Gaming Media and Social Effects

Yiyu Cai
Wouter van Joolingen
Zachary Walker *Editors*

VR, Simulations and Serious Games for Education

Springer

Gaming Media and Social Effects

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Introduction

Yiyu Cai, Wouter van Joolingen and Zachary Walker

Abstract This book is our continuous effort (Cai in 3D Immersive and interactive learning. Springer, Berlin, 2012; Cai and Goei in Simulation, serious games and their applications. Springer, Berlin, 2014; Cai et al. in Simulation and serious games in education. Springer, Berlin, 2016) to promote simulation and serious gaming. The eleven chapters book presents a multi-facet view of simulation and serious games for educational applications from STEM to Special Needs. Virtual Reality is one of the emphases in this book.

1 Background

In 2012, the first Asia-Europe Symposium on Simulation and Serious Games was held at Nanyang Technological University, Singapore. Best papers selected from the symposium were published in a book Simulation, Serious Games and Their Applications by Springer (Cai and Goei 2014). The second version of Europe-Asia Symposium on Simulation and Serious Games was held at Windesheim University of Applied Sciences, The Netherland, in 2014. A book entitled Simulation and Serious Games in Education based on the selected papers from the 2014 symposium was published by Springer (Cai et al. 2016). The third version of Asia-Europe Symposium on Simulation and Serious Games was held in Beijing Normal University at Zuhai in 2016 as part of the 2016 ACM SIGGRAPH International Conference on

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Fig. 1 The 2016 Asia-Europe Symposium on Simulation and Serious Games as part of the ACM SIGGRAPH VRCAI 2016 Conference

Virtual-Reality Continuum and Applications in Industry (VRCAI 2016) (see, Fig. 1) (Cai and Thalmann 2016). Partially based on the 2016 symposium, this new book is devoted to Virtual Reality, Simulation and Serious Games in Education. For those best papers selected from the symposium presentation, substantial enhancements are made before they are accepted as book chapters in the new book.

2 About the Book

This book has eleven chapters organized as follows.

This chapter is an introduction by the book editors Yiyu Cai, Wouter van Joolingen and Zachary Walker. In Chap. 2, Veermans and Jaakkola will share their work on design considerations for educational simulations and games. In Chap. 3, Anne van der Linden and Wouter van Joolingen will present their work using a serious game supporting conceptual change in mechanics. In Chap. 4, Casano et al. will describe the evaluation of a re-designed framework for embodied cognition math games. In Chap. 5, Ryan et al. will elaborate their research on the use of virtual & augmented reality technology to enhance the learning and understanding of biological molecules. In Chap. 6, Wu and Zheng will discuss their study on autism education through motion sensing based gaming. In Chap. 7, Yang et al. will investigate vehicle behaviours simulation technology based on neural network. In Chap. 8, Liang et al. will showcase their multi-player, and cross-platform competitive social game BlockTower. In Chap. 9, Hovardas and Zacharia will discuss an inquiry-based approach for learning system dynamics and modeling of the prey-predator system. In Chap. 10, Siti et al. will report their research and development on VR Serious Game for Special Needs Education. In Chap. 11, Xie et al. will describe Virtual Reality Simulation for Engine Disassembly with Natural Hand-Based Interaction.

Researchers and developers in Simulation and Serious Games for educational use will benefit from this book. Training professionals and educators can also benefit from this book by learning the possible applications of Virtual Reality, Simulation and Serious Games in various areas.

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Pedagogy in Educational Simulations and Games

Koen Veermans and Tomi Jaakkola

Abstract Educational simulations and serious games hold great potential for creating engaging and productive learning environments in science, technology, engineering and mathematics (STEM) domains. In this paper, we present and reflect on some of our research findings from a series of studies on a computer simulation in the domain of electricity. These studies used the same simulation with varying instructional designs and over a range of grades. Interestingly, each design had a unique influence on either student performance or student engagement, or both. We hope our results can provide insight for designers producing simulations (or, serious games) for education and for educators utilizing these designs in practical settings.

1 Introduction

From their inception, educational simulations have held the promise of creating engaging and productive learning environments in science, technology, engineering and mathematics (STEM) domains. Some of the advantages that have been put forward in the literature include simulations being learner-centric, scalable, reusable; having affordances related to illustration and visualization; leading to student interest and engagement; and producing desirable learning outcomes, particularly in terms of conceptual knowledge but also with regard to developing understanding about scientific inquiry (Slavin et al. 2014).

In addition to these advantages, the current learning analytics trend towards obtaining learner data in order to analyze productive learner behavior also adds to renewed and strengthened interest in educational simulations and serious games. However, this trend does not mean that the outcomes of learning with and from educational simulations or games are straightforward or always positive. In this paper, we will

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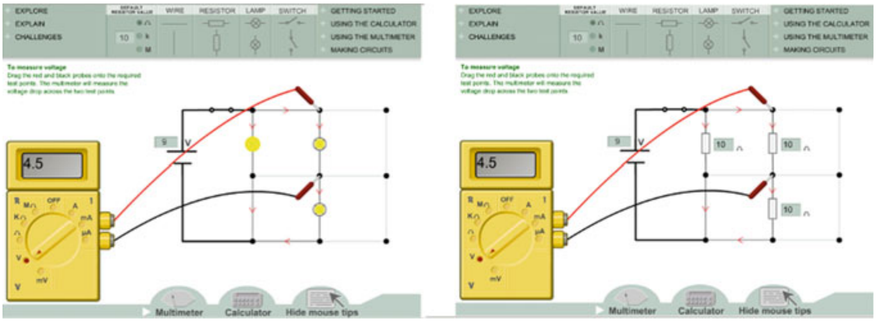

To measure voltage
Drag the red and black probes onto the required test points. The multimeter will measure the voltage drop across the two test points.

Fig. 1 The simulation with bulbs (left) and resistors (right) as used in the studies

present and reflect on some of our research findings from a series of studies with a computer simulation in the domain of electricity (e.g. Jaakkola and Nurmi 2008; Jaakkola et al. 2010, 2011; Jaakkola 2012; Jaakkola and Veermans 2015, 2018). Through these studies, our aim is to demonstrate that sound pedagogical design can make a simulation (or a game) suitable and effective across a wide age range of pupils, and that different pedagogical decisions can have notable impact on students' learning.

2 General Settings in the Studies

In the studies that are reviewed in this paper, student participants used the same simulation (see Fig. 1) to build circuits, observe circuit behavior, and study the properties and underlying principles of electric circuits. The representation level of the simulation was semi-realistic; it displayed circuits schematically but also included light bulbs with dynamically-changing brightness and realistic measuring devices. The simulated model was authentic but for two exceptions: The wires had no resistance and the battery was always ideal (i.e. there was no change in its potential difference with time).

The students' inquiry process with the circuit simulation was supported and guided by instructional worksheets designed to confront and overcome common misconceptions about electric circuits. In general, the worksheets asked students to construct various circuits and conduct electrical measurements with the simulation. The worksheet also provided scaffolding for the students to predict, investigate and infer how the changes and differences in circuit configurations affected circuit behavior. The worksheets began with a very simple and structured task, wherein the students were asked to construct a circuit with one battery, wires, and a bulb. Subsequent tasks were progressively more challenging and open-ended, requiring students to construct more complex circuits that met a specific criterion (e.g. brightness of bulbs has to be A > B = C).

The general procedure was identical across all studies. In the beginning, students took a pre-test designed to assess their baseline knowledge of electric circuits. The pre-test scores were then used to assign students into the different conditions. Matched pairs of students were created based on the pre-test scores, and the students in each pair were allocated randomly to either of the conditions. This procedure ensured relatively small differences in pre-test knowledge between the conditions, which made the assessment of learning gains during the intervention easier between the conditions. After students were allocated into the conditions, random pairs of students were created within conditions. These pairs then had approximately 90 min to build and study circuits in the simulation and solve various circuit challenges listed in the worksheets. To assess students' level of engagement during the simulation task, students were asked to indicate their situational interest in the beginning, middle, and end of the intervention in some of the studies. The post-test that was designed to assess changes in students' subject knowledge during the intervention was administered one day after the intervention. Although the students worked in pairs during the intervention, they completed all the tests individually.

Interestingly, though the overall impact was predominantly positive, each design had a unique influence on student performance and/or engagement. We hope our results can provide some new insights for designers when designing simulations (or, serious games) for education and for educators utilizing these designs in practical settings.

3 Learning Outcomes, Interest and Learning Time

The general goal of our studies has always been to study learning outcomes across different settings, but gradually, due to reports and literature indicating that students' motivation and interest towards science start declining from their early years at school (European Commission 2011; Osborne and Dillon 2008; Vedder-Weiss and Fortus 2011, 2012), interest in science (more specifically, interest during science tasks) became an integral part of our investigations (Tapola et al. 2013, 2014). In other words, the goal should be to design learning environments that are both productive (good learning outcomes) and engaging (motivating from students' perspectives).

As a starting point, we present the global findings on learning outcomes and interest that were obtained in studies across a range of grades (Fig. 2) As can be seen from the first graph, regardless of their initial knowledge, students gained knowledge while interacting with the simulation-based learning environment in all five grades, with the smallest gain occurring in grade 4, the largest in grade 5, and similar gains in grades 6 and 8 (the overall outcome shows a significant linear interaction between grade level and post-test scores; students scored higher as a function of grade level, $p < .001$). Interest was above midpoint for all grades, but the second graph shows the presence of a tendency for decreasing interest with increasing grade.

Based on the overall outcomes, it can be argued that the learning environments used in these studies fulfilled the aims of the learning environments both in terms