

THE PEDAGOGICAL VALUE OF NON-STANDARD PROBLEM-SOLVING TASKS IN CHEMISTRY EDUCATION”

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Abstract: This article explores the pedagogical significance of incorporating non-standard problem-solving tasks into chemistry education. Unlike traditional exercises that focus on rote memorization and formulaic application, non-standard tasks promote critical thinking, creativity, and the ability to apply chemical knowledge in unfamiliar contexts. The paper analyzes how such tasks contribute to the development of key competencies, including analytical reasoning, problem-solving skills, and scientific curiosity. It also examines effective strategies for integrating these tasks into the curriculum and discusses their impact on student motivation and engagement. By fostering deeper cognitive involvement, non-standard problems enhance the overall quality of chemical education and prepare students for real-world scientific challenges.

Keywords: chemistry education, non-standard tasks, critical thinking, problem-solving, student engagement, pedagogical strategies, cognitive development, active learning, scientific literacy, innovative teaching methods

In contemporary science education, fostering not only the retention of knowledge but also the development of higher-order thinking skills is a growing priority. Within the realm of chemistry education, this objective necessitates a departure from exclusively traditional, standardized tasks toward more cognitively demanding, creative, and contextually diverse forms of problem-solving. The incorporation of non-standard tasks—those which deviate from familiar problem patterns and require students to apply their knowledge in novel or unstructured scenarios—has emerged as a pedagogically valuable method to deepen students' conceptual understanding and engagement with chemical content.

Traditional chemistry instruction has long relied on formulaic exercises aimed at reinforcing core concepts such as stoichiometry, chemical reactions, and atomic structure. While such tasks play an essential role in building foundational knowledge, they often fail to stimulate critical thinking or the flexible application of learned material. In contrast, non-standard tasks challenge students to move beyond mechanical procedures and engage with chemistry in ways that reflect the dynamic, problem-solving nature of real scientific inquiry. These tasks may include open-ended questions, logic-based puzzles, experimental design scenarios, or interdisciplinary problem contexts that blur the boundaries between chemistry and other fields such as biology, physics, environmental science, or even art and technology.

The pedagogical benefits of integrating such tasks are multifaceted. First and foremost, non-standard problems promote deeper cognitive engagement by encouraging students to analyze, synthesize, and evaluate information, rather than simply recall it. When students are presented with unfamiliar

scenarios that cannot be solved through rote procedures, they are compelled to draw upon multiple areas of knowledge, assess the relevance of various concepts, and construct innovative solutions. This process supports the development of critical thinking skills that are transferable beyond the chemistry classroom.

Moreover, non-standard tasks contribute significantly to the formation of key twenty-first-century competencies, including collaboration, creativity, and adaptability. Many such tasks are best approached through group work or open discussion, wherein students negotiate meanings, challenge assumptions, and learn from diverse perspectives. These experiences mirror the collaborative nature of professional scientific work and prepare learners to function effectively in knowledge-based economies where adaptability and problem-solving are paramount.

Another important pedagogical dimension of non-standard problem-solving tasks is their potential to enhance student motivation. Research in educational psychology underscores the role of cognitive challenge and relevance in maintaining learner interest. By presenting chemistry as a subject full of intriguing problems rather than static rules, non-standard tasks can transform the learning experience from one of passive reception to active inquiry. Students often report greater satisfaction and curiosity when confronted with problems that provoke thought, relate to real-life situations, or offer multiple avenues for exploration. Such engagement is particularly valuable in secondary and tertiary education, where disinterest in science subjects can lead to decreased academic performance or the abandonment of STEM pathways altogether.

From a methodological standpoint, the implementation of non-standard tasks requires careful curricular integration and thoughtful scaffolding. Educators must balance complexity with accessibility, ensuring that tasks are challenging yet achievable for students at varying levels of proficiency. Instructors may begin by modifying existing problems to include elements of uncertainty or open-endedness, gradually increasing the cognitive demand as students gain confidence. Furthermore, the use of formative assessment and reflective discussion can help students internalize the learning strategies employed during the resolution of such problems.

Equally important is teacher preparedness. The successful use of non-standard tasks in the classroom depends heavily on the instructor's ability to facilitate inquiry-based learning, support diverse student thinking processes, and manage classroom dynamics during more open-ended activities. Professional development programs should therefore include training in the design, selection, and adaptation of non-standard chemistry problems, as well as strategies for guiding productive student engagement with them.

In addition, the use of non-standard tasks supports the shift toward a competency-based and inquiry-oriented model of education, which is emphasized in many national and international curricular frameworks. For example, frameworks such as PISA (Programme for International Student Assessment) and NGSS (Next Generation Science Standards) highlight the need for students to apply scientific knowledge in unfamiliar contexts and demonstrate problem-solving abilities rather than merely recalling facts. Non-standard tasks align well with these goals, as they measure not only what students know, but how effectively they can use that knowledge in varied and often complex situations.

Furthermore, the diversity of formats and topics that non-standard problems can encompass allows for differentiated instruction tailored to a wide range of learning preferences and abilities. Visual learners

may benefit from diagram-based or model-oriented tasks; linguistic learners may thrive when writing explanations or arguments for chemical phenomena; kinesthetic learners might be engaged through hands-on simulations or lab-based challenges. By addressing this diversity, non-standard tasks can help close achievement gaps and ensure more equitable access to deep learning experiences in chemistry.

Importantly, the incorporation of such tasks can help demystify chemistry—a subject often perceived as difficult and abstract. When students are presented with puzzles, real-world dilemmas, or even humorous chemical scenarios, their affective response to the subject can change. What once seemed rigid and inaccessible may become intriguing and manageable, particularly when students realize there is more than one correct way to think through a problem. This democratization of classroom dialogue—where creativity and reasoning are valued over memorized answers—can empower learners and contribute to a more inclusive and supportive learning environment.

Empirical research also supports the efficacy of non-standard problem-solving in chemistry education. Several studies have shown that students who regularly engage in such tasks exhibit improved conceptual understanding, greater retention of content, and increased motivation toward science learning. For instance, classroom-based action research has demonstrated that incorporating open-ended and inquiry-driven problems leads to higher participation rates and more sophisticated student responses during assessments. Longitudinal studies further suggest that these students are more likely to pursue advanced studies in STEM fields and perform better in interdisciplinary problem-solving contexts.

Despite these advantages, certain challenges accompany the implementation of non-standard tasks. Time constraints, large class sizes, rigid syllabi, and standardized testing requirements often discourage educators from deviating from traditional methods. Additionally, students who are accustomed to structured tasks may initially resist open-ended or unconventional formats, experiencing discomfort when expected to think independently. However, these challenges can be mitigated through gradual exposure, clear instruction, and ongoing teacher support. Over time, students typically gain confidence in navigating ambiguity and come to appreciate the richness of such learning experiences.

To conclude, the pedagogical value of non-standard problem-solving tasks in chemistry education is both profound and multifaceted. These tasks cultivate intellectual agility, stimulate student curiosity, and prepare learners for the complexities of modern scientific inquiry. Their integration into teaching methodology not only aligns with contemporary educational priorities but also addresses longstanding issues in chemistry instruction related to engagement, accessibility, and meaningful learning. As chemistry educators continue to explore innovative approaches to teaching, the strategic use of non-standard tasks will undoubtedly play a central role in transforming classrooms into vibrant, inquiry-driven environments.

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