities to investigate independently, they may require scaffolding when formulating questions, designing procedures, interpreting data, or constructing explanations. Recent research on learners' difficulties with experiments emphasizes the need for tailored scaffolding to support students across different stages of scientific investigation (Kalthoff et al., 2022).

Laboratory inquiry can also strengthen students' scientific literacy by involving them in authentic scientific practices. Students may be required to design investigations, collect and analyze data, develop claims, provide evidence, and justify their conclusions. These activities move laboratory learning beyond procedural completion and encourage students to understand science as a process of constructing and evaluating explanations based on evidence (Eymur & Çetin, 2024).

Addressing misconceptions through inquiry can be particularly effective when the investigation is intentionally connected to the misconception being targeted. In a study using an inquiry-based digital laboratory, students who participated in activities specifically designed to address identified misconceptions demonstrated greater conceptual change than students who participated in inquiry activities without the same misconception-focused design. This finding suggests that inquiry should be purposeful rather than simply exploratory (2023).

The use of laboratory environments can also make scientific concepts more concrete for students. When students can observe a phenomenon and interact with experimental materials, abstract scientific relationships may become easier to interpret. Recent research on inquiry-based laboratory instruction indicates that students' engagement in designing investigations and analyzing evidence can contribute to improved scientific literacy and deeper understanding of scientific concepts (Eymur & Çetin, 2024).

However, laboratory-based inquiry also presents challenges. Students may have difficulties understanding experimental procedures, identifying appropriate variables, formulating research questions, interpreting data, and making epistemic judgments about evidence. These challenges can occur across educational levels, demonstrating that inquiry skills should be explicitly developed rather than assumed to emerge automatically from laboratory participation (Kalthoff et al., 2022).

Another challenge concerns the level of inquiry provided to students. Completely open inquiry may place substantial cognitive and organizational demands on learners, particularly those with limited prior inquiry experience. Recent research suggests that although open inquiry can positively affect science learning, successful implementation requires flexibility, classroom management, teacher-student interaction, and appropriate teacher support (Dah et al., 2024).

The findings also indicate that inquiry-based laboratory instruction can support more than conceptual knowledge. Students may develop scientific literacy, critical thinking, argumentation, investigation skills, and greater engagement with science. These outcomes are important because conceptual understanding becomes more meaningful when students can use scientific concepts to investigate and explain real phenomena (Eymur & Çetin, 2024).

Overall, recent research supports the use of laboratory-based inquiry as an approach for addressing science misconceptions and strengthening conceptual understanding. Its effectiveness is greatest when laboratory activities are explicitly connected to students' prior conceptions, involve meaningful scientific investigation, provide opportunities to compare predictions with evidence, and include appropriate teacher guidance. Therefore, laboratory-based inquiry should be viewed not simply as practical work but as a structured learning process that supports conceptual change and scientific reasoning (Pacaci et al., 2024).

4. Conclusion

Laboratory based inquiry plays an important role in correcting science misconceptions and strengthening students' conceptual understanding. Through inquiry-oriented laboratory activities, students have opportunities to express their initial conceptions, make predictions, conduct investigations, observe scientific phenomena, analyze evidence, and compare experimental findings with their previous understanding. These processes can help students recognize inconsistencies in their initial ideas and gradually develop explanations that are more scientifically appropriate.

The effectiveness of laboratory-based inquiry depends on the design and implementation of the learning activities. Laboratory activities should not focus only on following procedures or obtaining experimental results but should encourage students to think, investigate, interpret evidence, and reflect on their understanding. Appropriate teacher guidance is also important to help students formulate questions, interpret findings, and connect experimental evidence with scientific concepts.

Overall, laboratory-based inquiry can be used as an effective approach to support conceptual change and improve students' understanding of science. When implemented systematically and supported by meaningful investigation, discussion, evidence analysis, and reflection, laboratory-based inquiry can transform laboratory activities into a learning experience that promotes deeper conceptual understanding and scientific reasoning.

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