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Editorial: Creativity and innovation in STEAM education

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Editorial on the Research Topic
Creativity and innovation in STEAM education

STEAM is an acronym for Science, Technology, Engineering, Arts, and Mathematics. The acronym STEM (Science, Technology, Engineering, and Mathematics) proceeds STEAM, was introduced in 2001 by scientific administrators at eh US National Science Foundation (NSF), replacing an old acronym SMET, referring to the career fields in disciplines such as Science, Technology, Engineering, and Mathematics (Hallinen, 2021). Soon, the acronym entered schools as STEM education, aiming to prepare students for entering STEM career fields that often lead to economic stability and upward social mobility. Educators and researchers quickly realized that humanity was missing in STEM education. The "A" was added to represent the art/humanities to emphasize the importance of integrating STEM and art into the curriculum (Conradty and Bogner, 2018; Mejias et al., 2021). A hallmark of the STEAM program is to engage students in inquiry-based learning and incorporate innovation and creativity into teaching. Since the introduction of STEAM, the STAEM-focused curriculum has become popular not only in the United States but also around the globe, including in Europe, Asia, and Australia.

This special issue includes 13 original studies, the majority from Chinese-speaking regions (i.e., nine from mainland China and two from Taiwan), exploring creativity and innovation in STEAM (Science, Technology, Engineering, Arts, and Mathematics) education, focusing on teaching innovation and creative outcomes for students. It provides a perspective outside the United States viewing STEAM education. This special issue may contribute to the literature on STEAM education in the following three areas.

First, how to evaluate the effectiveness of STEAM education; in other words, what is the primary goal of STEAM education?

To Chinese scholars, the primary goal of STEAM or STEM education is to cultivate critical competencies of students so that they may adapt to the future's flexible and complex social environment (Hu and Guo). Most contributors to this special issue pointed out creativity (Cheng et al.; Jia et al.; Park et al.; Ruan et al.; Sha et al.; Tran et al.; Xia et al.; Ngoc et al.) and critical thinking (Park et al.; Shen et al.) as two essential targeted skills for STEAM education. Cheng et al. argued that creativity should be measured at individual and group levels using a multi-method approach as a crucial STEAM competence. Jia et al. proposed that motivation, self-efficacy, and interdisciplinary knowledge acquisition can be considered STEAM competence, and

Liu et al. added subjective experiences, such as happiness, onto the list. Hu and Guo presented a model to illustrate STEAM competencies, including scientific thinking, inquiry practice, information literacy competencies, and attitudes and accountability in the STEAM area. They suggested using both formative and summative approaches to evaluate student STEM competencies.

Unlike Chinese scholars, Leroy and Romero argued that teachers' competencies, especially their awareness of the mindset and automatic engagement in creative activities, are essential in STEAM teaching. Teachers' creative competencies are equally critical to, if not more important than, students' competencies in STEAM education. This view represents a uniquely French perspective.

The second contribution of this special issue is the inclusion of studies exploring factors that affect the effectiveness of STEAM competencies. The first important factor is the creative environment the teacher sets up in classrooms. Hu and Guo advocated six criteria to evaluate effective STEM teaching: (1) setting up a learning situation, (2) asking student questions, (3) encouraging independent inquiry, (4) emphasizing cooperation, (5) encouraging summary and reflection in communication, and (6) promote consolidation and transfer of information.

The second factor is the teacher's characteristics. Leroy and Romero explored aspects that would effectively help teachers develop their creative competence (both divergent and convergent thinking). Besides assessing teachers' divergent and convert thinking, they asked participants to engage in self-reflection about their engagement in the creative activities and the difficulties they had in solving creative problems. They argue that teachers' automatic engagement in creative activities and willingness to overcome their conservative perspective can effectively predict their creative competencies. A short teacher training session allowing teachers to increase their awareness of the necessary prerequisite for the creative process could improve their creative competencies and subsequently enhance students' creativity. Accordingly, teachers must consider these factors when developing and delivering their courses.

The third factor is the students' experience. In a cross-cultural investigation, Park et al. explored how college experience affects the development of critical thinking and creativity. They found that whereas Chinese students outperform American students in measures of critical thinking, Americans outperform Chinese students in standards of creativity. They also demonstrate that having some college research experience (such as taking research method courses) could positively influence these two essential skills of students from the United States and China.

This special issue's third and final contribution showcases ten different STEAM programs outside the United States. These studies can be further grouped into three categories: short-term longitudinal studies, cross-sectional studies, and descriptive studies. Here, we would like to highlight four short-term longitudinal studies examining the effectiveness of STEAM-based curricula in science teaching.

Cheng et al. compared two pedagogical approaches: one adopting STEAM-based teaching (Integration of multiple disciples and inquiry-based learning) and the other a more traditional science teaching model (knowledge-based multidisciplinary education) regarding their effectiveness in science achievement, creative potential, and creative behaviors at both individual and group levels. In two 4th-grade science classrooms adopting one of the two distinct teaching approaches, students were expected to acquire skills in multiple disciplines, including physics, engineering, mathematics, music, and arts, and apply what they learned to complete a project: a musical instrument by the end of the 6-week intervention. Their results demonstrated the advantage of STEAM-based pedagogy over the traditional approach in creativity but science achievement.

Tran et al. recruited elementary school students from Taiwan and had them go through two stages of the science course: one traditional science course (learning concepts and principles in multiple disciples, including science, technology, engineering, and mathematics) and the other STEAM-based course (assembling installing and painting house-shaped money saving tube and engaging in inquiry-based learning), each stage lasted about 2 weeks. Half of the participants took the STEAM-based course first, then the traditional science course (the experimental condition), and the other half went in the opposite order (the control condition). Their results showed students from both conditions significantly improved their scientific creativity, especially the fluency and flexible scores.

Similarly, Ngoc et al. examined the effectiveness of a STEAM-based curriculum on junior high school students' scientific creativity. Like Tran et al., they also had all their participants go through the two-stage course with one group taking the STEAM-based course first, then the traditional science course (the experimental condition), and the other group in the opposite order (the control condition) with an end product of designing a gear wheel. Their results indicated that students benefited more from their scientific creativity in the experimental group than in the control condition.

In response to the global pandemic, universities must adapt online and offline teaching. Liu et al. use qualitative and quantitative methods to compare two teaching models: the industrial innovation and entrepreneurship talent cultivation (IIETC) model (combining online practical training from companies and theoretical guidance from professors) and the traditional teaching model (without online practical training). Their results demonstrate that ILETC positively impacts biology students' academic performance, self-evaluation of their future success, and overall happiness.

This special issue also includes four cross-sectional studies examining social conditions' influence on creativity. For example, priming multiple identities of high school students could enhance their creative performance (Ruan et al.). Emotional design in multimedia facilitates middle school students' appreciation and understanding of Chinese poetry (Wang et al.). Teachers' informative feedback could effectively improve college students' creativity in 3D printing technology (Shen et al.). Design training improves students' ability to generate ideas but does not improve their ability to evaluate the usefulness of these ideas (Xia et al.).

The last category of the STEAM programs includes two descriptive studies. Jia et al. demonstrated that an integrated design STEAM course could promote elementary school students' motivation, self-efficacy, and acquisition of interdisciplinary knowledge. Sha et al. showed that students' engagement in STEAM courses positively influenced critical thinking.

Overall, this special issue provides a unique perspective from scholars outside the United States on the definition of STEAM competencies, influencing factors on STEAM education, and a sample of different STEAM programs in promoting STEAM competencies, which could shed some light on the current status of STEAM education and the role of creativity and innovation in STEAM education.

Author contributions

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

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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.

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