
Implementation of experiment-based learning to improve students' understanding of corrosion concepts

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Abstract

This study aims to implement experiment-based learning to improve students' understanding of corrosion concepts. Experimental learning was selected because it provides more contextual learning experiences and helps students understand scientific concepts through direct observation. The study was conducted through corrosion experiments using iron plates subjected to coating treatment and immersion in NaCl solution with different immersion durations. The learning activities were designed to develop students' observation, analytical, and problem-solving skills during the experimental process. The study employed an experimental approach by involving students in observing changes in material conditions caused by corrosion processes. The research data were obtained from observation results, practicum documentation, and evaluations of students' conceptual understanding after the learning activities were completed. The findings showed that experiment-based learning helped students better understand corrosion concepts and the factors influencing corrosion rates. In addition, students demonstrated increased engagement and learning interest during the practicum activities. These findings indicate that experiment-based learning can serve as an effective alternative learning approach to support more meaningful and applicable science learning.

Keywords

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Introduction

Science learning should help students understand concepts through direct experiences connected to everyday situations. One science topic closely related to daily life is corrosion. Corrosion can be found in many environments, such as rusted iron fences, damaged bridges, ship structures exposed to seawater, and metal tools that gradually deteriorate over time. Because of its close relationship with daily life and industrial activities, corrosion is considered an important topic in science learning, especially in chemistry and material-related subjects. According to Priyotomo et al. (2020), corrosion is a natural process that causes metal degradation due to interaction with the surrounding environment. This process often occurs slowly, making it difficult for students to observe and understand only through theoretical explanations in the classroom.

In many schools, corrosion is commonly taught through lectures and textbook explanations. Although this approach helps students recognize definitions and basic theories, students often experience difficulties in understanding how corrosion occurs and which factors influence the corrosion process. Learning that focuses mostly on memorization often makes students less interested and less active in class. As a result, students may understand the concept only superficially without being able to relate it to real situations. According to Cheng et al. (2019), science learning becomes more meaningful when students are actively involved in observation, experimentation, and problem-solving activities. Therefore, practical and contextual learning approaches are needed to help students understand scientific concepts more effectively.

Experiment-based learning can help students understand science concepts more clearly and become more involved during classroom activities. Through experiments, students are encouraged to observe phenomena directly, collect data, analyze results, and draw conclusions based on their observations. This process not only strengthens conceptual understanding but also develops scientific attitudes and analytical thinking skills. Chung et al. (2019) explain that experimental learning provides opportunities for students to connect scientific theories with real-world applications, making learning activities more interactive and meaningful. In addition, experiment-based learning can increase students' curiosity because they are directly involved in investigating scientific phenomena.

Corrosion experiments are particularly suitable for contextual science learning because students can observe visible physical changes on metal surfaces over time. Simple experimental activities can also demonstrate factors affecting corrosion, such as exposure to salt solutions, moisture, and protective coatings (Lyon et al., 2017; Wei & Gao, 2023). In this study, iron plates were immersed in sodium chloride (NaCl) solution to observe the corrosion process under different immersion durations. NaCl was selected because chloride ions are known to accelerate corrosion reactions on metal surfaces, especially iron and steel materials (Chen et al., 2022). Through direct observation, students can see how environmental factors affect corrosion rates and material degradation.

Besides observing corrosion processes, students can also learn how coatings help reduce metal damage. In industrial applications, protective coatings are widely used to prevent direct contact between metals and corrosive environments. One of the materials frequently used in protective coatings is polydimethylsiloxane (PDMS), which is known for its hydrophobic properties and chemical stability. Additional materials such as silica and manganese are often

incorporated to improve coating performance and increase resistance against corrosion (Putra & Aritonang, 2023). In the context of learning, introducing coating materials through experiments may help students understand how science concepts are applied in real technological and industrial situations.

Experiment-based learning also supports the development of scientific process skills among students. During experimental activities, students are encouraged to formulate observations, identify changes in materials, compare experimental results, and discuss possible explanations related to the corrosion process. These activities may improve students' analytical thinking and problem-solving skills. According to Lin et al. (2016), students who participate actively in science experiments tend to demonstrate better conceptual understanding and stronger learning motivation compared to students who only receive theoretical explanations. Therefore, experiments can function not only as demonstrations but also as learning experiences that encourage active participation.

Another important aspect of experiment-based learning is student engagement. Practical activities generally create a more interactive classroom atmosphere because students become directly involved in observing and discussing scientific phenomena. In several learning situations, students often show greater interest when they are allowed to perform experiments independently or in groups. Collaborative learning during experiments may also improve communication and teamwork skills among students. This condition supports the implementation of student-centered learning, which is increasingly emphasized in current educational practices.

In addition, experiment-based learning may help students connect science concepts with environmental and industrial issues. Corrosion is not only a scientific topic but also a practical problem that affects infrastructure, transportation, and economic activities. Introducing students to corrosion through experiments can increase their awareness of material maintenance and environmental factors influencing metal degradation. This contextual understanding is important because students are more likely to remember concepts that are related to real experiences and practical applications.

Despite the benefits of experiment-based learning, practical activities in schools are sometimes limited by laboratory facilities, time allocation, and instructional strategies. In some cases, science learning still focuses mainly on theoretical instruction, while experimental activities are conducted only occasionally. As a result, students may have limited opportunities to develop scientific investigation skills through direct experience. Therefore, developing practical and manageable experimental activities becomes important for supporting more effective science learning in schools.

Based on these considerations, this study aims to implement experiment-based learning to improve students' understanding of corrosion concepts through observation of iron plates immersed in NaCl solution. The study also examines how experimental activities can support student engagement, observation skills, and conceptual understanding during the learning process. It is expected that the findings of this study will provide useful contributions to the development of more contextual and meaningful science learning, particularly in topics related to corrosion and material protection.

Research Methodology

This study used an experimental learning approach to help students understand corrosion concepts through direct observation and simple practicum activities. Experimental learning was chosen because students can learn science concepts more easily when they are involved in hands-on activities and real observations. In this study, students observed the corrosion process on iron plates immersed in sodium chloride (NaCl) solution for different periods of time. The learning activities were designed to encourage students to observe changes, discuss findings, and connect the experiment with concepts learned in class. Experiment-based learning is considered effective in improving conceptual understanding and student engagement because students actively participate in scientific investigations and problem-solving activities (Purbosari et al., 2025).

The study was carried out through several activities, including material preparation, classroom experiments, observation, and evaluation of students' understanding iron plates were prepared as the main material in the experiment. Some samples were coated with SiMn/PDMS to observe how protective layers affect corrosion resistance, while other samples were left without coating for comparison. The iron plates were then immersed in NaCl solution with different immersion durations so students could observe the visible changes on the metal surfaces.

During the learning activities, students worked in groups to observe the condition of the iron plates before and after immersion. They recorded color changes, rust formation, and differences between coated and uncoated samples. Students discussed why corrosion happened and how environmental conditions affected the metal surface. This activity helped students relate scientific concepts to situations commonly found in everyday life.

Data collection was carried out using observation sheets, documentation, and short learning evaluations. Observation sheets were used to record students' participation and responses during the experiment. Documentation was conducted by taking photographs of the experimental process and the condition of the iron plates after immersion. In addition, students completed simple written reflections to explain the corrosion process and the factors affecting it based on their observations.

Several supporting tools were also introduced to help students better understand the experiment. Surface images from Scanning Electron Microscope (SEM) observations were shown to explain changes on the metal surface after corrosion exposure. Contact angle images were also used to introduce the idea of hydrophobic coating materials in a simpler and more understandable way. These images were used to support classroom discussion and help students understand corrosion protection more easily. The use of experimental visualization and observation-based learning media has also been reported to strengthen students' conceptual understanding in science learning environments (Kamilah et al., 2025).

The collected data were analyzed descriptively by examining students' observations, participation, and explanations during the learning activities. The analysis focused on how students understood corrosion concepts, identified factors influencing corrosion, and explained the role of protective coatings in reducing metal damage. Through these experimental activities, students were expected to gain a more meaningful understanding of corrosion concepts and become more actively involved in science learning.

Findings

This study examined the implementation of experiment-based learning to improve students' understanding of corrosion concepts in science learning activities. The learning process was carried out through simple experimental activities using iron plates immersed in NaCl solution under different conditions. During the experiment, students were encouraged to observe changes on the metal surfaces, discuss the causes of corrosion, and explain the relationship between environmental factors and metal degradation. The findings indicate that experiment-based learning created a more active and meaningful learning atmosphere compared to conventional classroom instruction.

Most students were actively involved during the learning activities. They were actively involved in observing the condition of the iron plates, recording changes during immersion, and discussing their observations with group members. Some students who initially struggled to understand corrosion became more active after joining the experiment activities. This shows that practical activities helped students connect classroom theories with real situations they could observe themselves.

Student participation during experiment-based learning

The findings show that students demonstrated good participation throughout the experiment activities. During classroom observations, students appeared more interested when they were allowed to conduct direct observations rather than only listening to theoretical explanations. Group discussions also became more interactive because students exchanged opinions regarding the corrosion process and factors affecting metal damage.

Table 1. *Student participation during learning activities*

Learning Activity	Observation Result
Observing corrosion changes	Students actively recorded visible changes on iron surfaces
Group discussion	Most students participated in discussions and shared observations
Question and answer session	Students asked questions related to corrosion causes and prevention
Practical activities	Students showed enthusiasm during immersion and observation processes

The findings from classroom observations indicate that experiment-based learning encouraged students to become more involved in the learning process. Several students appeared more confident when presenting their observations and explaining the results of the experiment in front of the class.

Students' understanding of corrosion concepts

The experiment activities helped students understand corrosion concepts more clearly because they could directly observe rust formation and surface changes on the iron plates.

Students were able to identify that longer immersion in salt solution caused greater visible corrosion. They also understood that protective coatings could help reduce direct contact between the metal surface and the corrosive environment.

Many students explained that they understood the topic more easily after observing the experiment results themselves. Instead of only memorizing definitions, students were able to relate corrosion concepts to real examples found in daily life, such as rusted fences, damaged metal tools, and corroded ship structures.

Table 2. *Students' conceptual understanding*

Concept observed	Student understanding
Corrosion process	Students recognized corrosion as metal damage caused by environmental exposure
Effect of NaCl solution	Students understood that salt solution accelerated corrosion
Role of coating materials	Students explained that coatings helped protect metal surfaces
Environmental influence	Students connected humidity and salt exposure with corrosion processes

Direct observation helped students understand science concepts more clearly. Learning activities became more contextual because students could connect classroom material with real environmental problems.

Student responses toward experiment activities

Most students responded positively to the experiment-based learning activities. Several students stated that practical activities made science learning more interesting and easier to understand. Students also expressed that observing real changes during the experiment increased their curiosity and motivation to participate in class discussions.

Some students mentioned that they usually found science topics difficult when explained only through textbooks. However, after participating in the experiment, they became more interested in discussing corrosion and material protection. This indicates that experiment-based learning may improve students' motivation and classroom engagement.

Table 3. *Student responses to learning activities*

Student Response	Observation
Learning interest	Students showed greater enthusiasm during practical activities
Motivation to learn	Students became more active in asking and answering questions
Classroom engagement	Students participated actively during group discussions
Learning experience	Students considered the experiment helpful for understanding concepts

Classroom activities became more interactive during the experiment sessions. Students appeared more comfortable discussing their ideas and sharing observations with classmates.

Challenges during experiment-based learning

Although the learning activities ran well overall, several challenges were identified during the implementation process. Some students initially experienced difficulties in understanding scientific terms related to corrosion and coating materials. In addition, limited laboratory time made it difficult for students to observe long-term corrosion changes directly.

Another challenge involved differences in students' learning speed and observation skills. Some students were able to identify changes quickly, while others required additional explanation from the teacher. Therefore, teacher guidance remained important during the experimental activities to ensure that all students understood the objectives and concepts being studied.

Table 4. *Challenges during learning activities*

Challenge	Description
Limited laboratory time	Observation duration was relatively short
Scientific terminology	Some students needed additional explanation
Observation differences	Students showed different levels of understanding
Equipment limitations	Experimental tools were still limited

These findings indicate that experiment-based learning requires proper classroom management, clear instructions, and sufficient preparation to support effective learning activities.

Effectiveness of experiment-based learning

Overall, the findings show that experiment-based learning helped students understand corrosion concepts in a more meaningful way. Students not only learned theoretical explanations but also became directly involved in observation, discussion, and interpretation of scientific phenomena. The learning activities encouraged active participation, collaboration, and problem-solving during classroom instruction.

The implementation of experiment-based learning also created opportunities for students to connect science concepts with practical situations found in everyday life. This contextual approach helped students understand why corrosion occurs and why material protection is important in real environments. As a result, learning became more relevant, interactive, and easier for students to remember. The findings suggest that experiment-based learning can be used as an alternative instructional strategy to support more student-centered science learning. By involving students directly in practical activities, teachers may create learning experiences that improve conceptual understanding, classroom participation, and student engagement simultaneously.

Discussions

Experiment-based learning and student participation

The findings show that experiment-based learning made science lessons more active and interactive. Students were more involved in classroom activities because they were not only listening to explanations from the teacher but also directly observing the corrosion process

through simple experiments. During the learning activities, students participated in group discussions, observed changes on iron surfaces, and shared their opinions regarding the causes of corrosion. This condition indicates that practical learning activities may increase students' participation and classroom interaction.

Several students appeared more confident when discussing the experiment results with their classmates. Some students who were usually passive during regular classroom lessons became more willing to ask questions and express their ideas during the experiment. This indicates that experiment activities encouraged more student-centered learning. In addition, collaborative activities during the experiment encouraged students to work together and exchange information with group members. Ghavifekr (2020) explain that collaborative experimental activities can improve communication and social interaction among students because they are required to discuss and solve problems together during the learning process.

These findings support previous studies explaining that practical learning activities can improve classroom engagement and participation. According to Rosen and Kelly (2023), students tend to become more active when they are involved directly in observing scientific phenomena rather than only receiving theoretical explanations. Similarly, Dewi and Primayana (2019) found that contextual learning activities encourage students to participate more actively because they can connect lesson materials with situations found in everyday life. Experiment-based learning also provides opportunities for students to explore concepts independently and build understanding through experience.

Another important point identified during the learning process was the role of the teacher in guiding discussions and helping students interpret observations. Although students were actively involved in the experiment, teacher guidance remained important, especially when students experienced difficulties understanding scientific terms or explaining the corrosion process. This finding indicates that successful experiment-based learning requires not only practical activities but also effective classroom management and instructional support from teachers.

Students' understanding of corrosion concepts

The study found that experiment-based learning helped students understand corrosion concepts more clearly and meaningfully. Before the experiment, some students only understood corrosion as rust appearing on metal surfaces without understanding the process behind it. After observing the iron plates immersed in NaCl solution, students became more aware that corrosion occurs because of environmental interactions affecting metal materials over time. Students were able to identify visible differences between coated and uncoated iron plates. They also understood that salt solution accelerated corrosion processes and that protective coatings helped reduce metal damage. Through direct observation, students connected scientific theories with situations commonly found in daily life, such as rusted fences, damaged tools, and corroded ship structures.

Students understood and remembered the concepts more easily because they observed the process directly. Several students explained that they understood the topic better after seeing physical changes on the metal surfaces themselves. This condition suggests that contextual learning activities may strengthen conceptual understanding compared to memorization-based instruction. Gunawan and Lestari (2020) state that practical learning activities can help students understand abstract science concepts more concretely because students are involved directly in observation and experimentation processes.

These results are consistent with the findings of [Suryawati and Osman \(2017\)](#), who explained that contextual science learning supports deeper conceptual understanding because students are directly involved in practical activities and problem-solving processes. [Deniş-Çeliker and Dere \(2022\)](#) also found that experiment-based instruction improves students' critical thinking skills because students are encouraged to analyze observations and explain scientific phenomena independently. Another interesting finding was that students became more curious about corrosion prevention after observing the experiment. Some students asked additional questions about why certain metals rust faster and how industries protect metal materials from corrosion. This response indicates that experiment activities not only improved conceptual understanding but also stimulated students' curiosity and interest in science learning.

Student responses toward learning activities

Most students responded positively to the implementation of experiment-based learning. During classroom observations, students appeared more enthusiastic and interested compared to regular theory-based lessons. Students stated that practical activities made learning more enjoyable because they were able to see direct evidence of scientific concepts rather than only reading explanations from textbooks. Several students explained that observing the corrosion process helped them understand science concepts in a simpler and more realistic way. In addition, students appreciated the opportunity to work in groups because discussions with classmates helped them interpret the experiment results more easily. This finding suggests that collaborative practical activities may improve communication and interaction among students during learning.

Students also became more active during classroom discussions and question sessions. Students asked questions related to corrosion causes, environmental effects, and methods used to protect metals from damage. This condition indicates that experiment-based learning encouraged students to become more curious and actively involved in classroom discussions. [Snětinová et al. \(2018\)](#) explain that students generally show higher motivation during experimental learning because they are involved directly in observing scientific changes and discussing experiment results.

According to [Groenendijk et al. \(2013\)](#), learning activities involving observation and experimentation may increase students' motivation because students become directly connected with the learning process. [Aydin-Ceran \(2021\)](#) also emphasize that contextual science learning encourages stronger classroom interaction because students feel more engaged when discussing practical problems related to real-life situations. The findings also suggest that learning experiences become more memorable when students are allowed to explore concepts independently. Instead of depending entirely on teacher explanations, students learned through observation, discussion, and interpretation of experiment results. This approach helped create a more interactive and engaging classroom environment.

Challenges during experiment-based learning

Although the implementation of experiment-based learning generally showed positive results, several challenges were identified during the learning process. One of the main challenges was the limited time available for conducting experiments and discussions. Some

students needed more time to observe corrosion changes carefully and understand the explanations related to coating materials and corrosion mechanisms.

Another challenge involved differences in students' observation and analytical abilities. Some students quickly identified visible changes on the iron plates, while others required additional explanation and guidance from the teacher. This condition indicates that teachers need to provide continuous support during practical activities to ensure that all students can follow the learning process effectively.

Laboratory equipment and material availability also influenced the learning process (Ezeiheukwu, 2025; Mohammed, 2021). In several situations, limited experimental tools reduced opportunities for students to perform observations individually. As a result, students often worked together in groups during observations and discussions. Although group work encouraged collaboration, adequate laboratory facilities are still important for supporting more effective experiment-based learning activities. Muleta and Seid (2016) explain that the availability of experimental facilities and classroom preparation significantly influence the effectiveness of practical learning activities in science education. Despite these challenges, the experiment activities still provided valuable learning experiences for students. Students remained actively involved during discussions and showed interest in observing scientific phenomena directly. The experiment activities still worked well even though the facilities were limited, if teachers manage learning activities carefully and provide clear instructions.

Effectiveness of experiment-based learning in science education

Overall, the findings of this study indicate that experiment-based learning was effective in improving students' understanding of corrosion concepts and increasing classroom participation. Students became more actively involved in observing, discussing, and interpreting scientific phenomena during the learning process. Through direct observation, students were able to connect theoretical concepts with real environmental situations, making learning more meaningful and contextual.

The implementation of practical activities also supported the development of observation, communication, and problem-solving skills among students. Experiment-based learning encouraged students to think critically about why corrosion occurs and how environmental factors influence metal damage (Linden et al., 2024 & Wang et al., 2021). In addition, collaborative activities during the experiment helped students develop teamwork and communication skills in classroom settings.

These findings suggest that experiment-based learning can be used as an alternative instructional strategy in science education, particularly for topics that are closely related to everyday life. By involving students directly in practical activities, teachers may create learning experiences that are more interactive, student-centered, and easier for students to understand. Therefore, integrating simple experiments into science learning may help improve both conceptual understanding and student engagement in the classroom.

Conclusions

This study showed that experiment-based learning helped students understand corrosion concepts more clearly. Through direct observation and practical activities, students were able to identify visible corrosion processes, recognize the effects of salt solution on metal

surfaces, and understand the role of protective coatings in reducing corrosion. The activities helped students connect classroom theories with real situations in daily life, making science learning more contextual and easier to understand.

The findings also show that experiment-based learning increased student participation and classroom interaction during the learning process. Students became more active in observing, discussing, asking questions, and sharing ideas with classmates during the experiment activities. In addition, collaborative learning during practical sessions helped students develop communication and problem-solving skills while improving their confidence in explaining scientific phenomena.

Although several challenges were identified, such as limited laboratory time and differences in students' observation abilities, the implementation of experiment-based learning generally created a more engaging and student-centered learning environment. Teacher guidance and classroom management remained important to support students during the observation and discussion processes.

Overall, experiment-based learning can be used as an effective way to improve students' understanding and participation in science learning. By involving students directly in practical activities, science lessons become more interactive, meaningful, and closely related to real-life experiences. Therefore, the integration of simple experiments into classroom instruction may support more effective and contextual science education practices in schools.

Disclosure Statement

No potential conflict of interest was reported by the authors.

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