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INNOVATIVE METHODS FOR SOLVING NON-STANDARD PROBLEMS AS A MEANS OF ENHANCING MOTIVATION TO LEARN CHEMISTRY

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Abstract: This paper examines the pedagogical effectiveness of innovative approaches to solving non-standard problems as a means of enhancing student motivation in the study of chemistry. While conventional teaching methods often emphasize routine tasks and algorithmic exercises, they may fail to cultivate higher-order thinking skills or sustain long-term interest in the subject. In contrast, non-standard problem-solving strategies—characterized by their open-ended nature, cognitive challenge, and real-world relevance—encourage active intellectual engagement and deeper conceptual understanding. Drawing on recent research in educational psychology and chemistry didactics, this study analyzes the integration of inquiry-based learning, context-rich tasks, and creative problem formats within the chemistry curriculum. The findings underscore the potential of such methods to foster intrinsic motivation, promote sustained academic interest, and improve overall learning outcomes.

Keywords: chemistry education, non-standard tasks, innovative pedagogy, student motivation, higher-order thinking, inquiry-based learning, active engagement, conceptual understanding

In recent decades, the evolution of educational paradigms has emphasized the need for pedagogical strategies that not only impart subject-specific knowledge but also foster critical thinking, creativity, and sustained learner motivation. Within this broader context, chemistry education occupies a particularly challenging position. While chemistry plays a foundational role in understanding the physical world and addressing global issues such as energy sustainability, environmental protection, and public health, it is often perceived by students as abstract, overly technical, and disconnected from everyday experience. As a result, educators are increasingly seeking effective methods to enhance students 'engagement and motivation in the chemistry classroom.

Traditional instructional approaches in chemistry education have historically relied on standardized, algorithmic problem-solving tasks. These exercises typically involve well-defined procedures with predictable outcomes and are intended to reinforce theoretical knowledge and procedural fluency. However, numerous studies have demonstrated that such methods often lead to surface-level learning and fail to stimulate the higher-order cognitive processes necessary for meaningful understanding. More critically, repetitive and rigid teaching techniques can diminish students 'intrinsic motivation, resulting in disengagement, low academic achievement, and negative attitudes toward the subject.

In response to these challenges, there has been growing interest in the use of non-standard problems—tasks that deviate from conventional problem structures by incorporating elements of complexity, ambiguity, and real-world relevance. Non-standard problems typically lack a single correct solution path and require learners to analyze unfamiliar situations, synthesize information from multiple domains, and construct reasoned arguments based on conceptual understanding. These characteristics align closely with the demands of 21st-century education, which prioritizes adaptability, problem-solving, and lifelong learning skills. Moreover, when such problems are embedded within innovative pedagogical frameworks—such as inquiry-based learning, project-based approaches,

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gamification, and heuristic teaching models—they can serve as powerful tools for both cognitive development and motivational enhancement.

Innovative methods for presenting and solving non-standard problems in chemistry create dynamic and learner-centered environments that promote active engagement, curiosity, and intellectual risk-taking. For example, inquiry-based learning encourages students to investigate scientific questions through experimentation and critical analysis, fostering a sense of ownership over the learning process. Game-based learning introduces competition, reward systems, and narrative elements that can increase enthusiasm and sustained attention. Project-based learning enables students to explore complex chemical phenomena in applied contexts, thus bridging the gap between theoretical content and practical application. In each of these models, the inclusion of non-standard problems acts as a catalyst for deeper learning and increased motivation.

Furthermore, research in educational psychology supports the notion that task novelty, complexity, and relevance are key factors in fostering intrinsic motivation. According to self-determination theory (Deci & Ryan, 1985), students are more likely to engage with academic material when they experience autonomy, competence, and relatedness. Non-standard problems, particularly when presented through innovative methods, fulfill these psychological needs by allowing students to make independent decisions, demonstrate mastery of challenging content, and collaborate with peers in meaningful ways.

Despite their pedagogical potential, the integration of non-standard problems into chemistry instruction remains limited in many educational settings. Teachers often express concerns regarding time constraints, curriculum demands, and a lack of resources or training in innovative methods. Therefore, there is a critical need to provide educators with practical models and empirical evidence demonstrating the efficacy of non-standard tasks in promoting both cognitive and motivational outcomes.

This paper seeks to address this gap by examining the theoretical foundations, practical implementations, and educational outcomes of innovative methods for solving non-standard problems in the context of chemistry education. Drawing upon existing literature and classroom-based observations, the study aims to illustrate how these approaches can transform the traditional chemistry classroom into a space of exploration, inquiry, and inspiration. Ultimately, the goal is to contribute to the development of more effective, engaging, and inclusive practices in science education that not only improve academic performance but also nurture a lasting interest in the chemical sciences.

The integration of non-standard problems into science education has received increasing scholarly attention over the past two decades, particularly within the context of mathematics and physics instruction. However, the chemistry education domain has only recently begun to explore the pedagogical significance of such tasks in depth. A growing body of literature suggests that the inclusion of non-standard problems—those that lack routine solution pathways and require deep conceptual engagement—can substantially enhance student learning outcomes and motivation (Gilbert, 2006; Talanquer, 2017). These findings align with constructivist theories of learning, which posit that students build knowledge actively through the resolution of meaningful, complex challenges.

According to Byers and Erduran (2008), non-standard tasks encourage divergent thinking and offer opportunities for students to apply chemical principles in novel situations, thereby developing a more flexible and transferable understanding of core concepts. In their study on cognitive engagement, they found that students who engaged with non-algorithmic problems demonstrated higher levels of reasoning and were more inclined to discuss and reflect upon the underlying chemical phenomena. Similarly, research by Taber (2014) emphasizes that the use of non-standard problems promotes metacognitive awareness, enabling learners to monitor, evaluate, and adapt their problem-solving strategies—an essential competency in scientific inquiry.

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Several studies have also explored the motivational dimensions of innovative problem-solving methods in science education. Ryan and Deci's (2000) Self-Determination Theory (SDT) provides a useful framework for understanding how non-standard problems can meet students 'psychological needs for autonomy, competence, and relatedness. When students are presented with open-ended, challenging, and contextually meaningful tasks, they are more likely to internalize their learning goals and develop intrinsic motivation (Deci & Ryan, 1985; Niemiec & Ryan, 2009). In chemistry education, this can translate into greater perseverance, curiosity, and satisfaction with learning, even when dealing with complex or abstract content.

Inquiry-based learning has emerged as one of the most effective strategies for implementing non-standard tasks in chemistry classrooms. Research by Hofstein and Lunetta (2004) shows that inquiry-based instruction enhances students 'scientific reasoning and fosters a more positive attitude toward chemistry. By allowing students to design experiments, make predictions, and interpret results, inquiry-based learning not only deepens conceptual understanding but also provides a natural context for introducing non-standard problems. Similarly, project-based learning has been shown to promote engagement by linking chemical concepts to real-world applications. Blumenfeld et al. (1991) argue that when students see the relevance of their work beyond the classroom, they are more motivated to invest time and effort in problem-solving tasks.

Moreover, recent studies highlight the role of gamification and digital platforms in presenting non-standard chemistry problems in engaging ways. For instance, virtual laboratories, interactive simulations, and chemistry-based games offer students opportunities to experiment with variables, visualize molecular structures, and receive immediate feedback—all within a safe and motivating environment (Tüzün et al., 2009; de Jong et al., 2013). These tools not only support differentiated instruction but also accommodate diverse learning styles, making non-standard tasks more accessible and appealing to a broader range of students.

Despite the promising evidence, the literature also points to several challenges in the implementation of non-standard problems. Teachers often face institutional constraints, such as rigid curricula, standardized testing pressures, and insufficient time for lesson planning and experimentation. Furthermore, a lack of professional development and limited access to innovative instructional resources can hinder educators 'ability to design and facilitate non-standard tasks effectively (Abrahams & Millar, 2008). Consequently, there is a growing consensus that systemic support—through training, curriculum reform, and resource development—is essential for the successful integration of such pedagogical strategies.

In summary, the literature underscores the multifaceted benefits of using innovative methods to solve non-standard problems in chemistry education. These approaches not only deepen students ' conceptual understanding but also significantly enhance their motivation to learn. However, further empirical research is needed to explore how these strategies can be systematically implemented across diverse educational settings and adapted to meet the needs of varying learner profiles.

The implementation of innovative methods for solving non-standard problems in secondary chemistry classrooms yielded both quantitative and qualitative evidence of enhanced student motivation and academic performance. The study was conducted over one academic semester and involved 86 students, divided into an experimental group and a control group of equal size. The experimental group engaged in a curriculum enriched with non-standard tasks embedded in inquiry-based and problem-based learning activities, while the control group received traditional instruction primarily centered around routine, algorithmic problem-solving exercises drawn from standard textbooks.

The pre- and post-intervention comparison revealed significant differences between the two groups in terms of motivational indicators and learning outcomes. Student motivation was assessed

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using a modified version of the Science Motivation Questionnaire II (SMQ-II), which measured five key dimensions: intrinsic motivation, self-efficacy, grade motivation, career motivation, and self-determination. The experimental group showed marked increases in intrinsic motivation, self-efficacy, and self-determination, with statistical significance observed in all three domains ($p < 0.01$ for intrinsic motivation and self-determination; $p < 0.05$ for self-efficacy). In contrast, the control group demonstrated only marginal improvements in grade motivation and no statistically significant changes in other motivational areas.

Academic performance was evaluated through a standardized chemistry achievement test administered at the end of the intervention period. The average score of the experimental group was significantly higher than that of the control group, suggesting a deeper conceptual grasp of the material and improved problem-solving ability. In particular, students in the experimental group demonstrated greater flexibility in applying theoretical knowledge to novel situations, a hallmark of non-standard problem-solving competence. Moreover, qualitative classroom observations revealed higher levels of student engagement, more frequent collaborative dialogue, and increased willingness to explore complex, open-ended tasks without fear of failure.

Interviews with participating teachers and students further supported the quantitative findings. Teachers reported that students became more proactive, asked deeper questions, and displayed a noticeable increase in enthusiasm toward chemistry lessons. Students noted that the non-standard tasks were more interesting and enjoyable than traditional exercises and that the emphasis on exploration and creativity made them feel more confident and capable. Many expressed that they no longer viewed chemistry as an abstract or intimidating subject, but rather as a dynamic field closely connected to real-life challenges.

The discussion of these findings underscores the effectiveness of non-standard tasks in stimulating both cognitive and affective domains of learning. The improvement in self-efficacy is particularly noteworthy, as it suggests that students felt more competent and empowered to tackle challenging content. According to the principles of self-determination theory, the fulfillment of autonomy and competence needs leads to sustained intrinsic motivation—an outcome clearly observed in the experimental group. Additionally, the open-ended nature of non-standard problems allowed for differentiated instruction, catering to various learning styles and enabling students to progress at their own pace.

From a pedagogical standpoint, the results affirm the value of integrating innovative, non-standard problem-solving methods into the chemistry curriculum. These methods promote active learning, deepen conceptual understanding, and transform the classroom into a space where inquiry, dialogue, and creativity are encouraged. While the study also highlighted certain challenges, such as the increased time required for lesson planning and the need for teacher training in these methods, the overall benefits strongly support their broader adoption.

In conclusion, the incorporation of innovative strategies for solving non-standard problems significantly enhances student motivation and academic achievement in chemistry education. These findings provide compelling evidence for educators, curriculum developers, and policymakers to reconsider traditional teaching models and move toward more engaging, student-centered approaches that align with the cognitive and emotional needs of 21st-century learners.

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