

GUEST EDITORS' INTRODUCTION

SPECIAL ISSUE “OPTIMIZING LEARNING: TECHNOLOGY MEETS LEARNING SCIENCES”

In the 21st century, knowledge and skills required for work, citizenship and life are vastly different from those of earlier times. Students are now expected to acquire the ability to anticipate, identify, collaborate, solve complex problems, communicate and make decisions in the face of uncertainty. The ability to transfer these critical goals into real-life situations would make them effective members of society. These new educational goals require a rethink of what is taught, how teaching occurs, and how students' learning is assessed. These questions form the core of the new science of learning: the “learning sciences”. The “learning sciences” is an interdisciplinary science which brings together the disciplines of cognitive science, educational psychology, computer science, anthropology, sociology, informational sciences, neurosciences, education, design studies, and instructional design. Learning scientists investigate formal and informal learning to understand the cognitive and social processes that nurture deep and meaningful learning. The advancement and ubiquitousness of technology have resulted in technology being a common tool in educational institutions. The literature generally supports the view that appropriate use of technology has the potential to enhance student achievement and learning. The pervasive use of technology in educational environments raises the question of how technology can be employed to enhance learning.

Learning sciences research can provide valuable answers to the above question. Research in learning sciences and learning technologies has shown that some learning design and development principles such as customized learning, diverse knowledge sources, collaborative learning, and assessment of deeper understanding can optimize learning, enabling students to acquire the knowledge and skills needed in the 21st century. Optimizing learning refers to connected and integrated learning, and to deeper conceptual understanding rather than memorization of factual details. The confluence of findings on learning from the sciences of learning, combined with continuing improvements in technology, can contribute to the optimization of learning, assisting learners and teachers to develop core competencies needed for the present and future society.

This special issue aims to report new ways of optimizing learning with technology, supported by developments in the field of learning sciences. To prepare this issue, we sought out research articles that advance our understanding of learning, including learning in authentic situations, and meaningful learning using technologies. Four papers are featured in this special issue. The first two papers in this special issue report ways of

evaluating and scaffolding interactions within technology integrated, collaborative and complex learning environments. The third paper discusses the designs of e-books based on multimedia learning and cognitive theories and evaluation of the three formats of e-books. The last paper examines a scoring method for multiple-choice questions that provides teachers and students with a deeper understanding of learning. This study also made use of technology to enhance the delivery of the scoring method. These four papers contribute to the learning sciences and to learning technologies research especially in the areas of learning design and development principles, diverse knowledge sources, collaborative learning, and assessment of deeper conceptual understanding. It is our hope that these papers will help guide the use of technologies in the teaching and learning processes and spur further research in this area of study.

The first paper by Thompson et al., *Discovering Processes and Patterns of Learning in Collaborative Learning Environments using Multi-Modal Discourse Analysis* reports the findings of a study that captured and analysed students' learning patterns in a Multi-User Virtual Environment (MUVE). The MUVE required students to interact with software tools and also with each other. Data from recorded synchronous interaction between participants and video screen captures were analysed. Multimodal discourse analysis (first order Markov and heuristic mining) was used to analyse the multiple data sources and enhance understanding of learning processes in the complex learning environment, in particular collaboration within the dyad as they interacted with the software tools. The analyses provide insight into the behaviour of the learners in response to the design of the task in the virtual world, the collaboration, and the role of the scaffolding. The results suggest that multiple layers of scaffolding are needed for collaborative and complex tasks. The scaffolding provided to learners concentrated on knowledge acquisition; however, the collaborative processes as well as navigation around the virtual world proved to be challenging for students. Time was an important consideration in designing tasks in complex learning environments and enough time should be provided to accommodate substantial interaction with materials and other learners. The paper concludes with discussions on the implications of the findings for the design of learning tasks for complex learning environments.

The second paper, *Learning With or Without Mobile Devices? A Comparison of Traditional Schoolfield Trips and Inquiry-Based Mobile Learning Devices*, by Nouri et al., looks at differences in students' learning processes and outcomes in traditional and mobile technology supported approaches to field trips. The study was carried out with a mix of quantitative and qualitative data collection techniques. The qualitative data was analysed using the Activity Theory framework, with the goal of understanding students' interactions in the complex learning environments. The quantitative data was analysed using two-way mixed design ANOVA. The findings indicated the mobile learning technology could support actions relevant to inquiry-based learning. Nonetheless, no significant differences were found between the two field trip approaches in terms of students' performance gains between the pre- and post-tests. Lastly, the paper argues that integrating new technologies into complex learning environments requires careful

planning in preparing teachers and students to handle the technology used, and also in successfully managing inquiry-based tasks, designing of the technology-based inquiry tasks, and consideration of costs.

The third paper by Lim et al., *E-Book Design and Undergraduates' Learning of Statistics: A Malaysian Perspective* presents findings on an empirical study on the effects of e-book presentation formats on students' learning of statistics. Three versions of the e-book - text and multimedia, text and animation and text and static image - were designed and developed by the researchers based on multimedia principles and cognitive theory of multimedia learning. The quasi-experimental study involved first year undergraduate students enrolled in a statistics subject at an Australian branch university in Malaysia. The different e-book formats were found to have different impacts on students' achievement in learning statistics. Students using the text and animation and text and multimedia e-book formats did better in the unit assessment than did those who used the text and static image e-book format. In addition, students in these two e-book formats also reported more positive learning experiences and higher preferences for using e-books. Thus, as e-books become more popular, this research suggests they will be more successful if they integrate animation and multimedia rather than simply text and static images.

The fourth paper is *Robustness of Number Right Elimination Testing (NRET) Scoring Method for Multiple-Choice Items in Computer-Adaptive Assessment System (CAAS)*, by Lau et al. This paper compared the robustness of a new hybrid scoring method for multiple-choice items in CAAS with existing scoring methods of Number Right (NR) and Elimination Testing (ET). NRET scoring method credits partial knowledge and penalizes guessing and detects misconceptions. The study used a quasi-experimental research design involving secondary school students, and the robustness of the NRET method was evaluated using mathematics items and science items. Students' perceptions of NRET and CAAS were also investigated. The results indicated that the NRET method was more efficient in estimating students' ability with NRET scores showing higher reliability level and lower standard error of measurement. For the NRET method, test length could also be shortened without affecting the reliability level of the test. Students also perceived NRET method to be practical and they were willing to use CAAS.

Together, these four papers demonstrate the potential of bringing together learning sciences research with learning technologies. If new technologies are implemented in classrooms, but those technologies are not grounded in learning sciences research, then they are likely to fail to reach their full potential. The true power of new interactive and multimedia technologies is the potential to support the design of learning environments that are more closely aligned with how people learn, than are traditional classroom designs.

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Guest Editors