Introduction

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The design and development of learning games is a field of endeavor that crosses the boundaries of several disciplines. A successful computer game for learning (a.k.a. training game, educational game, serious game, instructional game) must weave together the skills and decision making of instructional system designers, game designers, software developers, story developers, assessment professionals, educational scientists, graphic artists, subject matter experts, instructors, and more. While prior publications have addressed theoretical issues from the perspective of one or two of these fields, and some publications have explored practical design and development issues, none has addressed the central methodological issues of how to produce an effective game with an explicit multidisciplinary approach. This book draws on the expertise and experience of a number of active participants in the field of learning games to provide practical guidelines and recommendations from a multidisciplinary perspective to assist you in your efforts to create effective learning games.

1 Definition of Learning Games

Before we dive into the issues surrounding the design of learning games, we must clarify what we mean by *learning game*. The literature reveals no consistent, widely accepted definition of learning games, although they are often classified as a subset of serious games for nonentertainment purposes (Sawyer & Smith, 2008). We prefer to distinguish learning games as having certain characteristics. In this book, we define learning games as games intentionally designed to help the player meet instructional goals while actively interacting with and being engaged and immersed in the experience. The learning game provides an environment in which the player must demonstrate a level of understanding of a body of knowledge or skills (expressed as learning objectives) to achieve game goals by solving challenges posed in the environment (e.g., identifying or resolving problems, completing tasks). The type of learning games we refer to require a significant design effort to achieve the learning goals.

We recognize that games designed purely for entertainment may also have an unintended instructional benefit. For example, *SimCity* was designed to entertain, but success in this strategy game requires correct application of realistic relationships (e.g., educational level impacts the types of desirable jobs in a geographic area) and ability to solve real-world problems (e.g., using public transportation to ease traffic jams and balancing a budget). One could argue that by playing *SimCity* players learn these concepts. However, instructional strategies are not intentionally used to ensure that players acquire, retain, and transfer *intentional* learning. Therefore, these types of games do not fit into our definition of a learning game.

There are also games that are intended to instruct, but have an underlying structure and set of rules that are not related to the content. For example, a word search, tic-tac-toe, or *Jeopardy* format can be used with any content. These games frequently focus on drilling players so that they remember declarative information. The content learned and the context of the game are not necessarily linked and these types of games also do not fit within our definition of learning games.

The word *game* is often associated with having fun – something typically, in turn, associated with entertainment. A good learning game design, much like good instruction, keeps learners engaged through intrinsic motivation – learners play because they are interested in or enjoy the game. In many cases, there is an appropriate element of fun that can build and maintain this intrinsic motivation in a good design. In other cases, though, fun in the sense of entertainment is not an accepted motivation (e.g., certain serious military or medical domains) – here, a good learning game design may engage players by emphasizing the powerful motivators of real-life relevance, purpose, and reward (e.g., saving lives), and the experience of fun in the game corresponds to the joy of performing your job well (and learning to perform it better).

Learning games provide the learner an experience within the game context that is tailored to the content and is a critical component to foster learning. Context-specific experiences like this are designed for a learning game to support learning and enable the learner to achieve advanced learning objectives (e.g., understanding cause and effect and decision making). Success in the game is dependent on understanding the content and using that understanding to succeed. The rules of the game are linked to the content and require players to first learn the rules and then play by the rules to win. Learning the content is a natural part of the game as instruction and feedback are fully integrated into the game context. Feedback consists of more than whether players are right or wrong; it is constructive to help players understand their mistakes and correct their actions. It is within this context that we explore learning game design in the chapters of this book.

2 Intended Audience

Our primary audience is professionals and academics interested in developing and researching learning games. This book targets experienced learning game professionals seeking guidance in improving their ability to create effective learning games, experienced professionals in one field seeking to transfer their skills to the multidisciplinary field of learning games, new practitioners seeking to better understand the

methods involved, and academics seeking to enhance their understanding of the state of the art in learning games methodologies. Our secondary target audience is customers and educators interested in understanding how a learning game may enhance their curriculum and how to proceed with acquiring and using an appropriate game. This book is intended as a practical guide used to inform the reader's design, development, and deployment efforts. However, it can also be used, together with other materials in the literature, to provide instruction on serious games in a college setting.

3 Organization of the Book

This book is comprised of three main types of chapters – *core* chapters that discuss key topics in the field and present multidisciplinary methods for addressing those issues, *game review* chapters that present an analysis of the strengths and weaknesses of a specific existing learning game, and *development methods* chapters that discuss the methods used in creating each reviewed game from the perspective of the developers.

The topics of the core chapters are drawn from discussions and workshops held within the *Design of Learning Games* community of practice between 2009 and 2012, and seek to cover the key issues in the field. The topics were vetted by the community during workshops and Web conferences, and authors were determined by their interests and professional diversity – most core chapters are written by several people from different disciplines. The chapters focus on defining robust approaches to the key issues, and discuss terminology, methods, and lessons that are of greatest use to the practitioner. Chapters on each topic are intended to be thorough, and may offer multiple, complementary, or competing approaches if no single combined approach has been determined at this point in time.

Our initial core chapters begin by laying out the foundations of the field – its multidisciplinary nature, key issues, and scientific grounding.

1. Learning Game Disciplines: Their Methods, Strengths, and Challenges
   - What different disciplines and methods do learning games draw on?
2. Communication for Stronger Learning Game Design
   - How do we facilitate communication among the disciplines on a learning game design team to exploit the best of each discipline?
3. Instructional and Gaming Elements: What Are They and Where Do They Intersect?
   - What are the essential game elements? What are the essential instructional elements? And what is their intersection?

The next set of core chapters focuses on three of the key design issues in learning games that are often central to success – and that often are thought of in different ways by the different disciplines involved.

4. Story for Learning and Gaming
   - How does story support learning in learning games? When and how do we adapt the story as development proceeds?

5. Authenticity in Learning Games
   - How do we achieve the authenticity needed to produce the desired learning outcomes?
6. Design Better Games: Flow, Motivation, and Fun
   - How do we maintain learner motivation during a learning game?

The final core chapters focus on the practical issues encountered and approaches to consider within your team and outside your team as you design, develop, and deploy your game.

7. Bridging the Gap from Design to Implementation
   - How do you ensure that your game design appropriately balances instructional and gaming elements? How can your team use design patterns to create your design efficiently and with minimal misunderstandings?
8. Integrating Games into Learning Environments
   - What place does a learning game have in the larger learning environment?
9. Multidisciplinary Learning Game Development Method
   - What is an integrated, multidisciplinary method you can follow for all phases of a learning game development effort? What are the key considerations and issues for the different tasks of the effort? How should the different disciplines and stakeholders collaborate on those tasks?

Following the core chapters are fifteen chapters that discuss the merits and issues for seven existing learning games – each a successful game in its own right. The games were selected to cover a range of game domains, types, and genres. Domains include health training, military training, public education, and professional skills training. Game types include 2-D games, 3-D games, single and multiplayer games, and virtual worlds. Game genres include action games, role-playing games, adventure games, and puzzle games. The games chosen are strong exemplars that highlight best practice. All are in active use (except for one that was in widespread use during its peak years and whose successor is in active use) and four of the seven have won awards for the quality of their design.

Chapter 10 introduces all the games as well as describes the consistent set of criteria against which all games are reviewed. These review criteria were determined based on community discussions, and are grounded in the topics of the core chapters of this book.

Each game review chapter is written by authors who were not involved in the development of that game. In these chapters, you will find examples, lessons, and guidance to assist you in your own learning game design efforts.

Each game review chapter is followed by a development methods chapter written by the developers of the game or of solutions based on the game. Each development method chapter describes the process the developer's team went through and captures design decisions made, issues encountered, and the developer's view of what worked well and what didn't. These chapters provide guidance, grounded in specific experiences, to assist you in following an effective learning game development process.

4 Authors

In November 2009, the *Design of Learning Games* community of interest had its inaugural meeting. The group represented a variety of disciplines including educational assessment, software development, game design, graphic arts, project management, storytelling, and instructional design. During this meeting, participants identified the multidisciplinary nature of learning game design as the most important as well as the most challenging part of creating effective learning games. This highlighted the need to continue providing a forum for the learning game disciplines to talk about the issues that most impact our games. The community decided to continue meeting and produce a publication that summarized our experiences, discussions, and lesson learned. This book is the result – it documents our collective knowledge and experiences and emphasizes practical ways for readers to leverage this information in their own learning games. Together, the authors represent all the key supporting disciplines for learning games. We hope that our multidisciplinary approach to the challenge of learning game design will inspire you, your team, and your customers, and that our recommendations will help you achieve success in your efforts.

5 Reference

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CHAPTER 1

Learning Game Disciplines: Their Methods, Strengths, and Challenges

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Abstract

As you get started on your project to create a serious game for learning, it is important for you to recognize that you and your team will likely need the skills of several different disciplines to achieve success. Usually, this means that you will be working with colleagues who have been trained in a different field from yours. By better understanding what the key concerns and methods of their disciplines are, you will better understand where your teammates are coming from and the processes they are used to. We introduce the standard methods used in the supporting fields of instructional system design, software development, game design, assessment development, and story creation and discuss some of the main strengths of each area as well as some of the typical challenges that practitioners in each area face.

1 Introduction

So, you're thinking of developing a game to help teach some valuable knowledge and/or skills. How do you go about designing and developing your learning game efficiently? What steps are involved? Who needs to be involved? What are the gotchas to be aware of and how do you address those issues effectively? How do you ensure that your learning game successfully engages your learners while effectively teaching them?

The field of learning games has grown significantly over the past decade, and the practitioners creating this new, powerful type of product have gradually formed new design and development methods tuned to the particular needs of producing a game that is both entertaining as a game and effective as a learning product. A distinguishing characteristic of most efforts to create learning games is that they are multidisciplinary. You not only need game designers, software developers, story writers, artists, and the other professionals required to create an engaging game, you also need the instructional

system designers, instructors, subject matter experts, and assessment experts required to create a useful training product. The rich and diverse set of skills brought by such a team provides opportunities for bringing together complementary perspectives and building revolutionary products, but also provides room for significant misunderstandings and unexpected inefficiencies.

On the one hand, the different professions can collaborate to bring mutually reinforcing properties to game elements – such as providing feedback in the game that both reinforces the skill being taught and furthers the plot of the game's story. On the other hand, the different professions bring different design and development methods and different priorities to the table. For instance, software developers may use highly iterative spiral or agile development methods and focus on how usable, robust, and feature-complete the system is; game developers may use ad hoc, creative design methods with extensive playtesting and focus on how engaging the gaming experience is; and instructional system designers may use a science-based design method and focus on how appropriate, complete, and effective the instruction is. In this chapter, we provide an overview of the different disciplines that are often needed on a team to create an effective learning game – in particular: instructional system design, entertainment game development, software development, performance assessment, and story development. We discuss some of the typical methods used in these disciplines, the concerns and issues on which practitioners in these disciplines generally focus, and some of the strengths and challenges of their methods.

In this chapter, you will learn:

- Typical methods used in instructional system design
- Key questions that motivate an instructional system designer
- Typical methods used in software development
- Key issues that software developers focus on
- How game designers approach creating a game
- Issues regarding and methods for assessing the performance of a learner
- Story development methods

2 Instructional System Design

Instructional system design (ISD) offers a systematic and reflective means for "translating principles of learning and instruction into plans for instructional materials, activities, information resources and evaluation" (Smith & Ragan, 2005, p. 4). ISD rests on the premise that learning takes place in a system and therefore examining the elements – including learners, teachers/facilitators, learning environments, and learning materials – is needed to achieve learning goals (Dick, Carey & Carey, 1996; Rothwell & Kazanas, 1998; Smith & Ragan, 2005). As with any system, a change in one element affects others.

By understanding how the elements of the system work together in a specific situation, a designer can apply empirically based best practices to guide learners in reaching the intended outcomes. In other words, rather than merely providing learners with information and assuming that learners will learn that information, or creating an

environment without forethought as to the learning implications of elements within it, designers apply research on learning and cognitive processes to design learning experiences that will increase the likelihood that content will become part of each learner's body of knowledge or skills. The underlying beliefs are that (a) learning can be enhanced through deliberate actions and (b) distractions that interfere with learning can be minimized if we understand the intended learner, the environment, and the expected learning outcome.

Through instructional system design, we use the best available research to select strategies and to design materials, experiences, and/or environments to promote attainment of those learning goals in the most efficient way possible. Although individual designers may rely on different instructional design models, the key premise driving all models is that learning takes place in a system that consists of various interrelated factors. By understanding the characteristics of the factors in that system, designers can make informed decisions and optimize the instructional opportunities for learning. It is important to note that instructional design is used when training or education is deemed necessary to address performance issues. However, other factors falling outside the domain of instructional design, including policy, staffing, or organizational structure, may also affect individual performance. Unless those factors are addressed, instructional interventions will not produce the desired outcomes.

2.1 Key Questions Addressed

After it is determined that learning or training is needed, instructional designers focus on identifying and clarifying the learning goals. At the most basic level, instructional system design addresses three questions (Mager, 1984):

- What are the learning goals? (i.e., what do learners need to know or do?)
- How will learners achieve them? (i.e., what methods and media will be used?)
- How will we know when learners have achieved them? (i.e., how will we measure their performance?)

These foundational questions arose at a time when face-to-face instruction was the norm and a nod or comment from a teacher let learners know if they were on track for achieving the ultimate learning goals. Currently, the focus is less instructor-centric and more learner-centric, with learners often learning independently (e.g., computer-based learning, mobile learning). Therefore, designers now also pay careful attention to the frequency and type of feedback learners will receive. For that reason, we add an additional key question:

- How will learners know when they have achieved the intended learning outcomes and how will learners assess their own progress? (i.e., will they receive specific feedback, natural consequences, a combination?)

During the design process, an instructional designer not only seeks to address these questions, but also gathers specific information about the intended learners, their

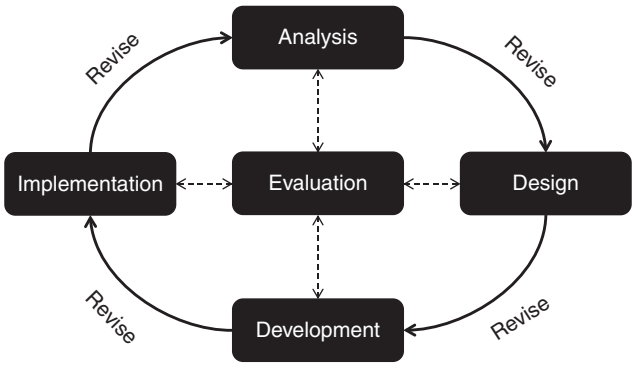

Figure 1.1. Illustration of the phases of the ADDIE method.

environment, and the nature of the learning content to help determine the strategy and techniques for learning and assessment. That specific information includes:

- Targeted learners, their characteristics, and their previous knowledge and experience;
- Nature and context of the content learners must learn (e.g., facts, procedures, cause/effect relationships);
- Learning environment(s) (e.g., classroom, online, laboratory, field exercises, on the job);
- Environment(s) in which learners will demonstrate what they have learned after the learning events are completed; and
- Behaviors, conditions, and criteria that will be used to measure what learners have learned (e.g., subsequent job performance).

2.2 Methods

The method often associated with instructional system design has become known as the ADDIE. ADDIE is the acronym for the five phases in the model: Analyze, Design, Develop, Implement, and Evaluate. The precise origin of the acronym is uncertain, although some attribute it back to work done by Florida State University for the military circa 1975 (Branson et al., 1975; Clark, 1995; Moldena, 2003). ADDIE has come to be viewed as an inclusive term representing a systematic approach to instructional design, and although designers may use a variety of models, it provides a way to illustrate a generic ISD model. Figure 1.1 portrays each of the five phases, phases that look similar to a general problem-solving model.

2.2.1 ADDIE Phases

Analysis is the starting point for instructional design. Much as a software developer conducts an analysis to determine the requirements for software, an instructional designer conducts an analysis to define the performance issues and gather data for potential solutions. Various types of analyses may be conducted, but analyses of both the learners and the learning problem are essential. Learner analysis focuses on understanding

what learners know, what preferences and biases they might have, and what specific performance will be expected of them, providing information to guide decisions about the content, learning strategies, and assessment approaches. Based on this information, for example, the design of a learning intervention for an experienced air traffic controller who must demonstrate mastery of emergency procedures in a real-time simulation would likely differ in strategy, complexity, and type of feedback from instruction designed for a novice who will be expected to explain how aircraft are spaced in routine and emergency conditions. Other important analyses include content analysis (working with subject matter experts (SMEs) to assess what must be taught), context analysis, (where the product will be used physically and the curriculum in which it will be used), and task analysis (which also requires SMEs – possibly different ones).

Design and development are closely linked as the design process includes feedback loops to refine and modify instruction based on observed outcomes. Initial design requires an understanding of the subject matter (i.e., target domain) and the science of learning (e.g., how individuals learn, strategies to optimize learning and reduce interference). In the first case for the expert air traffic controller, a learning objective might be "the learner will safely manage the flight pattern during a storm and subsequent power outage." For the novice, the learning objectives might be "the learner will provide a plan for spacing aircraft during a storm" and "the learner will provide the rationale for the distances represented in their plan." These objectives will drive the design of the learning interventions, including the complexity of tasks, pace, and frequency and type of feedback.

To ensure subject matter knowledge, designers work closely with subject matter experts to create meaningful learning experiences. This partnership must recognize the strengths of both the designers and subject matter experts to focus on what each does best. While experts are good at what they do, designers cannot and should not expect them to always know the best way to teach specific skills. Subject matter experts may not be aware of science of learning best practices that address how people learn, best practices for feedback, or strategies to manage cognitive load that must be factored into good design. Subject matter experts also may not fully recall what it is like to learn something as a beginner or they may be constricted in thinking only of how *they* learned something. Subject matter experts are essential, to help the instructional designer define the tasks, working environment, and common errors learners make.

During **implementation** learning products are delivered to students and data is collected to determine how well the intervention achieved its intended outcomes and to identify opportunities for improvement.

Evaluation captures both formative and summative evaluation activities. In Figure 1.1, arrows represent the feedback loops for formative evaluation that occurs during each of the phases of instructional design so improvements can be made. Summative evaluation occurs at the end of the instructional intervention to determine the extent to which the learning objectives were achieved.

2.2.2 Instructional Design Models

While ADDIE phases alert the designer to the types of decisions that must be made regarding instruction, the ISD models do not constitute a prescriptive formula detailing how instruction must be designed. Rather they can be viewed as a process that