From the Editor

Conundrums and Bellwethers: Interpreting Research Trends

Along with all of my colleagues who completed their teacher preparation programs in the late 1960s and early 1970s, the content and practices we learned reflected the literacy needs of an industrial society. At that time in the US, one of the primary textbooks used in teaching the content/practices was *The World of Manufacturing* authored by Donald Lux and Willis Ray, which came out of the Industrial Arts Curriculum Project (IACP) and first published in 1968. As the title implies, the content and practice knowledge addressed through this textbook focused on preparing students with the literacy needed to participate in an industrial society. However, as Herschbach (2009) portrayed, by the late ‘70s and early ‘80s the country’s shift toward a technological society drove changes to the profession, which in 1985 ultimately resulted in recasting itself as Technology Education. In 2000, fifteen years later, the first national standards for Technological Literacy were published which identified across four grade bands what all students should know (content) and have the capacity to perform (practices). Over the next fifteen years, society transitioned into an information age dominated by digital devices, the Internet, and globalization. Consequently, the literacy needs shifted once again, only this time the trend was toward preparing students with the cognitive abilities and conceptual understanding needed for the next generation workforce. These rapid transitions challenged the field of technology education to keep pace, and to focus less on students demonstrating their procedural (doing) and declarative (knowing) types of knowledge, and more on demonstrating their higher order schematic (conceptual connections/understanding) and strategic (when/where decision-making) types of knowledge. Such changes in pedagogical focus also placed the profession in direct competition with the signature pedagogies of the core disciplines, all of whom have long traditions of teaching explicitly to promote the development of higher order, critical thinking skills.

In response, recent publications in the JTE and other notable research journals are documenting a growing trend in the profession of research focused on transdisciplinary designerly pedagogical approaches that emphasize the cognitive demands inherent with technological/engineering design based learning (T/E DBL).

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Delivered through an integrative STEM education (I-STEM ED) pedagogy, T/E DBL naturally imposes on learners an authentic need to know and understand when engaged in solving open-ended design challenges (Wells, 2016). Unlike the typical contrived design activities adopted by core disciplines to teach their content, current studies investigating T/E DBL are validating student development of cognitive abilities and conceptual understanding as a result of this integrative approach to teaching and learning.

Within the US educational system PK-12 students have traditionally been taught two primary knowledge acquisition heuristics (KAHs): the scientific method and the hermeneutic method. T/E DBL teaches students a third KAH: the designerly method (Wells, 2021, p. 235). Students who possess the complete triad of scientific, hermeneutic, and designerly KAHs are arguably best prepared with the cadre of higher order thinking abilities needed for addressing complex problems. Furthermore, unlike the scientific and hermeneutic KAHs which tend to focus heavily on declarative and procedural knowledge, the designerly KAH taught through technology and engineering education (TEE) imposes on learners the need to also develop a broad base of technological knowledge and skills. And it is interesting to note that students in the core subjects, in particular the sciences, are expected to possess and use technological knowledge and skills even though they are not addressed through the curricula. Furthermore, common to all subject areas where technological knowledge and skills are needed, there is a phenomenon associated with using technologies typically not recognized or accounted for by educators. Specifically, tool use (e.g., how to use a multimeter or perform a gel electrophoresis) and use of tool (e.g., when/why you use the multimeter or run a gel electrophoresis) impose more than just cognitive and technical demands – there are equally challenging emotional demands associated with using tools, equipment, and machines.

The emotional connections, whether small or large, associated with acquiring technological skills and abilities, are generally not consciously considered by most educators during instruction. Historically, the pedagogical approaches promoted through teacher preparation programs, whether in Industrial Arts, Technology Education, Technology and Engineering Education, Design and Technology Education, or Science Education programs, give no attention to the emotional connections that may be in play between the learner and the technologies they will be expected to utilize. Specifically, the pedagogies we have been taught did not explicitly acknowledge emotions as a factor to be accounted for when teaching students how to use a given tool, piece of equipment, or machine. Looking back on my own preservice preparation, particularly the biology, physics, and chemistry labs required for science education, I observed firsthand the difficulties and emotions most students taking those classes with me had in using science materials, equipment, and machinery. And later throughout my years of teaching technology and science education, I recall clear instances in both my science and technology classes when students experienced positive and/or negative emotions when learning to use a variety of tools, materials, equipment, and machinery. These included a range of emotions from overt fear, to over confidence (i.e., lack of respect for potential risk) when first learning to use certain power tools, machines, or some of the hazardous equipment and materials required to conduct science experiments. And though not directly addressed through our pedagogical preparation, I suspect when confronted with a student experiencing some level of emotional angst or over confidence, most educators will assess the situation and find a way to mitigate the emotion. But not all emotions will be openly evident, and nor might the teacher be present when a student finds themselves experiencing some level of emotional apprehension. Attention to emotions as a variable to account for when teaching students to use technologies was simply not a part of the typical teacher preparation experience. However, observations such as those described above are reason enough to recognize there is a need for raising awareness regarding the existence of emotional connections between a student and their tool use, and/or use of tool.

In the first article of this spring 2025 issue, the research conducted by Gullberg et al. documents how undergraduate civil engineering students in Sweden experience varying levels of emotion when having to use tools, equipment, and machinery required as part of their laboratory classes. Their findings are particularly significant in showing that these emotions will have a direct impact on the learning process. This is noteworthy given no attention to how teachers should deal with such cognitive phenomena is provided through our curricula, nor in the preparation of educators who will teach that curricula. This has particular relevance to the second article by Ku et al. who present their research on professional development intended to guide inservice educators in collaborating on the design and implementation of integrated STEM education curricula. Acknowledged in their conclusions is the need to emphasize safety issues within their professional development model, which perhaps opens the door for also including attention to emotional factors. In the article by Jackson, qualitative research was conducted to explore how self-regulation and self-reflection are manifest by novice designers when completing design iterations. Here too in this research we find connections to emotions that are having an impact on student learning. For example, quotes from novice designers such as *Oh, I love this project* and *I'm very excited*, or *My life is ruined* and *it was really frustrating and we got really discouraged* appear to insinuate there can be both positive and negative emotional connections with design thinking and even with designers themselves that are impacting the learning process. Similarly, the Shi and Hill article highlights the need for teachers to be sensitive to how the developmental stage of preschool children has an impact on their ability to build socio-technical relationships when introducing them to the basics of robot coding. The existence of emotional connections can also be recognized in the research article by Sung et al. which is addressing the attitudes of marginalized groups in rural communities toward STEM. The premise of their research is that design-based learning has been recognized as an effective instructional strategy for STEM education and can therefore play an important role in enhancing the attitudes of high school students toward the STEM fields. Highlighted by this research are the connections between STEM attitudes and higher self-efficacy, which is linked to the positive emotions associated with design-based learning experiences. Either directly or indirectly, all of these researchers are investigating cognitive phenomena associated with T/E design-based learning.

To come full circle in this editorial, the body of research presented in this issue of the JTE reflects the international trend in research focusing on the connections between the learning process, the psychology of learning, and the imposed cognitive demands associated with student engagement in T/E Design Based Learning. Of perhaps equal importance, these articles reflect investigations into design-based learning being conducted by educational researchers around the globe and from across the full spectrum of STEM disciplines. And beyond journal publications are the discussions on this topic among researchers attending major conferences such as the ITEEA, PATT, NARST, NSTA, TENZ, and ICTE to name but a few. Such discussions are spawning new international research collaborations and building strong relations among institutions and colleagues around the world. Of significance within the context of this trend in international research collaborations, is that the TEE footprint in the US continues to shrink year after year. Recent data on the status of TEE preservice programs shows a decline from 174 programs in 1990 to 62 in 2005, and 34 in 2025. These data show an 80% decline in programs since 1990, and in the past 20 years a 45% decline in preservice programs and a 73% drop in degrees granted by them (Hacker et al., 2025). The international community on the other hand, appears to be going in quite the opposite direction. We see this reflected in the development of new programs such as the recently launched Integrative STEM Education graduate program at National Taiwan Normal University, and the steadily increasing interest and participation in international conferences such as PATT and ICTE by researchers from across the STEM disciplines interested in research surrounding T/E design-based learning. This stark contrast in trends presents a real conundrum. And as we ponder the reasons behind these distinct differences in trends, it is worth considering that the groundswell of international collaborations might well be a bellwether for the next major evolution of the field.

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