CHAPTER 10

Methods of Design

An Overview of Game Design Techniques

Katrin Becker, *Mink Hollow Media and Mount Royal University, Calgary, Alberta, Canada, becker.minkhollow@gmail.com*
Jim Parker, *University of Calgary and Mink Hollow Media, Calgary, Alberta, Canada, parker@minkhollow.ca*

Key Summary Points

1. The design of games for learning requires knowledge of game design and of instructional design. One cannot merely be layer on top of the other.
2. A learning game must be designed to meet pre-specified learning objectives.
3. Games have specific characteristics that require specific design skills: they are entertaining as well as instructional, interactive, visually appealing, and often replayable.

Key Terms

Edutainment
Design
Models
Instructional design
Playtesting
Rapid prototyping
Instructional objectives

Introduction

Design is an applied endeavor: to design something one must have extensive knowledge of the thing being designed. Design is also a complex activity and while each design discipline shares some aspect with most other design disciplines, each also has important distinctions. It is simply not possible to be an expert designer in the general sense. Knowing how to design children's clothing or buildings does not qualify one to design theater sets or costumes, although that knowledge may well help in some situations. While digital games arguably share elements with other kinds of digital objects as well as with traditional games (such as board and card games), neither software designers nor traditional game designers are necessarily equipped to design digital games, although, just as in the previous example, that knowledge may well help.

To complicate matters further, designing a game for learning is not simply a matter of designing a game and adding some learning elements. Designing games for learning is a goal-driven activity. When we design a game for learning, we obviously have some learning goal in mind, such as learning about Mendelian genetics, for example.

Most design disciplines have various models or theories intended to help in the design process, and several of the ones for designing games are presented in this chapter. Simply knowing a design model, however, is usually insufficient preparation unless you also have experience actually building that thing, or at the very least using it. Becoming skilled at design always requires hands-on experience. When designing games for learning, this means that designers must play games as well as design them.

Finally, games for learning combine at least two distinct design disciplines: game design and instructional design, and some kinds of games also include aspects of simulation, which necessitates the involvement of a third design discipline, namely simulation design (Becker & Parker, 2011). The approaches taken for each can be very different so combining them is not straightforward, as will be seen. This chapter will examine some of the issues facing designers of games for learning and will highlight and discuss several models currently used to design these games.

Designing a game

The design of a digital game involves at least two design disciplines: game design and software design (i.e., knowledge of programming, the design of computer algorithms, and simulation design) and while many design models can be found for software (Budgen, 2003), far fewer exist for game design. Salen & Zimmerman's (2004) *Rules of Play* and Fullerton's *Game Design Workshop* (2008) approach the game design process, but do not include a concise design model. According to Fullerton, games are formal systems that include a variety of elements, including, but not limited to: objectives, procedures, rules, resources, boundaries, conflicts, and dramatic elements.

In addition to being games, digital games are also software systems, and are made up of computer algorithms. Therefore, we would expect a game design model to include some elements of software design.

Designing instruction

Instructional design is the practice of designing and creating instructional interventions and the development of models and frameworks to support the process of instructional design is common. Even those who advocate for the most structured approaches will admit that such models are often best suited as a support system for practitioners new to the field. Many experts still do make use of these models, but when they do, they often use them as rough guides, rather than prescriptions (Kenny, Zhang, Schwier, & Campbell, 2005).

In instructional design, there are well-known models that promote a fairly linear approach to design, such as Gagné's Nine Events of Instruction (Gagné, Briggs, & Wager, 1992), while others suggest more of an iterative approach (Dick, Carey, & Carey, 2001), and still others advocate an agile one (Piskurich, 2000). Briefly, Gagné's Nine Events of Instruction are: 1) Gaining Attention, 2) Informing Learners of the Objective, 3) Stimulating Recall, 4) Presenting the Stimulus, 5) Providing Learning Guidance, 6) Eliciting Performance, 7) Providing Feedback, 8) Assessing Performance, and 9) Enhancing Retention and Transfer. Many instructional design models have similar elements and the well-known ADDIE template (see Figure 1) that often forms the basis for these models (Molenda, 2003) still serves as a reasonable common denominator for all. The acronym became popular much later than the process itself (Branson, Rayner, & Cox, 1975) and in spite of being overly simplified, it remains a very popular model in professional training and should in some form be included in any design framework intended to support the design of a game for learning.

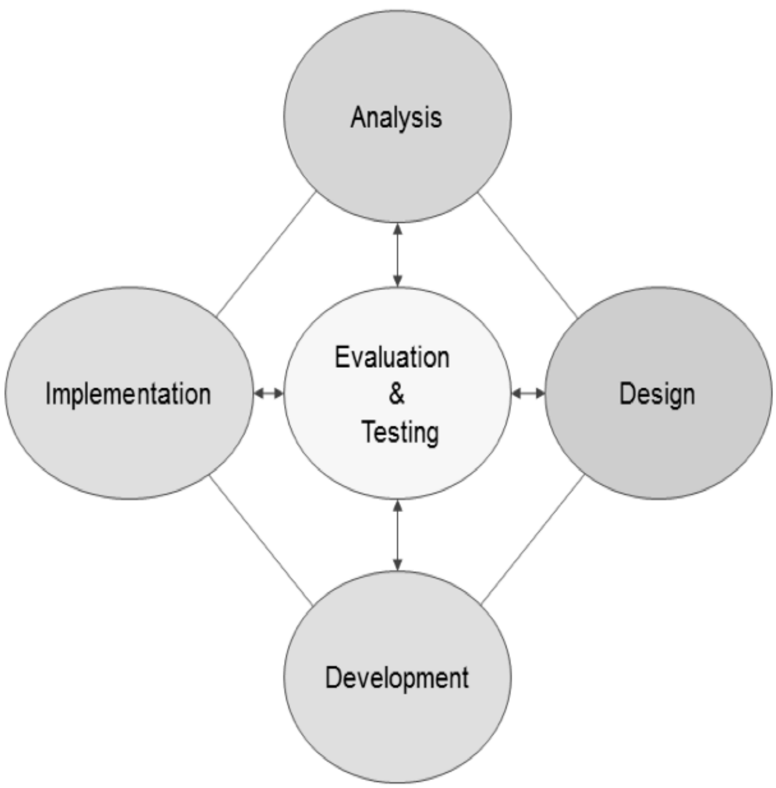

Figure 1. The ADDIE Instructional Design Model

The five parts of the ADDIE model are outlined below:

1. **Analysis**: The process for defining desired outcomes.
2. **Design:** The process of determining how desired outcomes are to be accomplished based on supporting system(s) needed, required resources, timetable, and budget.
3. **Development:** The process of establishing requisite system(s) and acquiring needed resources to attain desired outcomes.
4. **Implementation:** The process of implementing design and development plans within the real-world environment.
5. **Evaluation:** The process of measuring the effectiveness and efficiency of the implemented system and using collected data as opportunities for improvement in closing gaps between actual and desired outcomes.

What's important in a game for learning?

Serious games are games designed for purposes other than, or in addition to entertainment. Serious games, of which educational games are a subset, are distinct from traditional entertainment games in a number of ways, and these differences influence design. For instance, in a traditional game the key question is "Is it fun?" Fun is an ill-defined characteristic and is hard to design for, but it is a key motivator in the purchase and evaluation of a game. In an educational game fun is important too, but instead of relating to game sales, it concerns the delivery of the learning goals. An educational game that is fun will be played voluntarily and for a longer time, allowing longer exposure to the educational material being presented.

The set of learning objectives is lacking in a traditional game, but must be first and foremost present in an educational one. They must guide the design by providing an initial framework within which the game is played. For example, a game that teaches about sea life is likely to take place on a beach or under water. The learning objectives also provide a set of underlying assumptions that cannot be violated. The previously mentioned game about sea life must portray an accurate representation of the facts with respect to the organisms seen within the game. We can play fast and loose with other aspects of the game, though: players might be able to breathe the underwater or use hypothetical vehicles. Table 1 provides a summary of the key differences between commercial games and serious games.

Table 1. Commercial vs. Serious Games

Differences	Commercial Game Design	Serious Game Design
Concept Catalyst	Core Amusement	Performance or Knowledge Gap
Key Question	Is it fun?	Does it meet learning objectives?
Focus	Player Experience (the "how")	Content / Message (the "what")
Content / Method	Method is primary (content may be irrelevant)	Method secondary to content (game as receptacle?)
Vantage Point	Entertainment and Software Engineering	Special Interest Group (SIG) (e.g., medicine, military, social change)
Fidelity	Self-consistent, otherwise irrelevant	Faithfulness to message essential
Credentials	Industry	SIG (and industry)

Learning game design—what do we need?

Instructional designers say all we need is instructional design (Gunter, Kenny, & Vick, 2006); game designers say all we need is game design—even Gee implies this (Gee, 2003). The ongoing battle between these two groups, while softening, is still evident in the literature. Instructional designers claim that game designers suck all the learning out of games and game designers claim the other side is to blame: that instructional designers suck all the fun out of games (McDowell, Cannon-Bowers, & Prensky, 2005). There is truth to all four claims:

1. **"Instructional Design (ID) is all we need."** There is a well-researched body of knowledge in ID on what works and how to design instruction (Ely & Plomp, 1996).
2. **"Game design is all we need."** Many commercial games already do an excellent job of teaching players what they need to know to win the game (Becker, 2008b).
3. **"Game designers suck all the learning out of games."** Game designers without experience in education make educational games that are hollow—they end up taking their current favorite game and effectively "skinning" it with an educational veneer ("edufication") (Becker, 2008a).
4. **"Instructional designers suck all the fun out of games."** Instructional designers without game experience also skin, but they do it the other way around—they wrap a game around some instruction. Edutainment could be gamification at its worst. (Van Eck, 2011).

The solution is the development of approaches that are a true synergy of both instructional design and of game design (see Figure 2).

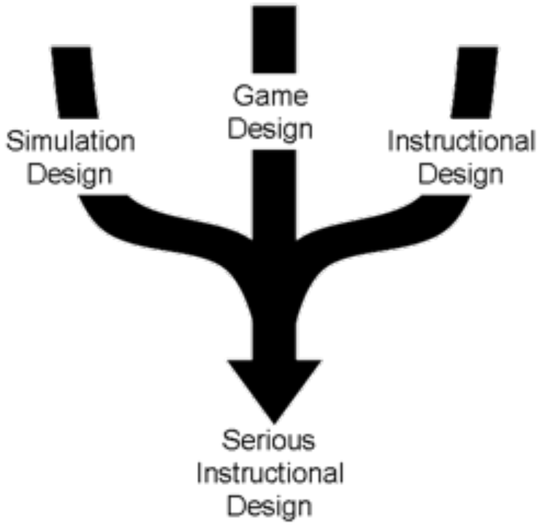

Figure 2. Serious instructional design (ID)

Case Study One: *Pavlov's Dog*

As a good example of an educational game, consider *Pavlov's Dog*. This game is quite clear about the educational objectives: to answer the questions "What's a conditioned reflex?", "What's a stimulus?", and "How can you learn a conditioned reflex?" The game's object is to train Pavlov's dog to respond to a signal that it will associate with being fed, just as in the scientific tale.

When the game begins, a cartoon dog is seen sleeping beside a food dish. On the left of the screen are food items that can be dragged into the dish using the mouse, such as bananas, drumsticks, and hot dogs. Along the bottom of the screen are icons representing three things that can make a sound: a horn, a drum, and a bell. The player needs to condition the dog to one of the sounds by clicking on a sound maker, thereby playing a relevant sound and waking the dog. Then, the player must quickly drag a food item into the dish. The dog will not eat the bananas, but gobbles up any of the other items, then goes back to sleep. After three repetitions of this process, the sound will result in the dog waking up and salivating without the food being present. When this occurs, the player wins, and the dog appears holding a diploma. The other sounds simply wake the dog. Feeding the dog without the sound has no effect, other than perhaps making the dog fat.

The game has a selection of educational material associated with it, about conditioned responses, Pavlov himself, and the Nobel Prize that Pavlov won in 1904. The art is cartoon style, which is appropriate, and the sounds are simple and to the point. There is no music. A key to this style of game is to focus on one educational issue, which this game does well.

Key Frameworks

There is a dearth of design models for educational game design. Instead, what is most commonly found are guidelines or design issues, which amount to things that should be kept in mind while designing such a game. These can be useful, but assume that one already knows how to design a game, and that an educational game is a game with extra conditions and content.

For example, Aldrich (2004) suggested four important criteria to be considered when designing educational simulations:

1. Scenarios must be authentic and relevant.
2. Scenarios should be compelling for the students. For example, student age and background must be considered.
3. Scenarios should offer many choices.
4. Scenarios should be replayable. The implication is that there will be some degree of variation or randomness in the decisions that the game makes.

One can see how to use these ideas in an educational game at the design level, but they are guidelines to use while designing, not a design strategy per se. There are too many of these guidelines to list all of them, but some are fundamental. If the game is to be used in a classroom then it is obviously a good idea to take into account that environment, and to ask teachers for their input. Kirriemuir (2005) did just that, and summarized the following requirements based on speaking with teachers:

1. The game should come with classroom plans and examples, preferably tested by teachers. Teachers work very hard and have little time to try to figure out how to use a game in a classroom, especially if the designers have not provided assistance.
2. The game should be able to be started at a point useful to the teacher. Daily lessons can begin in many different ways and can end in random places. Teachers need to be able to pick up where they left off. They also need to be able to assign homework or in-class tasks.
3. Games should be "light," in that long expositions, videos, and narrations should be kept to a minimum or removed altogether.
4. The game must be accurate in the process and facts it conveys, and should avoid political or scientific controversy. A game can remove the uninteresting parts of a simulation if they are not essential. For example, time can be speeded up.

In fact, Kirriemuir was discussing how to use pre-existing games (called commercial off-the-shelf games) in a classroom, but the rules can apply to a game being designed for the purpose. The guidelines are those that any instructional designer would probably know, and so a key lesson is to include instructional designers on the development team at an early stage—at the very beginning, if possible.

Four Frameworks

Chris Crawford's Game Design Model

One of the earliest game design models published is that of Chris Crawford, a game designer perhaps best known for his game *Balance of Power* (1985). In his 1982 book, *The Art of Computer Game Design* (Crawford), he outlines seven main phases in the design process:

1. Choosing a goal and a topic (Objective and premise)
2. Research and preparation
3. Design phase
    a. Input output structure (Interface)
    b. Game structure (gameplay and game mechanics)
    c. Program structure
    d. Evaluation of the design
4. Pre-programming phase
5. Programming phase
6. Playtesting phase
7. Post-mortem

This process was created in the context of entertainment games and acknowledges the fact that a game is a program (or a system of programs) and is useful for initiating the process of designing a game for learning.

Game Design by Brainstorming

Jesse Schell is a game designer and researcher who has developed a framework described in detail in his book, *The Art of Game Design: A Book of Lenses* (2008). Schell's approach involves examining games from various perspectives, such as the theme, characters, player's experience, aesthetics, and technology used. As a supplement, Schell created a deck of cards printed with questions intended to help designers remember the principles associated with the lenses.

There are also other decks of cards designed to help people brainstorm their game designs, such as Titlfactor's *Grow-A-Game* cards, available in three variations: Apprentice, Classic, and Expert (Belman, Nissenbaum, Flanagan, & Diamond, 2011). This deck consists of 86 cards containing words and phrases intended to help designers create game concepts that include oral, social, and political values. The Design for Playful Impact research program at the Utrecht School of the Arts has taken the concept of brainstorming cards to another level by turning their brainstorming cards into an actual game, where players play as game designers who follow the instructions given to them on the cards to produce game concepts and designs (Zaman, et al., 2012).

Rapid iterative prototyping

The term rapid prototyping originally referred to the techniques used to build models or examples of physical objects, like machine parts, buildings, and devices. Software developers, who created prototypes of software modules that are part of a larger system, also used this process. Rapid prototyping has the advantage of providing a visible, if non-functional, object that can be evaluated to see whether it is what the designers and users have in mind. This method was extended using typical software development methods to become rapid application development (RAD), a scheme that abandons significant advanced planning and begins projects by building rough prototypes, then refining them by interleaving stages of design and prototyping. The final prototype ends up being the product.

A computer game certainly has a software component, but is a more complex object than merely a computer program. A game is more like a motion picture or television program, requiring technical expertise, but also writers, artists, musicians, and designers. RAD only works for an educational game if a creative team first outlines possible directions of the game, using the learning objectives as guidelines. A small set of initial prototypes are developed, which are largely non-functional game units, but with including art and sound in the proposed style, and basic interactions to take the evaluators from game scenario to game scenario. We can think of these prototypes as instantiations of the high concept design for each of the proposals.

It is essential that each of these prototypes begin with considerations based on the learning objectives. Games generally begin with a set of ideas drawn for the designer's experience, similar, one would imagine, to the process a novelist or scriptwriter would use in their work. An educational game must begin by including the material to be taught as an integral component or theme. Imagine that the goal is to expose the students to the consequences of Newton's Law: $F=ma$. This particular learning objective does not limit the creativity of the game designer because there is a vast collection of interesting objects in the real world that interact using this rule. Games based on teaching about Newton's Law could include: ball games, including snooker; car and racing games; spacecraft; canons and games involving ballistics; and a host of other design concepts. A second aspect of the design is that the game should expose the learning objective (the underlying physical law in this case) instead of hiding it. Most games use Newtonian physics, but do not show the player explicitly what is happening. Collisions, for example, take place in games and are examples of this physical law, but do not show the player how it works or how to control it. Control is a key part of the learning experience.

The team evaluates the prototypes and selects one for development. At this point, a more detailed design document is prepared, and as this happens, more game prototypes are constructed and tested. At all times a playable version of the game is kept available for evaluation. Some parts of the game are more complete than others, of course, and it is important to realize that the fact that parts are advanced while others should not affect the basic design. The developers must be prepared to discard working parts of the game if they become obsolete by virtue of design changes. In fact, this is one disadvantage of this scheme is that sometimes work is done that needs to be discarded.

Evaluation of the prototypes is done at multiple levels:

1. **As software:** Does the game software work as intended?
2. **As learning:** Are the objectives embodied in the games and are they effective?
3. **As art:** Is the visual and auditory style consistent and effective?
4. **As a game:** Is it entertaining and fun to play?

The game testing process must evaluate all of these things and the results should be used to improve the next version.

Serious Instructional Design Model

Games and instruction are often designed from different starting points. Because there is often a need for accuracy in the models used for educational games it is necessary to examine design approaches in simulation as well as games and instruction. Simulation design includes elements that address approaches to data collection as well as data validation. Games are often built up from a single core idea—some experience, activity, or idea the designer finds interesting. Simulations, on the other hand are typically built to answer some sort of "what if?" question or to create some sort of environment that can be explored or experienced. Finally, instruction is designed from the starting point of some identified performance gap or a gap in understanding. Each field has its approaches to design and no single approach is likely to be able to account for the complexity of designing something that is, in essence, all three. The Serious Instructional Design Model was created as a synergy of all three. This model combines Chris Crawford's game design (Crawford, 1982); Zeigler's simulation design (Zeigler, 1976); and Rothwell & Kazana's instructional design models (Rothwell & Kazanas, 1998) to produce a new design model that is a blend of the important elements of each.

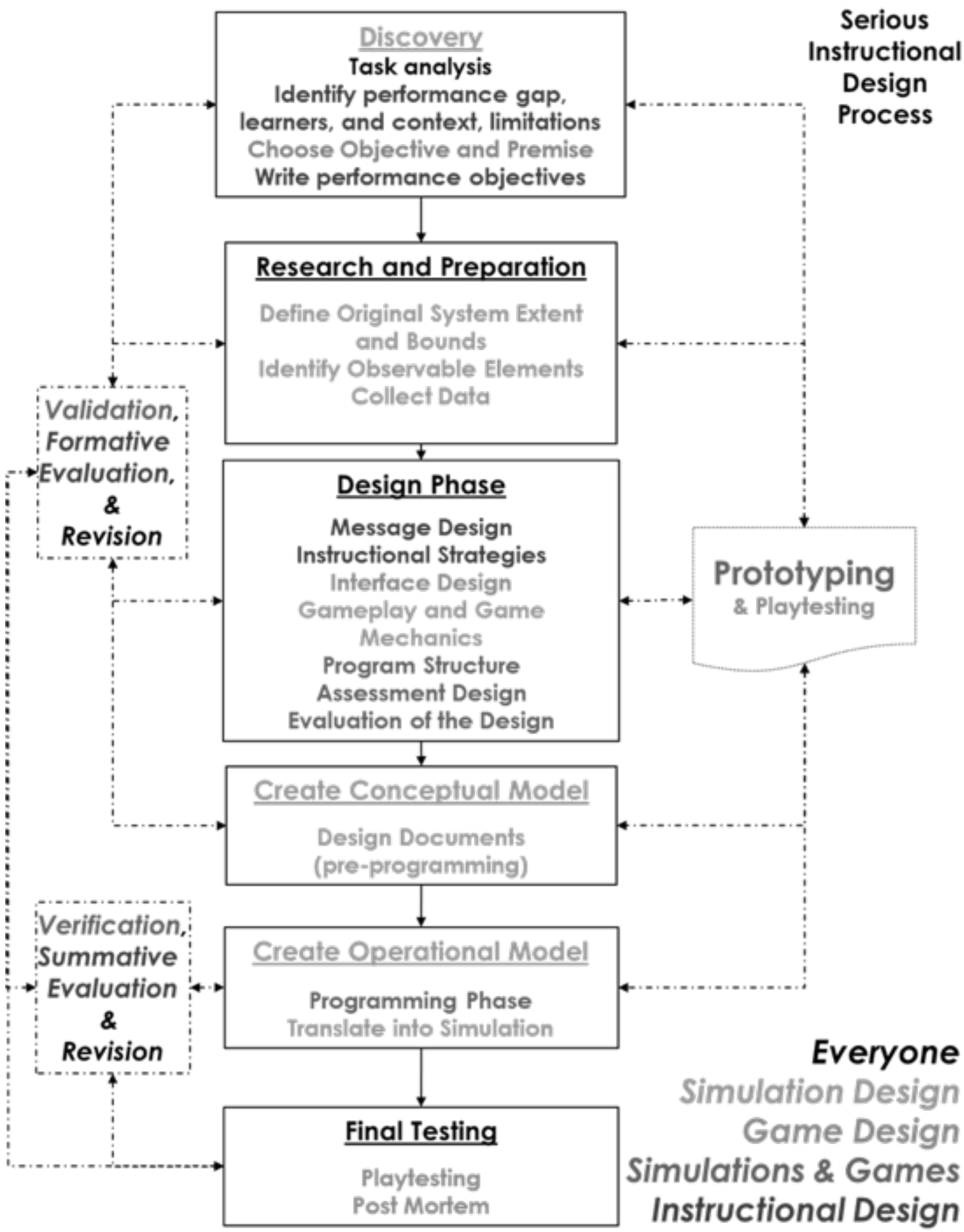

Figure 3. A schematic of The Serious Instruction Design Model.

The following are the components of The Serious Instructional Design Model:

1. **The discovery phase**: This is the initial phase of the process and includes all the usual needs analysis, and high-level outlines that will be needed later on. Since the game being design is the instructional strategy, it is possible that the bulk of the instructional needs analysis was completed before we even got to the point of knowing we wanted to make a game.
2. **Research and preparation:** This combines simulation-style data gathering, as well as deciding which details will need to be accurate and which can be omitted or even transformed.
3. **The design phase:** This is where the simulation or game will take shape. It is important at this phase to maintain connections between the overarching goals, which are instructional, and the simulation details or gameplay. Although it is not necessary for every aspect of the simulation or game to further the instructional objectives, it is necessary that they coincide often enough to ensure that the time spent in the simulation or game is time well spent.
4. **Creation of a conceptual model:** This is not normally part of an instructional design model but it does have a counterpart in game design, namely the first playables and proofs of concept. This is effectively the last stage where it will be feasible to back up for major revisions if problems are detected. The outcome of this phase will be the detailed design document and it should incorporate both the design elements of the simulation or game and the checkpoints needed to ensure that this solution has a reasonable likelihood of delivering on its instructional objectives.
5. **Playtesting:** Although the final phase is the only one that explicitly lists playtesting, it is highly recommended that playtesting be performed as early and as often as possible. The full educational potential of the game may not be testable in the early stages, but its playability can be, and that is crucial.

Case Study Two: *Fission Impossible*

The game *Fission Impossible* is an example of a less successful educational game than *Pavlov's Dog*. The game is intended to explain the basic concepts behind nuclear fission. Fission is a process that takes place at the atomic level. Essentially, large atoms such as Uranium are struck very hard by a subatomic particle called a neutron. The Uranium atom breaks apart, releasing energy, some new elements, and some more neutrons. These new neutrons strike more Uranium atoms, which also break apart, thus creating a chain reaction if enough Uranium atoms are in close proximity. A type of Uranium dubbed U-235 will do this, whereas U-238 will not.

In the game, the opening screen shows a U-235 atom (a green sphere) within a semi-circle of black circular objects, which turn out to be U-238 atoms, below which we see an orange sphere that represents a neutron. Immediately the neutron begins to drop off of the screen, and the play must use the arrow keys to guide it to strike the U-235 atom. This is hard to do, as some force seems to be pulling the neutron to the bottom of the screen. If the neutron goes outside of a circle of fixed radius centered at the U-235 atom, the game restarts. This circle is invisible until the neutron leaves it, so it is a very frustrating process: the player must fight the invisible force using arrow keys, not go outside the invisible circle, and hit the green sphere. When the player finally succeeds, there is a brief animation of spheres moving about, but nothing like what one would expect from a chain reaction; more like bubbles, really. Now the player is in level 2. There are now even more black U-238 atoms protecting the target, but otherwise no change.

Educationally, the game does not really reflect the physics of the situation. There is no chain reaction, no breaking apart of the U-235 into components, and the U-238 does not protect the U-235 from impact as it does in the game. As a game it is exceptionally frustrating. At the beginning, the neutron falls off of the screen five to six times before a typical player figures out how to prevent it. They then guide the neutron outside of the invisible circle many times and hit the U-238 many more times before figuring out the puzzle. At level two, the puzzle is harder, and when they inevitably fail that task the game starts over at level one; which makes the game tedious. The game cannot be started at a teacher-specified location, making it harder for a teacher to use effectively. The art is simple and clear, but the music is banal and repetitive, encouraging the player to turn the sound off. There is a pop-up window giving science information, but it is confusing and incomplete. Moreover, the learning objectives are not met by this game's design. A player can get through it (eventually) without reading anything or learning anything.

Key Findings

The design of a game for learning requires a synergy of multiple design disciplines: instructional design, simulation design, and game design. These design approaches cannot simply be layered upon one another, but instead must be combined to form a new approach that reflects a true synergy. That there is no single approach that is generally accepted reflects two key facts about learning game design. The first is that design generally is as much an art as it is engineering or science, and the moment a box is drawn around it as a process and rules are created, a limit is defined concerning what can be done. In other words, certain ideas and games are likely to be excluded by a restrictive design process, in other words. The earlier the formal design method begins in the process, the more possibilities will be discarded.

The second fact to consider is that games for learning should be designed with a learning model in mind, and modern instructional theories are still not complete. Indeed, there are disagreements between them that should be resolved. A game design process should collaborate in many specific ways with an ID model. Formal design processes help novices much more than experts, and so it would seem to be valuable to integrate a specific ID model with a learning game design so that novices have a place to begin. As experience is gathered, an expert will pick and choose among methods as being more or less relevant for a specific task.

As an example, consider the RETAIN model (Gunter, Kenny, & Vick, 2007) for game design. This has been devised specifically using Gagné's Nine Events of Instruction (Gagné, Briggs, & Wager, 1992) and follows it very closely by providing essentially one step for each event (see Table 2).

Table 2. A comparison of Gagne's Nine Events of Instruction and the RETAIN model.

	Gagné, Briggs, & Wager (1992)	Gunter, Kenny, & Vick (2007)
1	Gain attention	Game focus/Hook describes the essence of the game and provide an entry point for play.
2	Describe the goal	Didactic focus defines the subject matter to be taught and provide an entry point for instruction.
3	Stimulate recall of prior knowledge	Provide references to beyond-the-object reference sources that inform the pedagogic content development for the game.
4	Present the material to be learned	Game progression describes the individual game units (this process also has nine stages)
5	Provide guidance for learning	Define the critical path for gameplay and didactic resolution
6	Elicit performance practice	Define pedagogic elements to be used
7	Provide informative feedback	Describe how formative feedback will be distributed during each unit of gameplay.
8	Assess performance test, if the lesson has been learned. Also sometimes gives general progress information.	Describe how summative feedback will be distributed during each unit of gameplay and at the conclusion.
9	Enhance retention and transfer	Describe how replay will be encouraging to assist in retention and to remediate shortcomings.

In the RETAIN model, the game design steps described are in lock step with the ID model and this provides a very specific and detailed plan for someone starting out on a new design. After some years of experience, the designer would almost certainly use a large variety of ID models and find ways to incorporate the game design principles learned into the new (perhaps one-time-only) scheme.

Assessment Considerations

Educational research

An educational game can only be considered a success if it assists in communicating the target facts and processes to the student. The design cannot really be assessed independently from the implementation, as with any other educational experience. Fortunately, the field of educational research is well developed and includes multiple methodologies for examining everything from individual elements of a lesson to complete curricula.

People often ask for proof of a game's effectiveness if it is to be used for learning, especially in a formal setting. It is possible to use many of the commonly use research methods, such as pre- and post-testing, case studies, and surveys. If the design of a game for learning needs to be a mix of multiple design approaches, so must the evaluation of a game for learning also include methodologies specifically tailored to games for learning. A recent examination by Mayer et al. (2013) suggests that often those proposing to use a game for learning already have their own procedures and preferences for evaluations, which in some cases may even be mandatory (Mayer et al., 2013). There are some common elements that should be included in any examination of a game's effectiveness. These include:

1. Demographic information about the players and context.
2. The players' prior experience and knowledge.
3. Measures of in-game performance, whether collected within the game itself, or externally via observations or data collection.
4. Aspects of the gameplay itself (which is explained further in the next section).
5. Player satisfaction.
6. First order learning, which is short-term, usually measured on an individual player basis, and usually involves self-reported and measured changes in knowledge, attitudes, skills, or behavior.
7. Second order learning, which is longer-term, and can be self-reported, as well as measured changes in the larger group or organization.

Unfortunately, as in almost all research that attempts to measure the effectiveness of an instructional intervention, it is rarely possible to create the kinds of controlled conditions necessary for conclusive results.

Playtesting

Playtesting is fundamental to the development process in the game industry generally. The goal is to find out whether the game is fun to play, what parts are not fun, what parts are hard or confusing, and whether the players are generally pleased with the result. The process varies from developer to developer, but essentially involves watching typical players interact with the game. A small set of people in the correct demographic group for the game are recruited, are given the game and its instructions, and then told to start playing. Video recordings are often made of these play sessions for later analysis, and the game itself if often instrumented to record player actions, speeds, and strategies. Sometimes a questionnaire or interview is done after a play session, but it is important not to guide the players in advance of play or the responses might not be useful.

A playtesting session can be done as soon as a playable game exists, which should be early in the process, and playtesting should be repeated regularly. After each session the results should be examined to see if there are any problems in the design, and those should be repaired and tested in the next sessions. The idea is not to collect statistics but to gather impressions. The concept of "fun" has eluded definition, so playtesting enables the design to see whether actual players find the game entertaining, and where they have failed. Fun is hard to define, but most people know when they are having it.

For an educational game, playtesting is done to determine whether the target audience will be engaged with the game. If they are not, then the educational objectives will be missed. Fun, rather than being the opposite of learning, may well be the human's natural reaction to discovering something new. The playtest should indicate the places within the game where players have difficulties, and also those places that are most enjoyable. Both can be used to improve the next iteration. There is a variety of guides on how to conduct a play test to be found on the Internet and some quite valuable books on the subject (e.g., Schultz).

Future Needs

Many of the design methods describe here do not provide access to most issues important to a game designer, which includes matters of theme, play, and narrative. These are most frequently described vaguely as "describe the essence of the game," but in fact game design as a specific discipline concerns itself primarily with those things. Schell's design scheme considers those matters as a specific issue, and he does so as a more or less random juxtaposition of objects and activities. For example, there may be some game themes and mechanics that are better in the context of a game to teach history, and those may be different themes and mechanics than what would be used to teach physics. It would be useful to know how mechanics and other aspects of games influence learning. A computer game can keep track of everything a user (player) does. A very important feature of a game designed for learning is to provide feedback and an essential part of research into these games is an assessment of their effectiveness. We need more work on the automatic evaluation of games based on collected data and on determining exactly what feedback is best for the player.

Best Practices

It is critical when designing a game for learning to specifically consider the instructional objectives. As a key side issue, it is probably important for these objectives to be given to the game designers rather than for the designers to come up with them. These seem like obvious statements, but are all too frequently overlooked or underestimated. The objectives must be kept in mind when examining playable versions of a game. It is very easy to get caught up in the compelling aspects of a game and not pay sufficient attention to the original goals. The fact that games are compelling is why we want to use them, but design time is wasted if they do not help teach what is wanted.

If measurements are important, decide what measures of success will be used before the game is designed. A good scientific experiment always does this, of course, but it also means that you can do a better job of building in ways to collect data to support the evaluation. Games can generate a lot of data. It is important to be selective.

A complete game may teach many aspects of a subject, but each specific scenario or level should focus on just one of two things. Keep the situation, rules, and scoring system simple, or the learning objectives will be confused with the game objectives. Doing this makes evaluation and feedback possible and allows players to make a logical progression through the material.

Game designers know how players play games and how to engage them. Players rarely read game instructions, so create a tutorial level that clearly describes the scenario and the game rules and mechanics, and at a level that can be understood by the intended audience. Listen to game design experts with respect to player behaviors. For example, a good game can be replayed many times. A game designer knows how to do that, and if an educational game gets replayed then learning is reinforced.

Highly interactive games are better than ones that are not. For example, games based on questions and answers (e.g., Jeopardy style) are relatively passive and are nor really much better than a Q&A session in a classroom. Games that allow players to discover things are a more realistic presentation and require action on the part of the player.

The actions performed by the player in the game should be related to those used in the activity to be learned. For instance, some games have pop-up questions during play for the learner to answer. This never happens in real life. It is better if the questions are integrated into the game so that the player answers then because the answer is required by the play. An equation may need to be solved because the answer helps in navigation, for example, and not just because it is a math game.

Resources

Related Researchers
Katrin Becker
Simon Egenfeldt-Nielsen
Mary Flanagan
Tracy Fullerton
James Paul Gee
Carrie Heeter
Clark N. Quinn
Katie Salen
David W. Schaffer
Kurt Squire

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Games, Game Engines, Design Tools

Construct 2 (www.scirra.com)

Fission Impossible (game to teach basic principles of fission reactions) (http://www.wonderville.ca/asset/fission-impossible)

GameMaker (engine)

Pavlov's Dog (game to teach basics of classical conditioning) (http://www.nobelprize.org/educational/medicine/pavlov/)

Processing (programming language)

Unity (engine)

UDK (Unreal Development Kit)

Game Seeds (brainstorming card game)

Grow-A-Game (brainstorming cards)

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