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INVENTION EDUCATION: PREPARING THE NEXT GENERATION OF INNOVATORS

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INTRODUCTION

This special issue of *Technology and Innovation* explores ways educators are designing and making available to diverse groups of people opportunities to learn the processes, practices, and ways of thinking like inventors. It also examines what is happening within particular approaches to invention education, including who does what, with whom, under what conditions, and with what outcomes in specific educational and social settings.

Invention education is an emerging field that transcends disciplinary boundaries. The instructional approach responds to the need for creative problem solvers who draw on expertise from multiple disciplines, cultural knowledge, and a diverse range of lived experiences to construct innovative solutions to real-world challenges. The growing dialogue about invention education assumes that the creativity and inventiveness needed to create new and novel, useful and unique solutions is something that can be nurtured and cultivated in people of all ages and from diverse walks of life. As articles in this special issue demonstrate, educators across the U.S. are embracing this notion and are making a wide range of inventing opportunities available in K-12 schools, after school settings, and in universities.

Authors featured in this journal base their work on different research traditions and utilize a variety of research methods. Each paper, therefore, makes its own unique contribution to what can be known about this new field. The articles make visible the ways different aspects of invention education can be studied to construct complex representations of the field. Each of the articles, therefore, can be read from two perspectives: one focusing on what can be learned about invention education and the second on how this new field can be studied and expanded through diverse methodological explorations.

OVERVIEW OF THE ARTICLES

The first section of the journal, *Program Designs for Developing Creativity and Inventiveness,* includes two articles that describe ways faculty are conceptualizing and designing new learning opportunities for college-age students and a third article that examines linkages among arts, crafts, design and patenting behavior. In the first article, Susan L. Sokolowski describes a new master's degree program in Sports Product Design at the University of Oregon that develops graduate students' abilities to use theories and creative problem-solving skills from different disciplines to invent products that push the boundaries of athletic performance. The University is situated in close proximity to 800 companies, with many major name brands specializing in sports product design. Specialized coursework that

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integrates human physiology, journalism, and business design has been designed to develop students' problem-solving skills in ways that are highly relevant to the specialized needs of this industry, reflecting a shift away from a more generic focus on design/engineering for general areas of interest. Sokolowski offers preliminary evidence that demonstrates that the program is enabling students to invent new performance products, win design innovation competitions, and secure internships and employment post-graduation.

Christine E. King, Chris Hoo, William C. Tang, and Michelle Khine describe a new three-quarter senior design capstone course at the University of California, Irvine, which focuses on solving real-world biomedical engineering problems. The course incorporates multidisciplinary team science and mentorship by faculty, physicians, industry sponsors, inventors, and seasoned entrepreneurs. The intent of the course design, according to King et al., was to break down the silos within academia and between academia and industry in ways that helps catalyze the translation of technologies from engineering laboratories to the bedside. To date, the program has successfully prepared over 326 students (approximately 108 students per year) to engage in technology commercialization and enterprise building.

The third paper by Robert Root-Bernstein, Amber Peruski, Megan VanDyke, Michele Root-Bernstein, Rex LaMore, John Schweitzer, James Lawton, and Eileen Roraback is a broader examination of the correlation between patents and participation in learning opportunities found in 23 literary, arts, crafts, or design (ACD) disciplines. The study examines and reports findings related to the differential preparation in ACD of women (whose experiences tended to be in the "fine arts") and men (whose experiences tended to be in "crafts" avocations) during childhood and in the adolescent years. "Crafts" avocations (woodworking, metalworking, mechanics, electronics, glassblowing, and printmaking) were found to be highly correlated with filing patents among both men and women. The study was inspired by the notion that the most inventive STEMM (science, technology, engineering, mathematics, and medicine) professionals are excellent communicators and are generally "cultured."

The second section, *Research Within Invention Education Programs,* makes visible what counts as invention education, examines ways of teaching as an invention educator, and explores the implications of particular actions for student learning. Roxanne Moore, Sunni Newton, and Meltem Alexander frame invention education within the context of a competition for K-12 students. In this model, students work in small groups to develop an invention over the course of multiple months. The students' work includes finding a problem to solve, presenting ideas to others, soliciting feedback, iterating on designs, and building prototypes. The paper describes the impact of participation on teachers and teachers' perceptions of the impact on students.

In the second article in this section, Helen Zhang, Leigh Estabrooks, and Anthony Perry provide a case study of a middle school teacher's experiences with modifying invention education curriculum in ways that allow the teaching of invention processes and practices to be integrated into the teacher's existing seventh-grade science curriculum. Researchers trace the work of the teacher across time and events, document challenges, and compare the experiences in this telling case to a five-stage diffusion of innovation process model.

Three other papers in this section focus on students' experiences and outcomes. Research by Deoksoon Kim, Eunhye Cho, Stephanie Couch, and Mike Barnett builds on the efforts described by Zhang et al. to integrate invention education into middle school science courses by adding visualizations and supplementary "HomeFun" activities designed to meet the needs of English Language Learners (ELLs). The study examines ways these additions to the curriculum, which constitute one approach to providing for culturally relevant science learning, contribute to the learning outcomes of participating ELL students.

The remaining two student-focused studies were conducted with high school students. Levi Maaia offers a case study of high school students who are learning while working as 'makers.' Making (as described in this case study) and inventing are closely related in the sense that both involve building something to solve a problem, learning through iterative cycles of activity, and developing hands-on and technical skills through iterative activity cycles. Maaia's study offers evidence of ways interactions between student team members engaged in the

problem-solving processes helped students develop new knowledge and skills.

Stephanie Couch, Audra Skukauskaite, and Leigh Estabrooks examine ways six students who have worked as inventors across an entire school year inscribe their identities on an end-of-year survey and in interviews with one of the researchers. Grounding their focus in the discourse of the students, the authors explore factors that may have impacted each student's portrayal of self as being an inventor or like an inventor (or not).

The third section, *Theoretical and Epistemological Stances Underpinning Invention Education Programs,* consists of an article by Noreen Balos, Maria Teresa Napoli, and Judith Green. The article describes the design and implementation of a developing Navy workforce program that incorporates many of the processes and practices employed by inventors. The paper also describes ways program developers and researchers were able to understand what was being learned through the emic perspectives of students uncovered as part of the researchers' interactional ethnographic analysis. The paper provides glimpses into the discursive nature of knowledge construction and evidence of the ways students' construction of knowledge developed across time and events.

The fourth and final section, *Youth Action Researchers,* makes visible the research findings of high school students Abbigail Foss and Caitlin Wilcoxen, who have taken a reflexive stance by researching their own efforts to teach robotics to third grade students. We applaud the work of these early career education researchers!

In regular *T&I* features, Linda Hosler of the USPTO showcases the invention education efforts of the National Inventors Hall of Fame; the NAI Chapter Spotlight focuses on the innovation and invention community at the University of South Florida; and the NAI Fellow Profile highlights the work of inventor, entrepreneur, and philanthropist Dr. Henry Samueli.

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