Book Review

de Vries, M. J., Fletcher, S., Kruse, S., Labudde, P., Lang, M., Mammes, I., Max, C., Münk, D., Nicholl, B., Strobel, J., & Winterbottom, M. (Eds.). (2020). *The impact of technology education: International insights*. Center of Excellence for Technology Education (CETE), Vol. 3. Waxmann Verlag. ISBN: 9783830941415 (paperback), $46.03, 180 pages.

The Impact of Technology Education: International Insights is the third volume of international research prepared by the Center of Excellence for Technology Education (CETE). There are nine chapters of different research activities that attempt to substantiate the claim that technology education can be a powerful teaching and learning tool in preK–12 schools and postsecondary settings. The researchers assert an urgent need to expose students to technical subjects and realistic problem-solving as early and as often as possible. Although each chapter presents different kinds of research and insights on the impact of technology education, the call for a unified effort to support technology education is the central theme of these chapters.

This book informs us of successes achieved in developing technological literacies and reminds us of the work that needs to be continued to demonstrate the value of technology education. What follows is a summary of specific chapters in this book.

PreK and Primary Education

Several studies presented in this book deal with the challenges of determining the problem-solving abilities of preschool and primary students and the impact that technology lessons have on children. Technology education is not recognized as a subject in those levels of education. However, supporters of technology education suggest that it should be integrated into the preschool and primary grades curricula. Student avoidance of technology and engineering classes in later years may be a sign that they did not have access to technology or design-based activities during primary education. These studies were conducted to support the inclusion of technical content into preschool and primary school curricula.

Guided by a framework developed by the Society for Didactics of General Education, Mammes analyzed social studies and science curricula from the 16 federal states of Germany to determine the relationships that these curricular areas have with technology. The results of the analysis indicated that all but one

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of the federal states had some form of technology content offered. The matrix developed from the analysis offered evidence that could lead to a larger implementation of technology in preschool and primary school. Furthermore, this level of schooling provides the necessary environment for students to observe phenomena in contexts familiar to the students. The addition of technology to early learning ensures that students can be technologically capable well into their later school years.

In another research project on early learners directed by Adenstedt and Gooß, primary school students were recruited as study subjects to determine self-efficacy and its influence on solving problem-based design tasks. Previous studies had focused on young adults' efficacy with technological devices; therefore, little was known about primary students' self-efficacy. Two studies are presented in this chapter: One study focused on technological self-efficacy, and the other focused on self-efficacy in accomplishing a problem-solving design task (in progress at the time of publication). The introduction of technology education into primary subjects is viewed by supporters as a means to nurture skills, attitudes, and competencies in early learners. Infusion of technological subject matter into primary curricula is believed to reduce gender biases and girls' avoidance of technology.

Over 500 primary school students participated in the first study. A questionnaire was developed for students to respond to items about their technological self-efficacy. Not unexpectedly, the results revealed that boys' scores for self-efficacy were slightly higher than those of girls, but the data disclosed that girls' self-efficacy grew from age 8 to age 10. In this study, both primary school boys and girls had above-average belief in their ability to work with technology.

The second study presented a design task for primary students to complete. The influence of self-efficacy on problem-solving abilities was the focus of this study. In order to determine how children solve problems, the researchers developed an authentic problem-based design activity using Lego. The research was also designed to explain the different approaches used by children to solve problems. Data for the project were collected from a questionnaire with items concerning self-efficacy in addition to a series of questions about the children's use of technology and self-evaluation of their designing and building skills. The investigation used video to record how children solved the design problem. In this activity, students were offered three forms of assistance, if needed, to accomplish the tasks. This strategy was used to guarantee that children did not avoid completing the activity. Upon completion of the design problem, the students were interviewed about their decisions and the processes that they used to solve the problem. All of the students completed the task, with 12 of 23 children using one of the forms of assistance. The results of the two studies demonstrated that there was a direct link between technological self-efficacy and technological problem-solving. Teachers who understand this dynamic should be better able to develop activities that are realistic and strengthen children's belief in their capabilities.

Affinity for Technology at the Lower Secondary School Level

An intervention using natural science with technical design was used to investigate Swiss lower secondary school students' conceptions of technology and the technical competencies that they acquired through the intervention. Teams of teachers volunteered to participate in the project, beginning with in-service training. The educators were assigned to an experimental group or a control group for the purpose of this study. The research focused on "Affinity for Technology" (AFT), a term derived from the "Explicit, Reflective Technology Education" model research supported by the Swiss National Foundation. Four variables were selected for the research study: "general acceptance of technology," "individual interest," "self-efficacy in solving technical tasks," and "career aspirations" (p. 51). Data were collected from online pretest/posttest surveys, interviews with students, and working journals. Special attention was given to analyses of students' interest in learning about and working with technology and students' interest in the design process. The findings revealed that students generally had a positive attitude toward technology, but their interest lowered when specific situations and topics were presented. They also reported that interest in the design process was associated with high scores on creativity but lower scores on interest in cognitive processes such as understanding and evaluation. Students fully engaged in the intervention with technology education displayed increased AFT. Although they found a stereotypical gender gap during the study, it was reported that girls liked the activities as much as boys. Girls also showed positive changes between pre- and post-tests. One explanation for that was the cooperative and creative nature of the intervention activities. The products from this research were useful instruments that measured AFT and provided documentation for ways to motivate students with design processes.

Measuring Technological Literacy

In the chapter written by Stefan Fletcher, he notes that little attention has been given to measuring secondary level students' technical knowledge. The lack of data on the state of technological literacy in adolescents leaves many new opportunities for national and international study. The dearth of information was the inspiration for the development of a testing instrument by CETE and its collaborators. Without a clear set of uniform standards across several nations, the research group had to create a development model using situational contexts. Observable and measurable behaviors were cataloged in order to measure the extent of technological thinking and doing. With this information, a matrix was designed for each of the participating countries. The matrix contained areas of technological knowledge, action form (i.e., typical forms of technological action), and areas of action. This foundation prepared the way for nations to collaborate on identifying common technological tasks and knowledge that could be used to measure students' technological literacy.

A test instrument was designed with the awareness of the idiosyncrasies that come with working with different international educational systems and differences in technology education coursework. The resulting effort produced a test with 57 tasks that were germane to the study's countries. The task format was formulated into a two-tier response system. On the first level, a content question was generated with several available answers. Test takers were asked to review the questions and mark whether their answer was "right" or "wrong." They then moved to the second tier of the test and would identify how confident they were of their answers. The use of the two-tier system for this evaluation was determined to increase the validity of the recorded results. Linguistics was also a priority for the test instrument; it was formulated in German, and it was used in two other countries without translation. Experts added English and Dutch translations to ensure that test item meaning would be accurate. The results of the testing were not described here, but it is noted that they can be found in a 2019 issue of the *Journal of Technical Education*. The researchers concluded that the test instrument met the quality criteria and suggested that they have developed a new tool for measuring technological literacy across international boundaries.

Gaming and Simulations in Technology Education

Gamifying instruction and the use of simulations in the technology education classroom are powerful tools to motivate student learning and to impact students' decision-making skills. The chapter by Karl and Lukosch speculates that gaming and simulations are appropriate practices to teach students decision-making skills and the design process. The researchers deployed a series of exercises with their undergraduate and graduate students that addressed the complexity of systems and human interactions often found in industry, in this case, construction and engineering. Their undergraduate students' program concentrates on introducing management competencies and engineering skills. For the first experience, the researchers employed game theory (models of conflict and cooperation between decision-makers) to allow students to determine how their decisions impact the other players. In the second scenario, graduate students designed their own management-style games. It should be noted that, in both cases, the researchers preferred the use of board games over internet-based simulations. Technology was not always available to students, and the researchers determined that the board game was more convenient for student learning.

In the first experience, students took on the roles of contractors and were presented with a city that was in need of infrastructure and building improvements. Project cards were used to determine the construction activity in which the student would engage. In their role-playing, students had to research the cost of materials, look at construction trends, and manage their company. Up to six students were playing the game at once. Instruction was provided to the students as they moved through processes such as negotiating, resource planning and acquisition, marketing, and financing and estimating. The knowledge and skills that they learned in class were then utilized for the game.

In the second experience, graduate students utilized a game design based on a real problem related to technology. A Triadic Game Design was incorporated into the work because it encompasses the elements of reality, meaning, and play. Game designers had to accommodate their designs for players' actions, interactions with other players, understanding of goals, strategies, and engagement in realistic situations.

At the end of the experiences, students were asked to reflect on the process of game design to determine the value of their learning. Their responses were positive for both groups, and the students' narratives demonstrated that they took theoretical information and applied it in a practical manner.

Digitalization

Acquisition of digitalization competencies by all workers will be necessary in the future. Kruse and Koch contend that digitization will play a major role in the industrial production sector in the near future. This project addressed the content requirements and competencies necessary for work in the future. The study was a replication of an earlier analysis performed on the Swiss German Curriculum 21. The intent of the new project was to extend the content and reevaluate the original study. Technology topics that defined the first study were: "Internet of Things," "Cyber-Physical Systems," "Socio-Technical Systems," and Human-"Machine Systems" (p. 86). These areas were used to provide categories for content and teaching and learning requirements. The curricula were analyzed for digital theme references and associated competencies. These competencies were then assigned to occupational qualifications established for future skilled workers. The researchers utilized a widely accepted instrument from the Association of German Engineers (VDI) to analyze technical education competencies using a VDI grid of five competence areas. A quantitative consensus Delphi design was developed for three dyads of German specialists that would rate the potential of domains from the first study. Each domain was rated for content relevancy in transitions from school to vocational education and training, from school to university, and for future potential for each technical domain. There was strong agreement from the specialists that the competencies defined were important to students following one of the transition paths. The data gathered could be used to improve content in general technical education. The experts also suggested that innovation to teaching strategies was appropriate. Interventions will be necessary to prevent a knowledge gap between skilled and unskilled workers by creating opportunities to make digital opportunities more available and to prevent digital illiteracy.

Tinkering

Tinkering within technology education offers students the freedom to explore personally meaningful projects. Rich in the tradition of constructivism, tinkering is not defined by a final product but by observation of phenomena and the processes of exploration and problem-solving that help to explain what is occurring. The authors are quick to remind us that many maker activities include step-by-step instructions to complete a project. They consider tinkering as open-ended activities in which the learner's personal goals may change as they resolve a problem. "The emphasis in Tinkering is exploring and discovering problems worth solving" (p. 135). In a way, developing responsibility for learning is an advantage of the tinkering process. Students often control the structure of what they learn and how they learn it.

In the researchers' review of the literature, they discovered that tinkering provided "unifying engineering characteristics and the habits of mind" strongly tied to engineering practices (p. 132). Royal Academy of Engineering reports revealed that tinkering provided the necessary elements that could attract students to engineering fields. The role of tinkering in STEM education clearly removes the emphasis on planning for events and entertains a "messier," more creative approach to exploring and solving problems. This teaching approach shifts learning from a formal process to a more personal frame of inquiry. The authors maintain that tinkering should become an essential component of engineering practices necessary to engage future engineers.

Public–Private Partnerships

Public–private partnerships (PPP) were suggested as a key factor for encouraging students in the United States to become engaged in STEM activities that could lead to exploring occupations or pursuing pathways to careers in STEM fields. Strobel and Sun argue that encouraging these collaborations will be critical for schools to overcome the funding cuts that have impacted technical programs. The reduction in available resources has led to a smaller pool of technology-savvy candidates from which industry and businesses can recruit employees. The authors assert that schools, businesses, and other stakeholders benefit from cooperative efforts, schools improve STEM education with newfound support, and business and industry can provide work-based experiences that help them recruit and mentor students in technological settings. Among the many challenges facing the development of strong PPP is students' aversion to mathematics coursework. As one of the pillars of STEM, math proficiency is required for success in most high technology fields. Another issue, a theme that occurs throughout this volume, is the lack of professional development opportunities for teachers who need to grow confident with the content and methods of STEM subjects, most importantly, engineering and technology. The authors suggest that industry and businesses might be able to assume some responsibility to assist instructors with their enhancement of real-world work habits.

In order to understand how K–12 STEM school and industry partnerships worked and were sustained, the researchers developed a taxonomy using case studies, professional publications, and school and industry websites that addressed the issues of school and industry collaborations. Content analysis was used as a means to comprehend these relationships and establish categories for these associations. Once patterns were determined, themes became apparent and were combined with the categories to create the taxonomy for this study. Five categories were defined and employed to describe the interactions among schools, industry partners, and other stakeholders. The culmination of this work was the design and implementation of a model to assess STEM school and industry partnerships. The authors hope to use the taxonomy and their model in the future as a guide to identifying and developing successful partnerships. The use of categorization was deemed a useful tool to assist others who seek to understand and develop school and industry partnerships.

Ultimately, this effort could support the implementation of improved STEM programs around the nation. The taxonomy and the model provide the basis for planning, implementing, and assessing K–12 STEM school and industry partnerships.

National Evaluations to Defend the Value of Technology Education

In the last chapter of this volume, de Vries champions the cause for conducting more national evaluations to discover the impacts of technology education on students in primary and secondary schools. Using data collected from two historic national evaluations—"Technology in Basic Education: Evaluating the First Five Years" (1999) from the Netherlands and "Meeting Technological Challenges? Design and Technology in the Schools" (2011) from England—de Vries provides us with insights of both studies. The fact that these investigations were completed 12 years apart makes them no less valuable as models for others to determine the present state of technology education. In both cases, national education inspectors enlisted the services of universities, teacher education institutes, school boards, and teachers to complete these evaluations. De Vries compares and contrasts the two reports, noting that these documents are examples of rare instances in which education studies have been released to a broader audience. He proposes that these can be used as models for an ambitious and necessary study of the field. Ultimately, the success and acceptance of technology education must be based on the "proven value" of the subject.

Conclusion

This book covers a wide array of research efforts that seek to explain the current state of international technology education and its impact on student learning. Each chapter provides interesting approaches illustrating the value of technology education. Collectively, the investigators' intentions will be familiar to most technical educators, that is, to advance the status of technology education by using first-hand evidence. *The Impact of Technology Education: International Insights* is valuable because of the insights it yields about the work that international researchers are doing to improve instruction with novel approaches in their classrooms. The research studies presented on preK–12 and postsecondary education serve as examples that might be replicated in other countries with larger groups of students. Findings from these investigations might be helpful for promoting the continued expansion of technology education in elementary programs and in areas where it is not well represented.

This compilation of research succeeds in its attempt to highlight investigations by international researchers that expand our knowledge of practices within technology education that impact learners of all ages. Taken as a whole, the descriptions of research in each chapter weave a thematic response to the value of technology education. This book would make a fine addition to any library because of the thought-provoking examples presented and the opportunities it offers for further research.

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