COMMENTARY

Problem-Based Learning: An Effective Teaching Method for Science Competence Development

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"A problem well stated is a problem half solved."
-John Dewey

MODERN society places exceptionally high premiums on science education. To make science classes more productive, researchers and educators have experimented with a plurality of non-traditional instructional approaches that are expected to be effective in fueling students' interest in science subjects and fostering their scientific reasoning ability and creativity. Among them, problem-based learning has been well received by teachers. Its adoption in science classrooms was first recommended by certain researchers in the 20th century (Gallagher et al., 1995). Problem-based learning enables the student to develop knowledge through analyzing and solving problems, rather than through memorizing a wealth of existing information and theories. It can help the student transition from a passive receptacle of knowledge to an active learner and a problem solver (Akınoğlu & Tandoğan, 2007). Despite there being no conclusive definition of this teaching method, the three features summarized by Akcay (2009) are deemed basic elements of problem-based learning: (i) engaging students as stakeholders in a problem situation; (ii) organizing the curriculum around this holistic problem, enabling student learning in relevant and connected ways; (iii) creating a learning environment in which teachers coach student thinking and guide student inquiry, facilitating deeper levels of understanding.

Over the last few decades, researchers have come up with a variety of models for implementing problem-based learning. For example, Wood (2003) proposed a 7-step problem-based learning model, which includes term identification, problem definition, brainstorming, retrospection and elaboration, objective formulation, independent study, and intra-group exchanges. There is not a fixed implementation pattern for this teaching

method; rather, the pattern varies by discipline, instructional objective, and other factors. Yet, the majority of studies have focused on the following components in developing problem-based learning activities: nature of problems, small group, student-centered iterative inquiry process, communication of the group's findings to whole class, learning resources (e.g., library, experimental equipment), technology (e.g., internet, educational platform), partnership with community, and teachers' role as facilitators (Merritt et al., 2017). Considering the method's heavy demands on education resources, some researchers conducted experimental studies to identify the most relevant factors related to its outcomes. According to Pease and Kuhn (2011), the focus on engagement with a problem is the core advantage of problem-based learning, whereas collaborative organization, such as group study, is not as important as generally assumed. This finding may serve as an implication that the teacher can save those non-fundamental steps in implementing problem-based learning in the context of limited teaching conditions.

While problem-based learning has been acclaimed as an ideal method for science education, its efficacy in science classrooms deserves more rigid examination. *Problem-Based Learning (PBL) in Science Education: A Mixed-Meta Method Study* in this issue is a mixed-meta-analysis of the method's effectiveness in science education, consisting of a meta-analysis of quantitative data from 78 experimental studies and a meta-thematic analysis of qualitative data from 15 studies based on literature reviews (Yaşar et al., 2024). Its research results reveal that most of the studies included suggest that problem-based learning is supportive of the enactment of science education, with positive effects on student academic achievements and the development of the 21st century skills in them. Also discussed are the method's negative effects on science instruction. This article offers a broader lens for our understanding the outcomes of problem-based learning in science education.

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