Preface

Immersive technology has increasingly found its presence in school classrooms. It provides alternative real-world experience to promote students' deep understanding and innovative thinking in education. Immersive technology as an umbrella concept consists of multiple emerging technologies including augmented reality (AR), virtual reality (VR), 3D gaming, computerized simulation, 3D printing, and wearables.

The decade of 2010s is characterized by mobile technologies as represented by smartphones that have significantly changed people's way of communication, information sharing, and social behaviors. It is predicted that the next decade is going to be an era of immersive technology with augmented reality, virtual reality, and other immersive technologies becoming the mainstream technology that influence every aspect of our lives and work (Feuer, 2020). Early evidence in research has demonstrated cognitive and affective benefits of immersive technology that provides unique learning opportunities for experiential learning, facilitates multiple perspectives, and promotes knowledge transfer (Kim & Ko, 2019). Immersive technology is therefore to have great potentials in changing the educational landscape in the decades to come.

Regardless of the benefits and great potentials of immersive technology in education, research on the role of cognitive and affective processes pertaining to immersive technology is underdeveloped. Fundamental questions regarding how immersive technology facilitates learners' surface and deep level learning processing remain unanswered. Moreover, there is an imminent need to (1) identify the factors that influence the performance and process in immersive technology use, (2) guide the research and practice of immersive technology-integrated learning, and (3) provide the support for developing effective approaches and strategies for immersive technology-based instruction. This edited volume contains essays that represent the state-of-the-art research on immersive technology. It covers a wide range of topics: from designing immersive technology for K-16 schools to the construct of immersive metaverse in immersive technology; from automated detection of student behaviors in virtual learning environments to learner immersive experience with immersive technology; and from affordances of 3D mixed reality in non-cognitive skill development to student motivation and engagement in immersive learning. The book not only covers the various functional roles of immersive technology (e.g., 3D printing, augmented reality, virtual reality, wearables, etc.) but also explores the underlying theoretical assumptions and frameworks that have explicated the relationship between immersive technology and learning. As such, this book is well poised to provide the necessary knowledge and expertise to researchers and educators as they engage in the research and design of immersive technology for learning.

THE CONTRIBUTION OF THIS BOOK

This edited volume represents the collective effort of scholars who put together a collection of essays that provide timely guidance to the research and practice in immersive technology learning. The goal is to fill the gap in research and practice by presenting a body of studies on the cognitive and affective processes involved in immersive technology. With that in mind, three objectives were included to guide the direction of the book. They are: (1) presenting a corpse of up-to-date research on immersive technology undergirded by a consistent theoretical framework; (2) introducing methodology and instructional strategies pertaining to the design and implementation of immersive technology in educational and professional training settings; and (3) including cases that highlight the cognitive and affective processes in immersive technology and successful application of immersive technology in education. The book is featured by its unique focus on educational aspects in designing, developing and applying immersive technology to teaching and learning. The studies are based on sound theories and theoretical framework that help the readers understand the relationships between theory and practice and ultimately apply the findings to their own educational settings. Instead of focusing on one particularly type of immersive technology (e.g., augmented reality), the book covers a wide range of immersive technologies to help readers understand, in multiple perspectives, how different immersive technologies function in a variety of educational settings. Moreover, the book traverses across multiple disciplines and subject domains (e.g., language, engineering, museum science, computer science, etc.) to showcase the critical role of immersive technology in the improvement of learners' cognitive and affective performance. In that regard, the book has contributed to the research of immersive technology at both theoretical and practical levels.

At the theoretical level, the book presents a range of theoretical models and frameworks that unveil the relationship between immersive technology and learners' cognitive and affective performance. For example, Hite and McIntosh (Chapter 9) studied the 3D mixed reality in STEM education based off a theoretical framework proposed by Bybee (2010) known as 4Cs, namely, critical thinking, communication, collaboration, and creativity. The study unveils the underlying processes associated with immersive technology-based STEM learning. At the practical level, the book provides cases and studies that illuminate the steps and approaches to effectively implement immersive technology in education. This includes identifying factors that enable or hinder implementation of game development activities in learning environments (Hava, Guyer, Cakir, Chapter 14) and discussing the affordances and challenges in the deployment of immersive technology like embodied agents in virtual reality in learning (Ke et al., Chapter 8). The edited volume is therefore suited for educators, professional trainers, and instructional designers who are interested in designing and developing immersive technology for learners. It can also serve a reference book for researchers and graduate students who focus on the cognitive and affective processes in immersive technology.

ORGANIZATION OF THIS BOOK

The book is organized in two sections: Section 1, "Theories on Cognitive and Affective Perspectives on Immersive Technology," and Section 2, "Integrating Immersive Technology in Cognitive and Affective Learning." Section 1 introduces theories, theoretical models and frameworks related to immersive technology integration and application. Section 2 highlights the aspects of immersive technology by

presenting studies focusing on a variety of immersive technologies across the academic domains including computer programming, language, leadership training, engineering, museum study, and so forth.

Section 1 includes six chapters covering the theoretical aspects pertaining to immersive technology. The chapters includes cognitive aspects in immersive technology, the design of immersion in terms of cognition and motivation, application of augmented reality (AR) and relevant theories, and visual cognition, among others.

Chapter 1, written by Robert Zheng of University of Utah, USA, focuses on the cognitive process relating to immersive technology in learning. By reviewing the cognitive theories in human cognitive architecture, the author argues that learners' learning can be significantly improved with technologies that promote deep processing through sensory immersive experience. Discussion on the features of immersive technologies are made in relation to deep processing in learning. Suggestions for future research and application of immersive technology in education are offered in helping educators and professionals better integrate immersive technology in teaching and training.

Chapter 2 presents a guiding pathway for exploration and development of immersive technology. Drs. Eileen O'Conner and Jelia Domingo of State University of New York-Empire State College, USA, argue that with all the features afforded by immersive technology (e.g., scenarios, immersions, interactions and role-playing, shared and solo experiences), imagination and creativity can move designs well beyond present text, image, and video limitations, by using elements of gaming, storytelling, and conversation. The authors note that envisioning and designing for these environments is challenging, however, since learning can reach beyond past boundaries, educators are in a unique era when they can move into new realms to develop and provide successful learning environments for learners.

In Chapter 3 Pamela Ponners of University of West Georgia, USA and Yuila Piller of University of Texas-Southwestern Medical School, USA discuss the reality of augmented reality in the classroom. The authors point out that the days of showing a PowerPoint with your lecture and calling it technology integration are gone. Today's educators, and students, are looking for interactive and student-centered immersive technology experiences. The chapter attempts to answer the questions of: What is the reality of bringing Augmented Reality (AR) into the classroom? How feasible is it to introduce students to these experiences in a meaningful and academically challenging way? The chapter include multiple learning theories that provide the basis for using AR in the classroom as well as an overview of best practices for AR integration.

Chapter 4 presents an interesting topic focusing on the transition from visual culture in the immersive metaverse to visual cognition in education. Hsiao-Cheng Sandrine Han of The University of British Columbia, Canada discusses visual culture in the immersive metaverse through the visual cognition lens. Visual cognition pertains to how we learn through visual means. As educators, we should be aware of how our students learn consciously and unconsciously through the visual sense so that we can help them navigate the immersive metaverse they encounter. Culture and visual culture are discussed. Visual perception, specifically schema and Gestalt, are explained. Learning in the immersive metaverse is as concrete as in the physical world; therefore, teaching students to decode images, perceive the metaverse, and think about images from multiple cultural backgrounds becomes an issue of special importance when education occurs in the visualized immersive metaverse.

Chapter 5, authored by Joseph Crawford, Andrea Carr, and Kerryn Butler-Henderson of University of Tasmania, Australia, examines authentic leadership in immersive learning environments. Immersive learning environments require effective facilitators to enable student learning. In current literature on immersive learning, there is limited insights on the role that teacher behaviors have on fostering learn-

ing. Despite this, there is considerable literature on the role of the teacher as a leader in contemporary classrooms. This Chapter focuses on the authentic leader behaviors in teachers, and how this may affect student success. While student learning can be viewed from many perspectives, this Chapter focuses on three perspectives: affective, cognitive, and pedagogical. The literature enables the establishment of the belief that teachers who embody authentic leader behaviors are likely to be more successful in facilitating student learning within an immersive learning environment. Implications and future research opportunities are also highlighted as a result of the theory generation in this chapter.

Chapter 6 presents an overview of immersive technology through the lenses of past, present and future. Robert Zheng and Kevin Greenberg of University of Utah, USA present a conceptual discussion on the roles of immersive technology relating to its past, present and future. The underlying theories and assumptions pertinent to each stage of immersive technology are discussed by emphasizing the influences on pedagogical practices and assessment. Discussions on future immersive technologies are made by making a connection between immersive technology and other new technologies like artificial intelligence. The chapter concludes with suggestions for future research in immersive technology.

Section 2 contains chapters on the use and application of immersive technology. The chapters cover a variety of immersive technology including 3D printing, 3D Mixed Virtual Reality, augmented reality, wearables, virtual reality, virtual game development in a wide range of settings ranging from museum to engineering, to computer programming, and so forth. The authors provide compelling evidence about how immersive technology can benefit learners cognitively and affectively in learning.

Chapter 7 focuses on wearables measuring electrodermal activity in an afterschool maker program to document engagement of students. Ryan Cain of Weber State University, USA and Victor Lee of Stanford University, USA describe a new approach for exploring individual participants' engagement in immersive youth maker activities. Participants were outfitted with wearable first person point-of-view still-image cameras and wrist-based electrodermal sensors. The researchers analyzed the recorded electrodermal data stream for surges in skin conductivity and compared them with the corresponding photographs based on their time-stamp. In following with prior work, these surges were interpreted as moments of engagement. A comparison sample was created to look at moments that lacked this psychophysiological marker. Results suggested that the two participants had both shared and divergent engagements with the after-school program's activities. While the group project of building a high altitude balloon had been established prior to the youth's participation, the girls were able to choose what aspect of the project they wanted to be responsible for. This range of activities provided opportunities for youth to sample a variety of practices typically associated with making.

Chapter 8 introduces the design of virtual agents for simulation-based learning in virtual reality. Fengfeng Ke, Zhaihuan Dai, Chih-Pu Dai, Mariya Pachman, Ram Sharan Chaulagain, and Xin Yuan of Florida State University, USA explore the approaches and core elements of designing virtual agents that contextualize and scaffold simulation-based learning. The chapter starts by reviewing the literature and prior research on the nature, role, design claims, and evidence of virtual agents in digital and multimedia learning environments, followed by analyzing the educational affordances of virtual reality (VR) for agent-supported, simulation-based learning as well as the design challenges for creating interactive virtual agents. Through an empirical design case, the researchers present a conceptual and design framework of creating and using virtual agents for VR simulation-based teaching training. Specifically, the chapter aims to provide a contextualized design account along with an analytical synthesis of core design elements, including specific design problems associated with virtual agents, the design solutions, and the patterns of transferring or scaling these design solutions to other cases of virtual agent development.

In Chapter 9, Rebecca Hite and Andrew McIntosh of Texas Tech University, USA examine the affordances of 3d mixed reality in cultivating secondary students' non-cognitive skills use and development in the engineering design process. Ascribed as skills of the 21st century or soft skills, non-cognitive skills include the '4Cs' of communication, collaboration, critical thinking, and creativity as well as persistence, resilience and grit; requisite abilities for engineers of today and the future. This chapter presents a single illustrative experimental case study of sixteen 7th grade students who designed boats using the Engineering Design Process (EDP) and 3D Mixed Reality (a combination of virtual and augmented realities) to understand students' non-cognitive skill use and perceived growth. Qualitative data converged to suggest that critical thinking, creativity and grit were the most salient skills used (observed) and developed (reported). Further, findings indicated that the MR technology (zSpace) was easy to use and helped students with enhanced 3D visualization (immersion) and control (interaction) of designs. Collaboration and communication were perceived as skills that had decreased and were less observed. This research provides insight to how MR elicits secondary students' non-cognitive abilities in STEM.

Chapter 10 introduces using augmented reality technology in shaping adult training. Kirsi Aaltola of University of Jyväskylä, Finland presents a case study on learning experiences and integration of immersive learning solutions. The author examines learning experiences in AR learning game and suggests an alternative implementation model for the integration of immersive learning content to adult training. Specifically, the study examines immersive learning tool and game integrated to training for professionals working in peacebuilding context. The study points to a relevance of cognitive and constructive learning processes with special attention to experience and reflection, and that technological immersive tools can positively support training when designed properly.

Chapter 11 presents an important topic in museum informal learning: modeling interactive behaviors while learning with digitized objects in virtual reality environments. Eric Poitras, Matt Orr, and Kirsten Butcher of University of Utah, USA outline a framework for automated detection of student behaviors in the context of virtual learning environments. The components of the framework establish several parameters for data acquisition, preprocessing, and processing as a means to classify different types of behaviors. The authors illustrate the steps in training and evaluating a detector that differentiates between students' observations and functional behaviors while students interact with three-dimensional (3D) virtual models of dinosaur fossils. Synthetic data were generated in controlled conditions to obtain time series data from different channels (i.e., orientation from the virtual model and remote controllers) and modalities (i.e., orientation in the form of Euler angles and quaternions). Results suggest that accurate detection of interaction behaviors with 3D virtual models requires smaller moving windows to segment the log trace data as well as features that characterize orientation of virtual models in the form of quaternions. The discussions on the implications for personalized instruction in virtual learning environments were made.

In Chapter 12 Alice Gruber of University of Applied Sciences Heilbronn, Germany and Regina Kaplan-Rakowski of University of North Texas, USA investigated user experience in virtual reality setting for public speaking. The authors examined how the sense of presence and the plausibility illusion of high-immersion VR impact students' public speaking anxiety in a foreign language. In the study, the students' task was to give four presentations in a VR classroom using a high-immersion VR headset. The students' audience consisted of a virtual audience resembling potential classmates who were programmed to show non-verbal behavior, such as gestures, mimicry, and body motion. Individual semi-structured interviews with the students focused students' sense of presence and their perceptions of the virtual audience and the virtual space. The participants were also asked about the perceived usefulness

of the VR setting used for the purpose of reducing public speaking anxiety. All the interviews were recorded, transcribed, and analyzed by the researchers. The analysis of the interviews revealed that users experience a sense of presence and plausibility illusion. The users also perceive VR as a useful setting for practicing public speaking with potential reduction in anxiety.

Chapter 13, authored by Mark Anthony Camilleri of University of Malta, Malta and Adriana Caterina Camilleri of Malta College of Arts, Science and Technology, Malta studied the use of mobile learning technologies in primary education. The researchers examined the rationale behind the utilization of mobile learning technologies and studied students' perceptions toward the use of educational applications (apps) that are available on their mobile devices, including smartphones and tablets. The researchers organized semi-structured, face-to-face interview sessions with primary school students who were using mobile technologies at their institution. The students reported that their engagement with the educational apps has improved their competencies. They acquired relational and communicative skills as they collaborated in teams.

In Chapter 14 Kevser Hava of Yozgat Bozok University, Turkey and Tolga Guyer and Hasan Çakir of Gazi University, Turkey studied the factors that enable or hinder the implementation of game development activity in learning environments. This study aims to investigate the factors that enable or hinder the implementation of game development activity in the instructional process. One instructor and 15 gifted students between the ages of 11 and 15 took part in the study. The students developed computer games related to science topics using MS KODU game engine within the implementation process. According to the findings, it is seen that instructional practices have great importance and the instructor plays a key role in the activity. Making and playing games have been the greatest motivation resource for students. Besides, the social environment can be an important tool in sustaining students' motivation level. The students' negative attitudes toward educational game topics and non-computer activities hinder the successful implementation of the activity. The MS KODU game engine might be appropriate for novice designers but not be enough for teaching programming concepts. Team-based game development activity is believed to be useful for developing advanced games and increasing the level of interaction between students.

CONCLUSION

The current book focuses on the role of immersive technologies and their relevant cognitive and affective processes in learning. Although evidences have shown the benefits of immersive technology in learning, research on the cognitive and affective processes relating to immersive technology is understudied which has hampered the practice in immersive technology-based learning. The book *Cognitive and Affective Perspectives on Immersive Technology in Education* represents the effort to respond to this imminent need. The studies in this book unveil the unique roles of immersive technology (e.g., 3D printing, 3D Mixed Virtual Reality, VR, AR, wearables, games) in facilitating individual learner's cognitive and affective processes. The theoretical frameworks proposed by authors in this book provide a useful guidance to teachers, educators, administrators, and policy makers with respect to how to effectively integrate immersive technologies in teaching and learning.

With the advancement of digital technology, immersive technology has seen its in-roads into classrooms and schools. Yet, a book that systematically examines various roles of immersive technologies

and their relation to learning is lacking. The current book provides a much needed resource for those who are interested in applying immersive technology to education.

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