The Design, Play, and Experience Framework

Brian M. Winn
Games for Entertainment and Learning (GEL) Lab
Dept. of Telecommunication, Information Studies, and Media
Michigan State University

253 Communication Arts & Sciences Building
East Lansing, MI 48824
517-353-5497 (voice)
517-353-5498 (fax)
winnb@msu.edu (email)

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ABSTRACT

This chapter introduces a framework for the design of serious games for learning, called the Design, Play, and Experience framework. The author argues that the great potential of serious games will not be realized without a formal design approach. To that end, the author presents and thoroughly explains the Design, Play, and Experience framework which provides a formal approach to designing the learning, storytelling, gameplay, user experience, and technology components of a serious game. The author concludes by detailing how the framework provides a common language to discuss serious game design, a methodology to analyze a design, and a process to design a serious game for learning.

INTRODUCTION

The *serious games movement* asserts that the game medium can serve many functions, and a sole focus on entertainment significantly undersells its potential (Jenkins, 2006). Serious games have a purpose beyond entertainment, including (but not limited to) learning, health, advertising, and social change (Sawyer, 2002; Prensky, 2001). Some serious games are thought to provide *stealth learning* as players are focused not on learning but on playing (Shreve, 2005).

Serious game design is a relatively new discipline. As such, there is a lack of a common language and a lack of standard practices for designing serious games. To date, serious game development teams have utilized a diverse mix of game design and instructional design methodologies to help realize their designs, but often without a unifying framework to bring these diverse perspectives together. This chapter describes a unifying framework to help serious game development teams achieve their full potential.

BACKGROUND

While learning through play is not a new concept (Dewey, 1916; Piaget, 1951; Malone, 1981; Papert, 1998), increasing technical and aesthetic sophistication, and growing popularity of commercial digital games across diverse demographics (ESA, 2006), have attracted a rebirth of interest on the part of scholars and teachers to create new and improved games for learning (Van Eck, 2006). Evidence of perceptual, cognitive, and social benefits of playing games is growing (e.g., Shafer, 2006; Gee, 2003 & 2005; Johnson, 2005; Ritterfeld et. al., 2004; Kierrimuir & McFarlane, 2004; Lieberman. 2006). Linguist and learning scholar James Gee (2003, 2005) believes that games are enjoyable because of learning - they present just the right amount of challenge, support, and feedback, progressively rewarding mastery with new challenges. This experience parallels other known optimal states of happiness, or *flow* (Csikszentmihaly, 1990).

The structure of games mirrors good pedagogy, offering progressive problem solving and scaffolded learning. Van Eck (2006) demonstrates that games embody all phases of Gagne's

(1985) Nine Events of Instruction (events that activate processes needed for effective learning). These events are: gain attention, inform learner of objectives, stimulate recall of prior learning, present stimulus material, provide learner guidance, elicit performance, provide feedback, assess performance, and enhance retention and transfer.

Games excel where traditional in-person classroom training and online web-based training fall short. Most notably, games are effective at engaging students and making them an active participant in their education process. Among education scholars, this is referred to as active learning. Active learning is a form of constructivism, based on a student-center model of instruction (Svinicki, 1999). Active learning assumes the student must be active in the construction of his or her own knowledge, what Dewey (1949) referred to as learning by doing, rather than a passive recipient of information. Active learning has been shown to promote better recall, enjoyment, and understanding than traditional instructional techniques, such as lecturing (Gibbs, 1992; Muji & Reynolds, 2001; Petty, 2004) and is the cornerstone of other progressive pedagogy, including problem-based learning and collaborative learning.

Communication and education scholar Deborah Lieberman (2006) lists eight learning benefits of games:

- Games provide the player with an active experience.
- Games encourage the player to learn by doing.
- Games are a social medium providing the player with human-to-human like interactions and emotional responses.
- Games are participatory by providing the player with customized, rapid feedback.
- Games are engaging. Participation makes the player pay close attention. It demands thoughtful planning and decision-making. It demands learning in order to succeed (if you don't learn, then you can't succeed).
- Games promote behavioral learning. The game gives the player rewards for behavior (points, power, rank, and so forth). This positive feedback in the game can encourage desired behaviors in real life.
- Games offer consequences. These are not abstract or hypothetical; they are represented in the game directly. The player plays a character and identifies with him or her. Success and failure map directly to the player's actions; one's ego and self-image are invested in the experience.
- Games provide role models for the player. The player can learn from the game characters and understand their behavioral experiences.

Serious games offer serious opportunities for learning, but only if the game is designed effectively. The design process is a creative, sometimes chaotic process. Making a *good* game is hard. Making a good serious game is even harder. The reason it is so difficult is that rather than simply trying to optimize the entertainment aspect of the game, or the so called *fun factor*, one must also optimize to achieve a specific set of serious outcomes. For example, the NSF-funded Life Preservers game was designed to be an appealing, entertaining game for middle school students of both genders while teaching the national science standards on evolution and

adaptation, as well as serve as the stimulus for research on gender and playtesting in learning games. This was not an easy task. (Heeter, Winn, & Greene, 2005).

In designing Life Preservers, it was realized that there are three perspectives on designing serious games: that of the academic, interested in various academic theories, be they from educational pedagogy, communication theory, etc; that of the content expert, interested in the given subject matter; and that of the game designer, focused on creating engaging and entertaining game play (Winn & Heeter, 2006). On a typical development team, a different individual or group of individuals usually represents each of these perspectives. In order to have a serious game that met its goals, the Life Preservers' team quickly discovered that they needed to converge on game design features so that the theory, content, and game design were compatible and complementary.

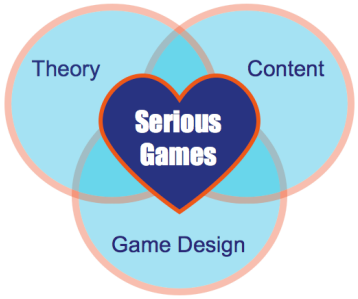

Figure 1: Heart of Serious Game Design

The overlap between theory, content, and game design form, what we have dubbed, the heart of serious game design (See Figure 1). The concept of the heart of serious game design parallels the Technological Pedagogical Content Knowledge (TPCK) model proposed by Mishra and Koehler (2006). This model defines the overlap in knowledge about technology, pedagogy, and content as TPCK. TPCK is an emergent form of knowledge that goes beyond the three individual components to yield a result that is more than the sum of its parts. The same sort of emergent knowledge between theory, content, and game design is particularly relevant for realizing effective serious game designs. One of the greatest challenges that collaborative teams face in the design of serious games is working through their disciplinary tensions and converging on the heart of serious game design.

To be sure, such tensions will vary depending on the nature of the serious game in question. In the case of exogenous educational games, conflicts between theory, content, and game design rarely arise since the game mechanics and pedagogical theory are already defined at the outset. Such games separate learning content and game mechanics (Halverson, 2005; Malone & Lepper, 1987). Designers of exogenous educational games typically reuse successful game mechanics, such as hangman, a Jeopardy-style game show, or a Space Invaders-style shooter, inserting the content to be learned into the preexisting game structure and rules. Content is often the only new input, and the learning tends to be limited to reinforcing knowledge recall. This can be seen in

early edutainment titles, such as Math Blaster[1] or more recent web-based titles such as Trivia Archer[2].

In contrast, endogenous educational games target more complex learning goals beyond memorization and do so in part by integrating learning content into the structure of the game (Halverson, 2005). Like exogenous games, endogenous games frequently adopt familiar game genres such as role play or adventure games, board or card games, or puzzles. The defining characteristic of endogenous games, however, is that the gameplay itself informs the pedagogical theory and embodies the learning content. By requiring players to explore the game space and use their knowledge to meet game challenges, designers of endogenous games promote active problem-solving and reinforce context-specific learning goals. Consequently, endogenous educational game designers begin with a more or less blank slate. They seek an idealized convergence of content, theory, and game design that achieves the hypothetical potential of games to promote advanced forms of learning (aka, the heart of serious game design). The vast challenge being, of course, is that this ill-specified design problem has infinite possible solutions. Oregon Trail (MECC, 1985) is an example of an early endogenous learning game. More recent examples include Life Preservers (2006), Hot Shot Business[3], and Times Attacks[4].

THE MDA FRAMEWORK

The Mechanics, Dynamics, and Aesthetics (MDA) framework was designed and taught by Marc LeBlanc (2005a) to "…clarify and strengthen the iterative processes of developers, scholars and researchers alike, making it easier for all parties to decompose, study and design a broad class of game designs and game artifacts" (Hunicke, LeBlanc, & Zubek, 2004, p. 1).

The MDA framework depicts the relationship of the designer and the player (see Figure 2.) The designer designs the mechanics, or formal rules of the game. These rules are instantiated at playtime and influenced by the player's inputs, forming the dynamics, or run-time behavior of the game. The aesthetics of the game are the resulting emotional responses in the player when playing.

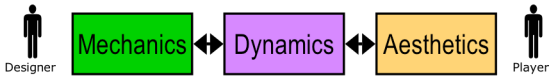

Figure 2: The MDA Framework

In this framework, the designer only has direct control over the mechanics of the game. Therefore, the designer must determine the desired aesthetic he or she hopes to create for the

[1] http://www.knowledgeadventure.com/mathblaster
[2] http://funschool.kaboose.com/fun-blaster/back-to-school/games/game_trivia_archer.html
[3] http://spapps.go.com/hsb4/landing
[4] http://www.bigbrainz.com

player and then design the mechanics to achieve these desired aesthetic. The designer utilizes playtesting and game balancing to modify the mechanics over time to achieve the desired aesthetic through an iterative process.

While the MDA framework has proven to be a useful approach to designing and analyzing gameplay (LeBlanc, 2005b), it does not specifically address aspects of game design beyond the gameplay, including the storytelling, user experience, and influence of technology on the design. This is partially due to the gameplay-centric language used in the framework. For example, we can attempt to decompose the mechanics, dynamics, and aesthetics of the storytelling and user experience, but the semantics of the terminology often get in the way of doing so. This approach also jettisons the discipline-specific language used in storytelling and user experience design.

Further, the MDA framework focuses on the design of games for entertainment. Designing serious games offers a unique set of design challenges (Winn & Heeter, 2006) that are not encompassed in the MDA framework.

THE DPE FRAMEWORK

The Design, Play, and Experience (DPE) framework was created as an expansion of the MDA framework to address the needs of serious game design for learning, while also attempting to address some of the semantic barriers described above. The DPE framework presents a language to discuss design, a methodology to analyze a design, and a process to design a serious game for learning.

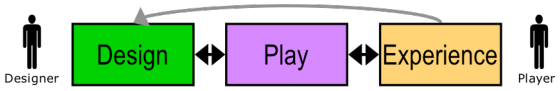

Figure 3: The DPE Framework

Similar to the MDA framework, the DPE framework depicts the relationship between the designer and the player (see Figure 3). The designer designs the game; the player plays the game; which results in the player's experience. The designer only has direct control over the design itself. To design a game effectively, the designer should first come up with goals for the resulting experience. These goals can be used both to guide the design and to gage the effectiveness of the design once implemented. The arrow from Experience back to Design represents both the influence of the goals on the original design and the iteration on the design once a prototype of the game is tested against the experience goals. This reflects the inherently iterative process of game design (Salen & Zimmerman, 2004), including designing, prototyping, playtesting, and iterating back to the design based on the experience of the playtesting (see Figure 4).

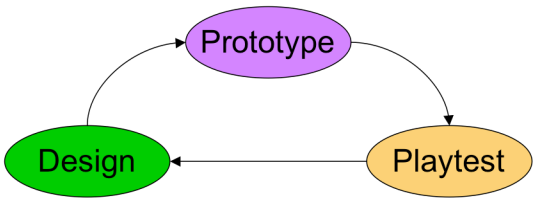

Figure 4: Iterative Design Process

However, play is a mediated experience. Play is greatly influenced by not only the design, but also the player, including his or her cognitive, social, cultural, and experiential background that he or she brings to the given play experience. Therefore, the experience of one player may be profoundly different than the experience of another player. The target audience for the game must be strongly taken into account throughout the design process.

The expanded DPE framework (see Figure 5) depicts the subcomponents of serious game design, including the Learning, Storytelling, Gameplay, and User Experience layers. Each layer has a design, play, and experience aspect (described below). Technology is represented in the bottom layer. While the designer does not necessarily design the technology, the design itself is realized (or not) on the technology.

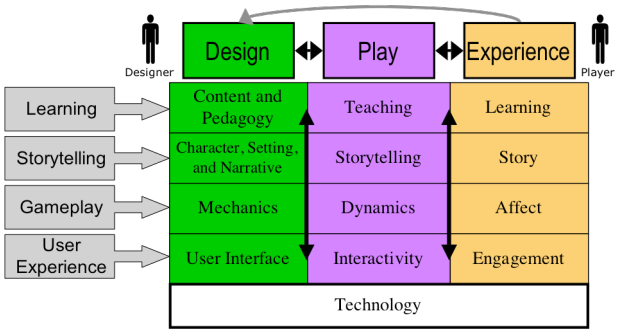

Figure 5: Expanded DPE Framework

While the serious game design process is often lead by a team of individuals with diverse expertise (as described above), to simplify the conversation, the design team will simply be referred to as the designer in the discussion that follows. To that end, the potential players of the serious game will be discussed as a figurative individual player.

Learning Layer

In the Learning layer the designer designs the content and pedagogy, which results (hopefully) in teaching when the player plays the game. This leads to a set of learning outcomes (either realized or not) derived from the overall experience.

As described above, the designer should first come up with goals, or in this case, learning outcomes for the resulting experience and then design the content and pedagogy to meet these goals. Just as an instructor might do in their curriculum development, the designer can define their learning outcomes using proven instructional design techniques.

Bloom's Taxonomy on Teaching and Learning (1956) is useful in thinking about and generating the student learning outcomes in serious game design. This taxonomy defines three types of learning, including cognitive, psychomotor, and affective learning, commonly simplified as knowledge, skills, and attitude (KSA). The taxonomy also further subcategorizes cognitive and affective learning into a range of behaviors, from simplest to advance. For example, cognitive learning is subcategorized into knowledge, comprehension, application, analysis, synthesis, and evaluation. While Bloom's taxonomy did not subcategorize psychomotor learning, others since have (Simpson, 1972; Harrow, 1972; Dave, 1975).

There are many resources available to help serious game designers generate student-learning outcomes using Bloom's taxonomy (e.g. Clark, 1999) or using any number of other learning taxonomies. The main point is to take the time early in the design process to think about and rigorously define your learning goals. The goals not only form the basis for the design of the content and pedagogy but also can form the basis for the assessment of the game's learning effectiveness on the player. With an increase in focus on testing and monitoring student performance, generating effective forms of assessment is rapidly becoming a must for any serious game.

Storytelling Layer

There are two perspectives on storytelling in games, the designer's story and the player's story (Rouse, 2001, p. 216-218). The designer's story is the storytelling that is designed into the game. The designer's story can be used to set the stage, provide purpose and engagement, and convey content, among other things. The setting, character design, and narrative are the designers primary design tools.

The storytelling that occurs during play combines the designer's story with the interactions and choices the player makes. The resulting experience crafts the player's story. Some games have stronger designer stories, such as adventure and role-playing games, while others have little to no designer story, such as classic arcade games like Pacman and puzzle games like Tetris. However, all games have a player's story, which at the very least reflects the story of the gameplay challenges encountered by the player and how the player addressed them. When approaching a design, the designer must first decide on what type of stories he or she wants the player to be able to experience and design the setting, character design, and narrative to achieve this.

The learning outcomes often complicate the storytelling in serious game design. For example, if you are developing a serious game to teach history, how much can the games storytelling deviate from the actual events of history and still accomplish its objectives? If you are developing a

serious game to teach science, can your storytelling integrate elements of science fiction? Each of these important storytelling design decisions must be tempered with the desired learning outcomes.

Gameplay Layer

The gameplay layer defines what the player *does* in the game. That is, what choices the player can make in the game world and what ramifications those choices will have on the rest of the game (Adams & Rollings, 2007, p. 277). The gameplay layer is broken down into mechanics, dynamics, and affects. The mechanics are the rules that define the operation of the game world, what the player can do, the challenges the player will face, and the player's goals. The dynamics are the resulting behavior when the rules are instantiated over time with the influence of the player's interactions. The resulting experiences, or emotions derived in the player, are the affects.

The gameplay layer most closely resembles the original MDA framework that was the inspiration of the DPE framework. The notable exception is the change of terminology from *aesthetics*, which for many represents a visual arts term representing the beauty of something, to *affect*, a psychological term meaning emotion or desire.

As in the MDA framework, the designer must take a formal approach in defining what emotions he or she wants to raise in the player. From a player's perspective, the game may be described as *fun* or *not fun*. However, as a designer, it is important to move beyond simply describing the desired emotion as *fun*. The designer must decompose fun and understand the particular aspects that derive a fun experience in the player.

Marc LeBlanc lists eight kinds of fun as *aesthetic goals* (Hunicke, LeBlanc, & Zubek, 2004), which I will refer to here as *affective goals*. Pierre-Alexandre Garneau wrote an article that proposed fourteen forms of fun (2001). Heeter et al. expanded this to sixteen forms of fun (2003), including beauty, immersion, intellectual problem solving, competition, social interaction, comedy, thrill of danger, physical activity, love, creation, power, discovery, advancement and completion, application of an ability, altruism, and learning.

LeBlanc further formalizes the process of defining the affective goals by creating a rigorous definition of each goal, which includes criteria for success and failure. For example, LeBlanc (2005a) defines competition as a game where the players are emotionally invested in defeating each other. The players are adversaries and want to win are the criteria for success while the players feel that they cannot win or players feel they are unable to gage their progress are criteria for failure of the model.

Once the affective goals are defined, the designer must then devise the mechanics to realize these goals through the dynamics of the play experience.

The only way to determine if the mechanics actually do realize the affective goals is through playtesting. With appropriate formal models for success in hand, it becomes quickly apparent to what degree the goals are being reached. The designer can then use this information to modify the mechanics to better achieve the goals. This process is known as balancing the game. Several iterations of designing, prototyping, playtesting, and revising are often required to balance a game.

One common form of gameplay balancing is the balancing of the level of difficulty. Figure 6 contains pschologyist Mihaly Csikszentmihalyi (1990) theory of flow, which demonstrates that in order for the flow state to be achieved, the level of challenge must match the player's abilities as his or her skills increase. If the challenge is too great, the player will become frustrated and may give up. If the challenge is too little, the player will quickly become bored and may quite playing.

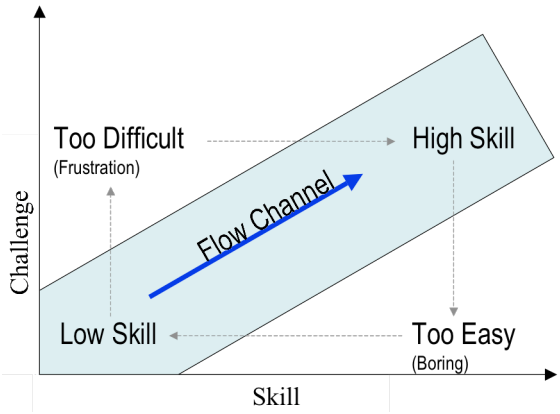

Figure 6: Balancing the level of difficulty

Another form of gameplay balancing relates to the frequency of rewards given to the player. Figure 7 represents a common learning curve in the game. A designer usually wants to balance the game so that the player is rewarded more often (represented as stars) during the steepest part of the game's learning curve, or during the most challenging parts of the game, in order to keep the player playing. This can be thought as a form of operant conditioning with the rewards representing reinforcements at key points as the player learns how to play and overcome the game's challenges.

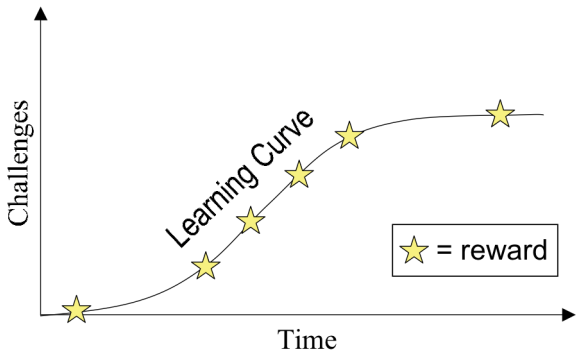

Figure 7: Balancing the frequency of rewards

The designer often also needs to balance the progression of play. Early in the game the player may be overwhelmed with a great deal of choices as they learn how to play. Therefore, the designer often wants to limit the choices early in the game and then ramp the number of choices up as the game progresses as shown in Figure 8. The typical pattern for introducing new choices is that the designer will present the player with a new goal in the game. The player will need to gain some new skill in order to achieve the goal. The player will learn and practice this new skill until they master the skill and finally achieve the goal. The process then repeats, building on the previously introduced skills.

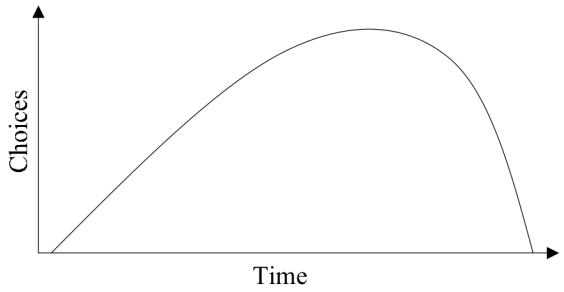

Figure 8: Balancing the progression of play

Rollings and Adams (2003, p. 240) state, "a balanced (entertainment) game is one where the main determining factor for success of the player is the skill level of that player." While this is often true as well in a serious game, the goals in balancing a serious game often are influence by additional factors, most notably factors related to the desired learning outcomes (see section on "Influence Between Layers" below.)

User Experience Layer

While the user experience layer is represented as the deepest layer in the framework, it is actually the most visible (or surface) layer from the perspective of the player. Bruce Shelly with Ensemble Studios, a well-known designer of entertainment games, once said, "the game

designer's principal goal is to create entertaining gameplay. The purpose of the interface is to make that entertainment accessible." (Saltzman, 2000, p. 256) While this is true as well for serious games, the purpose of the user interface is also to create a vehicle to realize the desired serious outcomes.

The game design manifests itself through the user interface. The interface encompasses everything the user sees, hears, and interacts with and how that interaction happens (i.e., the control system.) Ultimately the goal of the designer is (usually) to develop a game that immerses the player in the game world and engages them in the play experience. Good user interfaces are said to be transparent, that is, the player does not have to focus their attention on how to play the game (i.e., what button to press) but rather on the gameplay, storytelling, and learning experience.

Influence Between Layers

The vertical arrows shown in Figure 5 reflect the fact that each layer has influence over the other layers. For example, the learning will influence and be influenced by the storytelling, gameplay, and user experience. Certain design decisions are complementary or conflicting across the layers. Sherry and Pacheco (2004) argue that serious games for learning are most effective when a game's gameplay matches the desired learning outcome. They developed a heuristic for mapping different types of learning, based on Bloom's taxomony, to game genres. Marc Prensky (2001, p. 156) developed a similar table that maps different types of learning to potential activities and game styles. For example, for the learning of skills, Prensky proposes the use of "imitation, feedback coaching, continuous practice, and increasing challenge" for learning activities, and "role-play games, adventure games, and detective games" as potential game styles.

When making design decisions, you must always consider the impact of those decisions on the other aspects of the game. In working out design conflicts, I suggest starting with the top-most layer and working you way down. For most serious games for learning, the learning is the most important aspect and usually the least malleable. Storytelling is often tied closely to the learning content and therefore should be addressed next, but is usually much more malleable. The gameplay and user experience layers are the most malleable and often must adapt to the learning and storytelling. However, as discussed, design is an iterative and creative process. Decisions in lower levels and discovers in playtesting will influence you design across all layers and should be addressed. For example, certain gameplay and storytelling may not be compatible. Rather than change the gameplay, the designer may elect instead to modify the storytelling.

Technology Layer

Everything is grounded on the technology that you are building the serious game upon. Some design choices are more dependent on the technology than others, usually from the bottom layer up in the framework.

The user experience is most tightly tied to technology. A designer could design the gameplay, storytelling, and learning components of a serious game and develop them into a simple paper prototype, such as a board or card game, for rapid playtesting. While this paper prototype will likely help in assessing the effectiveness of the design, it's user interface will be very different than a computer-based version of the same game. The experience of playing the paper version of the game will therefore be quite different than playing the digital version.

Moreover, certain designs may only be possible based on the technology the game is built upon. For example, game mechanics that require a real-time simulation of Newtonian physics or a user interface that requires the detailed representation of a 3D world would not map well to a paper prototype. These complex mechanics and user interface features requires a much higher level of sophistication in the game technology and, as a result, will likely require greater resources to implement. Therefore, technology can be both an enabler and a limiter.

Overall, the capabilities and limitations of the technology and the resources required to implement the technology may greatly influence the design and should be considered throughout the design process.

APPLYING THE DPE FRAMEWORK

The DPE framework has been successfully used in a number of serious game design workshops (Winn, 2006a, 2006b) and is currently being applied in the serious game design graduate curriculum and on various projects in the Games for Entertainment and Learning (GEL) Lab at Michigan State University.

One way the framework has been used is in the analysis of existing serious games. The framework gives a structure to decompose the elements of a design. For example, a student of serious game design can playtest and critique an existing serious game, breaking down and discuss its learning, storytelling, gameplay, user experience, and technology, each as separate components. He or she can further deconstruct the design, play, and experience aspects of each component. The student can ascertain what the experience goals were for the game (from product marketing for example), and then determine if these goals were met through the design. A growing list of serious games analyses that employ the DPE framework is available online (http://seriousgames.msu.edu/analyses/).

The framework not only provides the structure to analyze a game, but also a uniform language in which a group of individuals can discuss and critique a game's design. The terminology used in the framework builds on the language from the disciplines of education and instructional design, storytelling, game design, and user experience design; the disciplines that make up serious game design. By bringing this terminology into a framework that defines the relationship between the disciplinary vocabulary, it helps team members with diverse expertise communicate and converge on game design features to achieve the goals in their respective games, reaching the heart of serious game design.

As discussed above, the framework creates an organizing structure and a formal process to guide a design. By following this formal process of rigorously defining the experience goals, designing, prototyping, playtesting, and iterating to balance the game, the design team can alleviate much of the problems that stem from a more ad hoc, chaotic approach to design.

FUTURE TRENDS

There are rising concerns that the traditional classroom model of education, with one instructor to many students, is falling far short in its promise of motivating and educating the knowledge workers of tomorrow (Svinicki, 1999). Educators and business trainers are also beginning to recognize that web-based instruction, that often is no more than a set of online reading assignments followed by a multiple choice test, is not providing the engaging experience necessary to provide effective education and training (Prensky, 2001).

Serious attention is being given now to the promise of serious games (Van Eck, 2006). Educators and learning scientists observe the deep engagement and long hours individuals spend playing challenging console and PC-based commercial games and imagine a world where this immensely engaging medium is used to teach meaningful content. The United States military has been using games for some time to train and recruit the next generation of soldiers (Bergeron, 2006). The medical and corporate training industries have also begun to look to games to enhance their arsenal of training tools. A recent Ambient Insight market report lists games and simulations as one of the fastest areas of growth in the US corporate training market (Adkins, 2007). To address this growth, new companies are forming, such as Break Away Games, Games2Train, PIXELearning, and Virtual Heroes, while existing companies are building serious game initiatives.

To match the expectations that those have for serious games, the serious game designer must build effective serious games; games that are engaging and enjoyable for the player to play, while satisfying the serious objectives for which the game was built. To that end, serious game design needs to apply a more formal approach; an approach that brings together the collective wisdom of the diverse disciplines involved in the design while also providing them a framework to work together and a process to realize their goals.

The DPE framework represents a more formal approach to designing serious games. By employing this approach, serious game developers can build better serious games. Without such an approach, the games will likely not live up to the expectations of the stakeholders. In the short term, this will diminish the current enthusiasm surrounding serious games. In the long term, if serious games continue to miss the mark, they may begin to be viewed as an over-hyped, computer-based training fad and a great opportunity to truly revolutionize education will be lost.

CONCLUSION

The Design, Play, and Experience framework expands on the MDA framework used in the design of entertainment games, adapting it to serious game design. The DPE framework addresses shortcomings in the emerging discipline of serious game design by providing a language to discuss design, a methodology to analyze a design, and a process to design. The DPE framework parallels the iterative design process used in game development while emphasizing a formal approach that surpasses the ad hoc approach often found in serious game development to date.

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Key Terms

balancing – a key activity in the iterative game design process in which the designer refines the design of a game after playtesting to better achieve the goals of the design that were not realized in the playtest.

endogenous educational games – games where the gameplay is informed by the learning content and pedagogical theory.

exogenous educational games – games in which the learning content is adding on top of successful game mechanics without significant modification.

game design – the process of developing a plan for the learning content, pedagogy, game mechanics, and user interface in a serious game.

game dynamics – the resulting run-time behavior of the game when the game's rules, or mechanics, are instantiated over time with the influence of the player's interactions.

game mechanics – the formal rules that define the operation of the game world, what the player can do, the challenges the player will face, and the player's goals.

heart of serious game design – the ideal overlap between pedagogical theory, subject matter content, and game design.

iterative game design – the typical game development process, including crafting an initial design, creating a prototype of the design, playtesting the prototype, and iterating back to modify the design based on the results of the playtest.

prototyping – developing a game design into a playable format for purposes of playtesting in a fashion that requires minimal time and resources to implement. The prototype is often not built on the actual technology of the final game. For example, a computer game may first be prototyped as a board game.

serious games – games that serve a purpose beyond just entertainment, such as education or training.