COMMENTARY

Infusing the Engineer Design Process into Education

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"Engineering is the closest thing to magic that exists in the world."
–Elon Musk

THE ENGINEERING design process (EDP) is an iterative decision-making process, in which basic science, math, and engineering concepts are applied to develop optimal solutions to meet an established objective (Mangold & Robinson, 2013). There is no unitary standard for the EDP, and researchers have different ideas about the basic steps that should be included in the process. In practice, the EDP may varies by discipline and project, but it's essential features typically include: (1) starting with the definition of the problem or needs; (2) being open-ended with multiple possible solutions; (3) involving mathematical modeling and scientific analysis; (4) being highly iterative (Atman et al., 2007; Hynes, 2012; Berland et al., 2014).

The EDP is not only applied in the domain of engineering but is also a useful tool applicable at all levels of education. It can provide students with an opportunity to learn scientific knowledge in a real-world scenario (Berland et al., 2014) while also contributing to developing their schema of design thinking, especially with respect to clarifying the problem, generating ideas, modeling, and feasibility analysis (Lin et al., 2021). With the increased awareness of the significance of the EDP as a pedagogical strategy, educators began to experiment with it in K-12 engineering teaching to promote the development of 21st century skills in students. For example, the University of California, Berkeley launched the ADEPT (Applied Design Engineering Project Teams) program to design and deploy standards-based engineering curriculum for middle and high school students (in grades 6-12). The program was designed to integrate mathematics and science concepts applied in engineering projects to inspire secondary students, helping them succeed in relevant subjects, and to strengthen the classroom experience of current and future teaching staff in math, science, and engineering (Mangold & Robinson, 2013). Earlier research found certain challenges of the use of the EDP in instruction including students' neglect of its quantitative aspects, such as quantifying needs, establishing structured methods to reach solutions, and developing mathematical models (Crismond & Adams, 2012; Berland et al., 2014). To address these issues, teachers needed to design special contexts and questions to engage students in the quantitative work of the design process. However, it does not mean the qualitative content of the EDP, such as identifying problems and modifying solutions, is less important. Instead, these aspects of the EDP allow students the perception of steady progress as they are more manipulable and familiar to learners (Barnett, 2005; Hmelo et al., 2000).

In recent years, the alignment between the EDP's application outcomes and the objectives of STEM education has inspired researchers to incorporate the EDP into the latter, such as 3D printing education (Hou, 2019). Some researchers asserted that the EDP was integral to STEM teaching and highlighted the three requirements for designing EDP-based STEM education programs: adhering to student-centeredness; linking the problem or task to the actual life of students; and adopting the formative assessment to document students' learning process and encourage reflections on learning outcomes (Zhang et al., 2019). Other researchers tried to combine the EDP with STEM project-based learning to create the more sophisticated model of EDP-STEM-PBL. This model seeks to situates scientific and mathematical knowledge within the context of technological design to build a problem-solving learning environment which facilitates students formulating solutions to design challenges, gathering information, and solving real problems using the EDP (Lin et al., 2021).

Despite the validations of the positive effects of the integration of the EDP into STEM education in the literature (Hafiz & Ayop, 2019), insufficient is the research on applicable strategies for the design and implementation of EDP-based curricula, and studies of localized EDP application are even fewer. In this issue, *Engineering Design-Based STEM Activity for Middle Schools: How Can I Slide Faster?* is a study of the design and implementation of an EDP-based STEM education activity for the instruction of "friction force and water resistance" based on the US's Next Generation Science Standards (NGSS) and the objectives and outcomes set for the 5th-grade science curriculum by the Turkish Ministry of National Education. Twenty-one Turkish students in grade 5 participated in the study, who were required to design a water slide boat that would be least affected by water resistance and friction (Gökşena et al., 2024). The activity was meant to improve students' engineering and design skills. Despite its elaboration on the design and implementation steps of EDP-based STEM education activity, there was no quantitative analysis of students' learning outcomes in the study, resulting in the lack of an objective and explicit demonstration of the activity's effectiveness. Still, the research findings of this study can provide valuable guidance to science teachers for their practices of integrating the EDP into the design and implementation of STEM teaching activities. It is hoped that these findings can spark explorations of the application of the EDP in a more extensive range of disciplines.

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