Book Review

Khine, M.S. (2017). *Robotics in STEM education: Redesigning the learning experience*. Cham, Switzerland: Springer. ISBN: 978-3-319-57785-2 (Hardback), $99.99, 262 pages.

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Robotics in STEM Education: Redesigning the Learning Experience

Technology and the global market is changing with greater speed—such as driverless cars, automated vending machines, bionic human prosthesis, and farming robots that weed and seed. Despite these changes that will demand new skills for the workplace, public education has remained essentially static. Khine suggests if teachers from the nineteenth century were invited into the classroom, they would have no problem teaching our students because most schools are still using the same practices they have always used in the past, such as not requiring students to acquire critical thinking and reasoning skills, and connect their learning to their lives.

Many curriculum developers and scholars in the field of science, technology, engineering, and mathematics (STEM) ask, "How can we support students in building a deep, integrated knowledge of STEM so that they have the practical knowledge and problem-solving skills necessary to live in and improve the world?" (Krajcik & Delen, 2017, p. 35). Careers that will be available to the next generation workforce will require practical knowledge, the ability to collaborate with others, problem-solving, critical thinking, decision-making, and innovative skills.

The authors in *Robotics in STEM Education: Redesigning the Learning Experience*, provide a collection of current lessons, projects, and ideas that use innovative methods of integrating robotics inside and outside the classroom. The overall purpose of this book is to provide strategies to transform students from being consumers of learning to think deeply about their learning—not only in the STEM field but also across many other disciplines. Ideas for integrating robotics extends into the arts and even into the fields of storytelling and drama. The authors explain the theoretical foundation of educational robotics, connecting robotics education with STEM and other standards, such as the Common Core State Standards. The authors of this text provide educators with a new perspective on the uses and applications of robotics as effective learning tools in the classroom.

Khine and the authors note that STEM education is progressing, and therefore, a redesign is needed to meet the needs of diverse learners, and address issues and challenges, such as creating more enthusiasm among students in the

area of STEM. Similar to his past books, Khine gathers a collection of lesson and project ideas from various authors, and each chapter provides the reader with visuals and examples of authentic projects. Khine also discusses pedagogy and cognitive strategies to improve teaching and learning.

This book is organized into three parts. Part I includes Chapters 1-4 and focuses on robotics curriculum and schools; these chapters are based on the benefits of hands-on learning that stems from the constructivism theory. The constructivism theory derives from the constructivist theory of Jean Piaget. Robotics supports this theory since the learner is not just gaining facts to construct in their mind but building knowledge by engaging in the manipulation of a tangible object. The book also makes mention of Paulo Freire's book, *Pedagogy of Oppressed* (1994), where educational practice trains teachers to deliver facts and requires students to be like containers to be filled up by the instructor. Educational robotics is a tool that allows for this inquiry and creative thinking to promote technological fluency or literacy.

Within chapter one is a list of eight mathematics practical standards, English language arts standards, and college and career readiness standards from the Common Core State Standards. The author explains how the use of educational robotics in the classroom addresses some of these standards.

Chapter two contains information on how to teach students to think by using the systems thinking approach. In this scaffolding method, the curriculum is viewed as having many elements and interdependencies within, where students understand and apply the big ideas of STEM. Big ideas link concepts from a wide range of subject fields. Robotics is a learning tool that helps facilitate these ideas, such as computational learning, which many students are reluctant to learn, in part due to their perceptions about the difficulty of computer programming and coding.

Chapter three is primarily based on coding tools, such as Lego Mindstorms, that allows for more visual and hands-on learning that is engaging, and more motivating to students. Within the chapter the author discusses how there is research to support using games as a pedagogical approach to computational skills to improve student understanding. Affordability and accessibility of resources, such as open source academic robotic kits and software, lowers the barriers for all students in high school and undergraduate STEM academics. Students apply and acquire knowledge across many disciplines in the construction of the robot. The Open Academic Robotic Kit (OARKit) already comes with codes and mechanical parts ready for use.

Part two of the text focuses on the influence, support, and alignment of robotics with STEM curriculum. A visual chart and step-by-step explanations are provided on how to conduct a systematic review to analyze all recent research in the field of educational robotics. Educational robotics has allowed teachers to apply mathematics and science concepts in more authentic ways. The

tangibility of robotics and their interdisciplinary nature foster the learning of both scientific and artistic concepts. The influence of robotics learning by students is divided into four main categories: "cognitive, conceptual, language, and social (collaboration) skills" (p. 106).

Chapter six is an overview of robotics competitions designed for STEM+C (Computer Science) Education. These competitions promote awareness and interest in the field among students, parents, and the community. They allow students to apply and exercise STEM knowledge as well as other disciplines.

Chapter seven provides us with information about the much-needed skills for the automation industry. Robotics is a major aspect of the new workforce due to growing automation developments. Although some lower skill jobs are being replaced by robots, more jobs are being created by robots, especially in the automotive and manufacturing sectors. To meet this demand, stand-alone training centers, as well as high school and college curriculum, is being developed and implemented. Learning institutions are generating more interest among students in the STEM field, and the cost of implementing these types of courses is becoming more affordable. Modules are available to pre-college and college students. This helps with students transitioning from high school to college in the robotics and the STEM field.

Creative development among children and STEAM education, which includes the arts, is the focus of Part three of this book. The authors provide illustrations and examples of how children interact with educational robots. They note two main creative areas: design and problem solving. Designing involves the conceptual, visual, and tangible creation of the robot. Creativity involves dialogue, understanding, and making of new meanings; it is also the diversity of the way in which the students think or interact culturally with each other and society in constructing new ideas. Creativity is the tangibility of the object, where students are able to hold, play with, and manipulate it. For example, to get more girls interested in robotics and STEM, they may want to make their robot look like more like themselves. The authors explain that the inclusion of all learners in robotics must include the physical look of the object itself. In addition to creativity, problem solving with robots involves critical thinking and idea generation using various methods, such as debating, negotiating, and coordinating.

Chapter ten contends that teachers can use robotics to teach about robotics, or they can use robotics to teach other disciplines. The engineering design process, which is a process engineers use, is explained. As described by the newest acronym, STEAM, which helps promote creativity and expression through technology, educators can go beyond the sciences into arts, culture, social studies, language, dance, and many other fields. The authors explain several interdisciplinary robotics kits, such as *Dances from Around the World*, where children become choreographers, engineers, and stage managers.

This book is recommended for STEM teachers, and particularly engineering and robotics instructors because it provides lesson ideas that align with the curriculum. It also includes recent research specific to educational robotics, which helps educators construct new understandings, and theories. Educational leaders in the STEM field benefit because of its strength of current research findings, and strategies of how to effectively implement STEM, and more specifically, robotics. The authors not only provide methods from the research of successful ways to implement educational robotics, but also warn the reader by listing important factors for successful implementation, such as the role of the teacher as a positive influence, the physical space and learning environment, and the design and variety of the robot itself for inclusion of all students.

Each chapter offers great insight and ideas on redesigning the learning experience by the book chapter authors. Educators may want to follow up with further research that includes student feedback during or after taking a course that utilized educational robotics, and summative assessment data. The book provides an easy to understand and practical compilation of new ideas and perspectives on how to redesign the learning experience in the STEM classroom and beyond.

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