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Editorial: Current perspectives on the value, teaching, learning, and assessment of design in STEM education

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Editorial on the Research Topic
Current perspectives on the value, teaching, learning, and assessment of design in STEM education

1. Introduction

Despite the value that design methodologies have as a vehicle for learning science, technology, engineering, and mathematics (STEM)-related subject matter, their integration into STEM curricula remains a burgeoning phenomenon. The role of designing and the field's epistemological, ontological, axiological, and methodological foundations are still in the process of being shaped and refined by scholars in STEM-related fields. For instance, the knowledge base of designerly thinking and doing, though growing, is yet to be articulated in terms of "what" constitutes design knowledge, "how" it is constituted, "when" and "how" it is and can be acquired, and "why" it matters (Buckley et al., 2021). Furthermore, methodological frameworks for guiding, measuring, and evaluating designerly thinking, doing, and learning are in their developmental stages, indicating a need for empirical studies (Blom and Bogaers, 2020; Hartell and Buckley, 2021). The ontological perspectives of design—its nature, its purpose, and its role in learning and societal progress—are also subjects of ongoing discourse (Norström and Hallström, 2023). It is these challenges and opportunities that brought us to contribute to the maturation of these foundations, thereby cultivating a more robust understanding of design's role in STEM education.

2. Emergent themes in this Research Topic

Through the establishment of this Research Topic, we aimed to progress the conversation on the role or roles that design has and can have in STEM education. Ultimately, the topic consists of 11 articles which include reviews, original research, and a conceptual analysis. The included articles are diverse in nature, reflecting the myriad of ways in which both design and STEM can be conceived, and serving to advance this conversation while also illustrating its complexities. Several underlying themes permeate the included articles, but two take

prominence: how design functions in the establishment of STEM curricula and the purpose of design in terms of the associated outputs. Within these themes, in some cases, solutions or answers are proposed to critical questions. For example, Hallström and Ankiewicz frame design as a critical mechanism for the successful integration of STEM domains. In other cases, design was less prominent in the presented study, but the questions posed remained relevant and thought-provoking. For example, Ghosh et al. present a study on vaccine development knowledge and its association with engagement in formal educational settings. While not explicitly related to design, it is one of the several studies (see, e.g., Behrendt et al.; Sudirman et al.) that stimulate the question of where design-related learning can, does, and should take place, which is related to both central themes. Given the contributions, we see their collective contribution as providing a platform to guide future discourse through their capacity to inform new questions, and as such, present their underlying themes in this way.

2.1. Design and STEM curricula

The first major question raised in considering design and STEM together is what is meant by STEM to begin with. Ilyas et al. discuss the siloed view of STEM, in which each of the four domains is considered separately, the embedded view of STEM, in which one STEM discipline is embedded within another, such as using an engineering design approach to teach a mathematical concept, and the integrated view of STEM, in which teaching and/or learning takes place among or between two or more STEM disciplines. This discourse on the various interpretations of STEM is further developed by Sun et al. by adding the dimension that STEM is often broadened into, among other abbreviated groupings, STEAM. In the silo and embedded views of STEM, design is seen to fit through its positioning within the individual disciplines. Nichols et al. and Oliveira and Bonito provide examples of this by considering how, through the design process, students in science classrooms can develop science and broader STEM competencies. In terms of integrated STEM, as previously noted, Hallström and Ankiewicz highlight the potential of design to act as a means of integration. In contrast, Sun et al., who introduced the idea of STEAM to this Research Topic, questioned how the various STEAM disciplines could be integrated into design education, highlighting a bi-directional relationship between design and STEAM.

2.2. Design outputs in STEM education

A second major theme that emerged is related to the product of the design process within STEM education. It is quite typical to conceive designerly outputs as artifacts, with an associated portfolio describing the design process. In this sense, the artifact is often a physical or virtual artifact, as is the case in the work of Nguyen. Some articles on this topic, however, highlight how this interpretation of an artifact may be too narrow. For example, Saha and Sudirman et al. present empirical studies that capture design through the lens of the teacher, with the output of the design process being a learning activity or experience. In Saha's study, emphasis is given to the teachers' design of a learning activity that mirrors the real-world experience of a transport engineer. Sudirman et al. examine this idea more broadly at a pedagogical framing level and speak to the design of inquiry-based vs. direct-instruction teaching methods. Finally, at the broadest level we see in this topic, Hendriana et al. expand this conversation through a discussion on teachers' capacity to design whole-learning environments within a humanist ethno-metaphorical framework.

3. Conclusion

This Research Topic underscores the dynamic and evolving nature of designerly learning within the context of STEM education and the necessity for these fields to continue to grow. The diversity of perspectives presented highlights the global importance of designerly thinking and doing in STEM education, as well as the shared challenges and triumphs experienced in different educational contexts. The breadth of research that is shared in this Research Topic highlights the urgency for a shift from traditional, siloed approaches toward more integrated, real-world, and student-centered strategies. Furthermore, it foregrounds the critical role that designerly thinking and doing, in combination with STEM education, can provide in addressing broader societal and sustainability issues. We hope this Research Topic will inspire and provoke thought, leading to the advancement of STEM education to meet the needs of learners in a rapidly changing world, and we look forward to continuing this important dialogue and supporting the evolution of STEM education for the betterment of learners and society at large.

Author contributions

All authors listed have made a substantial, direct, and intellectual contribution to the work and approved it for publication.

Conflict of interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

Publisher's note

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