Preface

Can a game or simulation teach a teacher? Can it improve one's knowledge and skill as an instructor? As part of an international dialog between researchers in educational technology, this key question, and many more related to it, has led to this new collection of ideas, research, and reflections by researchers looking for answers.

The word "digital" is included in the title of this book to make sure readers know we are talking about the heart of computer game engines and the computational underpinnings of models and representations of real world processes. However, the book is not intended primarily for computer programmers or technical designers, but for a broader audience of anyone who is looking into games and simulations with an eye to their potential for improving teaching and learning. If this is you, then welcome to an emerging community!

The authors here approach their work variously as experimental, development-based, philosophical, conceptual and pragmatic, sometimes in several configurations of these perspectives. Hopefully, this means you'll find several chapters here that are to your immediate liking and others that will appeal to you in time. Perhaps a few chapters won't be exactly what you are looking for now, but we trust they will all guide you to think further about the issues, lead you to deeper levels of research and help link you with active researchers in this emerging field.

An edited collection of different authors presents a challenge – the unity of the ideas and at the same time, an opportunity – a diversity of viewpoints, opinions, and research perspectives. We think this book will repay your time spent in browsing and sampling its many offerings and will serve you as a reference for future forays into its subject – the design, implementation, and research on digital simulations that seek to improve teaching and learning.

DEFINING THE CONTEXT

Creating an educational simulation is a fully collaborative process. For example, as an embryologist is needed to verify if a simulation of a chick developing in an egg is accurate, a simulation expert is needed to translate what is known into a description of a model that can be implemented, and an educator is needed to design the learning experience and assessment. "A Simulation Primer" by Katrin Becker and James R. Parker of the University of Calgary, Canada, offers an introduction to digital simulations for those interested in using or designing them for instructional purposes. The structure and characteristics of discrete and continuous simulations are described with rationales and contexts for use.

Young Kyun Baek, of the Korea National University of Education in South Korea, expands upon the definition of a simulation with two categories: experiential and symbolic. In his chapter "Digital Simulation in Teaching and Learning" he discusses the interactive, experiential trend in digital teaching and learning and the educational merits of simulations. In summary, an educational simulation

...has an adequate model of a complex real-world problem or situation with which the student interacts, a defined role with a set of available actions, a data-rich environment that permits a range of strategies from a variety of perspectives, feedback in the form of changes in the problem or situation, embedded instructional goals, and mechanisms for active participation and the promotion interest, which elicits deeper, more expedient, and better retention of understanding of a concept, mastery of a skill or strategy, or acquisition of knowledge.

Peter R. Albion of the University of Southern Queensland, Australia, in the chapter titled "Virtual Spaces for Teaching and Learning: Mapping the Territory", creates a broad taxonomy for thinking about interactions within virtual environments for learning. He conceptualizes the context as a "cubic structure" of three kinds of interactions: learner with content, learner with instructor, and learner with learner to help organize the complex problems confronting teachers who face brand new kinds of challenges in orchestrating content, pedagogy, and technology to present sequences of learning experiences. The interaction categories can serve as a guide to exploring the possibilities for learning in virutal spaces.

David Williamson Shaffer, of the University of Wisconsin-Madison, in the most philosophical of the chapters in the book, offers a view of technological change that leads to a more inclusive approach to education for the information age. In his chapter "Multisubculturalism: Computers and the End of Progressive Education" he argues multiculturalism as it is typically understood, most often focuses on the means of education (how it is accomplished) rather than the ends (what it accomplishes). But "new computational media in the form of video games, simulations, and other micro worlds expand the range of domains that can be made accessible to students as a medium for meaningful activity," which exist in a diversity of communities of practice, or subcultures. So if we balance the diversity of both ends and means as well as the diversity of subcultures (e.g. doctors, lawyers, artists, mathematicians, historians), then digital simulations can help us "produce an educational system that prepares students for an increasingly diverse and interconnected world."

DESIGN CONSIDERATIONS

How can a designer add instruction to a game or simulation without reducing or removing the fun of playing it? There are no easy answers or lists of solutions. Celina Byers of Bloomsburg University, presents elements from two design frameworks that might be combined, "the powerful attraction of games and the proven effectiveness of instructional system design (ISD)," in her chapter "Combining Instructional Design and Game Design." She concludes that joining game design elements (e.g., rules, goals and objectives, outcomes and feedback, conflict and challenge, interaction, representation or story) with ISD elements (e.g., analysis, design, development, implementation, evaluation) requires "instructional game designers to have a double view, to be able to merge two mental models into one."

In "The Narrative Event Diagram: A Tool For Designing Professional Simulations," Helyn Gould, Michael Hughes, Paul Maharg, and Emma Nicol, University of Strathclyde, UK**,** add to our knowledge of simulation design by sharing the "narrative event diagram" tool they created as part of a new open-source application. The tool emerged within the development environment for their Web-based legal education simulation, Ardcalloch. The simulation centers on a fictional town modeled on the cultural and topographical elements of a typical Scottish west coast provincial town. Within the town, represented by a map and a directory of businesses, institutions, and citizens, the design team locates virtual law firms where teams of their students become engaged in legal issues, decisions and practices. In their application development story, they relate how a constant movement and reiteration among in interdisciplinary team

of experts in legal practice, education and computer science led to unique narrative templates, based on the needs of specific legal transactions. They discovered that a narrative framework offered a common ground for building a learning environment with a diverse team.

Contrasted with the design needs for a learning environment, in order for a digital simulation to provide an artificial teaching environment there needs to be a computational model of the act of teaching interacting with software agents. In "Modeling Classroom Cognition and Teaching Behaviors in Software Agents" I outline a new theoretical context for modeling the agency of an individual learner. The model, labeled "COVE," integrates ideas from learning theory, cognitive science, computational neuroscience, complex systems and artificial intelligence. The chapter will hopefully provide designers with a resource selection of ideas for computationally modeling software agents that possess the psychological, physical, cognitive, and social aspects of learning for the simulation of student and teacher behaviors in learning environments.

One of the critical design issues for creating interactive media (e.g. case studies, games and simulations) concerns assessment. Sara Dexter, of University of Virginia, notes "Because technology mediates learning in new ways, it engenders new forms of knowledge as well as possibilities for documentation and analysis." Dexter offers a synthesis perspective in "Design Principles for Interactive Learning Environments with Embedded Formative Assessments," based on the research on effective learning environments as well as research on effective assessments, which culminates in a blueprint grounded in evidentiary reasoning which is ideally then embedded into the flow of interactions of the user with the media. To create effective learning environments with effective embedded assessments will require "expertise in curriculum and instruction, psychometrics, and statistical analysis in order to develop a compelling game, simulation, or case that is grounded in strong student, task, and evidence models."

Penny deByl, of the University of Applied Sciences in The Netherlands, offers a method for delivering Web pages that combine two- and three-dimensional objects in her chapter "Hybrid 2D/3D Development of Web-Embedded Interactive Simulations." She presents an introduction to some of the open source tools and techniques that can be used with existing X3D models to embed and link with traditional Web pages. The ALIVE project which Penny started at the University of Southern Queensland (http://www.alivex3d.org) is currently creating an online editor that will provide educators with access to a repository of X3D models and wizard-like tools, which will guide the creation of such applications.

Designing authentic learning tasks through Case-Based Learning scenarios is beginning to emerge as a viable avenue to meet the needs of the game playing generation. In "Using Case Studies as the Narrative to Game Design and Development," a group of researchers at North Carolina State University—Len Annetta, James Minogue, Shawn Holmes, Meng-Tzu Cheng, Elizabeth Folta, and Marta Klesath—present several examples of using case studies as the narrative or back story for video game design and development.

CASE STUDIES FOCUSED ON IMPROVING TEACHING

Mark Girod of Western Oregon University presents research on the "Cook School District" online application, one of the first of the modern digital simulations of a classroom aimed at improving a teacher's skill. The application is founded in a decades-long research tradition on "Teacher Work Sample Methodology," which connects teaching actions to the learning of students. In his chapter "Exploring Teacher Problem Solving Using Simulation," he describes research in which important differences between more and less experienced teachers were found on problem framing, problem analyzing, and solution development activities while using the simulation.

Donguk Cheong, of Korea National University in Republic of Korea and Bokyeong Kim, of University of Virginia outline concepts and elements needed for a simulation that can be used by teachers in training for enhancing their skills in motivating students. Their chapter "A Simulation for Improving Teachers' Motivational Skills" presents the issues as part of three cyclic phases of interaction with the simulation: gaining and using new knowledge, exercise and practice, and debriefing and reflecting on what was learned.

Many teachers cite difficulties in classroom management as a contributing factor in why they leave the profession. Therefore Damián Piccolo, of AndenSolutions, and Anna Oskorus, of TiER1 Performance Solutions, in the United States, explain why aha! Process, Inc. created a series Classroom SIMs. Five design challenges are presented in their chapter "Challenges in Designing Commercial Simulations for Teacher Professional Development":

- *Accurately modeling simulation elements*
- *Designing compelling yet pedagogically sound simulations*
- *Creating scalable simulations that would be easy to update*
- *Designing for reusability to encourage practice*
- *Providing meaningful but unobtrusive feedback*

By applying the design principles they outline, it is hoped that developers can increase the scalability, reusability, ease of maintenance, and overall effectiveness of similar products, providing clear advantages to clients with limited project budgets.

Multi-user virtual environments provide pre-service teachers with pedagogical and instructional experiences that are increasingly difficult for university programs to provide. In "Simulating Teaching: The Value of Role-play in Pre-service Education,"

Scott J. Warren, University of North Texas and Richard A. Stein, of Indiana University-Bloomington, present a theory of communication along with design-based research suggestions that can inform an instructional design model of role-play experiences in simulations. The value of role-play simulations for pre-service teachers, according to the authors, is "to safely engage in the everyday communicative actions that make up teaching that range from negotiation and construction of knowledge to communication of student roles and norms."

Bokyeong Kim, of University of Virginia and Donguk Cheong, of Korea National University in Republic of Korea, present the theory, structure, and development process used in designing a teaching simulation – SimClass – that was designed to help teachers practice differentiated instruction based on student traits such as intelligence and personality. Their chapter "simClass: Simulate Your Class Before You Teach" describes a development process for a teaching simulation that consists of three phases: learning and analyzing the phenomenon of teaching, designing elements for a teaching simulation and developing and implementing field trials of the simulation.

In the chapter "Using Digital Games to Develop Ethical Teachers," authors Karen Schrier and Chuck Kinzer, of Teachers College, Columbia University, point out that games "like all media, reflect designed values systems that should be considered and analyzed" for their ethical, social, and educational implications. Digital simulations and games, according to the authors, "can encourage experimentation with alternative identities, possibilities, and perspectives" and do so within a learning environment in which cognition is situated, social and distributed. Their chapter presents potential game mechanics and design considerations for game creators and teacher educators to use when building ethics games and simulations for teachers.

It can be challenging for teachers to move beyond traditional beliefs about teaching and learning in order to implement new technologies and teaching strategies in the classroom and help their students meet 21st Century goals. In "Modeling in the Classroom Using Squeak Etoys," Shelby Morge of the University of North Carolina, Wilmington, outlines the process of adopting and using this new technology in the K-12 classroom by focusing on helping teachers create models and problem-based learning lesson plans correlated with state curriculum standards. Built on top of Squeak, an open source version of Smalltalk, Squeak Etoys is intended for use by school children to create their own models and simulations using a tile-based interface where they can create simple scripts to control objects they draw.

CASE STUDIES FOCUSED ON STUDENT LEARNING

Using the creation of a game or simulation as a student assessment product allows the student control over their learning objectives, means of assessment, and understanding of the role of their present experiences in the context of their future work. Mary Jo Dondlinger, of Richland College, and Scott Joseph Warren, of the University of North Texas, in "Alternate Reality Games as Simulations to Support Capstone Learning Experiences," present a framework for the design and development of an educational experience aimed at fostering global thinking and real-world problem-solving skills by engaging students in creating an (ARG). If games and simulations allow students to face the future while enlisting their passions, according to the authors, students will be motivated by the knowledge that their work is no longer just a game, it is a simulation of the work they will do once they move into the world of work.

Continuing with the theme of student-centered work in the chapter "Supporting Open-Ended Assignments in Learning Environments: A Case Study," Caitlin Kelleher, of Washington University, describes the design and implementation of Storytelling Alice, an application that helps students create animated stories while coincidentally teaching them computer programming. Based on the stories that students generate, a teacher can identify common needs for automated functions and processes and introduce short demonstrations of how to accomplish those tasks with computer programming. Her research on the "storytelling" version of the software ALICE indicates success in attracting young students to spend more time and use more sophisticated programming than the generic version of the software.

As a learning exercise, the capabilities of simulations enable a learner to observe how an expert creates a model or visualization of a process, explaining the necessary steps or skills required. Learners can then apply their understanding of the process to a particular problem or scenario by creating their own model or visualization, with opportunities for coaching, feedback, and corrective action by the expert. This is in essence, a cognitive apprenticeship. In the chapter "Enriching Minds with Cognitive Apprenticeship Inspired Simulations," Kay Kyeongju Seo, Aimee Byk, and Chris Collins, all of the University of Cincinnati, discuss how to design cognitive apprenticeship tasks in a 3D online digital world.

Information technologies are increasingly embedded into children's toys, games and activities, offering new ways to develop problem-solving skills. How do the new technologies extend a child's functional capabilities, and can the production of simulations and games help us form insights about how children learn with technology? These are central questions in the chapter "Learning By Doing Via Game Making" by

Jaeyeob Jung and Hyungsung Park, of the Korea National University of Education in South Korea. The chapter explores how learning by doing through making games can provides opportunities for higher-order thinking such as problem solving, decision-making, and knowledge construction in children.

ENGAGING GRADUATE STUDENTS IN DEVELOPMENT

In the future, instead of waiting for new serious games to be made available, students and teachers might learn to use game development kits as learning tools. Such kits might become as popular as "Powerpoint" and "iMovie" as project presentation tools. In "Video Game Making by Modification (Game Modding)—Lessons Learned," authors Christian Sebastian Loh and Jae Hwan Byun, of the Southern Illinois University in Carbondale, relate how making modifications of an existing game can be a learning tool for students. Their step-by-step outline should help any team interested in modding a serious game.

Engaging graduate students on teams to create new games is further explored in "Changing Middle School Science Virtually through STEAM: Science and Technology Enrichment for Appalachian Middle-schoolers," by Teresa Franklin, Chang Liu, and David Chelberg, of Ohio University. These authors discuss the design process through the use of teachers as content experts, the process of designing for middle schoolers, and the resulting impacts on middle school science teachers, the graduate students and school administrators, teachers and students during design and implementation.

EPILOGUE

The final chapter asserts that because teaching and learning are complex phenomena, a complex system framework is needed in the design of simulation engines and representations aimed at improving education. Gibson's chapter "Teaching simulations that embody complex systems concepts "introduces core ideas of complex systems and illustrates with examples from the simSchool simulation of teaching and learning.