INTRODUCTION

Twenty-five years ago, the idea that playing video games would lead to significant cognitive benefits flew in the face of conventional wisdom. Video games were seen as a frivolous waste of time, if not an insidious medium that promoted violence and signaled a decline in the work ethic and intelligence of our youth. Today, of course, playing video games is far less controversial, and the idea that games can have positive impacts is widely accepted.¹

While game researchers and designers might feel encouraged by the changes over the last quarter-century, a careful examination of the scholarship on games and cognition during this time is in many ways discouraging. Quantity is not quality, and while we can point to a vast number of authors and publications that now make up the games and learning landscape, closer inspection reveals a highly fragmented field that is at times surprisingly unaware of prior research, theories, and models. The popularity of games as an area of study has attracted many people from multiple disciplines and perspectives, which is good. But the value of diversity lies in the synergies that result from shared perspectives, and the literature in the emerging field of serious games has not always been characterized by this. Much of our scholarship has failed to build on existing research in related areas, with many assuming that as a new medium, serious games have no antecedents in prior research. Where and when scholars do look to prior research in areas like psychology, education, communication, and anthropology, they are often unaware of parallel research efforts by others who study games. This has resulted in a highly diverse but somewhat incoherent body of research in which we have unwittingly reinvented the wheel and failed to follow up on important avenues of research.

The diverse approach to research we all bring to this emerging field has generated a rich body of theory and practice. But a field only matures through periods of expansion and contraction, on the one hand generating enough theory and practice to build upon, yet on the other pausing at strategic times for critical examination of that base. The origins of this book are in this latter process.

WHY GAMING AND COGNITION?

While there are many aspects of this field worth studying, one could argue that the effects of digital game play on human cognition (in its broadest sense, human thinking and behavior) is the sin qua non of what we most commonly refer to as serious games. Yet this seemingly obvious conclusion often gets lost in practice and research. The number of people interested in designing and writing about games seems to be greater than the number of those interested in conducting the necessary research. Digital game researchers have been discussing flow and engagement in games for at least 20 years, for example, so
why don’t we have meaningful models that have been validated through empirical testing? Games are routinely cited for their ability to promote critical thinking and problem solving, yet the majority of our research in this area consists of thought experiments and convenience sample studies using unvalidated, inconsistent measures of these constructs. If we don’t conduct the research we need to validate and define these constructs, the field can never hope to evolve into a coherent discipline.

Like the gold rush of the 19th century in the United States, it is almost as if once the idea that games could have cognitive benefits caught on, the rush to design those games was on. To be sure, we learn a lot from the design process itself, and the theory that emerges is often unique and critical to refining our understanding of a phenomenon. But it is only one half of the research cycle: the “cool” half. We must also look to theory across disciplines to determine which are relevant to games and cognition, to propose and validate our own theories and models through empirical research, and to then use those theories to design games.

THE LEARNING SCIENCES

Cognition is studied across many different disciplines, including psychology, education, instructional design, and communication. While each of these fields brings critical theoretical and practical perspectives to bear on the study of cognition, perhaps none sufficiently captures the full range of theory as it relates to human cognition in the digital age. The need for cross-disciplinary approaches to the study of cognition, coupled with the increasing role of technology in human culture has led to a new field of studies referred to as the learning sciences. The learning sciences, which also include computer science and anthropology, emphasize a rigorous, empirical approach to theory and practice in the study of cognition in general and more specifically in learning and technology. As such, they may represent the best lens for studying the cognitive effects of digital games.

I come to the study of games via English, psychology, and instructional design, the latter two having the most to do with my interest in cognition. As someone interested in developing multimedia, I spent a lot of time looking for guidance on effective design rather than on the tools themselves. My search led me to the field of instructional design, where I spent the majority of my time reading work in what is now called the learning sciences but which at the time was cognitive psychology, education, communication, and instructional design. While everything I read was valuable, it was the studies that focused on empirical testing of well-established theories of cognition as they applied to learning and technology that had the greatest impact on my understanding and later design of games for learning. I attributed the small number of such studies to the relative immaturity of the field. It was not until 8 years later in 2003, when I read Shawn Green and Daphne Bavalier’s study of the effects of gameplay on visual processing that I realized how rare such studies had become. While there was no shortage of claims in the literature about how games could improve processing of visual and other forms of information, the majority of these claims relied solely on anecdotal and thought experiment evidence.

Green and Bavalier actually set out to test these assumptions. They employed rigorous, empirical protocols with eye-tracking equipment and meticulous operational definitions of separate visual processing skills to compare video game players (VGVs) to nonvideo game players (NVGVs). They found that VGVs outperformed NVGVs on a variety of skills. What made this stand out was not their conclusion, which many had asserted before, but their rigorous methodology in establishing it. This alone, for me, would have put them in the top 10% of research in this area, but it is what they did next that truly made the study unique among video game research. They followed up their research with a study that exposed NVGVs to 10 hours of gameplay to see if the observed differences were the result of self-selection (cor-
relation) or video game play itself (causation). They found that indeed it was video game play itself that resulted in visual processing improvement. The finding itself is among the most important research we’ve seen in this field for the last 20 years, but what made it really resonate for me was how much it was unlike most video game research published during this time period. Why has this kind of research been more the exception than the rule?

The answer is that it is harder to do. It takes expertise in the cognitive and learning sciences, knowledge of rigorous, empirical methodologies, specialized equipment, funding, and participants. Of course, this is only one kind of research, and I do not mean to suggest that it is the only approach with merit. Grounded theory, design theory, qualitative research, and philosophical approaches to the study of cultural, social, and anthropological effects are all important to the long-term success of the serious game field. Likewise, we cannot conduct experimental research without the theoretical and practical work that derives from these other approaches. But focusing on cognitive research theories, models, and methodologies is critical and too often ignored in video game studies, irrespective of the approach used. This book arises out of that belief, and it is my hope that you either already agree (by virtue of having selected this book for reading) or that you will come to see the value of the approaches the authors in this volume have taken to answer important questions about video games and cognition.

ABOUT THE BOOK

The chapters represent 15 different disciplines in the learning sciences (psychology, serious game design, educational technology, applied linguistics, instructional design, eLearning, computer engineering, educational psychology, cognitive science, digital media, human–computer interaction, artificial intelligence, computer science, anthropology, education), by authors from four countries (Australia, Canada, Singapore, and the United States).

Each chapter is the result of an original proposal, each of which was reviewed by three peers in a double-blind review process, with the exception of the first chapter which is an invited, updated version of Patricia Greenfield’s chapter on video games from 1984 (more on this shortly). In doing so, I assigned reviewers chapters based on interest, expertise, and in the case of reviewers who were also authors, on the potential of the authors to benefit from a different disciplinary perspective on work similar to their own. Based on these reviews, some authors were invited to submit full chapters, which were again reviewed using the same double-blind process as before.

Based on my readings and that of the reviewers, I organized these chapters into five sections: Historical Perspectives, New Theories and Models, Theory Into Practice, Research and Design, and Practitioner Perspectives. Like all good scholarship, each chapter in this volume focuses on theory past and present, and all have practical implications, so the classification of chapters into these different sections is somewhat artificial. The first section discusses past video game research in the learning sciences to help establish where we have been. The second section presents works by four learning sciences researchers who rely on existing theory and models to propose new frameworks, theories, and models for understanding learning and cognition in video games. The third section presents work that synthesizes across multiple disciplines and theories to propose specific heuristics for the design of video games for learning. The fourth section presents significant research studies that are as valuable for their methodologies and approaches as for their findings. The fifth section presents research by educational game developers that has both been informed by theories and models in cognitive science and which proposes new hybrid models for cognition in educational games.
Each author was also asked to generate a list of “must-reads” on their chapter topic for those who want to understand more about the theory and approach behind each chapter. In addition, they were also asked to identify what they would consider to be the most important texts for interdisciplinary studies of serious games. Both of these lists can be found at the end of each chapter, immediately after the references. I have collated all of the authors’ interdisciplinary texts across this book and a companion volume that collected the same information. I present this composite list sorted by rank and author at the end of the book.

You will find both a short and long version of the table of contents, the latter of which provides my own summary of what each chapter is about, so I will confine my comments here in the preface to a discussion of each section of the book and how I think each chapter contributes to that section.

HISTORICAL PERSPECTIVES

Patricia Greenfield’s original chapter on video games in 1984 (“Video Games,” in Mind and Media) is a seminal example of research on the cognitive benefits of video games. It is fitting, then, that this volume begins with a chapter in which she revisits her work 25 years later. Given the speed with which games and their study change from year to year, I was surprised to see how relevant her findings and suggestions from 1984 are today and dismayed by how many of the research avenues she suggested there remain, for the most part, unexplored. If the dates were changed, this chapter could for the most part be read as a contemporary contribution to the field, which is a testament to her foresight as well as a depressing commentary on our progress as scholars in this field. Dr. Greenfield provides an analysis and running commentary on this work from her perspective today, identifying what has changed and what has not as well as providing suggestions for current research (graduate students take note!).

As I described earlier, one of the weaknesses of research by new scholars in video games today is the failure to account for, build on, or refine existing research. While we are certain to need new theory to fully account for games and cognition, that theory must begin with prior research. Games may be a new medium, but cognition is the oldest game of them all, and unless video games have turned thousands of years of evolutionary process on its head, it stands to reason that some of what we know already about cognition will be useful in the study of games. In this spirit, Katrin Becker provides a literature review of games in education in this second chapter of this volume that highlights some of the most important findings of the last 50 years. While no literature review in this field can be comprehensive today, her critical analysis of some of the most significant research in our field should be required reading for new scholars and students in this field.

As fast as the literature in this field is growing, it is not necessarily representative of the full range of video games today. While massively multiplayer online role-playing games (MMORPGs) are among the fastest growing and most widely adopted type of game, the research base for them is quite sparse when it comes to empirical studies of their cognitive effects. Given the prevalence of MMORPGs and their potential to cross social, cultural, and cognitive areas of study, they are one of the most underexplored and important areas of video game research. In the final chapter in this section, Bodi Anderson provides a conceptual framework for MMORPG use in research and learning and describes current and future trends for their study.
NEW THEORIES AND MODELS

As we build on prior research across multiple disciplines in our own research, it stands to reason that new theories and models will also emerge. Whether as the result of our extension of existing theories as we apply them within this new medium or because of the unique features and applications of the medium itself, these new theories will serve as a bridge between past and future research.

In the first chapter in this section, John Dempsey weaves many strands from the past together using new concepts to propose a model for the design of learning outcomes in games. He argues persuasively that current instructional taxonomies are too unwieldy and impractical for widespread adoption and that they ignore critical differences between learning outcomes that are representative of the actual performance (elemental learning) and learning outcomes that serve a supporting cognitive role in that performance (synthetic learning). In addition to the resulting instructional implications (e.g., learning transfer vs. inert knowledge), this distinction also has game design implications (e.g., determining when contextual fidelity to the learning task is required and where and when synthetic content can be delivered didactically in or outside that game). The resulting five cognitive outcomes (two elemental and three synthetic) are unified by the overall concept of fidelity, which is manifested in a model he calls “the pyramid of fidelity.” The resulting conceptual model serves the same purpose as an instructional taxonomy but does so in a way that is more reflective of learning and game design than traditional approaches.

Richard Swan also focuses on the application of existing theory and practice to the solution of one of the most pervasive challenges for game-based learning design: engagement. All the learning theory in the world will make little practical impact if it fails to account for the unique nature of gameplay experience. While we may be able to design effective learning environments using games, doing so in a way that captures the engagement of commercial games remains an elusive goal. Swan identifies principles from design theory and applies them to the concept of engagement. The principles he uncovers not only have significant implications for the design of engaging educational games but serendipitously lead to a concept he calls feedforward. This latter concept reflects the anticipatory cognition that players employ during engagement, and he argues it may be far more useful than its conceptually flawed cousin, feedback. Like Dempsey’s chapter, the resulting framework and design heuristics make a valuable contribution to our understanding of the design of educational games.

In the final chapter in this section, Wen-Hao David Huang and Sharon Tettegah identify a gap in the literature that has important implications for the design of persuasive games, or games for change. Like Low, Jin, and Sweller’s chapter in the next section, Huang and Tettegah recognize the importance of considering cognitive load in learning game environments. Persuasive games, however, often focus on attitude change and, while this is an instructional outcome in many taxonomies, little attention has been paid to the instructional and cognitive requirements for promoting attitude change via gaming environments. One of the theoretical paths to attitude change in many persuasive games, they argue, is to induce empathy for characters in the game that ostensibly represent the people involved in those real-world situations (e.g., Darfur is Dying). They suggest that empathy itself may have its own cognitive load requirements that should be taken into account when designing persuasive games. Their conceptual framework for examining cognitive load and empathy not only points out a promising avenue of research but suggests other related research on emotional/cognitive constructs associated with gameplay (e.g., cognitive load during flow or engagement).
THEORY INTO PRACTICE

Theory must lead to practice both as a means of validating models through research and for guiding future development of games. This section comprises chapters that connect theory to practice in the form of principles and heuristics that can be used to guide future educational game design. Amy Adcock, Ginger Watson, Gary Morrison, and Lee Belfore argue that games with designed learning outcomes are essentially another form of exploratory learning and that the empirical literature and related design principles in exploratory learning environments is therefore relevant to the design of educational games. In connecting theory to the practice of educational game design, they rely on key concepts from the learning sciences such as interface affordances, cognitive load, and the development of expertise within gameplay. They propose a grounded set of design heuristics that can be validated and used to design education games today.

Renae Low, Putai Jin, and John Sweller connect the literature base in cognitive load, arguably one of the most significant issues facing educational game designers, to educational game design. Like Dempsey, they outline a key distinction in learning outcomes based on biologically primary and secondary knowledge. The result is an extensible model for classifying types of learning and managing cognitive load through the design of the game environment. Like Adcock et al., Low, Jin, and Sweller propose a set of design heuristics, derived in this case from evidence-based cognitive load principles and suggest promising lines of research.

Dennis Charsky articulates the connection between constructivist teaching structures, which he suggests are akin to open learning environments, and game genres and characteristics. Like Adcock et al., Charsky believes that the existing research and design principles for open learning environments are relevant to the design of educational games. By describing and mapping constructivist learning theory and the corresponding teaching and learning principles to specific instances of games and gameplay, he makes it possible for even those who are novices in this field to both understand and to begin to apply theory to the practice of game design.

Tim Marsh closes this section with his framework for designing scenarios in games that both honors the diversity of the term scenario as it is currently used while also bringing some much-needed structure and theoretical rigor to bear on its definition and application to game design. Borrowing from film, human–computer interaction, and activity theory, Marsh provides an operational definition for scenarios and proposes a standardized “template” for discussing and designing game scenarios.

RESEARCH AND DESIGN

Research and design go hand in hand in business and manufacturing circles, but they are too often viewed and conducted as separate endeavors in serious games. The result is research that fails to connect to practice and practice driven not by theory but by the idiosyncrasies of the design team and the exigencies of the moment. This need not be the case, however. Whether we are conducting research to identify new theories and design heuristics or to validate theories and models such as those proposed in the previous sections, we should all be designing games to test theory and using theory to design our games. The two chapters in this section exemplify the symbiotic relationship between research and design in serious games and illustrate how these processes are in fact two sides of the same coin. Each describes theory-driven game design that serves to operationally define existing game theory, identify new theories, and provide models for future game design and research practices.
Flow is a construct that virtually every researcher and designer of educational games would agree is part of what makes games engaging and effective (optimal) learning experiences. Csikszentmihalyi himself in an article about flow and television viewing in 1981 suggested that video games may promote flow. Yet in the nearly 30 years since, we have failed to operationalize flow in a way that allows for meaningful design and research or measures its impact on learning. For an idea deemed so central to our field, we have made shockingly little progress in understanding it.

In the first chapter in this section, Debbie Denise Reese describes the game system she and her colleagues have designed and the assessment toolset they use for measuring learning and engagement. The Flowometer tool for measuring flow during learning is alone a significant contribution to the field, but by describing the theoretical origins of this tool and providing data and analysis on its use in an educational game, she lays the groundwork for others to adopt and adapt the tool for research and design. More importantly, this chapter serves as a model for future research on other constructs like engagement and intrinsic motivation. By clearly articulating the theoretical basis of the games developed, describing the development of the tool within the context of a full assessment suite designed according to that model, and presenting data from a designed game that then puts their theory and tools to the test, she illustrates the full research and design cycle to which studies of games should adhere.

In the second chapter, Brian Magerko, Carrie Heeter, and Ben Medler identify a key, but often overlooked, challenge to educational games as an instructional medium: how to account for different prior experience and attitudes toward games during formal instruction with educational games. Rather than suggesting that we design alternative instructional experiences for those with little or no experience with or interest in games, they suggest we look to existing research on game literacy, motivation, goal orientation, and mindset, to design games that account for individual differences within a single game experience. Like Reese, they also report the results of a game designed using this model, which provides empirical support and points the way toward future research.

I have argued, here and elsewhere, that for our field to advance we must have theory and models that we test through research and design before we can establish a meaningful body of practice from which to draw conclusions. While we need hundreds, if not thousands, of learning games across a full range of content, environments, cultures, and game formats if we are to truly understand how games function in support of learning, this can only happen after we have done the necessary theoretical research and design. It is appropriate, then, that at the end of this volume (itself organized as a microcosm of this process), we turn to two examples of significant practice in the development of educational games.

In the first chapter, K. A. Barrett and Lewis Johnson describe the significant body of work that Alelo, Inc., has developed as a designer of games for training. The games they have developed to teach language and related tactical skills have been used by more than 50,000 people, which places them among the most robustly tested serious games today. More importantly, however, it represents the full process of educational game design. From existing learning theory to integrated theoretical models, to heuristics, to game design and project management approaches, they present a seamless picture of the game design process. Their approach, which relies on artificial intelligence, scaffolding for expertise, cultural contexts for learning, and instructional design, is also unique in that it eschews monolithic game design in favor of unified instructional environments that tap games only for the learning outcomes that they best support, relying on other instructional modalities for outcomes that do not require games (e.g., prior knowledge). In some ways, this serves as an example of the approaches suggested by Dempsey and by Low, Jin, and Sweller, earlier in this book. The end result is a set of theories that are well documented with real-world game examples that have been tested in the field.
Like Barrett and Johnson, Borchert and colleagues are also practitioners with years of experience and dozens of games to their credit, which they rely on in the final chapter in this section and the book. The games in question here, however, have been developed and tested in higher education environments rather than corporate/military environments. Like Barrett and Johnson, the authors also begin with a description of the theory that guides their practice. This theory is then tied to what they refer to as “signature elements,” or hallmarks of all the games they build, which makes it clear how theory is manifest in their design. Most significantly, because each signature element has been formatively evaluated in each of the games they have designed during the last decade, what emerges is a model for educational game design that is supported by a significant body of work and which is potentially transferable.

A FINAL NOTE

I believe that the field of serious games is at a significant crossroads in its development from concept to discipline. It is critical that we remain aware of the multiple disciplines that can inform our research and practice and avoid the all-too-common academic tendency to close ranks and create research silos within our own disciplines. If we do not strive for this, we will at best end up with duplicative research that slows the advance of the field and, at worst, will become so fractured that we fail to coalesce as a discipline.

Having said that, I must also confess that the title of this book comes as much from my experience with cognitive psychology research as it does from anything else. Cognitive psychology has a long history of studying how humans think and process information. Beyond this, however, cognitive psychology also has a tradition of rigorous experimental practice in studying what goes on in that black box we call the mind. Some of the most creative and important studies have come from researchers interested in nebulous, unobservable phenomena like memory, problem solving, sensory input, attitude, and emotion. The rigor and design of the experiments run in the study of these aspects of cognition is far too rare in game research today. I believe the chapters in this volume are examples of the kinds of approaches we should be taking, and it is my hope that many who read them will be inspired to conduct similar work in applying the principles of research in the study of human cognition to games. At the same time, as an educator, I am also aware of the significant limitations of these approaches, which trade ecological validity for replicability and measurement and too often ignore qualitative and anthropological methodologies in favor of clean laboratory tests. So while I hope that those not in the learning sciences are inspired to take a more rigorous approach to the study of games and cognition, I hope too that those in the learning sciences come to see the value in other approaches. No single approach or perspective will be sufficient, but each must be aware of, and build upon, the others.

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ENDNOTES