The importance of problem-based tasks in enhancing functional literacy among future chemistry teachers

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Abstract: *The development of functional literacy has become one of the primary objectives of contemporary education, particularly in the preparation of future teachers who are expected to apply scientific knowledge effectively in real-life situations. In chemistry education, problem-based tasks serve as an important pedagogical tool for fostering students' analytical thinking, problem-solving abilities, and the practical application of theoretical concepts. This study investigates the importance of problem-based tasks in enhancing the functional literacy of future chemistry teachers. The research focuses on the design and implementation of chemistry tasks based on real-life and professionally oriented problem situations. These tasks were developed to encourage students to analyze information, evaluate evidence, make informed decisions, and apply chemical knowledge to everyday and professional contexts. A quasi-experimental approach was employed to assess the effectiveness of problem-based tasks in improving students' functional literacy skills. The findings indicate that the systematic use of problem-based tasks significantly contributes to the development of functional literacy by promoting scientific reasoning, critical thinking, and the ability to transfer acquired knowledge to unfamiliar situations. Furthermore, the results demonstrate that students exposed to problem-based learning activities show higher levels of engagement, independence, and competence in solving practical chemistry-related problems compared with those taught through traditional instructional methods. The study highlights the pedagogical value of integrating problem-based tasks into chemistry teacher education programs and emphasizes their role in preparing future teachers for the demands of modern educational practice. The results may serve as a methodological basis for improving chemistry curricula aimed at developing functional literacy and meeting the requirements of contemporary educational standards.*

Keywords: *functional literacy, problem-based learning, chemistry education, future chemistry teachers, problem-based tasks, scientific reasoning, critical thinking, competency-based education, contextual learning, teacher training*

INTRODUCTION

The rapid development of science, technology, and information systems in the twenty-first century has significantly transformed the objectives and priorities of modern education. Contemporary educational systems are increasingly focused not only on the acquisition of theoretical knowledge but also on the development of competencies that enable learners to apply knowledge effectively in real-life situations. In this context, functional literacy has emerged as one of the key indicators of educational quality and an essential component of lifelong learning. Functional literacy refers to an individual's ability to use acquired knowledge, skills, and competencies to solve practical problems, make informed decisions, and successfully adapt to changing social and professional environments. The importance of functional literacy has been highlighted by international educational assessment programs such as the Organisation for Economic Co-operation and Development (OECD)

Programme for International Student Assessment (PISA). According to the PISA framework, scientific literacy involves not only understanding scientific concepts but also applying scientific knowledge to explain phenomena, evaluate evidence, and make reasoned judgments regarding issues related to science and technology. Consequently, educational institutions responsible for teacher preparation are expected to develop instructional approaches that foster these competencies among future educators.

In chemistry education, the development of functional literacy is particularly important because chemistry is closely connected with everyday life, industrial processes, environmental issues, and technological advancements. However, traditional teaching approaches often emphasize the memorization of concepts, formulas, and theoretical principles, providing limited opportunities for students to apply their knowledge in authentic contexts. As a result, many students experience difficulties when required to analyze real-world problems, interpret scientific information, or make evidence-based decisions. Problem-based learning has been recognized as an effective pedagogical approach for addressing these challenges. By engaging students in meaningful problem situations that reflect real-life contexts, problem-based tasks encourage active learning, critical thinking, scientific reasoning, and independent knowledge construction. Such tasks require learners to identify problems, collect and analyze information, formulate hypotheses, evaluate alternative solutions, and justify their conclusions using scientific evidence. These processes are closely aligned with the competencies associated with functional literacy. For future chemistry teachers, the ability to design, implement, and evaluate problem-based tasks is particularly significant. As future educators, they are expected not only to possess strong subject knowledge but also to facilitate the development of functional literacy among their students. Therefore, integrating problem-based tasks into teacher education programs can contribute to the formation of professional competencies necessary for effective teaching in contemporary educational environments.

Recent studies have demonstrated that problem-based learning positively influences students' academic achievement, motivation, problem-solving abilities, and scientific literacy. Nevertheless, further research is needed to examine its specific contribution to the development of functional literacy among future chemistry teachers, particularly within the context of higher education. Understanding this relationship may provide valuable insights for improving chemistry teacher training programs and aligning educational practices with international educational standards. The purpose of this study is to investigate the importance of problem-based tasks in enhancing the functional literacy of future chemistry teachers. The research examines the pedagogical potential of problem-based learning activities in developing students' ability to apply chemical knowledge in real-life situations, analyze scientific information, and make evidence-based decisions. The findings are expected to contribute to the improvement of chemistry education methodologies and support the preparation of competent and functionally literate future teachers.

MATERIAL AND METHODS

This study employed a quasi-experimental research design to investigate the importance of problem-based tasks in enhancing the functional literacy of future chemistry teachers. The research was conducted during the 2025–2026 academic year among undergraduate students enrolled in the Chemistry Education program. The study aimed to evaluate the effectiveness of problem-based learning activities in developing students' ability to apply chemical knowledge in practical and real-life situations. A total of 39 third-year students participated in the study. The participants were divided into two groups: an experimental group ($n = 19$) and a control group ($n = 20$). The experimental group was taught using problem-based chemistry tasks specifically designed to promote functional literacy, while the control group received instruction through traditional teaching methods based primarily on lectures, explanations, and standard exercises. Both groups studied the same chemistry content and were taught for an equal duration. Prior to the intervention, a diagnostic assessment was conducted to determine the initial level of functional literacy and to ensure the comparability of the two groups.

A set of problem-based chemistry tasks was developed based on the principles of contextual learning and functional literacy. The tasks were designed to reflect authentic situations encountered in everyday life, environmental protection, industrial production, public health, and household chemical applications. Each task required students to analyze information, interpret scientific data, formulate explanations, propose solutions, and justify their conclusions using chemical concepts and evidence. A functional literacy test consisting of contextual chemistry questions was developed based on international assessment frameworks and competency-based education principles. A structured observation checklist was used throughout the instructional process to monitor students' engagement, participation, collaboration, and problem-solving behaviors during classroom activities. At the end of the intervention, students completed a questionnaire designed to gather information about their perceptions of problem-based tasks, learning motivation, and self-reported development of functional literacy skills.

During the intervention, students in the experimental group regularly completed problem-based chemistry tasks integrated into lectures, seminars, and independent learning activities. The tasks encouraged students to work individually and collaboratively to investigate real-world problems and develop evidence-based solutions. In contrast, students in the control group were taught using conventional instructional approaches that emphasized theoretical explanations, textbook exercises, and teacher-centered activities. At the conclusion of the intervention, both groups completed the post-test assessment. The obtained results were compared to determine the effectiveness of problem-based tasks in developing functional literacy. The collected data were analyzed using quantitative and qualitative methods. Descriptive statistics, including mean scores, percentages, and standard deviations, were calculated to summarize student performance. Comparative analysis of pre-test and post-test results was conducted to evaluate changes in functional literacy levels between the experimental and control groups. Qualitative data obtained from observations and questionnaires were analyzed through thematic interpretation to identify students' experiences, perceptions, and attitudes toward problem-based learning activities. The combination of quantitative and qualitative approaches provided a comprehensive evaluation of the educational effectiveness of problem-based tasks in enhancing the functional literacy of future chemistry teachers.

RESULTS AND DISCUSSION

The primary objective of this study was to determine the effectiveness of problem-based chemistry tasks in enhancing the functional literacy of future chemistry teachers. To achieve this objective, a comparative analysis of the experimental and control groups was conducted before and after the implementation of the instructional intervention. The results of the initial diagnostic assessment demonstrated that both groups possessed comparable levels of functional literacy prior to the experiment. Students in both groups showed limited ability to apply chemical knowledge in real-life situations, analyze scientific information, and make evidence-based decisions. These findings confirmed the suitability of the selected groups for the experimental study. Following the instructional intervention, noticeable differences were observed between the experimental and control groups. Students who participated in problem-based learning activities demonstrated substantial improvement in their ability to interpret chemical phenomena, solve contextual problems, and justify their conclusions using scientific reasoning.

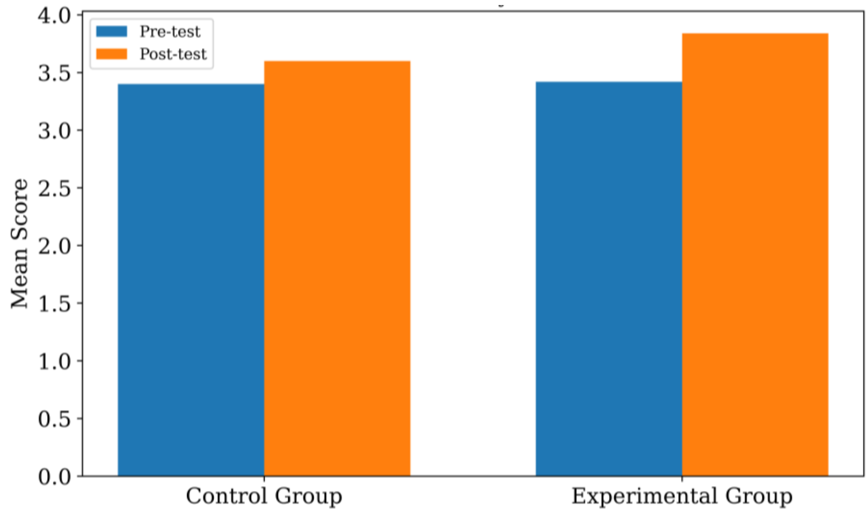

Figure 1. Comparison of functional literacy test results before and after the implementation of problem-based tasks.

The post-test results indicated that the experimental group achieved significantly higher scores than the control group. The improvement was particularly evident in tasks requiring the application of chemical concepts to everyday situations, environmental issues, and practical decision-making processes. These findings suggest that problem-based tasks contribute effectively to the development of competencies associated with functional literacy. One of the most important outcomes of the study was the enhancement of students' scientific reasoning abilities. During classroom observations, students in the experimental group actively engaged in discussions, formulated hypotheses, analyzed evidence, and evaluated alternative solutions to presented problems. Problem-based tasks encouraged students to move beyond memorization of theoretical concepts and focus on understanding the practical significance of chemical knowledge. As a result, students became more capable of explaining scientific phenomena, identifying cause-and-effect relationships, and applying logical reasoning in unfamiliar situations.

These findings support previous research indicating that problem-based learning promotes higher-order thinking skills and facilitates deeper conceptual understanding. The integration of real-life problem situations allowed students to connect theoretical knowledge with practical applications, thereby strengthening their scientific literacy and problem-solving competencies. Observation data and questionnaire responses revealed a positive influence of problem-based tasks on student engagement and motivation. Students reported that contextual chemistry problems were more interesting and meaningful than traditional exercises because they reflected situations that could be encountered in everyday life or professional practice. Many participants expressed greater confidence in their ability to apply chemistry knowledge outside the classroom environment. Furthermore, students demonstrated increased willingness to participate in discussions, collaborate with peers, and independently search for information needed to solve complex problems. The observed increase in learning motivation can be explained by the active and student-centered nature of problem-based learning. Unlike traditional instruction, which often emphasizes passive knowledge acquisition, problem-based tasks encourage learners to take responsibility for their own learning and actively construct knowledge through investigation and reflection.

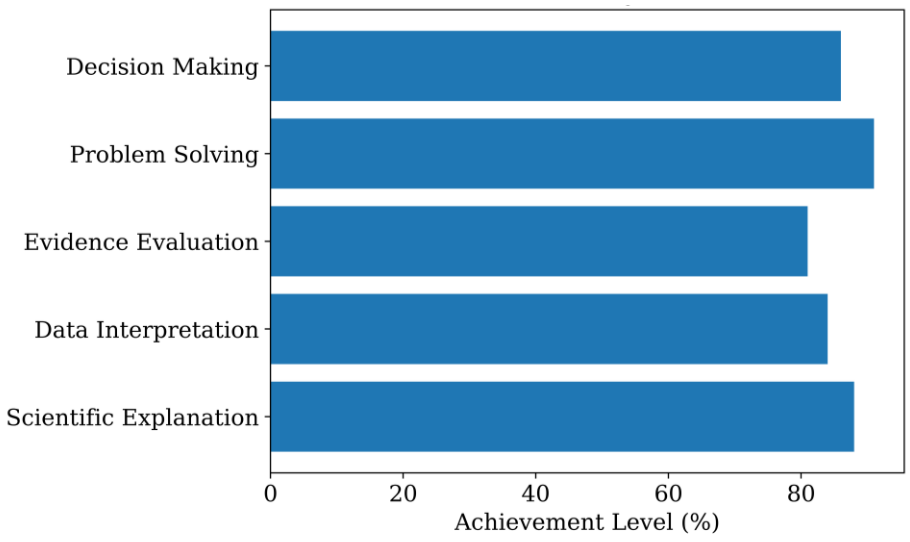

Figure 2. Development of functional literacy indicators among future chemistry teachers in the experimental group.

The most significant gains were observed in students' capacity to transfer knowledge from academic contexts to practical situations. This outcome is particularly important for future chemistry teachers, who will be expected to help their own students develop similar competencies. The results demonstrate that problem-based tasks can serve as an effective instructional tool for developing functional literacy in chemistry teacher education programs. The use of authentic and professionally relevant problem situations creates opportunities for meaningful learning and supports the development of competencies required by contemporary educational standards.

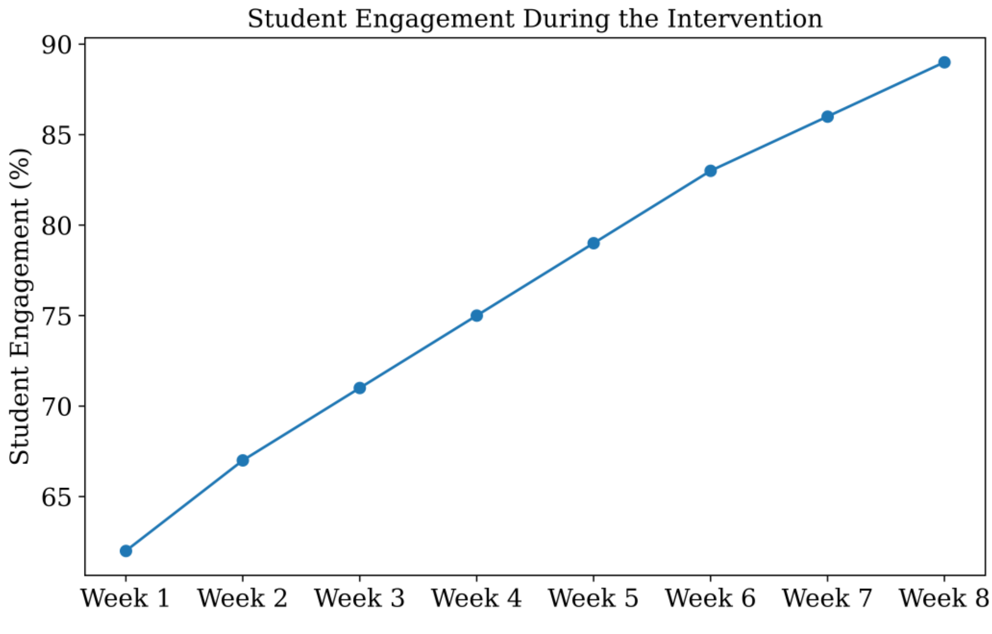

Figure 3. Changes in student engagement during the implementation of problem-based chemistry tasks.

The findings indicate that the integration of problem-based learning strategies into chemistry curricula may contribute to the preparation of future teachers who are capable of fostering scientific literacy, critical thinking, and problem-solving skills among their students. The study confirms that problem-based tasks play a significant role in enhancing the functional literacy of future chemistry teachers. By promoting active learning, scientific reasoning, and contextual application of knowledge, such tasks provide an effective means of preparing prospective educators for the challenges of modern science education.

CONCLUSION

The findings of this study demonstrate that problem-based tasks play a significant role in enhancing the functional literacy of future chemistry teachers. The integration of real-life and professionally oriented problem situations into the educational process created favorable conditions for the development of students' ability to apply chemical knowledge in practical contexts, analyze scientific information, evaluate evidence, and make informed decisions. The implementation of problem-based learning activities contributed to the improvement of several key components of functional literacy, including scientific reasoning, critical thinking, problem-solving skills, and the transfer of theoretical knowledge to real-world situations. Students who participated in problem-based instructional activities demonstrated higher levels of engagement, independence, and motivation compared with those who were taught through traditional teaching approaches.

The results further indicate that problem-based tasks encourage active participation in the learning process and promote deeper conceptual understanding of chemistry. By requiring students to investigate authentic problems, formulate explanations, and justify conclusions using scientific evidence, such tasks facilitate the development of competencies that are essential for both academic success and professional practice. From a pedagogical perspective, the study confirms that problem-based learning is an effective instructional strategy for preparing future chemistry teachers to meet the requirements of modern competency-based education. The use of contextual and inquiry-oriented tasks not only strengthens subject knowledge but also equips prospective teachers with the skills necessary to foster functional literacy among their future students. The research highlights the educational value of systematically incorporating problem-based tasks into chemistry teacher education programs. Their application contributes to the formation of functionally literate, scientifically competent, and professionally prepared future chemistry teachers capable of responding effectively to the challenges of contemporary science education. Future research may focus on the long-term impact of problem-based learning on professional competencies, classroom practice, and students' performance within international assessment frameworks.

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