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Guest Editorial

Current Trends in K-12 Engineering Education

Engineering education, which prepares students to create practical products by using scientific principles, technologies, and mathematical approaches, is a crucial element in STEM (Science, Technology, Engineering, and Mathematics) education. Through engineering learning/teaching process, students can potentially develop their skills in systematic thinking, problem solving, and team-based communication. In recent years, engineering educators have attempted to bring those identified learning benefits into K-12 classrooms. However, integrating engineering concepts and skills into existing K-12 science, mathematics, and technology curricula may prove to be challenging. This special issue explores the following research questions on pedagogical and learning issues in K-12 (pre-college) engineering education:

- What are students' and teachers' conceptions about knowledge transfer in engineering?
- How does curriculum design address engineering concepts and skills?
- What are effective instructional strategies to impart engineering knowledge?
- How do school educators integrate engineering education into existing K-12 curricula?
- What are possible formal/informal opportunities to facilitate students' engineering learning?
- What types of formal/informal activities can be employed to promote engineering professions in K-12?
- How do school teachers acquire their engineering knowledge?
- What types of emerging technologies are useful to facilitate students' engineering learning?
- How can students' learning outcomes be assessed during engineering instruction?
- How do underrepresented groups acquire engineering knowledge?

This special issue includes 19 outstanding papers, selected from the submitted manuscripts based on peer reviews, covering a range of important topics on K-12 in engineering education. These papers are briefly described as follows.

This K-12 special issue starts with Kimmel et al.'s article examining the basic issues related to the three dimensions in the implementation of STEM programs: (1) curricular design and development, (2) instructional methods and technologies, and (3) assessment.

(1) Curricular Design and Development

Cunningham and Kelly examine how engineering practices can be framed through an Engineering is Elementary (EiE) instructional unit. Discourse analysis of conduct was reported based on classroom videos and artifacts.

Chabalengula et al. investigate the current practices in K-12 engineering programs. Nine widely-used programs in the United States and across countries were analyzed through a content analysis method.

Ryan et al. investigate The Science Learning Integrating Design, Engineering, and Robotics (SLIDER) project, funded by the National Science Foundation (NSF). The integration through the use of robotics to develop conceptual understanding among eighth grade physical science students was studied.

(2) Instructional Methods and Technologies

García-García et al. use informal learning strategies to raise K-12 students' interest in engineering learning. The group learning process for generating collective knowledge through multidisciplinary team interaction and dialogue was analyzed.

English and King investigate how fourth-grade students solve an introductory civil engineering design-based problem, namely, Tumbling Towers, which was implemented at the beginning of a three-year longitudinal study. Set within a civil engineering context, the problem required student groups to design and then build the tallest tower within given constraints.

Moore et al. present their third-year implementation of a NSF-funded program called "InVenture Challenge." Data collected from a teacher survey and observed student outcomes were analyzed. Challenges and recommendations were discussed.

Chiu et al. describe the design of WISEngineering, a computer-based engineering design environment, in formal and informal settings. This paper provides insights into the implementation of WISEngineering in middle school and after-school settings.

Chou et al. study the effect of Google SketchUp on students' learning achievements in spatial visualization. A quasi-experimental with pretest-posttest design was used to analyze data collected from 84 fifth graders at a public elementary school in Taiwan.

Fernández-Samacá et al. presents a simple robotic prototype for preschool and elementary school students' engineering conceptual learning. The paper reported the assessment results of the proposed K-12 approach through qualitative data.

Hirsch et al. report fifth to seventh grade students' participations in a two-week summer camp, supported by The ExxonMobil. Students' understanding and application of the engineering design process were evaluated. A Draw-an-Engineer Test was used to measure their cognitive changes in perceptions after attending the camp.

(3) Assessment

Vidic assesses teachers' beliefs about STEM education based on an interdisciplinary project in the Slovenian school system. The Engineering Education Beliefs and Expectations Instrument (EEBEI) for STEM education was used to report teachers' beliefs and expectations about pre-college engineering instruction, college preparation, and career success in engineering.

Balta et al. investigate the Engineering Epistemological Beliefs (EEBs) of Turkish vocational high school students. A Turkish version of the Epistemological Belief Assessment for Engineering (EBAE) questionnaire was used to assess students' EEBs.

Shyr et al. develop a competency instrument in the subject of energy technology for vocational high school students in Taiwan. Behavioral event interviews and the Delphi technique were used in the study.

Alemdar et al. present the validation methods and results of an assessment tool to measure students' understanding of the Engineering Design Process (EDP). The utilization of Think Aloud Interviews and the application and analysis of qualitative coding schemes were described.

Hynes et al. provide a systematic literature review of 218 research articles from peer-reviewed journals in K-12 engineering education. The review summarized the status of the research in the field in terms of research subjects, sample sizes of the studies, methodological approaches, and the nature of the research questions.

Matusovich et al. study Appalachian students' interest in the field of engineering education. They used a qualitative multi-case study approach to first compare interest in engineering and healthcare fields among high school students and then to compare high school and college student interest in engineering careers.

Chou and Chen investigate elementary school students' conceptions of engineers by conducting the Chinese-version of the Draw-an-Engineer Test (CDET) in classrooms. A content analysis method and a phenomenology approach were used to analyze the collected data from a group of 750 Taiwanese students.

Beiler evaluates secondary school students' understanding of sustainability concepts focusing on education level, gender, and ethnicity. A pre- and post-test was used to assess high school students who attended a summer engineering camp and participated in a ninety-minute lesson on sustainable engineering.

On behalf of all the authors and reviewers contributing to this special issue, we would like to particularly thank Editor-in-Chief Ahmad Ibrahim for his continued support to our scholarly efforts. We hope you will find these papers informative and useful.

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