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Editorial: Invention education and STEM: perspectives and possibilities

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Editorial on the Research Topic
Invention education and STEM: perspectives and possibilities

Introduction

Generating solutions for society's complex problems requires a diverse workforce dedicated to technological and social innovation, and sustained efforts toward invention: the process of creating new, novel, and useful products to overcome challenges that affect quality of life and productivity (Couch et al., 2019). Historically, opportunities for K-12 students to develop inventive acumen have been rare and inequitably distributed, partly because educators were expected to provide such experiences without the support of professional development, curricular materials, and instructional examples. These issues have become the focus of an emergent field called Invention Education (IvE). IvE uses trans-disciplinary, equity-oriented pedagogies to promote students' knowledge and agency in habitual problem finding, solution design, prototyping, fabrication, intellectual property creation, and market sector investigation (InventEd, n.d.). This Research Topic, *Invention Education and STEM: Perspectives and Possibilities,* presents perspectives on IvE that coalesce around four questions.

What does it mean to be inventive?

In *The mind of a maker: a learning framework for a continuum of K-12 invention education*, Scharon et al. explore what it means to adopt an inventive stance toward the world. They describe eight dimensions in their *Mind of a Maker* learning framework: Imagination, Reflection, Perseverance, Skill-Building, Exploration, Initiative, Teamwork, and Perspective-taking. Using data from a museum-based program, they note that more than 80% of sampled youth experienced these dimensions. The authors highlight that researchers and practitioners should consider "what it means to have an Inventor or Maker identity…confident and empowered young adults who see themselves as capable changemakers" (p. 8).

Turning to school settings, in *Assessing learning and development through transdisciplinary problem-based invention education offerings*, Couch et al. align markers of inventiveness with U.S. Next Generation Science Standards (NGSS), Common Core Mathematics, and English Language Arts standards. They emphasize developmental evaluation (Patton, 2016), noting its utility in contexts that involve uncertainty, feedback loops, and novel solutions. On a practical note, the authors argue that rubrics and e-portfolios can supplement discipline-specific assessments and allow students to document their inventive competencies.

How can young people's intentions to pursue STEM and innovation be supported?

Two papers build on existing literature (e.g., Maltese and Cooper, 2017) to explore how social and cultural contexts and gender relate to students' perceptions that they belong in the STEM and innovation sector. Hernández-Pérez et al. foreground Bandura's (1978) Social Cognitive Theory in *The lack of STEM vocations and gender gap in secondary education students*. They propose that students' "perceptions of gender roles, social expectations, and environmental influences shape individual educational decisions" (p. 2). In this survey of Spanish students' STEM coursework motivation, the authors identify a need for students to feel supported by adults and other role models. More than half of their sample reported low perceived support, and more females than males stated that they "didn't like" or lacked "personal capacity" to pursue STEM.

In *Becoming an inventor: a young Latina's narrative*, Sáenz et al. use a case study approach to reveal nuances within these sociocultural factors as they document the development of an "inventor's identity." They elevate the voice of Lesly, a first-generation Latina college student in the United States, who draws from her experiences of participating in invention competitions and programs to internalize the identity of "inventor." Her experiences and narrative are a promising exception to other findings that young individuals from historically marginalized backgrounds may identify an inventor as someone other than themselves (Kaplan et al., 2023).

What features of educational programs support interest and persistence in STEM and innovation?

The paper *iINVENT pathways and practices: prizing the process over the product* by Rowe et al. describes a connected K-16 invention pathway for rural students, where elementary students participate in a six-lesson project, middle school students participate in summer camps, and high school students investigate local community needs. The authors identify sharing and receiving feedback, using technology, near-peer mentoring, and valuing inventive processes as factors that support motivation and engagement. Rowe et al. present an overarching model linking such experiences to students' "emerging inventor identity."

Kalainoff et al. present *Developing a use-inspired school and community 6th through 12th grade research and invention ecosystem leading to STEM careers: An ethnographic study of the Science Coach program*. The study, which draws on Social Cognitive Career Theory (Lent et al., 1994), describes an organization that supports teachers to coach students in research projects and invention competitions. The program embodies an ecosystem approach whereby students integrate career exploration into their educational experiences. The authors identify factors that underpin program longevity and capacity to support students from historically underserved backgrounds, including access to information about research and invention opportunities, student incentives, and the development of university and commercial partnerships.

Like inventions, IvE programs benefit from being refined over time, according to Jackson et al.. In *Inventors emerging in-school and out-of-school: six iterations of educational design to promote equitable student engagement,* the authors describe iterations of curricula emerging from a research-practitioner-community partnership that aims to solicit equitable participation among diverse students. Reported outcomes include increased self-efficacy for inventing, lower anxiety, and strategies to support learning differences. Jackson et al. present a framework specifying individual and social dimensions that support affective, behavioral, and cognitive engagement.

What issues are emerging in the research landscape of invention education?

Finally, in their *Systematic review of invention education research landscape: state of the discipline and future directions*, Dalela and Ahmed uncover topics and approaches to IvE. They note an increasing rate of publications, programmatic emphasis on broadening participation, and attention to students' identity development as well as knowledge and skill growth. Their analysis also reveals a lack of IvE research in developing countries and a need to train teachers to incorporate IvE into the curriculum. Notably, it specifies the strengths of in-school and out-of-school IvE in ways that can inform future research.

Author contributions

JG: Writing – original draft, Writing – review & editing. SG: Writing – review & editing. AM: Writing – review & editing.

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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