FORMATIVE RESEARCH ON AN INSTRUCTIONAL DESIGN THEORY FOR EDUCATIONAL VIDEO GAMES

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This dissertation is dedicated to my parents, Don and Heidi Watson, who are and have been the best parents anyone could hope for.

It is further dedicated to my brothers: Sean, who helped me play my first video game by controlling the spaceship while I fired the guns, and Ben, who I hope someday will realize that his little brother doesn't want to wrestle anymore.

Finally, I want to especially dedicate this dissertation to my wife, Sunnie Lee Watson, who is without a doubt the best thing imaginable to come from my decision to return to school, and also her wonderful family, for their warm love and support.

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Abstract

William R. Watson

Formative research on an instructional design theory for educational video games

An increasing number of researchers have acknowledged the deficiencies of current instructional approaches by turning to educational video games. Proponents of educational video games believe that they are the future of instruction, and the number of proponents is increasing as well. The Federation of American Scientists recently touted video games as having the potential to transform education and called for federal support for research on educational games, including how to best design them.

However, the number of quality research studies on educational video games is limited. Perhaps one reason for this is the lack of educational video games for researchers to implement in classrooms as well as the challenge of creating video games that are both engaging and educational. This study describes formative research conducted on the Games for Activating Thematic Engagement (GATE) instructional design theory, which was developed to guide both the design and implementation of educational video games. Formative research seeks to identify improvements for an instructional design theory based on a designed instance of this theory, in this case Lifecycle, an educational video game designed for use in an undergraduate course on systems analysis and design. The purpose of this study is to evaluate the GATE theory by answering the following questions: 1.) what GATE methods and recommendations work well? 2.) Which ones do not work well? and 3.) What improvements can be made?

Formative evaluation was conducted on the video game representing the designed instance of the GATE theory, using semi-structured interviews, a focus group interview, written participant reflections, and document analysis of the video game's design documents.

The results showed that it is feasible for a single instructional designer to design and develop an educational video game with limited resources. Student responses to the game were largely positive, but a number of specific improvements for the GATE theory were identified.

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CHAPTER 1: INTRODUCTION

In the field of educational technology, and indeed throughout society in general, there is an increasing dissatisfaction with current instructional approaches to education. The industrial age instructional approaches typically used no longer meet the needs of today's information age learners (Reigeluth, 1999b). An increasing number of researchers have acknowledged the deficiencies of current instructional approaches by turning to educational video games (Aldrich, 2004; Foreman, Gee, Herz, Hinrichs, Prensky, Sawyer 2004; Prensky, 2001; Quinn, 2005).

Video games have established themselves as an extremely popular form of entertainment. Computer and video game software sales exceeded a record $10.3 billion in the US in 2002, slowing but remaining strong with $10 billion in 2003 ("The NPD Group Reports Annual 2003 U.S. Video Game Industry Driven by Console Software Sales", 2004). This compared to $9.5 billion in box office sales for the US movie industry in 2002 ("U.S. Entertainment Industry: 2002 MPA Market Statistics").

Jenkins reports that a survey of incoming MIT students found that 88 percent had played games before the age of 10, more than 75 percent were still playing games at least once a month, and on the whole they were more involved with games than films, books, or television (2002). Anderson and Dill (2000) report that in a survey with a sample of 227, 88% of the female, and 97% of the male college students were video game players.

With such widespread popularity, video games have had a strong impact on the players themselves, altering the very ways in which they learn (Beck & Wade, 2004; Prensky, 2001). Given such issues as the popularity of video games and their impact on those playing them, proponents of educational video games believe that they are the future of instruction, and the number of proponents is increasing as well. The Federation of American Scientists (2006) recently touted video games as having the potential to transform education and called for federal support for research on educational games, including how to best design them.

Despite the strong push for the use of educational video games, the research literature contains very few quality studies on how effective educational games are at promoting learning (Fletcher & Tobias, 2006). One reason for the lack of research on educational games could be the limited development of new educational games to be studied. The development of a video game is a complicated and often expensive task, and there has been limited research in video game design in general (Bjork, Lundgren, & Holopainen, 2003) and educational video game design specifically (Dempsey, Rasmussen, & Lucassen, 1996).

The field of Educational Technology has traditionally concerned itself with the process of sound instructional design (Winn, 2004). There has been significant debate in the field regarding the implementation of instructional design models, with critics arguing that traditional instructional systems design (ISD) models (of which ADDIE is the most commonly identified) are unrealistic, unnecessary, and result in a slower and often ineffective process (Gordon & Zemke, 2000; Sivasailam Thiagarajan, 1993). This has led to some researchers in the field arguing that the traditional focus on models when teaching educational technology students is not beneficial (Bichelmeyer, Boling, & Gibbons, 2006). Furthermore, there have been few studies reporting on real-life instructional design practitioners and the level to which they adhere to models (LeMaistre, 1998; Wedman & Tessmer, 1993). The limited research in this area has revealed that most designers do not strictly adhere to models and some do not utilize models at all (Mann, 1996; Wedman & Tessmer, 1993); however, many designers consider current knowledge of instructional design models important to their careers (Liu, Gibby, Quiros, & Demps, 2002).This has created a repeated call for more research that examines what designers actually do when they design (Bichelmeyer, Boling, & Gibbons, 2006; Cox & Osguthorpe, 2003; Kenny, Zhang, Schwier, & Campbell, 2005). Dick (1996) in defending the Dick and Carey model noted that the model was largely designed to aid novice designers and was expected to be adapted by experts. This could address why practitioners consider models important but do not use them.

It is clear that there is a considerable difference in opinion as to the benefits of applying design models, and advocates and critics alike approach the topic with passion. Furthermore, some educational game designers proclaim that instructional designers should be kept entirely out of the design process as they will ensure that the game will not be fun (Prensky, 2001). However games and simulations have been utilized for decades in education, and reviews of the research show often mixed or negative results (Gredler, 1996; Leemkuil, de Jong, de Hoog, & Christopher, 2003; O'Neil, Wainess, & Baker, 2005; Wolfe, 1997). Many of these researchers blame these results on the lack of sound instructional design.

While a few instructional design theories for educational games do exist, as described in chapter two in detail, none of them recognizes the importance of also focusing on the implementation of the game in the learning environment (Garris, Ahlers, & Driskell, 2002; Leemkuil, de Jong, de Hoog, & Christopher, 2003; O'Neil, Wainess, & Baker, 2005; Wolfe, 1997). This includes such issues as instructional strategies used in presenting the game and additional scaffolding outside of the game. If instructors do not have clear guidelines on how to successfully implement an educational game, they are likely to not use it, or to use it ineffectively. Therefore, there is a clear need for a design theory which not only clearly defines how to design an effective educational game, but also focuses on providing the necessary support for implementation to improve its learning effectiveness.

This dissertation will conduct research to identify improvements to such a theory, the Games for Activating Thematic Engagement theory. The literature on types of games is first reviewed in order to specify how games are currently categorized, so a clear understanding of the type of game for which the GATE theory is suitable can be provided. The GATE theory is then presented in the third chapter. The fourth chapter presents the methodology of this study, which examines *Lifecycle*, an educational video game created using the GATE theory. The fifth chapter presents the results of the evaluation of *Lifecycle* used as a designed instance of the GATE theory in order to conduct formative research on the theory. The sixth chapter offers conclusions and suggested revisions to the theory.

CHAPTER 2: LITERATURE REVIEW

Introduction

This chapter reviews the existing literature on the design of educational video games by examining the categories of educational video games and defining the differences among the categories. It then examines the literature on designing one category of educational video games – the one that focuses on teaching critical thinking through problem-based learning. The review of literature in this area reveals the need for the development of more explicit design guidelines and models for this type of educational video game.

Categories of Educational Video Games

In examining educational games, there are several approaches to categorizing games by their differences. These include issues of game format, structure, content, learning goals, and so forth. The most common means of differentiating games is categorizing them as games or simulations or grouping them by genre. This chapter argues that a more useful categorization of educational games would focus on the learning goals of the game, for such a categorization is likely to have a stronger influence on the design of the game (Gagne, 1968, Merrill, 1983).

Games vs. Simulations

A common categorization of educational video games is by differentiating between games and simulations. Prensky (2001) identifies six structural factors that define games: rules, goals and objectives, outcomes and feedback, conflict/competition/challenge/opposition, interaction, and representation or story. He states that simulations are not games as they do not adhere to all of these factors. He notes simulations' lack of focus on fun, but he claims that simulations can be made into games by adding the missing structural features.

Appelman and Wilson (2005) examine games and simulations by identifying their characteristics and differentiating their outcomes. They state that all games have the following six characteristics: challenges, rules, interaction, contrivance, obstacles, and closure. Furthermore, when used in training, games may achieve desired outcomes such as: increased skill, understanding of the implementation of a process, deeper understanding of relationships and concepts, and awareness of cross-training needs in addition to the benefits of fun and engagement. Simulations have different weights of six characteristics: challenges, models, control, manipulation, authenticity, and consequences. They identify outcomes as the prime area of difference with simulations, highlighting how the fun and entertainment focus of games is not a primary concern of simulations.

Salen and Zimmerman (2004) compared eight different definitions of the term "game" from representatives of a variety of fields and came up with the following definition: "A game is a system in which players engage in an artificial conflict, defined by rules, that results in a quantifiable outcome" (p. 80). However, conflict in this context is used in a general sense, not precluding cooperation and including both solo competition with a game system and competition with other players. This broad definition applies to all kinds of games, including sports and board games, and not just video games. They also reviewed several definitions of simulation to come up with: "A simulation is a procedural representation of aspects of 'reality'" (Salen & Zimmerman, 2004). They note that there are certainly simulations which are not games and games

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which are not simulations, but that simulation games do exist with varying levels of fidelity.

Quinn (2005) defines simulations as relying on underlying models, not prescriptive branches, and games as simply being simulations that focus on creating optimal engagement. Aldrich (2005) also places games as a sub-set of simulations, stating that game-based models are one type of educational learning simulation.

Ellington, Gordon, and Fowlie (1998) recognize the inter-relatedness of games and simulations. They refer to previous definitions of each, while pointing out their shortcomings, which state that games must have rules and competition, while simulations must represent a real situation and be dynamic. They present the spectrum of pure games, pure simulations, and hybrid simulation/games to address what they see as overly restrictive delineations between the terms in the literature.

Heinich, Molenda, and Russell (1993) also recognize the inter-relatedness of simulations and games. They define a game as "an activity in which participants follow prescribed rules that differ from those of reality as they strive to attain a challenging goal" (p. 243). A simulation, on the other hand, is "an abstraction, or simplification of some real-life situation or process" (Heinich, Molenda, & Russell, 1993). Participants in a simulation often play a role and interact with other people or elements in the environment. They also address the issue of fidelity in simulations and note that the lack of reality is often desired in games. They also allow for hybrid forms, such as the simulation game.

The key differences between simulations and games are primarily highlighted in terms of the amount of focus on engagement and reality, while some also argue that simulations are more dynamic and system-model based and less linear than games. It is clear that simulations and games are similar and closely related when used for educational purposes. While there is substantial literature focusing on the differences between the terms, they are still often used interchangeably or with little discrimination in much of the literature. Therefore, the use of the terms for categorizing educational games is not helpful, and discussions utilizing these terms to categorize often devolve into debates on their true definitions and differences rather than advancing the true topic at hand.

Categorizing by Genre

The vast majority of discussions of categories of educational games focus on game genres. Bergeron (2006) lists standard genres "used to define entertainment and serious games" (pp. 146-147) as: action, adventure, arcade (retro), combat (fighting), driving, first-person shooter, military shooter, multiplayer, puzzle, real-time simulation, role playing game, shooter, simulation, sneaker, sports, strategy, third-person shooter, trivia, and turn-based; although a mixture of genres is not uncommon, and so they are therefore not mutually exclusive.

Quinn (2005) notes that the use of genres can be beneficial in understanding differences in games and types of engagement and in providing templates for game or simulation design. He lists the following game genres: action, fighting, driving or flying, sports, 3D shooter, card or board, strategy, fantasy role playing, adventure, multiplayer, massively multiplayer online role-playing game (MMORPG), and combinations of genres.

Prensky (2001) also identifies similar game genres, which can overlap: action, adventure, fighting, puzzle, role-playing, simulation, sports, and strategy. A review of the instructional gaming literature by Dempsey Rasmussen, and Lucassen (1996) also resulted in organizing the instructional games reviewed by genre: simulation, puzzle, adventure, experimental, motivational, modeling, and other.

Kirriemuir and McFarlane's (2004) literature review on games and learning references Herz's 1997 genre-based categorization system which categorized games into action, adventure, fighting, puzzle, role-playing, simulations, sports, and strategy. However, they again note that every year games come out which do not fit into these genres.

Apperley (2006) argues against the current use of genres to classify games. He claims that standard game genres categorize games by their representational characteristics or visual aesthetics and argues instead for categorizing games by focusing on the type of interaction the game requires of the player. While still categorizing video games with typical genre labels, such as role-playing, simulation, and adventure, Apperley's focus is on the type of interaction rather than the visual representation of the game.

The combinations of multiple genres and the listing of a general category for games that do not fit within the genres in the examples above illustrate the ineffectiveness of categorizing educational games by genre. Furthermore, there is evidence of dissatisfaction with the use of genres in the field of general game research. With the additional complexities and design requirements of educational games, the use of traditional video game genres is insufficient to help designers communicate their design concepts or discuss game types. For educational video games, it would make more sense to focus on the learning approach or outcomes of the game rather than the game genre. Literature to support this perspective will be reviewed next.

Categorizing by Learning Approach

There is literature reporting on the categorization of educational games by the learning approach which they utilize. Prensky (2001) identifies the following learning techniques that have already been used in educational video games: "practice and feedback, learning by doing, learning from mistakes, goal-oriented learning, discovery learning and guided discovery, task-based learning, question-led learning, role playing, coaching, constructivist learning, accelerated (multisense) learning, selecting from learning objects, and intelligent tutoring" (p. 157).

In their review of instructional video games, Dempsey and colleagues (1996) categorize the games they reviewed by the following learning approaches: "tutor, amuse, learn new skills, promote self-esteem, practice existing skills, drill existing skills, change attitude, other, and not able to determine" (p. 10).

Ellington, Gordon, and Fowlie (1998) categorize games and simulations by how much they involved case studies in their instructional approach. Kiili (2005) promotes using educational games to implement experiential learning. Maxwell, Mergendoller, and Bellisimo (2004) describe developing an educational game which utilized problem-based learning (PBL). Rieber (1996) advocates situated learning, and self-regulated learning within a microworld.

There are clearly varied approaches to implementing instruction in educational video games. These approaches run from the drill-and-practice approach where the games act as little more than interactive flash cards, to complex, virtual environments where learners are expected to experiment and use meta-cognitive skills to develop and reflect on their own learning. Educational games can also be categorized by the type of learning outcome the learner is expected to acquire by playing the game.

Categorizing by Learning Outcome

There have been repeated calls in the literature for the involvement of instructional designers in the design and development of educational games (Fletcher & Tobias, 2006; O'Neil, Wainess, & Baker, 2005). However Prensky (2001) states that the opposite is true and instructional designers should be left out of the process. He claims that his experience and the experience of other game designers has been that the addition of an instructional designer often results in stale, boring, educational games, and he points towards the criticisms of the instructional design process within the field itself (Gordon & Zemke, 2000).

Despite these criticisms, there has been little research on the effectiveness of educational games, and what research there is has shown mixed results. Furthermore, Fletcher and Tobias' (2006) report lists several studies that found the design of the entertainment aspects of some educational games resulted in negative impacts on the learning outcomes of those games. Gee (2003) argues that what is learned from a game is a function of the design of the game. It therefore follows that instructional designers can have an important place on the design team of an educational game and, as designers, will certainly be involved in the design of some games. As instructional designers find that different kinds of learning objectives require different kinds of instructional methods (or learning activities), it makes sense to categorize educational games by the learning objectives which they support.

Dempsey and colleagues (1996) categorized their review of educational games by Gagne's learning outcomes: attitude, motor skills, cognitive strategy, problem solving, rules, defined concepts, concrete concepts, verbal information, other, and not able to determine. The fact that they could not identify a large number of the educational games' learning outcomes is another indication of the importance of including instructional designers in the design process. They noted the positive fact that there was a large number of games which focused on higher-order thinking skills and attitudinal learning as opposed to verbal knowledge outcomes (1996).

Kirriemuir and McFarlane (2004) note that traditional educational games have often been repetitive drill and practice games, focusing on teaching declarative knowledge.

Prensky (2001) lists the following types of learning: "facts, skills, judgement [*sic*], behaviors, theories, reasoning, process, procedures, creativity, language, systems, observation, and communication" (p.156). He also provides a table where he ties these learning outcomes to the type of traditional game genres that might be most appropriate for acquiring the learning.

Warren (2001) reports on educational game studies evaluating behavioral, attitudinal/affect change and tolerating ambiguity as learning outcomes. It is clear that there are various kinds of learning outcomes which educational games seek to help learners achieve. Traditionally, the majority of educational games have focused on declarative knowledge through drill-and-practice approaches, but it appears that newer games are seeking to maximize the potential of educational games and move towards higher-order thinking. Higher-order thinking focuses on developing critical thinking skills and true understanding rather than rote knowledge. Problem-based, experiential learning and the constructivist concept of a microworld are instructional frameworks which match well with utilizing educational games to promote higher-order thinking skills. In fact, Dempsey and colleagues (1996) found that problem-solving was the largest specific learning outcome discussed in the educational video game research articles they reviewed.

This study will focus on educational video games that deal with developing higher-order thinking and problem-solving skills. While a more detailed discussion of why the researcher feels these types of learning outcomes are most suitable for the use of video games will be presented later, as stated above, the majority of researchers looking to apply video games to education are interested in outcomes like these. The next section will review identified aspects of designing games of this type.

Design Features of Problem-based, Experiential Educational Video Games

While the design literature on educational video games is quite limited, there are several design models and design features in the literature which address problem-based or experiential educational video games. Rieber (1996) frames learning through educational video games by grounding the design theory in the concept of self-regulated learning in a constructivist microworld and motivation in Csikszentmihalyi’s Flow Theory. Rieber (1996) notes that according to Piaget, learning cannot occur unless the learner is in a state of disequilibrium, and the purpose of a microworld is to “foster, nurture, and trigger the equilibrium process" (p. 48). This fits well with the concept of designing difficulties and challenges into a game.

Rieber (1996) reports that flow comes from activities that provide enjoyment. Enjoyment comes when an activity exhibits one or more of eight characteristics which are consistent with effective games:

1. challenge is optimized in the activity,
2. attention is completely absorbed in the activity,
3. the activity has clear goals,
4. the activity provides clear and consistent feedback,
5. the activity is so absorbing that the individual forgets other worries and frustrations,
6. the individual feels completely in control,
7. the individual loses all feelings of self-consciousness, and
8. time passes without the individual noticing.

These attributes of engaging activities offer guidelines for designing engaging games which can promote flow states and can be examined as important aspects to include when designing a problem-based, experiential, educational video game.

Maxwell, Mergendoller, and Bellisimo (2004) describe a problem-based simulation which they developed and implemented in their economics course. Using a PBL simulation, they presented a simulated, realistic problem to students. They set parameters and rules in the simulation so a definitive outcome could not be attained once play commenced. Students played the simulation, encountered difficulties, and were prompted by the teacher-coach to think of creative solutions. They note that in this type

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of simulation, students see the need for research; new rounds are then played utilizing newly acquired information, and learning is gained due to similarity of the simulation to an authentic situation.

While the previous examples of general guidelines for developing problem-based and experiential educational video games can provide some help to the designer, the process of developing an educational game that is not only engaging, but also founded on sound educational theory, is complicated and challenging. A number of researchers have determined that an instructional design model is needed to help guide game design and developed their own models. Amory and Seagram (2003) provide three different models: the Game Object Model (GOM), the Game Achievement Model (GAM), and the Persona Outlining Model (POM). The GOM focuses on uniting educational theory with game design. The POM focuses on bringing together software development with audience and intended outcomes. The GAM addresses game development and documentation. The three models can be used together; however, none of these models addresses flow theory or takes gameplay issues into account, except in a very general sense (Kiili, 2005).

Amory (2007) addresses some of these concerns by creating a second version of the GOM (see Figure 1) which seems to synthesize some of what the other two models offer as well as include more recent insights into educational game design. The GOM is loosely based on the Object Oriented Programming paradigm and lists components (objects) that promote and allow for realization of educational objectives. These components are described through abstract (pedagogical and theoretical constructs) or concrete (design element) interfaces. In the diagram, the objects are represented by rounded rectangles, and the interfaces by circles: concrete using white circles and abstract using black circles. Amory has made improvements to his original model and states that the new model will be useful to designers and could easily serve as a requirements checklist by comparing all the concrete interfaces to a game's specification. However, while the model has been improved and illustrates a wide range of theoretical and design components and concepts, it remains somewhat visually overwhelming and vague, and provides no consideration on how the educational game might be implemented.

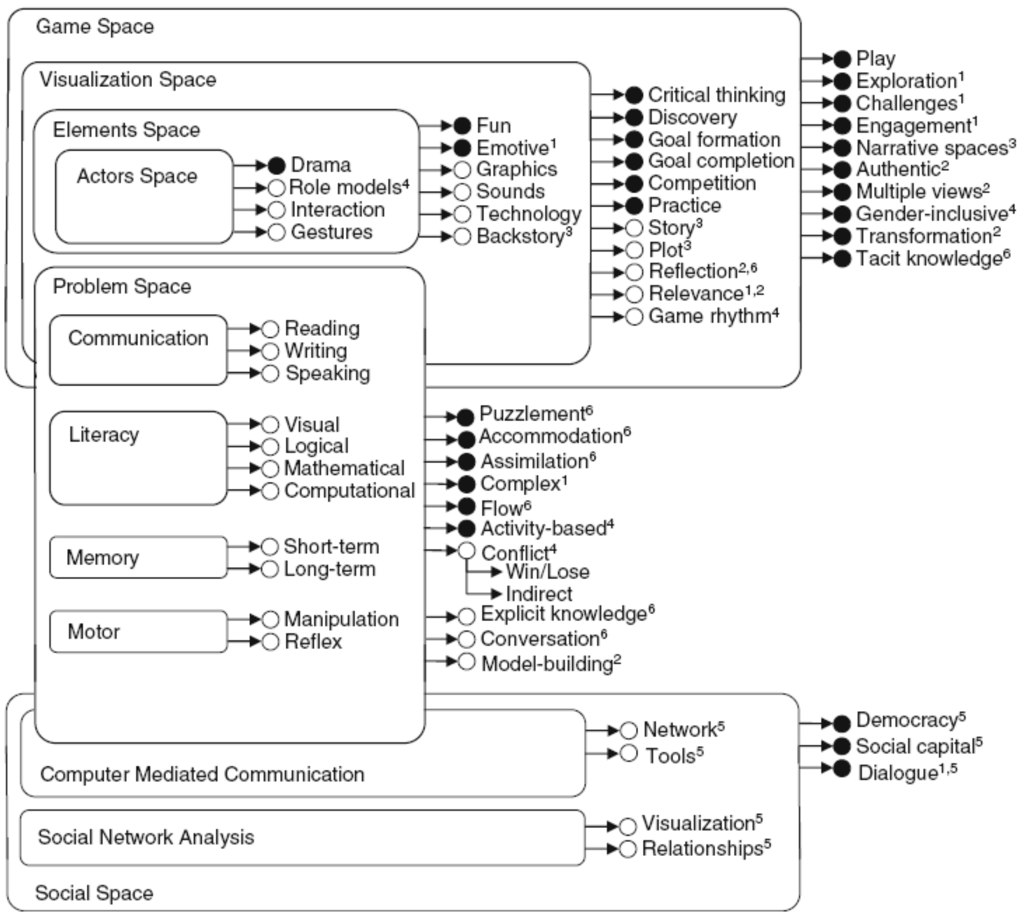

Fig. 2 Game object model version II (Core concepts: 1, Game definition; 2, authentic learning; 3, narrative; 4, gender; 5, social collaboration; 6, challenges-puzzles-quests)

Figure 1. Amory's Game Object Model version II.

Note. From Amory (2007), p. 55.

Kiili (2005) addresses the need for a model by developing her experiential gaming model (see Figure 2).

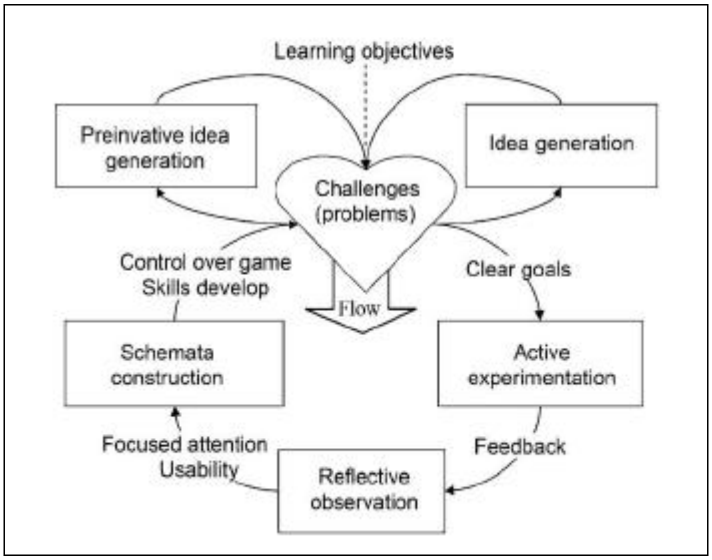

Figure 2. Kiili's experiential gaming model.

Note. From Kiili (2005), p. 18.

Kiili (2005) claims the model represents both constructivist and pragmatist views of learning, reflecting both cognitivist and behavioral learning. The model is meant to be used to design and analyze educational games; however, it seems to entirely reflect the learner's experience in a game and does not address design. Furthermore, Kiili (2005) states that the model "does not provide the means to a whole game design project" (p. 19).

While Kiili, like Amos and Seagram before her, has tried to merge game design with educational theory, and has gone a step further by including the important concepts of flow theory for motivation, none of the models succeeds in synthesizing the varied concepts into a usable design model.

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Conclusion

This chapter has reviewed the categorization of educational video games in the literature. The vast majority of the literature simply categorizes educational video games by traditional video game genres, giving no insight into what kinds of instructional methods will best promote learning from the game. For this reason, a categorization based on learning outcomes and instructional theory frameworks was recommended to put the focus on the learning rather than the game structure or aesthetics. The limited literature describing the categorization of educational video games by learning objectives based on instructional theory was presented.

Educational video games based on problem-solving and experiential, constructivist microworlds were selected as highly desirable. The current literature addresses the design of this type of educational video game, but not effectively, and research on the design of educational video games is very limited. Useful design models and instructional theories for educational video games are needed, particularly for games that teach higher-order thinking skills, such as problem-based learning educational video games.

CHAPTER 3: GATE INSTRUCTIONAL DESIGN THEORY

Introduction

This chapter introduces the GATE instructional design theory, which the researcher developed to guide the sound design of both an instructional video game as well as the context in which it should be implemented. These two aspects of design are deemed equally important to the success of the game and should therefore be integrated in the design process itself.

The great promise of instructional video games is their ability to engage learners. The GATE theory focuses on this engagement, as GATE stands for Games for Activating Thematic Engagement. The goal of this design theory is to utilize video games to engage students in a topic and encourage further exploration within that topic.

Before presenting the GATE theory itself, this chapter first overviews the research literature which informed the theory's design and grounds the theory's approaches. Relevant, established, instructional theories are first reviewed. The literature on entertainment video game design is then presented.

Instructional Theory

Traditional educational approaches are no longer meeting the needs of today's learners as society has shifted from the industrial age into what many are calling the information age (Reigeluth, 1994; Toffler, 1984). The current educational system is largely mired in the industrial age, placing instructors at the center of the educational process, treating students as if they are all the same, and encouraging them to be passive and disengage (Reigeluth, 1994). Information age appropriate instruction places an emphasis on a learner-centered approach as the role of instructors shifts from a source of

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knowledge to a facilitator of the knowledge acquisition process as students become more active in their learning process (McCombs & Whisler, 1997).

While there have been widespread calls to improve education, Reigeluth (1999b) highlights the essential need for more people to generate design theories rather than, as he quotes Pogrow, "preferring to philosophize and preach" (p. 15). This is an excellent reflection of the current status of educational video games in the literature, with a high volume of publications calling for their use but, as reflected in chapter two, a true scarcity of discussions as to how they can best be designed and used.

Reigeluth (1999b) defines an instructional design theory (also known as instructional theory or instructional model) as describing what instruction should be like in order to better help people to learn. This is differentiated from, although closely related to, instructional development (ID) models or instructional systems development (ISD) processes, which describe what process should be used to "plan and prepare for the instruction" (Reigeluth, 1999b, p. 13). He stresses that it is important to note that instructional design theory is "design-oriented (focusing on means to attain given goals for learning or development), rather than description oriented (focusing on the results of given events)" (p. 6). Furthermore, instructional design theories are probabilistic as opposed to deterministic, meaning they do not guarantee but instead increase the probability that the desired instructional and learning outcomes will occur.

Related to this notion, is the difference between instructional design theory and learning theory. Learning theories describe how learning occurs and are descriptive. Instructional design theories, while typically grounded in learning theory, are more easily applied to educational problems, as they describe specific methods of instruction for helping people to learn. A number of learning theories as well as instructional design theories offer descriptions of how people learn and present guidelines for the design and application of information age appropriate instruction. These theories influenced the GATE theory and ground its approaches, and they are discussed next.

Constructivism

Constructivism has its roots in previous learning theories such as the cognitive and developmental views of Piaget, the contextual nature of learning described in situated cognition, and the emphasis on interaction and culture in learning raised by Bruner and Vygotsky (Driscoll, 2005). While constructivism does not have a single, central instructional theory rising from it, a number of constructivist instructional theories have gained significant recognition and heavily influenced current approaches in education. Several of these are discussed more specifically in this section, but it is also helpful to look in more detail at some of the underlying influences on constructivism as well as some of the general beliefs and themes underlying constructivist approaches.

Bruner. As mentioned previously, the theories of Bruner and Vygotsky strongly influenced constructivism as well as the formation of the GATE theory. Bruner identifies the aim of education as helping the learner to become an autonomous and self-driven thinker (J. Bruner, 1961). He sees a theory of development as intrinsically linked with a theory of instruction. For a theory of development, Bruner (1964) highlights three sequential modes of representation that children utilize to make sense of their world: enactive representation, iconic representation, and symbolic representation. Enactive representation refers to representing experience through motor responses, an example being that a person might not be able to remember cognitively how to play a piano piece, but once he or she sits before the piano, he or she can readily play the piece. Iconic representation refers to memory that uses images and perceptions. Symbolic representation is the use of symbol systems to represent understanding, such as language or musical notation.

An important aspect of Bruner's theory on development and its stages of development is that instruction can be translated into a format appropriate for the learner's current mode (stage) of thinking based on the learner's prior knowledge, dominant mode of thinking, and whether the learning goal is one of speed or transfer (Driscoll, 2005). For example, if transfer to new situations is required, the learning may take a longer time and require symbolic representation of what has been learned; however, if time is of the essence, iconic representation may be suitable. The key concept here is that instruction should be presented to the learner in an appropriate format which he or she is able to understand, and any instruction is capable of being translated into an appropriate format. Learners can then further develop their understanding in a different format (stage) as they increase their understanding.

Bruner's (1961) instructional theory focuses on discovery learning, defining discovery as learners gaining knowledge for themselves using their own minds. Discovery requires the learners to create strategies for finding regularities and relationships through an act of construction, meaning with constraints in mind, and guided by models (Driscoll, 2005). Appropriate instructional strategies should therefore be used to optimize effectiveness, with Bruner recommending discovery through problem solving of culturally appropriate and realistic problems (Driscoll, 2005). Finally, providing meaningful feedback appropriate to the learner's current stage allows for better understanding and increased intrinsic motivation through the joy of discovery (Driscoll, 2005).

Bruner's belief in transforming instruction into a form appropriate for the learner's stage of development, focusing on problem solving grounded in the learner's culture, and supporting the intrinsic motivation of discovery and active learning had substantial impact on the constructivist movement in education. These components are likewise reflected in the GATE theory, which recommends video games as a form suitable for today's learners, is centered on context-bound problems, and focuses on developing active learning, motivation, and engagement with a topic.

Vygotsky. Another substantial contributor to constructivist approaches to instruction, Vygotsky, shares a number of similarities with Bruner in his approach to learning theory and instructional theory. Like Bruner, Vygotsky viewed the development of intelligence as reflecting the internalization of the tools of the learner's culture; however, he also placed equal importance on the historical perspective in understanding mental functions (Driscoll, 2005). Furthermore, like Bruner, Vygotsky recognized the importance of interaction for the learner, stressing a focus on the process of learning, rather than trying to identify cognitive stages; in doing so, he highlighted social interaction as the key to the process by which learners translate social activity into meaning, creating higher mental processes.

Vygotsky proposed two concepts to better understand this process: internalization and the zone of proximal development. Internalization refers to the process of an initially social function, an interpersonal activity, being transformed into a higher mental function, an intrapersonal activity, such as when a child learns to point to a desired object he or she wants, as reaching for such an object previously resulted in an adult getting it for the child (Driscoll, 2005).

Vygotsky also proposed the Zone of Proximal Development (ZPD), a gap between a child's actual level of development determined by individual problem solving and the child's potential development by problem solving with collaboration of peers or an adult (Vygotsky, 1978). With social interaction a key component of the process of learning, it is important for partnering learners to have a difference in level of expertise, to have a joint understanding of the task at hand, and for the more experienced partner to have a firm comprehension of what the less experienced partner requires so that appropriate guidance can be provided (Driscoll, 2005). The ZPD is key in describing the appropriate level of instruction necessary to help the learner further develop, which is echoed by Bruner's theory. Furthermore, it is clear how instruction that is not successfully placed in the learner's ZPD would either be too easy or too difficult for the learner, negatively impacting both the effectiveness of the learning and the learner's motivation. The GATE theory's recommendation for collaboration amongst learners and its stressing of appropriate and dynamic difficulty reflect these ideas.

Both Bruner and Vygotsky developed theories which made key contributions to constructivism. Their focus on learning leading to development through instruction appropriate for the learner's current developmental level and based on social interaction, and relevant problems situated in the learner's culture can be seen in current constructivist instructional theories.

Constructivist approaches to instruction. Constructivism assumes that knowledge is constructed by learners as they seek to understand their experiences:

learners “form, elaborate, and test candidate mental structures until a satisfactory one emerges” (Driscoll, 2005, p. 387). These mental structures must be reconstructed as learners encounter new and conflicting experiences and make sense of the new information.

Driscoll (2005) lists “problem solving, reasoning, critical thinking, and the active and reflective use of knowledge” (p. 393) as the goals of constructivist instruction and provides the following constructivist conditions for learning: (1) Embed learning in complex, realistic and relevant environments. (2) Provide for social negotiation as an integral part of learning. (3) Support multiple perspectives and the use of multiple modes of representation. (4) Encourage ownership in learning. And (5) Nurture self-awareness of the knowledge construction process.

Clearly, video games offer the potential of providing learners with a complex, realistic, and relevant environment to interact with while they learn. Furthermore, the potential impact of role-playing and the importance of multiple modes of representation had an impact on the development of the GATE theory. As will be explained later in this chapter, learning designed with the GATE theory is not supposed to remain isolated to the game but should expand beyond. Learners are given choice as to what mode of representation they wish to use in order to demonstrate their knowledge. Social negotiation is also encouraged in the GATE theory as learners are asked to interact within the game in the case of multiplayer games, or outside of the game as they reflect on their choices, or a combination of each.

Finally, the focus of the GATE theory is to engage students with a topic and encourage further exploration. This clearly reflects the constructivist focus on ownership of learning as well as self-awareness of the knowledge construction process, as learners are given choice in their demonstrations of mastery and are expected to reflect on their experiences individually and with peers. In the next sections, additional instructional theories which informed the foundation of the GATE theory's design will be discussed.

Situated Learning

Situated learning grew out of a focus on the concepts of apprenticeship and authentic tasks in learning in the late 1980s. While situated learning originally called for the requirement of authentic tasks completed in authentic, social and physical environments (J. S. Brown, Collins, & Duguid, 1989), Herrington and Oliver (1995) note that numerous researchers have since identified computers as a suitable alternative for producing an authentic context. They identify the following provisions of learning environments which adhere to the situated learning approach:

- authentic context which reflects how the knowledge will be used in real life,
- authentic actions,
- access to expert performances and process modeling,
- multiple perspectives and roles,
- construction of knowledge through collaboration,
- coaching and scaffolding,
- reflection,
- articulation to make tacit knowledge explicit,
- assessment of learning integrated within the tasks (Herrington & Oliver, 1995).

In adapting situated learning to interactive multimedia, the authors stress the importance of not focusing solely on the multimedia but also the individual learners as well as how the multimedia will be implemented. It is the inter-relation of these three components: the learner, the implementation, and the interactive multimedia which together meet the requirements of an efficient situated learning environment and which must all be taken into account.

The interplay of these three components is equally relevant to learning environments using video games, a form of interactive multimedia. The characteristics identified above have direct relevance to video games for learning and have impacted the formation of the GATE theory.

Problem-based Learning

Problem-based learning (PBL) evolved from the field of health sciences education as a way to move towards a more learner-centered, multi-disciplinary education that promotes lifelong learning in professional practice (Boud & Feletti, 1997). Savery (2006) defines PBL as:

> An instructional (and curricular) leaner-centered approach that empowers learners to conduct research, integrate theory and practice, and apply knowledge and skills to develop a viable solution to a defined problem. Critical to the success of the approach is the selection of ill-structured problems (often interdisciplinary) and a tutor who guides the learning process and conducts a thorough debriefing at the conclusion of the learning experience (p. 12).

Jonassen (1997) identifies six steps to designing and developing ill-structured problem-solving instruction: articulate problem context, introduce problem constraints, locate, select, and develop cases for learners, support knowledge base construction, support argument construction, and assess problem solutions.

Barrow’s PBL Initiative Website ("Generic problem-based learning essentials", n.d.) lists 10 minimal essentials for PBL:

> (1.) Students must have the responsibility for their own learning. (2.) The problem simulations used in problem-based learning must be ill-structured and allow for free inquiry. (3.) Learning should be integrated from a wide range of disciplines or subjects. (4.) Collaboration is essential. (5.) What students learn during their self-directed learning must be applied back to the problem with reanalysis and resolution. (6.) A closing analysis of what has been learned from work with the problem and a discussion of what concepts and principles have been learned is essential. (7.) Self and peer assessment should be carried out at the completion of each problem and at the end of every curricular unit. (8.) The activities carried out in problem-based learning must be those valued in the real world. (9.) Student examinations must measure student progress towards the goals of problem-based learning. (10.) Problem-based learning must be the pedagogical base in the curriculum and not part of a didactic curriculum.

Important characteristics of PBL which influenced the GATE theory include the instructor’s role as a tutor as PBL utilizes a learner-centered approach, the use of ill-defined, authentic, interdisciplinary problems in a relevant context, the active role of students, including a role in determining their learning outcomes, and the importance of debriefing the experience and requiring the students to reflect metacognitively on their learning. These aspects will be further discussed later in the description of the GATE theory.

Narrative-based Learning

Humans organize their experience and memory of events primarily in the form of narratives (J. Bruner, 1990; 1991). Gerrig (1993) states that narrative can allow people to feel transported to another time or place, and it can also allow people to act as participants as they engage with and experience the narrative, making interpretations and drawing conclusions. Because of this engagement with and immersion in the narrative, participants in narrative-centered environments can co-construct the narrative, explore the narrative, and reflect on the narrative (Mott, Callaway, Zettlemoyer, Lee, & Lester, 1999). Mott et al. (1999) argue that in a narrative-centered learning environment, particularly an interactive one created using computer models, a narrative world can be created which allows the elements of narrative (settings, characters, plot, and theme), to facilitate the meeting of learning goals through discovery.

The GATE theory places a focus on engaging learners with a topic through an educational video game. Narrative is an important aspect of video game design, as will be illustrated in the later section on entertainment game design; and the design of the educational game's context, which includes the narrative aspects of the game, is a key method of the GATE theory. Furthermore, video games allow users to actively participate in the unfolding narrative, and the GATE theory encourages reflection on the experience gained from actively participating in that narrative.

Thematic Learning

Thematic learning, also known as integrated curriculum, integrated thematic instruction (ITI), or interdisciplinary learning, refers to the concept that instruction should not be divided into isolated subjects taught individually, but instead these subjects should be related to relevant, shared themes or topics. Ellis and Fouts (2001) note that the theoretical base of integrated curriculum lies in progressive educational philosophy, primarily the works of John Dewey and later Vygotsky and the constructivist movement. They provide the following claims by advocates; although they note the need for more research to validate these claims:

> The interdisciplinary curriculum improves higher-level thinking skills. With the interdisciplinary curriculum, learning is less fragmented, and therefore students are provided with a more unified sense of process and content. The interdisciplinary curriculum provides real-world applications, hence heightening

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> the opportunity for transfer of learning. Improved mastery of content results from interdisciplinary learning. Interdisciplinary learning experiences positively shape learners' overall approach to knowledge through a heightened sense of initiative and autonomy and improves their perspective by teaching them to adopt multiple points of view on issues. Motivation to learn is improved in interdisciplinary settings (Ellis & Fouts, 2001, p. 24).

ITI is grounded in brain-research and calls for year-long themes composed of (approximately) weekly topics, a focus on mastery and learner choice, immediate feedback, collaboration, meaningful content, absence of threat, and a sequence of instruction that begins with real-world experiences, conceptual development, language development, and finally application to the real-world (Kovalik & McGeehan, 1999).

The GATE theory reflects many of these issues, encouraging a game which can connect multiple topics, games which offer immediate feedback in a risk-free environment, learner choice in demonstrating mastery, and games that reflect meaningful, engaging, and relevant content. Furthermore, a chief goal of the GATE theory is to promote learner engagement, higher-order thinking skills, and motivation for ownership of the learning process.

Motivational Theory and Engagement

In examining incorporation of motivation into instructional design, two key theories are currently examined in the literature. The ARCS model identifies four key strategies for incorporating motivation in instructional design: attention, relevance, confidence, and satisfaction (Keller, 1983). He further breaks these down into the following sub-components: attention can be gained through perceptual arousal, inquiry arousal, and variability; relevance may be reached through goal orientation, motive matching, and familiarity; confidence may be attained through learning requirements, success opportunities, and personal responsibility; and satisfaction strategies can incorporate internal reinforcement, extrinsic rewards, and equity (Small, 1997).

Flow theory is another driving force behind motivation in instruction. While Flow theory focuses on describing the state of motivation and some of the conditions that promote this state, it was not created with instructional design in mind. However, many researchers have looked to it for guidelines on designing highly motivating instruction. Csikszentmihalyi (1990) conducted interviews to identify the following eight components of deeply enjoyable activities: 1. a task the person is capable of completing; 2. the ability to concentrate on the task; 3. the task has clear goals; 4. the task provides immediate feedback; 5. the person acts with a deep but effortless involvement that removes stress of everyday activities; 6. the person perceives a sense of control over his or her actions; 7. self-concern disappears, yet self-awareness is strengthened following the activity; and 8. the sense of time is altered.

In describing flow-inducing activities, Csikszentmihalyi (1990) describes characteristics that make activities conducive to flow:

> They have rules that require the learning of skills, they set up goals, they provide feedback, they make control possible. They facilitate concentration and involvement by making the activity as distinct as possible from the so-called 'paramount reality of everyday existence' (p. 72).

Much of motivational theory for instructional design focuses on engaging the students with the instructional content. Saye and Brush (1999) define students' engaging with a topic as involving "psychological investment and effort directed toward mastering complex academic work" (p. 469). It is "an inner quality of concentration and effort to learn" (Newmann, Wehlage, & Lamborn, 1992, p. 13) or ""the student's psychological investment in and effort directed toward learning, understanding, or mastering the knowledge, skills, or crafts that academic work is intended to promote" (p. 12).

Dickey (2005) cites Jones et al. and Schlechty in identifying elements of engaged learning:

- Focused goals.
- Challenging tasks.
- Clear and compelling standards.
- Protection from adverse consequences for initial failures.
- Affirmation of performance.
- Affiliation with others.
- Novelty and variety.
- Choice.
- Authenticity (p. 70).

She then goes on to illustrate how video games engage players utilizing these very same elements.

Clearly video games have been strongly recognized in the literature for their potential for engagement. The GATE theory, in utilizing video games as a means of engaging learners with a topic, seeks to implement many of the elements identified in these theories on motivation through the design or application of an educational video game. These elements will be further discussed in a later section by examining how literature on entertainment video game design recommends designing for engagement

While the GATE theory is an instructional design theory and therefore focuses on what instruction should be like, it also presents a process for designing and developing an educational video game. The design process aspect of GATE was also influenced by established theory, which will be discussed next.

Rapid Prototyping and User-centered Design

In looking to an instructional design process that highlights efficiency, an important concept in the resource-greedy environment of video game design, rapid prototyping has been posited as an alternative design process to the traditional systematic approach of traditional instructional design processes (Tripp & Bichelmeyer, 1990). Rapid prototyping calls for “after a succinct statement of needs and objectives, research and development are conducted as parallel processes that create prototypes, which are then tested and which may or may not evolve into a final product” (Tripp & Bichelmeyer, 1990, p. 35).

In order to prototype the system, several elements are required: “the physical and logical definitions of the system, an opportunity to exercise the prototype, and software which allows the rapid building and modification of the prototype” (Tripp & Bichelmeyer, 1990, p. 35). Additionally, it should be noted that through the prototyping process, initial definitions of the system are evaluated and evolve into final definitions based on experience gained in the process.

While rapid prototyping stresses efficiency and early and frequent feedback, including the use of learners to feed the design process, the process could be even further enhanced by not initially relying on software-built prototypes, but instead incorporating paper prototypes earlier in the design process. Paper prototyping is: “a variation of usability testing where representative users perform realistic tasks by interacting with a paper version of the interface that is manipulated by a person 'playing computer,' who doesn't explain how the interface is intended to work" (Snyder, 2003, p. 4).

These design processes exemplify the principles of design for usability: early focus on users and tasks through developing an understanding of the users and their characteristics, empirical measurement by observing users interacting with prototypes and simulations, and an iterative design process composed of a cycle of design, test, measure and redesign, repeated as much as required (Gould & Lewis, 1985).

As well as an instructional design theory, the GATE theory also includes elements of an instructional design process suitable for educational video game design for those who wish to use the theory to design their own game. This process was heavily influenced by user-centered design and rapid-prototyping, as it recommends iterative cycles of design using prototypes early and often to evaluate the educational game. Finally, the GATE theory was also influenced by the design of video games for education, which will be discussed next.

Entertainment Video Game Design

Just as the GATE theory was heavily influenced by various instructional theories, as its focus is on educational video games, it was also influenced by commercial, entertainment video game design. While designing video games for entertainment is not standardized, there is a general structure to the typical design process.

Crawford (1982) identifies the following phases of the game design process: choice of a goal and topic phase, research and preparation phase, design phase, pre-programming phase, programming phase, playtesting phase, and post-mortem phase. The design phase is further broken up into defining the input and output structure of the game,

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the game structure itself (which defines the rules of the game system to reflect the design goals of the topic), the program (code) structure, and evaluation of the design. Since Crawford published his book in the 1980s, video games have become increasingly more complicated and recommended design processes have changed to stress an iterative and non-linear approach to game design. However, Crawford's strong focus on identifying an overarching design goal which will drive the structure and overall design of the game should be noted, and his identified process stages are still largely reflected in current design processes.

Current design processes recommend an iterative approach with frequent prototyping (Adams & Rollings, 2007; Fullerton, Swain, & Hoffman, 2004). Fullerton et al. stress the importance of physical prototyping, meaning creating playable prototypes using pen and paper or other craft items, and using user playtesters as soon as possible. These concepts echo the foundations of rapid-prototyping, paper prototyping, and user-centered design mentioned earlier and had a strong impact on the GATE theory.

The iterative process recommended by Fullerton et al. has four key phases: generate ideas, formalize ideas, test ideas, and evaluate results. These phases are composed of seven steps executed iteratively which span the phases: brainstorming, physical prototype, an optional presentation phase to secure funding or demonstrate game concepts, software prototype, design document, production, and quality assurance.

They also identify challenge, play, and story as the key components making up an engaging gameplaying experience. When designing for challenge, they recommend considering the following issues: reaching and exceeding goals, competing against opponents, stretching personal limits, exercising difficult skills, and making interesting choices (Fullerton, Swain, & Hoffman, 2004). Appropriate challenge is a key concept for engagement, mentioned previously in the instructional theory section on motivation and engagement. Papert (1998) uses the term “hard fun” to refer to the enjoyment that video game players experience from successfully completing a difficult task. Challenge is a large element of the enjoyment from and engagement with a game.

Likewise, Fullerton et al. (2004) state that the following issues regarding play should be considered: living out fantasies, social interaction, exploration and discovery, collecting, sensory stimulation, self-expression and performance, and construction or destruction. They note the following “fun killers” in games which should be avoided: micromanagement, stagnation, insurmountable obstacles, arbitrary events, and predictable paths.

Adams and Rollings (2007) identify a three stage, iterative design process composed of: concept stage, elaboration stage, and tuning stage. The concept stage entails the following steps: get a concept, define an audience, determine the player’s role, and fulfill the dream, which echoes Crawford’s focus on having a design goal to drive the game design and experience. The elaboration stage is composed of the following steps: define the primary gameplay mode (meaning the type of gameplay and user interface comprising typical play in the game), design the protagonist, define the game world, design the core mechanics, create additional gameplay modes, design levels, write the story, and build, test, and iterate. Finally, the tuning stage refers to polishing the overall game.

In analyzing entertainment game design, Dickey (2005) identifies the following elements of interactive design: setting, characters and roles, and hooks “that afford actions and feedback to the players" (p. 75). She notes the goal-oriented, rule-bound nature of game structure, and discusses how interaction is defined by supported player actions and choices taken to overcome obstacles. She cites Howland as identifying the following types of hooks: "action hooks, resource hooks, tactical and strategic hooks, and time hooks" (Dickey, 2005, p. 77).

Fullerton et al. (2004) present the following effective decision types for players in video games: informed decisions, dramatic decisions, weighted decisions (requiring a balanced decision based on consequences on both sides of the choice), immediate decisions, and long-term decisions. They further identify three negative decision types which should be redesigned or removed from the game: hollow decisions (which hold no real consequences), obvious decisions, and uninformed decisions (which are based on arbitrary choices).

Adams and Rollings (2007) identify the following common challenges presented to players in games: physical coordination challenges, logic and math challenges, races and time pressures, memory challenges, pattern recognition challenges, exploration challenges, conflict challenges (which require the direct opposition of forces), economic (or resource) challenges, and conceptual reasoning and lateral thinking puzzles.

In defining player choices in games, Salen and Zimmerman (2004) break down the anatomy of a choice through the following five questions which the game designer must answer:

1. What happened before the player was given the choice?
2. How is the possibility of choice conveyed to the player?
3. How did the player make the choice?

4. What is the result of the choice? How will it affect future choices?
5. How is the result of the choice conveyed to the player?

These game design processes, components, and questions helped guide the researcher to identify important aspects of the game design process which were incorporated into the GATE theory, which includes methods that address the design of educational video games. These elements, synthesized with the previously identified attributes of contributing instructional theories, set the foundation for the GATE theory and its methods. In the next section, the GATE theory will be presented and its methods explained.

GATE Theory Overview

The Games for Activating Thematic Engagement (GATE) theory was built on the foundation of the theories discussed in the previous sections and also seeks to provide process guidance for instructional designers to design and develop their own educational games. The researcher was inspired to explore the use of educational games primarily due to his own experience with educational games, both good and bad. The first educational game the researcher encountered was a popular one, still heavily used in schools today: *The Oregon Trail*. While this game has proved to be a financial success for its creator and no doubt has been used effectively in some contexts, the researcher's own experience with the game in school was that he was directed to play it as part of class and did so, but no effort to garner any learning from the experience was ever made by his teachers. Therefore, the lasting lessons learned from the game for the researcher are that it was fun to shoot deer and rabbits, but the pioneers could only carry so much meat back to camp. This is likely not the learning goal the teachers had in mind and shows the futility of introducing educational games without requiring students to reflect upon their game-playing experience and recognize what learning took place.

Another example of an educational game the researcher experienced as a child was the *Lemonade Stand* game. This game challenged the player to maximize profits by spending resources, advertising, dealing with the unpredictability of the weather, and other issues. Again, this game was played without any direction toward learning, but the potential for learning is clear.

Finally, as a graduate student, the researcher encountered an effective educational game that was implemented with directions and activities to reflect on the gameplay experience and identify underlying themes and concepts related to the course material. The game in this case was the *Diffusion Simulation Game*, a game dealing with implementing change in a school system.

The *Diffusion Simulation Game* (see Figure 3) is a text-based educational game to which students in the researcher's graduate program are typically introduced in their first year in the program. It is a Web-based version of an educational board game designed by Dr. Michael Molenda several decades ago which aimed to help students understand how to best implement change in a school system.

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Note: From "Diffusion Simulation Game: Welcome and Login: Instructional Systems Technology, School of Education, Indiana University Bloomington" http://education.indiana.edu/~istdemo/guest.html. Indiana University.

The researcher played the Web-based version as part of his class and, following a class debrief on the experience, was highly impressed by the game and was convinced that it was not only an effective instructional tool, but also highly motivating, given that some of his classmates had played the game in excess of ten times, trying to get a perfect score.

The game uses turns where players can choose an action, such as speaking with various stakeholders, or conducting training. These actions can unlock other actions, or access to other stakeholders, and the resulting gameplay is effective in conveying relationships between these concepts and in allowing players to gain some of the benefits they would experience from trying to implement change in a real-world situation without the real ramifications that come from making mistakes.

One important lesson learned from playing the *Diffusion* game in class was that without the class debrief, it was very easy to not attend to educational content in the game and instead focus solely on the gameplay. By reflecting and participating in the class discussion, students were able to meta-cognitively reflect on the strategies they applied, what worked in the game and did not, and how this related to a real world change effort. It was clear from this experience and the researcher's past experience with educational games that educational games would not be nearly as useful without requiring the players to reflect upon the gameplay experience and identify what learning occurred.

Goals and Preconditions

The primary goal of the GATE theory is to foster understanding and engagement with a topic in a motivating, interesting, and entertaining learning environment through the use of video games. Furthermore, the theory seeks to also specify a design process to guide the design and development of an educational video game; although it is also suitable for adapting pre-existing commercial off-the-shelf games for instruction. More on adapting existing games will be discussed later. This theory is appropriate for developing understanding of related themes and topics and for exploring ill-defined problems. The preconditions for application of this theory are based on the kinds of topics chosen for the instruction, as this theory does not address the instruction of basic skills, such as literacy, which might be requisite for true understanding of a given topic.

Values

Some the values upon which this theory is based include:

- Instruction should be interesting, enjoyable, entertaining, and engaging.
- Instruction should encourage creativity, critical thinking, divergent thinking, and experimentation.
- Instruction should be tailored to meet specific students' needs and goals while still requiring students to meet minimum, broad requirements.
- Instruction should encourage collaboration and debate.
- Instruction should promote meta-cognition and self-awareness.
- Instruction should not be limited by available technology or media, but should be adaptable to various learning resources and environments.
- Instruction should result in understanding, measured through learner performances.

Methods

The methods this theory offers include: (1) develop a context, problem space, or world of experience and supporting implementation structure, (2) prepare learners to benefit from game and implement game as designed and (3) provide feedback. Each of these is overviewed next prior to a more detailed discussion later in this chapter.

1. Develop a Context, Problem Space, or World of Experience and Supporting Implementation Structure

1.1. Select a topic or multiple topics which can be connected by themes.

1.2. Define supported learning objectives.

1.3. Analyze intended learning environment, learner attributes, and design environment in order to establish available resources and constraints, conduct feasibility and return on investment analyses, and specify scope.

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1.4. Define rules of context and overall structure of game, including story, goals, objects, supported actions, feedback, learner roles, and embedded values.

1.5. Promote desired learning opportunities through introduction of key obstacles, problems, and plot elements within the game and the implementation.

1.6. Design specific implementation guidelines and artifacts, including external activities and potential demonstrations of mastery.

1.7. Focus on engagement with the topic: incorporate and encourage competition and immersion through supporting learner control, challenge, fantasy, and curiosity within both the game and the implementation.

1.8. Design and develop the game through an iterative process which includes cycles of prototyping, evaluation, and redesign.

2. Prepare Learners to Benefit from Game and Implement Game as Designed

2.1. Prepare the learners for reflection and analysis.

2.2. Provide explicit instructions for recognizing and maximizing embedded learning opportunities.

2.3. Provide learners control in choosing actions and/or selecting their own goals through linked modules or "episodes", depending on scope.

3. Provide Feedback

3.1. Feedback should be provided within and outside the game in a natural way that fits with the context as well as the learning goals.

3.2. Learner interaction should be incorporated and encouraged, whether within or outside the game.

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3.3. Learners should demonstrate their understanding of themes, topics, and concepts through varied and multiple performances, within and outside the game.

Overarching GATE Values

Specific values behind the GATE theory were provided previously in this chapter. This section will detail the overarching values behind the earlier values and the theory in general. These include the importance of promoting understanding, engagement, and of understanding the need to be practical and realistic when setting the scope of educational games being developed.

The Value of Understanding

There are many goals in education; students are taught the skills of literacy so they can access others' ideas, and the skills of basic mathematics so they can balance a checkbook. However, it a common experience in today's educational environment that learning for students often stops with rote knowledge and a rudimentary understanding of skills. Students may memorize a line of Shakespeare, but they have no idea what it means; they may know the year of the American Revolution, but they have no understanding of how the underlying themes of the rebellion continue to impact their lives. Gardner notes the overwhelming number of studies which show that top-rated college and high school physics students have repeatedly demonstrated an inability to apply their knowledge in new situations (1999). The goals of today's educational system focus on standardized and often rote, easily measured knowledge. The system claims that it is built to ensure that no child is left behind; however, again and again, learners facing unique challenges are left behind, while other learners see their thirst for knowledge forever slaked when forced to slow their pace and limit their exploration. In today's information age, it is important that the way in which learners are taught is truly learner-centered and promotes a holistic, systemic understanding rather than the cookie-cutter, fragmented knowledge of the industrial age as today's workforce requires employees who are problem-solvers, can synthesize knowledge, and work well in teams (Reigeluth, 1999b). Furthermore, today's learners are also drastically different in both their approach to education and their need for engagement (Beck & Wade, 2004; Prensky, 2006).

While this theory stresses understanding, it does not claim that rote knowledge is worthless. On the contrary, certain basic skills and knowledge are required before higher-level understanding, critical thinking, and analysis can be expected. While it is certainly not impossible to teach literary analysis without the use of basic literacy skills, it is likely more challenging. However, this theory is designed to specifically address the formation of understanding of important themes, topics, and concepts as well as how they interrelate.

As a byproduct of the formation of this understanding, critical-thinking and analytic and meta-cognitive skills should be developed. More basic knowledge and skills certainly have a place in this theory, but only as tools used in the formation of the understanding, and not as primary goals. It is important to note, however, that through immersion in the virtual environment resulting from the application of this theory, factual knowledge can also be developed, but it should only be as a byproduct of the environment, and not as a primary goal of the instruction; a more thorough discussion of this will follow shortly. It is important to state again, however, that the true goal of this theory is the development of systemic and deep understanding as well as engagement with the topic, and this theory is therefore applicable to any environment, whether it is K-

12, higher education, or corporate, that focuses on developing and applying understanding and exploration of and engagement with inter-related themes. Any pre-requisite knowledge or skills are therefore specific to the chosen topics or themes.

The Value of Engagement

While the value of developing understanding in the information age has been stressed, it is perhaps not as important as the value of making learning fun and engaging learners with the topic to be learned. Stating that learning has to be made fun shows how ineffective the current state of instruction has become, as humans are naturally inquisitive and voracious learners. Furthermore, current learners who Beck and Wade (2004) identify as the Gamer Generation, and who Prensky (2006) calls Digital Natives naturally crave engagement and become quickly frustrated when they do not receive it.

Perhaps the primary tenet of this theory of instruction is that learning must be engaging. If learners become engaged with a topic and seek to truly understand it, they are more likely to recognize the value of the knowledge and how it relates to their own lives. Fun is also a byproduct of the choice that will be given the learner in shaping his or her own learning goals, as well as the interaction of the learner with his or her peers and instructor, who will challenge, provide feedback, and aid in developing the learner's understanding. However, even though the innate joy of learning can be realized through a more autonomous, challenging, and interactive environment than the current paradigm of instruction typically allows, this theory incorporates an additional feature to try to maximize the learner's fun: video games.

Video games have exploded from a niche pastime into mainstream society in the last few years. Not only are video games an extremely popular form of entertainment, but they are also a tool fertile for applying the concepts of the new paradigm: learner initiative, trial and error in a safe environment, and the application of advanced technology (Reigeluth, 1999b). Video games stress skills such as problem-solving and attributes such as a willingness to experiment. When including simulation games in the picture, the advantages of real-world environments and tasks are added. Furthermore, video games are a tool with which today's learners likely are familiar. Video games are becoming the choice of the information age generation for fun, and clearly mesh well with the demands of the new paradigm and therefore are the focus for this theory of instruction.

An Argument for Practicality

As a new technology, video games have not only a great deal of power, but also a number of challenges for the instructional designer. The development of a game or simulation can cost millions of dollars, requires a strong team of designers with varied talents, and can take years to complete (Aldrich, 2004). However, a video game does not need to be a multi-million dollar, precise simulation in order to be effective. If this theory could only be successful if it resulted in developing an educational game more fun or technologically advanced than the current top commercial entertainment game on the market, it is unlikely that the theory would ever actually be applied.

Internet short films have showed great success at telling stories despite the often simple techniques and low-budgets of some of the home filmmakers who have made them (having recently been added as a new award category at the Sundance Film Festival). In a similar way, a video game, even an entirely text-based one, can still be compelling and fun. MUDD's (Multi-User Dungeons and Dragons games) continue to entertain thousands of gamers on the Internet despite the fact that they are entirely text-based. Salen and Zimmerman (2004) describe the focus on dazzling technology as "the immersive fallacy" (2004, p. 450), which is "the belief that the pleasure of a media experience is the ability of that experience to sensually transport a player into an illusory reality" (p. 458). They note that this fallacy is particularly pervasive in the gaming industry but argue that it ignores the "metacommunicative nature of play" (p. 458), meaning that players are aware of the frame of a game as separate from reality.

Furthermore, the availability of such tools as Adobe's Flash software, the Gamemaker game development kit, and the modification of existing commercial games such as Neverwinter Nights, puts the power of game-creation in the hands of everyday users. High schools and universities should not be surprised to find students capable of creating an effective game utilizing these technologies on their campus. The design of the game should be the focus for instructional designers and developers. The limits of available technology will continue to fall away, but the capacity for the development of successful, inexpensive, instructional games currently exists.

GATE Methods

The primary tool of this instructional theory is a video game used as part of an environment for facilitating understanding. As summarized earlier, there are three primary methods for the development of this learning environment: developing the context, problem space or world of experience; preparing learners to benefit from game and implement game as designed**;** and providing feedback to the learner. Undoubtedly, the most challenging of these three methods is the one which must be done first, the development of the video game environment.

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1.0 Develop a Context, Problem Space, or World of Experience and Supporting Implementation Structure

The first GATE theory method is composed of the following sub-methods:

1.1. Select a topic or multiple topics which can be connected by themes.

1.2. Define supported learning objectives.

1.3. Analyze intended learning environment, learner attributes, and design environment in order to establish available resources and constraints, conduct feasibility and return on investment analyses, and specify scope.

1.4. Define rules of context and overall structure of game, including story, goals, objects, supported actions, feedback, learner roles, and embedded values.

1.5. Promote desired learning opportunities through introduction of key obstacles, problems, and plot elements within the game and the implementation.

1.6. Design specific implementation guidelines and artifacts, including external activities and potential demonstrations of mastery.

1.7. Focus on engagement with the topic: incorporate and encourage competition and immersion through supporting learner control, challenge, fantasy, and curiosity within both the game and the implementation.

1.8. Design and develop the game through an iterative process which includes cycles of prototyping, evaluation, and redesign.

This section will detail each of these sub-methods which compose the first method for the GATE theory.

1.1 Select a topic or multiple topics which can be connected by themes. The first step in actually designing the video game is to determine what context the game should present to the learner. Therefore, the first step in developing the context in which the learners will find themselves is to decide on a topic or a few topics which can be related by themes. The themes will drive what type of context the learner will interact with.

1.2 Define supported learning goals. Along with the identification of the topics and themes on which the game will focus is the identification of what learning goals will be supported. These elements relate to each other because in order for learners to have a choice of goals for their learning, the designer must build support for these goals into the game. Therefore, a strong analysis must be done on what learning goals will be supported and what themes and topics can be used to reflect these goals. These two elements are at the center of the entire design process. Unlike an entertainment game, which initially focuses largely on the gameplay or story, it is very important in an educational game that the learning goals remain firmly the center of the entire design process (see Figure 4).

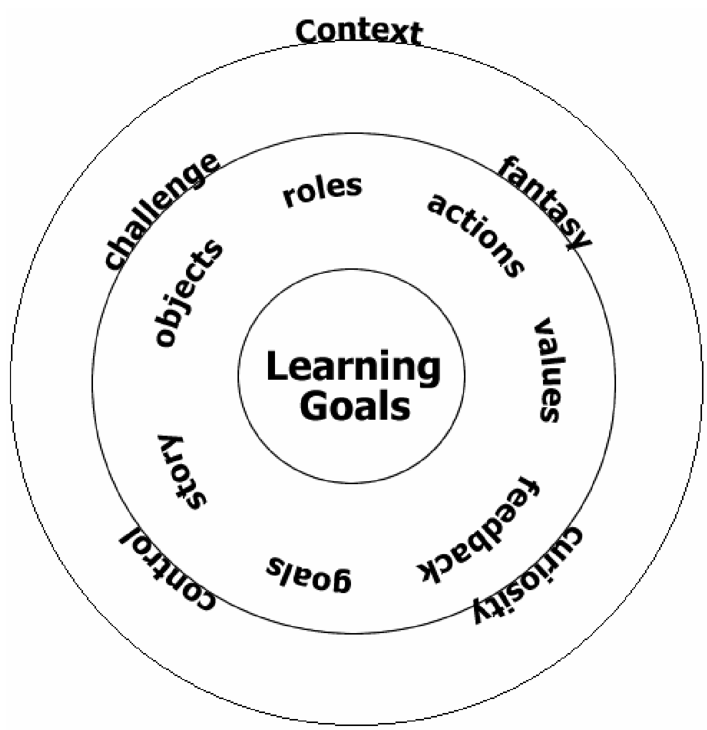

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Figure 4. Components for defining the context of an educational video game with learning goals as the focus.

1.3 Analyze intended learning environment, learner attributes, and design environment in order to establish available resources and constraints, conduct feasibility and return-on-investment analyses, and specify scope. Apart from specifying a preliminary definition of the learning goals and the topic or themes for the context, it is also important that an initial analysis of how the game will be implemented should be conducted in order to determine the scope of both how the game will be used and how complex the gameplay and structure will be. Educational games can be used in varying ways with varying breadth of scope. Van Eck (2006) notes that educational games can be used as a pre-instructional strategy, such as an advance organizer, as a co-instructional strategy, or as a post-instructional strategy. This is indeed true, but games can also be implemented as the sole instructional strategy. The entire three credit ECON 201 course at the University of North Carolina at Greensboro can be taken as an online video game (Boyce, 2006). It is therefore important to define the intended scope of the education game, whether it is to be used for a component of a single lesson, the primary content of a single lesson, of a series of lessons, or indeed of an entire course, or even beyond.

It is also important to determine the environment in which the game will be implemented. Will it be implemented in a face-to-face course? In an online course? In a hybrid course? In multiple courses? The answers to these questions will help to identify the intended learners, who can then be analyzed to further specify the learning goals.

How the educational game will be used and the environment in which it will be implemented will also help to determine the game's structure. Is it intended to be played within the classroom? If so the structure of the game will be impacted by the time available during a class period. Furthermore, if the learners have limited access to technology inside the classroom or at home, this can constrain what technology the game utilizes.

Finally, the resources available to the design team may also help to determine the scope and complexity of the game. Given a broad enough impact, such as a game that fits state standards, or seeks to engage K-12 students in science, technology, engineering, or math (STEM) subjects, the return on investment would justify a broad scope and high level of complexity. A game of broader scope and higher complexity will naturally cost more to develop but should be worth it. On the other hand, if a game is being developed for one lesson in a single course that will only be offered once, it should be decided if the benefits will be worth the cost in resources and time to develop, given that it likely will only be used once.

1.4 Define rules of context and overall structure of game, including story, goals, objects, supported actions, feedback, learner roles, and embedded values. Related to *defining the context* for the game and the *learning goals* it will support is *defining the rules* for the game and its overall structure. These three components all relate closely to each other, as they will determine the style and format of the game.

A strong element of defining the game and its rules is determined by the theories and topics chosen and vice-versa. A theory could be illustrated through an entirely fictitious world or through one based on history. Either choice would have its own pros and cons. A fictional world can allow for easier abstraction or use of metaphor, while a realistic world can allow for the delivery of additional knowledge such as geography or biographical data and the possibility of a more clearly defined relevance to the learner due to an easier and more natural transfer to real world situations. Similarly, realistic world rules could illustrate laws of nature or laws of man, while still allowing for some elements of fantasy such as granting the player superhuman abilities such as flight or invisibility to open the door for all sorts of additional opportunity for exploration. Whatever rules are chosen for the game, they should support the identified topics and theories and fit naturally within the overall context. The rules must be logical or natural enough to promote immersion and not destroy belief in the realism of the world, even if it is a fictional one. This can be illustrated by how a historical drama with poorly written dialogue can be seen as ridiculous even if it is more "realistic" than a science fiction movie. Ideally, the world should present realism through its use of rules and its support of actions that should be possible in the context, whether it is a real-world context or fantastical (Merrill, 1999).

The structure of the narrative is another element which must be defined. A complete narrative allows for a sense of completion, and a more controlled story arc can better allow the transfer of key concepts or better illustrate the inter-relatedness of certain themes. An open-ended context allows for more exploration and gives the learners the opportunity to write their own narratives. All of these considerations must be examined and defined. The strength of the narrative can be a strong motivational factor and a big part of the fun aspect of the game.

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Once defined, the context should support identified learning goals, theories and concepts. A number of different goals should be supported to allow for learner choice. The environment should make available broad, related concepts or themes which allow for exploration and the presentation of more precise concepts (Reigeluth, 1999a). These concepts can be presented as modules or "episodes" that fit within the overall narrative structure (Reigeluth, 1999a). This will further encourage the learner to revisit the game to explore additional concepts.

The game should also support exploration. This means that the learner should be given time for non-goal driven exploration and experimentation of the environment. If the learner finds a pond, let him or her fish! Little elements like this help with immersion in the environment and can be motivating. The environment should also provide hard-to-find and hidden elements in order to encourage exploration. Sometimes the environment itself can be a motivation. The rules of the environment should also offer enough varied system responses to be largely non-predictable, in order to encourage experimentation. Thomas Edison claimed that he failed his way to success, and this is an approach cultivated by the gaming generation. Build in support for multiple approaches to solving problems, as the learners will enjoy experimenting, and this is an attribute which should be cultivated in today's learners. The virtual environment is a good fit for the requirement of a "safe" environment that can be so important to encouraging experimentation and exploration (Kamradt & Kamradt, 1999).

1.5 Promote desired learning opportunities through introduction of key obstacles, problems, and plot elements within the game and/or the implementation. Ultimately, in defining the game and its structure, one of the key components, as mentioned in the previous section, is what learner actions are supported in the game and what responses and feedback to those actions the game will provide. This key component is so critical that it deserves further elaboration in this section. For an educational game to be engaging and therefore encourage learning, it is important that all components, especially actions, be realistically situated within the context. Salen and Zimmerman (2004) note the importance of this, stating:

> Meaningful play in a game emerges from the relationship between player action and system outcome; it is the process by which a player takes action within the designed system of a game and the system responds to the action. The meaning of an action in a game resides in the relationship between action and outcome…. Meaningful play occurs when the relationships between actions and outcomes in a game are both discernable and integrated into the larger context of the game (p. 33)

In a game, players will encounter various obstacles, impediments, or problems which they must solve. The players will make choices in how they attempt to overcome these problems, choices made through their actions in the game. As previously mentioned, Salen and Zimmerman (2004) identify five questions that, when answered, define the choices available in a game:

> What happened before the player was given the choice? How is the possibility of choice conveyed to the player? How did the player make the choice? What is the result of the choice? How will it affect future choices? How is the result of the choice conveyed to the player? (pp. 63-64)

1.6 Design specific implementation guidelines and artifacts, including external activities and potential demonstrations of mastery. While the dream of educational video games is that learners will not be able to avoid learning while playing the games, the reality is that learning is not likely to occur unless the learners are encouraged to attend to the learning opportunities embedded in the game. Numerous researchers have stated that learning with educational video games is not likely to be effective without additional instructional support and effective strategies for implementation (Leemkuil, de Jong, de Hoog, & Christopher, 2003; O'Neil, Wainess, & Baker, 2005; Wolfe, 1997). It is therefore very important that the educational game designers not only design the game with learning in mind, but also design specific guidelines for how the game should be best implemented. Sound instructional design does not end with the game, but should instead equally focus on what additional instructional supports are needed outside of the game to maximize the potential for learning.

Complete instructional artifacts and guidelines must be created, whether these materials are intended to be distributed by an instructor within a classroom environment or posted on the Internet to be used as part of an online game without monitoring by an instructor. Furthermore, designers should create these materials for a variety of situations, so that sound external instructional support is specified for whatever contexts in which the game might be applied.

The environment in which the game will be implemented should also be considered when taking in mind how it will be used. No matter how engaging a game might be, if it is a small component of a larger course which otherwise is not at all learner-centered in its approaches, whatever positive impact the game has in engaging the students may be eroded by the rest of the instructional approaches utilized during the course, and benefits may be limited to the scope of materials that the game itself covers. The impact of the game could likewise be further leveraged by implementing it in a learning environment that is learner-centered in all of its approaches. The designed implementation of the game could therefore well-serve instructors implementing the game by giving them examples of learner-centered instruction.

1.7 Focus on engagement with the topic: incorporate and encourage competition and immersion through supporting learner control, challenge, fantasy, and curiosity, within both the game and the implementation.

While learning goals are the focus of educational video games, engagement is extremely important as well, as it is the outcome which has led to the medium being touted for its instructional potential. It is therefore important very early in the design process to focus on how the game will engage learners. Howland (2002) defines a hook as “anything that requires the player to make a decision that relates to the game, and thus keeps them playing” (p. 78). As previously mentioned, he identifies four types of hooks: action, resource, tactics, and time. In defining the structure of the game, designers will have to decide what kinds of hooks are appropriate for engaging students while matching with the given topic. Gardner identifies techniques for engaging students in their search for understanding as “entry points”, which include narrational, social, hands-on, and aesthetic approaches, among others (1999). Video games utilize similar approaches with role-play, story, social interaction with other players, the aesthetics of the virtual world, the ability to explore, rewards for performance, and competition, whether it be with other players or with the game itself.

As previously discussed, in examining the motivational components of video games, Malone (1980) identifies four components that help make games motivational: control, challenge, fantasy, and curiosity. These components echo the preconditions of Flow Theory, a theory on motivation frequently utilized to explain the state of flow video game players often achieve, where they become so focused on the game play, that they are completely immersed in the experience and lose track of time and self-consciousness: a challenging activity, clear goals, feedback, and the paradox of having control in an uncertain situation (Csikszentmihalyi, 1992).

The narrative basis of the context and the role-playing opportunities provided clearly support players' fantasy, while the ability to explore or see how the story ends or the various ways in which it might end support curiosity. Control and challenge then are clearly tied to player control and the introduction of obstacles in the game, both covered in later sections.

Finally, the introduction of competition can really enhance the motivation and fun factor of the game. A scoring or feedback system should be supported to allow learners to evaluate their performance by comparing it to their peers or acceptable standards or competency levels. This is the first component of feedback provided to the students and also encourages competition. Rewarding learners for certain actions and punishing them for others within the context of the game is a way to support comprehension of concepts and even provide an element of affective instruction through the display of the effects of moral and immoral actions by players. Additionally, immersion in the virtual environment can be further enhanced by “tangible” rewards that are granted for completing goals, whether virtual “badges” for a learner’s avatar, or physical rewards for the learner himself or herself.

1.8 Design and develop the game through an iterative process which includes cycles of prototyping, evaluation, and redesign. The process of design and development should focus on cycles of design, development of prototypes, testing of the prototypes for evaluation and then redesign. Game development texts are consistent in their call for this process (Novak, 2005; Rouse, 2005), and it is also echoed in instructional design strategies such as rapid prototyping (Tripp & Bichelmeyer, 1990).

Prototypes, including paper prototypes, should be created early and often in the process. This can allow for early testing of game mechanics as well as the game’s user interface. User feedback from these evaluations can help ensure that appropriate feedback and gameplay difficulty are built into the game. Furthermore, it can help identify what gameplay components are aiding and impeding player engagement.

During this iterative process, designers will document the design decisions. While there are no standard documents in game design (outside of the general and not precisely defined design document), literature in the area is conceptually consistent on the sorts of documentation that might result from a game design process. By examining these examples, and adjusting for the further requirements of an educational video game, a reasonable outline of suggested documentation that will result from this process can be created. This outline further clarifies the sorts of decisions that will need to be made during the design process.

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Suggested documentation adapted and modified from Novak (2005) and Rouse (2005) includes:

1. Concept Document, Pitch Document, or Proposal
2. Design Document
    a. Table of Contents
    b. Introduction/Overview
    c. Target Audiences and Implementation Context
    d. Learning Objectives
    e. Hooks
    f. Game Mechanics
    g. Artificial Intelligence
    h. Game Elements (characters, items, and objects/mechanisms)
    i. Story Overview
    j. Game Progression
    k. User Interface
3. Implementation Artifacts and Guidelines (organized by implementation situation)
4. Flowcharts
5. Story Bible
6. Script
7. Art Bible
8. The Game Minute (detailed description of a short section of gameplay)
9. Storyboards
10. Technical Design Document

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11. Schedules and Business/Marketing Documents

2.0 Prepare Learners to Benefit from Game and Implement Game as Designed

Designing and developing the game is the most difficult aspect of implementing this theory. However, there are a number of things to keep in mind when preparing the learners as well because if the game is not properly implemented, it is unlikely to be successful. The following sub-methods compose this method and are discussed in detail in this section:

2.1 Prepare the learners for reflection and analysis.

2.2 Provide explicit instructions for recognizing and maximizing embedded learning opportunities.

2.3 Provide learners control in choosing actions and/or selecting their own goals through linked modules or "episodes", depending on scope.

2.1 Prepare the learners for reflection and analysis. It is important that prior to playing the game, the learners be prepared to reflect on and analyze their experiences. Ultimately, the game is a learning activity, and while students should be engaged with playing it, they should be reminded ahead of time to attend to what choices they make and what results and feedback they receive in response so that they are better able to recall and make explicit what they learned during the play experience.

2.2 Provide explicit instructions for recognizing and maximizing embedded learning opportunities. As support for the implementation is designed along with the game itself, these artifacts should then be implemented alongside the game playing activity. Having been prepared for how they will be asked to further practice, demonstrate, and verbalize their learning, learners should be provided clear instructions for what further supports are in place and what other activities besides playing the game they will be responsible for.

2.3 Provide learners control in choosing actions and/or selecting their own goals through linked modules or "episodes", depending on scope. If the context has been properly defined, it should support multiple learning goals and may tie together multiple themes. These themes and learning goals should be presented as related episodes, modules, plot lines or embedded activities and situations which fit naturally within the context or environment. By allowing learners to choose which episode they wish to pursue or how they will interact with the environment, learners will have some control over their goals and the opportunity to take different paths or make different choices during the game.

Furthermore, role-playing can be a powerful motivator as well as a powerful learning approach. Allowing learners the choice over the role they will take in the game and even giving them some control in the design of their avatar within the game can be extremely effective in fostering interest and learning.

Role-playing within the game should be encouraged. Allowing learners to fully express the role they have chosen can lead to wonderful discussion and feedback from peers. Learner choice should not be limited to within the video game, but should also be designed in the outside learning environment. Allowing students to make choices in how they will demonstrate their understanding of concepts is another consideration which will be further discussed in the feedback section. Finally, although learner choice is important, it is imperative that vital topics not be missed by learners. Therefore, exploration of some concepts may be restricted until certain minimum requirements or learning goals have been met. This is a common structure of video games where a level must be cleared, or a goal completed, before the player is allowed to continue.

3.0 Provide Feedback

The third and final GATE method is to provide feedback. It is composed of the following sub-methods which this section will detail:

3.1 Feedback should be provided within and outside the game in a natural way that fits with the context as well as the learning goals.

3.2 Learner interaction should be incorporated and encouraged, whether within or outside the game.

3.3 Learners should demonstrate their understanding of themes, topics, and concepts through varied and multiple performances, within and outside the game.

3.1 Feedback should be provided within and outside the game in a natural way that fits with the context as well as the learning goals. The final component of the learning environment design is defining how feedback will be provided to the learner. As mentioned earlier, some elements of feedback will be designed into the game, through the scoring system as well as system responses to learner actions. This sort of feedback should be provided in a quick and natural way that fits with the context and learning goals selected by the learner and supported by the themes chosen for the context. Furthermore, the episodic nature of a video game can provide stopping points or areas in the game to encourage reflection on feedback

3.2 Learner interaction should be incorporated and encouraged, whether within or outside the game. Learner interaction should be encouraged both within the virtual world and outside it. A multi-player environment would allow for increased learner interaction. In this situation, the game should allow varied and realistic communication between learners. If the technical demands of a multi-player environment disallow this sort of interaction, then the game should still demonstrate that cooperation and interaction are beneficial to achieving goals and solving problems through learners' interaction with game personalities. Even if a game is a single player experience, learner interaction should take place outside of the game environment. Learners should share experiences and reflect on them together, sharing strategies that worked or did not work within the game and analyzing together what could be learned from these experiences.

3.3 Learners should demonstrate their understanding of themes, topics, and concepts through varied and multiple performances, within and outside the game. Feedback should only begin with the video game. It is extremely important that additional feedback be provided outside of the video game environment. This feedback will be used to have learners demonstrate their understanding of themes, topics, and concepts. Varied and multiple performances by the learners should be used in order to support different learner mindsets. Group discussions, small-group discussions, reflective essays, fictional stories based on the game, research reports, and the creation of art are all examples of techniques for having the students demonstrate their understanding of concepts and theories and receive feedback from their peers and instructor. The learners should be given a good deal of choice over how they demonstrate their knowledge to better facilitate the unique strengths of each learner.

The instructor should help scaffold the knowledge gained and encourage discussion within the class over offered theories and encourage a creative, questioning classroom environment. Affective and cognitive learning goals should be kept in mind when debriefing learner experiences (what did the learner do, what were the consequences, what alternatives might have been chosen, what can be learned from this) (Stone-McCown & McCormick, 1999). Learners should elaborate on how and what they learned through their involvement with each scenario or episode in order to more firmly establish this knowledge in their minds, in addition to generating more practice at meta-cognitive self-reflection. Classroom norms for giving feedback should be predetermined by the learners in order to extend the safe environment of the virtual world into the real-world classroom.

GATE Context Examples

While the GATE theory is consistent in how it is to be implemented, some examples are provided in this section to explain how it can address different contexts. The theory consistently puts a focus on the game supporting multiple learning goals, but it has also highlighted the potential of using a game for learning across multiple topics or themes. While this approach would likely increase the scope of the game to be designed, it provides a powerful way to further motivate students and show the relevance and relationship of different topics that might look unrelated on the surface.

The GATE theory is also suitable for adapting an existing game for learning rather than designing one from scratch, the approach currently most commonly practiced. In this case, the designers should choose an existing game that incorporates a suitable topic or themes that has enough of a match with the academic topic of interest for successful use. The game should then be analyzed to identify what sort of learning and values are embedded in the game and to ensure that they are appropriate. The primary design activities will then focus on designing how the game will be implemented.

Finally, as mentioned previously, games can be implemented in varying contexts. The GATE theory applies equally to games that will be implemented within the classroom and therefore must be able to be completed within a class period, and games that are to be played at home, and therefore have no such time constraints. This will primarily impact the structure of the game and considerations of how the game will be saved or what the overall length of the game should be.

Conclusion

This instructional theory focuses on two primary components: the importance of understanding over surface knowledge and the power of video games as a tool for engaging learners and facilitating the growth of knowledge. While the design of a video game can be a daunting task, inexpensive tools are currently available, and the demand from the learners certainly exists. The inclusion of video games as the central component in a learning environment and the support of this tool for instruction within a learner-centered, active learning environment which requires students to demonstrate their knowledge should result in a fun and effective learning environment which fits the demands of the information age very well.

The purpose of this study is to evaluate the GATE theory by answering the following questions: 1.) What GATE methods and recommendations work well? 2.) What ones do not work well? and 3.) What improvements can be made? The next chapter will detail the methodology utilized to answer these questions.

CHAPTER 4: METHODOLOGY

Introduction

This study used a qualitative research design known as formative research in order to improve an existing design theory for designing and implementing educational video games. This chapter presents the methodology behind the study, first examining the philosophical foundations of inquiry. It then presents the rationale behind choosing a qualitative methodology, provides some assumptions behind qualitative research, and then reviews the formative research methodology and the design of the study. Finally, it presents methodological issues related to the formative research methodology.

Philosophical Foundations of Inquiry

The methodology that a researcher chooses to implement in a study reflects his or her worldview: his or her beliefs and assumptions about research, the nature of truth, the goals of research, and the means best suited to achieving those goals, among other issues (Frankel & Wallen, 2003). Guba and Lincoln (2005) compare the philosophical beliefs reflected in the major inquiry paradigms (positivism, postpositivism, critical theory, constructivism, and participatory inquiry) by looking at three issues:

1. Ontology: What is the nature of reality and what can be known about it?
2. Epistemology: What is the nature of knowledge, where does it originate, and how can it be obtained?
3. Methodology: What are the best methods or approaches that a researcher can apply to acquire knowledge about a given issue?

The next sections will describe the researcher's views on these issues by highlighting the qualitative methodology as his chosen methodology and grounding this choice in his ontological and epistemological views. While the current view of many researchers no longer promotes a continuation of the “paradigm wars” a discussion of the reasoning behind the researcher’s approach may prove helpful and therefore positivism and constructivism will be discussed prior to highlighting functional contextualism as an alternative philosophical perspective.

The positivist paradigm of inquiry ontologically holds that a true reality exists and is knowable. Epistemologically, positivism holds that the researcher and what he is seeking to know are separate, and this separation allows for objectivity on the researcher’s part. Methodologically, positivism calls for scientifically designed experiments where variables are manipulated, isolated, and controlled in order to test hypotheses.

Qualitative inquiry is typically utilized within the other major paradigms of inquiry. While there is a blurring of the postmodern paradigm genres (Geertz, 1993), a chosen methodology will be largely driven by the paradigm the researcher identifies with.

Constructivism, ontologically holds that there is not a single knowable reality, but instead that realities are socially constructed through interaction concerning different individual views of the same event (Frankel & Wallen, 2003). Epistemologically, constructivism offers that a researcher can never be truly separate from the subject of study; and therefore, it is appropriate for the researcher to interact with the subject and together make meaning and come to agreement about what has occurred. Methodologically, constructivists gather data through interaction and shared experience.

A philosophical perspective related to constructivism but less radical than constructivism’s notion of a lack of any objective truths is functional contextualism.

Functional contextualism espouses a worldview that understanding is holistically context-bound and focuses on truth only in so far as it leads to effective achievement of a goal (Fox, 2006). Fox (2006) elaborates that the focus of functional contextualism is on the belief that science is meant to be useful, and therefore, knowledge of an event is situated in the historical and current context and cannot be separated from it, and analysis is conducted in order to help prescribe useful solutions. He further focuses on the prescriptive approach for functional contextualism and therefore identifies experimental methods as the primary methods suitable for this perspective. However, Reigeluth and An (2006) embrace the usefulness of a functional contextualist perspective in instructional design and technology, while disagreeing with Fox's focus on prediction. They argue that functional contextualism is goal-oriented, as described by Fox, and therefore focuses on solution behavior, not on predictive behavior (which is based on descriptive theory not design theory) as Fox contends.

Functional contextualism is indeed a useful perspective with its pragmatic focus and systemic inclusion of context in analysis. While this researcher disagrees with Fox's (2006) focus on predictive goals and accompanying elevation of experimental methods, Fox does state the usefulness qualitative methods do have in functional contextualism. Furthermore, Reigeluth and An (2006) reject the focus on experimental methods and instead promote design-based research methods, which often focus on qualitative tools, as preferable, for the major goal of design theories is usefulness.

Rationale for Qualitative Methodology

The rationale for choosing a qualitative research methodology for this study was, as previously mentioned, driven by the researcher's own worldview, which embraces the constructivist paradigm, and the phenomenon to be studied: an instructional design theory. An instructional design theory is foremost design-oriented rather than descriptive, meaning it focuses on means for reaching learning goals and that these means are probabilistic rather than deterministic, meaning they do not ensure attainment of the goals (Reigeluth, 1999b). As instructional design theory is not predictive in nature, a study seeking to improve requires qualitative methods while research seeking to prove requires quantitative methods. As this study seeks to improve not prove the GATE theory, it is most appropriate to evaluate the theory using qualitative methods.

According to Becker (1996) quantitative and qualitative research differ in five key ways. Denzin and Lincoln (2005) discuss these five aspects: uses of positivism and postpositivism, acceptance of postmodern sensibilities, capturing the individual's point of view, examining the constraints of everyday life, and securing rich descriptions.

Key aspects of their discussion of the different methodological viewpoints reflect this researcher's choice of a qualitative methodology, including: quantitative research focuses on measuring and quantifying phenomena to isolate causes and effects in order to generalize and describe reality; qualitative researchers believe qualitative methods can more accurately capture individuals' points of view than the remote, inferential, quantitative approaches; quantitative research can be seen as "abstract from this world and seldom study[ing] it directly" (p. 12); and rich descriptions are valuable to qualitative researchers, while quantitative researchers are "deliberately unconcerned with rich descriptions because such detail interrupts the process of developing generalizations" (p.12).

Qualitative research incorporates assumptions which are contrary to quantitative research. These include gathering descriptions from a natural, real-world environment without intentionally manipulating that environment (Savenye & Robinson, 1996). It is this researcher's view that improving an instructional design theory is best done utilizing an implementation of that theory in a natural environment and focusing on collecting rich descriptions of the implementation in order to best evaluate the theory. Quantitative approaches tend to place greater emphasis on generalizability of findings; nevertheless, while this study focuses on qualitative methods, it still seeks to produce results that will be generalizable to other implementations of the GATE theory and which can inform and improve GATE.

Formative Research Methodology

As the purpose of this study is to evaluate and improve a design theory, the formative research methodology was chosen as a form of action or developmental research. The formative research methodology (Reigeluth & Frick, 1999) is similar to design experiments or design-based research (A. L. Brown, 1992; Collins, 1992), but its focus is identifying potential improvements for an instructional design theory. Reigeluth and Frick (1999) have found that "quantitative research methods (e.g., experiments, surveys, correlational analyses) are not particularly useful for improving instructional-design theory, especially in the early stages of development" (p.634). They therefore drew from the formative evaluation and case-study qualitative research methodologies to develop their formative research methods.

Reigeluth and Frick (1999) specify two major kinds of formative research studies: a designed case study and a naturalistic case study. In a designed case study, the researcher instantiates the instructional design theory and formatively evaluates the instantiation. In a naturalistic case study, the researcher picks a case which was not designed using the theory but serves the same goals and contexts, analyzes how the case relates to the theory, and formatively evaluates the case to see how it can inform the theory.

This research study represents a designed case, as the instructional video game and its implementation were designed utilizing the design theory being evaluated, the GATE theory. Reigeluth and Frick (1999) note that, as opposed to descriptive theory where the major methodological concern is validity, for design theory the major concern is preferability, how much better a method is than other known methods for attaining the desired goal. Three primary dimensions of the values determining preferability are effectiveness, efficiency, and appeal. This case study applies the formative research methodology to gather data regarding these dimensions for a specific instantiation of the GATE theory. In doing so, the study is seeking to improve the design theory itself rather than prove its superiority to alternative methods. According to Reigeluth and Frick (1999), this kind of study follows six steps:

1. Select a design theory.
2. Design an instance of the theory.
3. Collect and analyze formative data on the instance.
4. Revise the instance.
5. Repeat the data collection and revision cycle.
6. Offer tentative revisions for the theory.

The use of each of these steps in this study is described next.

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Formative Research Study Design

1. Select a Design Theory

Reigeluth and Frick (1999) specify that the focus of the formative research methodology is to improve an existing instructional theory, so the first step in the process is to choose a design theory to improve. For this case study, the researcher wanted to evaluate and improve his own instructional design theory: Games for Activating Thematic Engagement (GATE). Refer to chapter three for a detailed review of the GATE theory. GATE is a design theory in the early stages of development, and this study represents the first formal evaluation of the theory.

GATE is a design theory intended to provide specific guidance to instructional designers, regardless of budget and experience, on how to design and implement video games for engaging learners in a given topic or field. The goal of the study is to test and improve the guidance provided by GATE.

2. Design an Instance of the Theory

The scope of this study is to examine an application of GATE in the form of *Lifecycle*, a video game designed using the theory and implemented in the researcher's undergraduate computer information technology course on systems analysis and design. *Lifecycle* was designed by the researcher to engage his students and develop an understanding of Systems Analysis and Design (SAD) concepts using the Unified Modeling Language (UML) systems analysis and design methodology.

The researcher designed the game so that his students would be able to discover the underlying concepts and the relationship between these concepts and the hands-on tools they use in class to document system requirements through experimentation, feedback, and play. Another goal of the game was to allow students to put on the hat of a systems analyst and experience the process of developing an application in a short time-span and safe environment. The game was developed using two different undergraduate student interns over a year-and-half period and was developed in Adobe Flash.

The game was implemented during the Spring 2007 semester as a regular part of the course instruction, with a reflection assignment tied to the experience of playing the game. The course for which *Lifecycle* was designed and in which it was implemented was a sophomore level course in a computer information department at a large, urban, commuter campus in the Mid-west. The course was titled *Systems Analysis and Design* and was required of all majors in the department. As a commuter campus, the student body of this university was nearly equally comprised of both traditional students and non-traditional students. The researcher had taught this course with some regularity for a number of years with occasional breaks. This study took place in the researcher's Spring 2007 section of the course, following a pilot study in the previous semester's section

In order to gather data on the of the designed instance of the GATE theory, the educational video game, *Lifecycle*, students willing to participate in the study were individually interviewed by the researcher before and after playing the game for the first time. Students in the study are referred to by a randomized student number assigned to them. The class was composed of fifteen students, three female (students 2, 8, and 10) and the rest male. Fourteen of the students agreed to be interviewed, the lone exception being one of the female students (student 10). The class included one female, non-native speaker (student 2), and two male, non-native speakers (students 1 and 13), both of whom, unlike the female, had strong command of the language. Three of the male students, not

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including either of the non-native speakers, were non-traditional aged students, two were middle-aged (students 11 and 14) and one was nearing retirement (student 4).

3. Collect and Analyze Formative Data on the Instance

The researcher conducted formative evaluation (Bloom, Hastings, & Madaus, 1971; Cronbach, 1963; Scriven, 1967; S. Thiagarajan, Semmel, & Semmel, 1974) on the implementation of the *Lifecycle* game with the expectation that it would help to improve the GATE theory. Reigeluth and Frick (1999) stress that the most useful form of data gathering comes from conducting interviews. Using semi-structured interviewing, background on the students' experience with and perspectives of video games and educational video games as well as their perspectives on *Lifecycle* and recommendations for improving it were gathered. The students were video recorded as they played the game using software on the computer to capture the screen as they played, and their gameplay analyzed (see Appendix A). In addition, the faces of the students as they played the game were captured using an unobtrusive Webcam built into the computer they were playing the game in order to record video and audio to help describe their play experience with the game. Students were of course previously notified as to what was being recorded.

A focus group interview was also conducted with all of the students in the class in order to gather data regarding their additional experiences in playing the game and to confirm data reported in the individual interviews as well as additional recommendations for improving the game.

In addition, student written reflections in the form of a class assignment to reflect on the experience of playing the game and what strategies the student tried and found effective in the game were collected and analyzed. Member checking of student interviews was conducted via email to improve the validity of the analysis.

Design documents created during the design of the game were also reviewed and analyzed to highlight design decisions and changes made to the design based on various prototype evaluations. The purpose of analyzing these data was to identify strengths, weaknesses, and potential revisions of the GATE theory.

4. Revise the Instance

Reigeluth and Frick (1999) emphasize the importance of applying the findings throughout the course of the project in order to revise the implementation, rather than waiting until all data have been collected to make changes. A pilot study of the implementation was conducted in the same class during the previous semester, and the data was used to identify errors in the game itself. However, the instance described in this study was not revised during its implementation. Also, the GATE theory itself calls for evaluation of prototypes throughout the game's creation, so revisions to the game's structure were previously implemented but outside of the scope of this study.

Given the complicated nature of revising a technically complicated video game, it was not feasible to make ad hoc changes to the game during this implementation. Furthermore, the short time-span of this project allowed little time for changes to how the game was implemented in the class. However, results of this study will certainly inform revisions made to the theory prior to the next implementation of the game in the course.

5. Repeat the Data Collection and Revision Cycle

Reigeluth and Frick (1999) recommend repeating the cycle of collecting and analyzing data as much as possible. By repeating this cycle, the researcher is able to confirm results and identify situations and contexts in which specific aspects of the theory may not work as effectively as in others. This study represents the first round of data collection, analysis, and revision. The researcher intends to conduct further cycles in future implementations of the course.

6. Offer Tentative Revisions for the Theory

While Reigeluth and Frick (1999) recommend making revisions throughout the process, this study represents only the first implementation to be tested of the theory and was conducted over a relatively short period of time, as the game made up only a component of a larger course. The results section of this study presents recommendations for revisions to the theory based on the data analyzed during this study. Future studies will be conducted following revisions to both the theory and the specific implementation, and they will generate recommendations for additional refinement to the theory.

Methodological Issues

Qualitative research has faced continued criticism for lacking rigor, validity, and reliability by proponents of the quantitative approach. In fact, this viewpoint has received support in the current political climate as reflected in the No Child Left Behind Act of 2001 and the National Research Council (NRC) (Denzin & Lincoln, 2005; Lincoln & Canella, 2004), which promote positivist, experimental research that encourages researchers to employ “rigorous, systematic, and objective methodology to obtain reliable and valid knowledge” (Ryan & Hood, 2004, p. 80). Reigeluth and Frick (1999) note that case study research has been criticized for a lack of rigor; therefore, it is important to attend to three methodological issues: construct validity, sound data collection and analysis procedures, and attention to generalizability to the theory.

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Construct Validity

Construct validity focuses on “establishing correct operational measures for the concepts being studied” (Yin, 1984, p. 37). Applying Reigeluth and Frick’s (1999) specifications for formative research, the concepts of interest for this study are: the methods offered by the GATE design theory, the situation that influenced the use of those methods, and the indicators of strengths and weaknesses of the GATE theory.

Reigeluth and Frick (1999) note that there are two ways in which construct validity can be weakened: by not faithfully including an element of the theory and by including an element not called for by the theory. As the researcher designed the implementation, every effort was made to closely follow the guidelines of the theory, as much as resources allowed. As the developer of the theory, the researcher had a high understanding of what the theory called for and how it was to be implemented.

Yin (1984) provides three approaches for increasing construct validity: using multiple sources of evidence, establishing a chain of evidence during data collection, and having the case study report reviewed by key informants. As previously mentioned in the study design section, data were gathered from multiple sources, including individual and focus group interviews, observation of participants playing the game, as well as document analysis. The researcher kept detailed notes on the interviews in order to allow the reconstruction of where data were derived from, and all interviews were also audio recorded. Finally, the researcher used member checking to allow participants to review and confirm the analysis drawn from their comments.

Sound Data Collection and Analysis Procedures

Reigeluth and Frick (1999) note two major factors that influence sound data collection and analysis procedures: “the thoroughness or completeness of the data and the credibility or accuracy of the data” (p. 647). They specify several techniques which can enhance the thoroughness of the data, including: “advance preparation of participants, an emergent data-collection process, gradually decreasing obtrusivity, iteration until saturation, and identification of strengths as well as weaknesses” (p.647).

Advance preparation of participants. The researcher utilized students from his class, many of whom he had in previous classes. On the first day of class he informed them of the study and their opportunity to take part. The classroom environment was largely project-based, and students were used to interacting with the researcher in each class, so a good working relationship between the researcher and subjects had been established in advance.

An emergent data-collection process is recommended in formative research as weaknesses in the theory are typically not known heading into the study. Therefore, open-ended probes and flexible data gathering techniques are recommended. The researcher utilized open-ended questions in both focus-group and individual interviews. Furthermore, earlier interviews informed later interviews, allowing for exploration of emerging themes.

Gradually decreasing obtrusivity calls for the researcher to gradually become less obtrusive in later rounds of data collection. As this study represents the first round of data collection and the first implementation of the theory, the level to which the researcher could lessen his obtrusivity was minimal. In future implementations, the researcher will be able to further remove himself from interrupting the implementation and allow it to occur more naturally. However, for this study, gathering rich data was of great importance. That being said, students interacted with the game at their discretion at a time and place of their choosing within the flow of the normal course routine as a part of completing an assignment. The researcher only involved himself in the research process during the interviews and the observations, which were done by viewing the video record of the students playing the game rather than the researcher actively watching the students.

Iteration until saturation focuses on continuing iterations of data gathering until prior findings are confirmed. Each student represented a different iteration of the data gathering process and allowed confirmation of the findings. Multiple interviews and both individual and focus-group interviews were conducted to confirm prior findings.

Identification of strengths as well as weaknesses is a focus of the study, identifying not only how the theory might be improved but what it currently does well and therefore should not be changed.

Reigeluth and Frick (1999) also offer several techniques for improving credibility of the data: “triangulation, chain of evidence, member checks, and clarification of the researcher’s assumptions, biases, and theoretical orientation” (p. 648). Yin’s (1984) recommended techniques of triangulation, chain of evidence, and member checking have already been discussed as techniques for improving construct validity and also apply here. While it should be noted that the researcher had potential for bias as he developed both the theory being tested and the game comprising the focus of the theory implementation, it should be noted that the goal of this study was to improve the theory; therefore, it was in the researcher's interest to find data which could best support improvement of the theory. The formative research approach was chosen for this reason.

Attention to Generalizability to the Theory

Reigeluth and Frick (1999) also note that rigor in formative research can be enhanced by improving how the results can be generalized to the theory using two tools: recognizing situationality and replicating the study.

Recognizing situationality. It is important for the researcher to probe possible situationalities that may restrict how generalizable the results of the case are to other cases. This study utilizes rich descriptions of the situation in order to provide a level of detail that can allow readers to examine how the context described might differ from their specific context. Furthermore, the GATE theory itself incorporates situationalities that allow it to deal with a broader range of contexts.

Replication. As previously stated, this study represents the first evaluation of both the theory and the specific implementation format. Future studies are planned to confirm findings of this study using the *Lifecycle* game implemented in a similar format. Additional studies will also examine the implementation of the game in an online version of the course. Once findings are confirmed and the implementation format is further explored, it will be necessary to implement the theory in a different context and conduct additional rounds of evaluation.

Conclusion

This chapter has described the formative research methodology that was used in this study to improve the GATE instructional design theory. It has also justified the use of this methodology and detailed the techniques implemented to improve the rigor and validity of the study. The following chapters present results of the data analysis and initial recommendations for improving the GATE theory.

CHAPTER 5: RESULTS

Introduction

In this chapter, the results of the study are presented. As the goal of this study was to evaluate the GATE instructional design theory and identify improvements, this chapter is organized into findings for each of the three GATE methods: (1) develop a context, problem space, or world of experience and supporting implementation structure, (2) prepare learners to benefit from game and implement game as designed and (3) provide feedback. Each of these sections first describes what happened in the sub-methods, meaning how that particular sub-method of the over-arching method was implemented in this study, and then presents an evaluation of what did and did not go well, and tentative recommendations for the method as a whole.

(1) Develop a Context, Problem Space, or World of Experience and Supporting Implementation Structure

The first method of the GATE theory is to develop a context for the game to be developed as well as the supporting structure for implementing the game. This method is composed of a number of sub-methods which detail the design and development of the game and its implementation structure (see Chapter 3). This section details what happened during the completion of this method of the GATE theory during the design and development of the educational game, *Lifecycle*, the instance being evaluated in this study.

1.1 Select a Topic or Multiple Topics which Can be Connected by Themes

What Happened?

As previously mentioned, the course the researcher chose to implement the GATE theory in was an undergraduate course, *Systems Analysis and Design.* Among the courses taught by the researcher, this course involved the most problem-solving oriented approach, rather than a focus on technology skills. The course also focused on Object-oriented (OO) systems analysis and design (SAD) (known collectively as OOSAD), analyzing systems rather than building systems, a process much more grey in nature than most courses in the department. The grey nature of the course, where there were no right or wrong answers to design problems, often did not come naturally to the computer and information technology students, who consequently lacked engagement with the topic. The researcher therefore concluded that the course seemed best suited for the GATE theory and its goals of engagement and increased understanding through problem-solving.

As a required course, *Systems Analysis and Design* was often taken in the sophomore year. It required a course on database design as a pre or co-requisite; however, other than this restriction, students took the course when they chose. Because of this and the fractured nature of coursework at the University level, it was difficult to provide specific linkages across courses. It was therefore decided that a single topic would be chosen rather than multiple, connected topics.

What Did and Did Not Go Well?

The choice of the process of analyzing and designing a system as the primary topic for the context being developed seemed a natural one. The researcher had identified this particular topic as a potential for the GATE theory a number of years previously, and felt that it was a good fit. One student agreed after playing the game, saying: “It’s good for this class. You can see, cause that’s [the game action] what we’re doing [in class]” (Student 8, interview).

Originally, an additional focus on OO terminology was planned for the game as well; however, it was deemed that given that the course did not require an OO programming course as a pre-requisite, students would likely struggle with the terms and concepts of OO due to a lack of actual experience with using them. As the game was being designed, it became clear that the OO concepts and terms did not fit very neatly in the growing context of the game, and these elements were cut from the list of objectives.

Tentative Recommendations

It seems likely that the *Systems Analysis and Design* course could potentially benefit from being more closely tied to other courses at the University through shared themes. However, these ties were not currently in place with the course, and it was therefore decided to focus on a single topic well suited to benefit from an application of the GATE theory: the process of analyzing and designing a system.

The topic of SAD could certainly be seen as composed of multiple sub-themes, such as the importance of both communication and technical skills, change management processes, the iterative nature of the design process and so forth. These varying concepts were certainly included in the game and are naturally related to each other in the SAD context. It would therefore be possible to examine each of these sub-topics in more detail in a game with a larger scope. As it was for this study, the limited scope of the game, which will be discussed in the section on method 1.3, resulted in a fairly narrow focus on SAD, even though these multiple concepts were included in the game as learning goals.

While a focus on interrelated themes is an important concept in the GATE theory, it seems wise to keep the relation of any themes natural. Therefore, the relationship between these themes would need to be explored and established. It is highly recommended that future formative research on the GATE theory examine the relation of multiple topics within the context as this aspect of the theory was not explored in this study. As for this study, no data from the researcher's experience as a designer choosing a topic resulted in recommendations for improvement of this sub-method.

1.2 Define Supported Learning Goals

What Happened?

The researcher began defining the desired supported learning goals for the game by first analyzing what learning gaps existed in the course in its existing format. The researcher's years of experience teaching the course allowed him to note certain SAD concepts and terminology that students often struggled with or failed to demonstrate appropriate understanding of. As participants in a project-based course, the students in *Systems Analysis and Design* spent the majority of their time working in groups on a project. Because of this, the researcher felt that the students might be missing some important conceptual lessons related to SAD because of a lack of seeing the big picture. Furthermore, a career as a systems analyst was a real possibility for these students, and a very important goal of the course was to help students understand an analyst's responsibilities and necessary skills in a more engaging fashion than the day-to-day project work that can grow old over the course of a semester.

The researcher identified important concepts and terminology related to the SAD topic and determined that these would determine learning objectives for the game. He

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also contacted other instructors for the course to review the objectives he had determined for the game and make recommendations regarding them. The objectives for the game were to highlight and scaffold important concepts such as those discussed above, as well as the importance of such issues as effective teamwork, appropriate change management, the dangers of scope creep, the importance of business knowledge, strong communication skills, involving stakeholders, quality control issues, stakeholder buy-in, and understanding the overall OOSAD process and how the different models relate (see Appendix B). These concepts were covered in the class but typically as part of a short lecture or intermittently at various teaching points throughout the semester. It was felt that by using a game to shorten a project development lifecycle to one playing period on a computer, these concepts would be substantially highlighted and reinforced.

Additionally, the researcher felt it was important to scaffold terminology used in the course, including terms such as scope creep, change management, stakeholders, and feasibility (see Appendix B). And, the researcher also felt that it was important to help students to recognize the relationship between managing scope creep, fully identifying system requirements, managing change requests, developing a quality system, and meeting schedule requirements, as well as understanding the iterative nature of the OOSAD process and how models relate to each other and should be frequently revised to reflect changes in the project. Furthermore, it was important to try to convey how, in real-world projects, Murphy's Law (what can go wrong, will go wrong, and at the worst possible time) and unpredictability are the norm. It was felt that the more isolated and static nature of the classroom project did not represent these issues and relationships well.

What Did and Did Not Go Well?

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In determining the learning goals for the game, the researcher felt confidence in his analysis of learning goals based on past experience teaching the course. However, despite repeated attempts, feedback on these goals from other instructors was minimal and largely only supportive in nature without providing additional insights. Because of this, the researcher felt somewhat isolated in identifying the goals, a crucial aspect of designing the game. The researcher also removed some potential learning goals due to the challenge that would be presented in trying to incorporate them in the game. This is also discussed in sub-method 1.3 as part of the feasibility analysis but is worth mentioning here as well. A key goal of the course and SAD as a topic is helping learners to become comfortable using specific tools of an SAD methodology in the form of design models. This and the inclusion of OO programming terminology and concepts were other goals which were originally brainstormed by the researcher but removed from the final list due to game scope issues.

Tentative Recommendations

While the researcher felt comfortable with the learning goals he defined for the game, there was no true evaluation of the relevance or importance of these goals. As mentioned above, the researcher did seek additional input from other instructors but was largely unsuccessful in obtaining much of value.

The theory could be strengthened by providing guidelines for evaluating the importance and relevance of learning goals and reaching consensus on learning goals when a team of designers is involved. Furthermore, the theory offered no guidance outside of its stated goals on evaluating the appropriateness of learning goals for the GATE theory. As the developer of the GATE theory, the researcher felt comfortable in specifying learning goals that focus on developing greater understanding of SAD concepts and problem solving skills. However, the identification of learning goals could have been greatly guided through input from the students themselves. However, student input on learning goals was never obtained at any point in the process of defining those goals, and the theory might be improved by specifying such an approach.

1.3 Analyze Intended Learning Environment, Learner Attributes, and Design Environment in Order to Establish Available Resources and Constraints, Conduct Feasibility and Return on Investment Analyses, and Specify Scope

What Happened?

Learning Environment. As previously mentioned, the researcher was quite familiar with the learning environment the game would need to fit into as he had been an instructor of the course for several years. When designing the implementation of the game in the course, it was decided that, given the already intense schedule of the semester, coupled with the lack of available resources for development, the game should be a relatively short one that would allow students to play through a SAD lifecycle quickly and multiple times to gain feedback, identify underlying concepts and relationships, and identify best practice strategies for not only winning the game, but also applying its lessons in the real world.

Furthermore, the researcher recognized that a majority of sections of the course were offered online each semester. He therefore believed that the game could be particularly valuable to online students who had much less instructor and peer interaction and feedback than students enrolled in the physical course. It was determined that the game should be Web-based to allow for it to be implemented across all of the course's

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section and thereby have greater impact. This also allowed the game to be playable by anyone with a browser, increasing the availability of the game to students who wished to play at home

Learner attributes. The researcher was also quite familiar with the learners who would be utilizing the game as he had taught students from the course's department for seven years. In analyzing the attributes of these students, he realized several issues which were important to the game's design. The first was that there were of course both male and female students in the course each semester, and it would therefore be important to keep the game gender neutral if at all possible to allow both male and female students to put themselves into the role of an analyst.

Another learner attribute of note was that the students were commonly non-traditional students, adults working full-time who took classes online or on the weekends. It was therefore important that the game be easily available online and playable on any computer with a browser, as mentioned previously. Additionally, as students who worked full time and often had families, they would be more likely to play the game if it did not require a great deal of time from them, as they had so many commitments already.

Finally, it was common to have international students in the course. It was therefore thought that it would be important to provide game feedback in a fashion that did not rely solely on listening comprehension, which could prove more challenging to students who were non-native speakers.

Design environment, available resources and constraints. No analysis was needed for the researcher to recognize he had no budget for the game and was limited to using available students who would develop the game in return for University credit as student interns. Because of this and the need for a Web-based game, it was determined that Adobe (then Macromedia) Flash would be the most suitable development technology. Flash uses a scripting language called ActionScript which is very similar to JavaScript, another scripting language commonly taught to University computing majors.

Feasibility and return on investment analyses and specifying scope. In recognizing the limited resources available, the researcher realized the need for a game of limited scope as he would have to rely solely on student interns to develop the game. Furthermore, given that most students would only want a single semester's worth of internship credit due to a limited number of elective courses in the major, it would be best if the game could be completed in a single semester. This would certainly be a challenge, and it was therefore determined that aspects of the game would need to be prioritized so the critical features were developed first and additional non-critical elements could be added later if necessary. As for return on investment, nothing would be invested outside of the researcher's time, so the risk was minimal.

What Did and Did Not Go Well?

Given the limited resources available to the researcher as well as the learning environment the game would be implemented in, it was decided to keep the game rather simple. Having no budget not only restricted the potential development of the game, but also placed the researcher's time as the only true costs for the game. This allowed for the potential for strong returns on the investment, as multiple sections of the course are offered each semester, and the course is required of all computer and information technology majors. The analyses of the learning environment, learner attributes, and feasibility and return on investment potential were all rather straight forward for the researcher, given his familiarity with these aspects and no problems were experienced conducting them.

Tentative Recommendations

As no costs beyond the researcher's time and effort were at risk for this study, the cost-benefit analysis of the study was a simple one. Furthermore, given the limited scope of the game itself due to a reliance on student developers, the available design technology was also necessarily limited. In a game of larger scope, a strong feasibility and cost-benefits analysis would be extremely important. Therefore, while the theory in its current form was perfectly adequate for this study, more in depth guidance on these analyses would be beneficial for future designers.

1.4 Define Rules of Context and Overall Structure of Game, Including Story, Goals, Objects, Supported Actions, Feedback, Learner Roles, and Embedded Values

What Happened?

As mentioned in chapter 3, the researcher's experience as a student with the *Diffusion Simulation Game* impacted not only the GATE theory's design but also *Lifecycle's.* Designing the underlying rules that drove the gameplay was the most challenging aspect of the design process. In order to better understand underlying rule structures, the researcher sought to break down the *Diffusion Game*. To better understand the underlying structure of the game, the researcher met with Dr. Molenda, the designer of the original board game version of the game, and he brought out the original board game and identified how its underlying rules and relationships reflected the learning objectives he had intended to embed in the game (personal communication, February 25, 2005). The researcher heavily modeled the notion of choices unlocking additional actions and player feedback after the *Diffusion Game.*

Game structure and rules. To determine what factors drove the rules of the game, the researcher turned to the learning goals he had identified and the concepts which were to be embedded in the game (see Appendices B and C). As previously mentioned, these included such issues as quality control, change management, timeliness, stakeholder involvement, understanding of the business problem, and an iterative design process. A number of these concepts became underlying variables driving the structure of the game. The scoring and gameplay were based on five variables: time remaining to complete the project, systems analyst's business knowledge, quality of the system, client satisfaction, and project completion status.

As the researcher had defined the context as a SAD process, students would be playing the role of a systems analyst. Therefore, the goal of the game would naturally emerge from this. Based on his own knowledge of the goals of an effective systems analyst, the researcher defined the goal of the game: to develop the highest quality system, in the least amount of time, with the highest customer satisfaction.

Embedded values. Just as the researcher relied on his own knowledge of the topic to design the rule structure of the game, he also was able to embed values in the game based on his knowledge of what values are important to a successful systems analyst. Many of these aspects were stressed by the researcher in course discussions each semester, so they were quickly identified. They included such values as the importance of user-centered design, being a good communicator and team player, and developing a strong understanding of the business problem before proposing a solution.

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What Did and Did Not Go Well?

Focusing on identifying the underlying factors behind the success of a systems analyst allowed the researcher to use his knowledge of the topic to try and structure a realistic representation of the SAD process. As the sole designer of the game, he was able to brainstorm the rule structure of the game, analyze the resulting design, and make revisions quite quickly. As described later in this chapter, paper prototypes of the game helped the researcher to test his designs early and easily make changes to the rule structure to balance gameplay appropriately. There were no real problems that the researcher was aware of regarding the process of designing the rule structure of the game, outside of the initial daunting task itself. However, by letting his knowledge of the topic and the game's learning goals guide him, as directed by the GATE theory, the process was largely easy and seemed effective.

One significant test of how well the game was structured is student perspectives on the realism of the game, which the theory identifies as an important aspect of this sub-method (see chapter 3).

Student perspectives on the game's realism. Students felt that by and large the game accurately reflected the experience of being a real-world analyst, with a few exceptions. One student noted:

> Yes, it does a real well [sic] job representing what a systems analyst has to go through while creating a system. It mentions the creating and refining of the use cases and several diagrams. The game shows the people that the analyst must interact with. It also lets the user test out the system to make sure it runs smoothly and to the owner's specifications (Student 8, reflection assignment).
>
> Another student reiterated this, saying:
>
> I think it accurately modeled the real world, and in the sense of how you would manage it in the real world. You know, you've got to have some of these, you've

> got to have technical skills and manners. You need to go through all your documents in order to implement the other one. And usability tests. I think, ah, it simulated the, the way you'd have to manage something. You have to balance everything to get a difference (Student 11, class debrief).

The student who worked professionally as a systems analyst also agreed that the game was an accurate reflection of his job, particularly highlighting some of the unpredictable occurrences that the game dealt the player: "Actually, surprisingly yes, there are a lot of frustrations in the game and a lot of communication breakdowns, which in real life is surprisingly accurate" (Student 14, reflection)

One interesting dialogue that occurred during the class debrief was a short debate amongst the students as to whether the game was realistic or not. One student did not like the turn-based nature of the game, feeling that a week was too long a time period for most of the actions in the game, a point which several students disagreed with, including the professional analyst:

> Student 15: I'd really like to see a different system other than using weeks, because it's really unrealistic to say it would take you a week to build like a use case, or a week to talk to someone. Like, I understand why you're doing it, 'cause it's a turn, but in the real world, unless I'm terribly mistaken, it shouldn't take a week to do hardly anything that you have listed on there.
>
> Student 11: No…
>
> Student 14: I don't know…. I'm on week number five on the use cases.
>
> Student 15: If you're a systems analyst, it'd be different then being a student.
>
> Student 11: Maybe.
>
> Student 14: Yeah, I'm on week five on the use case I'm working on now, so….
>
> Student 11: Hmm, really?!
>
> Student 14: Yeah.
>
> Student 11: Actually? Really?

-

> Student 14: A real life use case, yeah.
>
> Student 11: How many of them do you have to do?
>
> Student 14: A hundred and one? [laughs]
>
> Student 15: It just doesn't make a whole lot of sense that it would take a week to like, you know, talk to somebody. And like, as he said, it took him like five weeks to do a use case. Uh, and it only takes you like one week to do a use case. So maybe like balancing things out (class debrief).

Of course, the turn-based system of the game is somewhat unrealistic in that most activities would not take one week to complete as they do in the game, whether it is developing a use case or talking to a client. However, not many students expressed much concern regarding this. A number of students did point out the limitations of the scope of the game by highlighting the lack of any actual development of diagrams or communication of what about the diagrams needed to be revised:

> In other ways the game does not represent an analyst's experiences regarding actually seeing the use case diagrams, class diagrams and, activity diagram. The game seems to miss the discussion with the customer regarding the diagrams and in particular what is right with the diagrams and what is wrong (Student 4, reflection assignment).

Another student pointed out the limitations of the lack of further depth and interactivity due to the game's scope:

> Just clicking, you know, "develop use case" doesn't, I don't really feel, teach people about being a systems analyst. Like maybe showing them a use case or having them work on one might be more helpful. I don't really feel like, if you're using it as a teaching tool, just clicking on, you know, "edit use case", "revise use case", that kind of thing, that doesn't really teach you what to do; it just kind of shows you the process (Student 15, class debrief).

Again, the students are absolutely correct in that the limited scope of the game has resulted in some severe limitations as to the realism the game is able to present. These issues should strongly be considered in future versions of the game. However, the elements they highlight are a part of the supporting project-based work in the class, and the game is certainly not intended as a stand-alone educational tool.

Tentative Recommendation.

The defining of the game's context and underlying rules was appropriately driven by a desire to realistically present a context which would well support the desired learning goals given the necessary limitations of the game's scope. As there was no true narrative in this study's game, the context was very basic and largely focused on underlying game rules.

The theory might be improved by encouraging a more creative brainstorming approach. The same learning goals might be supported by a variety of contexts and approaches, and on a project with a larger development team, it would be beneficial to initially brainstorm multiple contexts for the game. The inclusion of user feedback on coming to a consensus on what context is best suited for the highest levels of engagement and learning with the game could be an important aspect of the method which is not addressed by the current theory.

1.5 Promote Desired Learning Opportunities Through Introduction of Key Obstacles, Problems, and Plot Elements within the Game and the Implementation

What Happened?

Apart from the game's primary structure and rule-base, concepts were introduced through available game actions, obstacles and challenges within the game, and random impacts built into the game. After deciding on the goal of the game and what variables would determine how well players were able to reach that goal, the researcher designed what actions would be available to the players, again based on his own knowledge of the

OOSAD process which composed the topic of the game. These actions were largely taken directly from the UML OOSAD methodology taught in the class. For example, player actions included the building and revising of the exact design models taught in class. Other actions also arose from the researcher's knowledge of what a systems analyst's responsibilities are on a real SAD project. These included such actions as talking to stakeholders, testing the system, and communicating with other members of the development team. Again, as recommended by the GATE method, these actions were uncovered by looking at what actions an analyst takes in a real SAD project.

The researcher also wanted to identify additional challenges to the players and again looked to real-world SAD processes to identify these. Design and development is a dynamic process and therefore, no matter how much care is taken, unpredictable things occur which can sabotage a project. Looking at these ideas as well as the learning goals of the game, the researcher was able to identify random impacts that could further embed important concepts in the game, and related actions the players could take to address these occurrences.

A goal of this game was to help students to understand what an analyst does as well as what skills are important to pursue a career as an analyst. These include strong communication, technical, and teamwork skills. These concepts are reflected by negative random impacts that can occur if the player does not have the foresight to strengthen each of these areas by using the appropriate action. This can be further described by looking at the random impacts in the game (see Appendix C).

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Random impacts are used in the game to both add variability and increase the value of replaying the game, as well as to reinforce additional concepts, such as the importance of various skills to a systems analyst, as well as the unpredictable nature of real world development (see Appendix C). These impacts are meant to add to the game's fun and unpredictable nature and make each replay different than the previous while also reinforcing additional concepts covered in class.

What Did and Did Not Go Well?

Again, by following the GATE theory's recommendations to base this sub-method's process on capturing realism and embedding the desired learning goals, the process of designing player actions, random impacts and obstacles in the game went smoothly.

The previous section noted the largely positive student perspective on the game's realism. There were some issues with the random events that occurred in the game and made some students question how realistic the random events were. One student noted his frustration with having repeated team members get sick during one of the times he played the game: "If people were getting sick that much in a company I was working for I would leave them" (Student 5, reflection assignment).

While experiences like this were frustrating, other students highlighted the random events as reflecting the unpredictable nature of real world development: "[In the real world] you have to plan ahead to deal with unexpected things like [a] sick team member or waiting [for] confirmation from the boss" (Student 1, reflection assignment).

Tentative Recommendations

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Student comments about receiving an inordinate number of the same random event even after taking actions to lower the chance of that chance are corroborated not only by video of student gameplay but also by the researcher's own experience playing the game. For example, one student had two team arguments occur after having two team meetings which have the impact of reducing the chance of arguments occuring (Student 14, game play chart).

This issue was brought up with the developer multiple times, and the researcher was repeatedly assured that the function was operating correctly, and it was just by chance that the random events would occur again. However, this highlights the problem that the researcher had to rely on the developer as he could not decode the game's code by himself. A similar issue was solved by the researcher having the developer create an output screen that showed the current value of the game's primary scoring variable. By examining this, the researcher was able to identify where calculations were going wrong within the game's scoring structure and have those corrected.

It is recommended that a game's structure be made as transparent as possible during development so that the designed rule structures can be verified and accurately tested. Furthermore, the frustration of some students with the random occurrences highlights the importance of ensuring that the obstacles and problems introduced in the game fit naturally within the context and are tied to promoting learning opportunities through the game. For example, in this case, most of the random events were tied to specific game concepts; however, team members getting sick, while trying to accurately reflect life, created frustration for at least one student as the event is not tied to any action or SAD related concept.

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1.6 Design Specific Implementation Guidelines and Artifacts, including External Activities and Potential Demonstrations of Mastery

What Happened?

The researcher based many of his implementation guidelines on his own experience as a student playing the *Diffusion Simulation Game* in graduate school. In that instance, students played the game individually before debriefing the experience as a class. The researcher therefore decided to structure his implementation of the game in a similar way, with the addition of a written reflection assignment (see Appendix D) given to the students prior to the class debrief to help focus their comments. Furthermore, the *Lifecycle* game was given to students to play prior to their work on the course's final project, which required them to work in groups to fully document a fictional system. The final project tied to the game in that students would be going through their own development lifecycle of sorts using the researcher as their client and developing the same models represented in the game as player actions.

What Did and Did Not Go Well?

The results of the implementation of the game in the course will be described in later sections in this chapter. As for developing the implementation structure, again the researcher was largely guided by his own experience; although, the *Lifecycle* game was tied more closely to the SAD course goals and activities than the researcher's own experiences. Furthermore, as mentioned above, an additional reflection assignment was developed as well. However, it did become clear to the researcher as he developed this reflection assignment that the GATE theory stressed the importance of designing strong implementation support but offered little guidance in how to do so.

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Tentative Recommendations

Given the potentially unique characteristics of individual implementation contexts for future instances of the GATE theory, it could be helpful to provide specific examples of implementation approaches based on situationalities. As the GATE theory stresses the importance of focusing on the implementation of the game and not just the game itself due to the researcher's own experience, it is likely that future designers could benefit from more specific guidance and examples on effective implementations of games into varied learning environments. Therefore, the GATE theory could be improved by specifying detailed examples of how games might be effectively implemented to maximize student reflection and learning.

1.7 Focus on Engagement with the Topic: Incorporate and Encourage Competition and Immersion through Supporting Learner Control, Challenge, Fantasy, and Curiosity within both the Game and the Implementation

What Happened?

A focus on engagement was an important aspect of the game from its initial design, and the researcher called on his own experiences with engaging games as well as the guidelines provided by the GATE theory to try and design engaging elements into the game whenever possible. These would even include some elements which were not directly related to learning in the game but would encourage exploration of the game, as recommended by the theory.

Competition. The researcher knew from his own experience with the *Diffusion Simulation Game* that competition with peers would likely be a highly motivating aspect of the game to many students. Competition was therefore included as an aspect of the game in that the game design called for a high score screen so that students would be able to compare their score to that of their classmates.

Immersion. The researcher also sought to design as realistic a game interface as possible from the first-person perspective to encourage student immersion in the game. The researcher also wanted to allow personalization of the interface so students could really feel that they were the analyst in the game. Immersion in this role was encouraged by having the interface of the game focused on the desk environment of an analyst so that the game could be viewed from the visual perspective of an analyst. Other ideas related to this included personalization of the desk environment so that students would be able to choose what name to put on the name placard and possibly even upload pictures of their family members or pets to make the desk feel more like their own.

Control. Again, the researcher sought to provide the learners control over the analyst's actions in the game so they felt control in determining the game's outcome. Furthermore, the personalization options described in the previous section also gave players a greater sense of control.

Challenge. The researcher designed the game to be challenging with the idea that most players would not successfully win the game on the first try but instead run out of development time. This proved to be the case for all of the students who played the game. It was felt that losing the game would actually create more engagement for the students due to the challenge it offered. Furthermore, the game was made more challenging by including random occurrences to force the students to adapt and have a different gameplay experience each time they played the game.

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Fantasy. As mentioned previously, the researcher wanted to encourage student immersion in the role of a systems analyst. A career as a systems analyst would be a real possibility for computer and information technology students, as many developers often play the analyst role as they gain more responsibilities in a company, even if they retain some of their role as a developer as well. An important aspect for both engagement and learning for students in *Lifecycle* was for them to be able to explore and imagine themselves as systems analysts.

Curiosity. As mentioned previously in this section, the researcher designed the game to be challenging enough that students would likely have to play several times to win the game. He felt that curiosity to see a successful version of the end screen would further motivate the students to play the game again. Furthermore, the end screen was designed to have different outcomes based on how high the student's score would be. So, if the student was fired, it might show a picture of an unemployment line, while those winning the game would see nicer and nicer offices based on how high their score was. Curiosity to see these different outcomes would be another way to engage students with the game, and positive outcomes would engage them with the topic of SAD and the idea of potentially having a career as an analyst.

What Did and Did Not Go Well?

As a creative process, creating engagement is a challenging aspect of designing an educational video game. However, looking to the GATE theory's recommendations guided the researcher's brainstorming on ways to increase student engagement with the game. Play-testing of different prototypes also helped the researcher to correct gameplay to adjust for difficulty and other features. This was an important aspect of designing engagement and is discussed in detail later in the chapter.

The researcher also benefited from some ideas from his student intern who would also share ideas for making the game more engaging. Ultimately the process seemed effective to the researcher, and he sought feedback from the students to confirm that the process went as well as it seemed.

Student engagement with game. An overriding goal of the GATE theory is to engage students in a given topic or multiple themes. The theory identifies competition, learner control, challenge, fantasy, and curiosity as approaches to encouraging engagement with the game, and through that, the topic. Competition was clearly identified by several of the students as something that motivated them to play the game multiple times: “I wanted to win. That was the key” (Student 4, class debrief). Another student echoed this: “[I wanted the] top score” (Student 3, class debrief).

However, while some of the students identified competition as something that motivated them to play games in general, others expressed that they were not interested in competing with others: “I don’t get into that whole competing with others. I play games for pure personal enjoyment, not these social, you know the whole, I’m better than you…. I just play for personal enjoyment, not competition amongst everyone else” (Student 14, interview).

Students also consistently identified the challenge of the game and curiosity as elements that motivated them to play it: “I immediately wanted to play it again…. Not winning for one thing. Makes you want to play it again. Makes you want to do better” (Student 4, interview). Other students echoed this: “Oh yeah. I can’t just play once. I’ve got to see if I can do better. Figure out where I went wrong kind of thing" (Student 3, interview).

Other students noted the curiosity of seeing what happened if they won: "[I want to play again] just to see if I can actually not get a lose type of thing, just to see what a winning condition is" (Student 7, interview).

Humor was another aspect of the game that was engaging for some students. The researcher's picture was used for the "Bossman" character in the game, and several students found this funny: "I thought it was pretty cool how, like [laughs] the contact is you" (Student 12, interview). The end screen also tried to use humor by calling the students a loser if they lost and telling them they were fired (see Figure 5). The researcher felt some concern that this would offend some students, but in reviewing video from student gameplay, three students were observed laughing upon seeing the end screen (Student 11, gameplay video; Student 12, gameplay video; Student 14, gameplay video), and two others smiled upon seeing the screen (Student 5, gameplay video; Student 7, gameplay video), although Student 7 later said he thought it was funny but would leave off the "loser part" (interview). No other students expressed a problem with the end screen or a desire to remove the loser statement.

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Figure 5. Losing final score screen from *Lifecycle* with instructions for submitting score.

Several students expressed that they found the game interesting: “The game was good. It was interactive. It got me interested” (Student 7, interview). Another student stated: “It had my interest. I liked to play it. It didn’t make it too complicated or like, or I was not knowing what to do” (Student 9, interview). A third student stated: “I liked it. It was ok. It was a puzzle. How do you balance everything? Get everything done on time” (Student 11, class debrief).

However, some students noted that the game did not hold their interest or did not engage them for long:

> I don’t know, like, the game in total, as a whole, it helped that it had a good framework, but there wasn’t really enough interactivity in there. It was totally, you know click this, click that, click this, click that. There wasn’t, uh, there aren’t a whole lot of other options in there as far as typing stuff in, or, you know, going more in depth. I think the game would be a lot more entertaining if there were more to do (Student 15, class debrief).

Another student agreed with the above statement, saying: “It was rather dry” (Student 14, class debrief).

Students noted that the fact that the textual feedback does not change much during the course of the game and not at all between the games hurt their interest in playing the game: “As you keep playing, you pretty much know because there’s no variation of what’s said, you don’t have to read the messages anymore, so you just click through it… Once I didn’t have to read anything; it was kind of boring” (Student 3, class debrief). Another student agreed with the statement above, saying “It was boring” (Student 5, class debrief).

Students had some ideas for increasing the depth of the game:

> One thing I thought might be interesting would be if you could actually see examples of use cases that were created. Like there were several in a database, or I don’t know how it would be technology-wise, but like when you created your use case or your case diagram, you would see an example of it. If it was poorly written you would maybe look at that, and revise it. Or if it were well written…. That might be kind of interesting to see that (Student 14, class debrief).

Two other students also mentioned the use of visual representations of the SAD models, feeling that it would improve not only the visual interest of the game, but also how well it reflected the course content. One area of disagreement was that a few students wanted audio in the game, but there were a few students who disagreed with this and felt audio could be annoying. One student who had previously complained about the amount of text in the game felt that it was more important to reduce text than to provide audio: “I actually don’t even think you need the music, just maybe break up some of the wordiness of it with maybe, ‘You did a great job this week!’ You know, or something silly like that” (Student 14, class debrief).

Mini-games were also mentioned as another possibility for the game, confirming the researcher's original desire to include a few games. One student, showing an understanding of some of the real-world temptations facing analysts had a specific mini-game request: "You need a Windows computer sitting over there with solitaire on it and then you could lose a week by playing solitaire! [Laughs]" (Student 14, class debrief).

One way of examining how engaging students found the game is to look at how many times they played it (see Appendix A). As mentioned previously, students were asked to send in screen shots of their final screen each time they played the game. They were asked to play the game a minimum of one time. Two students did not submit screen shots of their scores. They each stated that they played the game more than one time, but it is not possible to verify this. It is also not possible to verify if all student scores were accurately submitted by the students, but in looking at the submitted scores of the thirteen students who did submit screen shots, a good idea of how many times they played the game can be determined.

Of the reported scores, the fewest times the game was played was 2. This was the mode for the game scores, with four students playing the game twice. Three of these four students never successfully won the game. It should be noted that an error in the scoring system was granting full scores to those who failed to fully the implement the system, instead of a score of zero, as specified (see Appendix C). This caused some confusion, which will be discussed later in the feedback section.

The mean for the number of times played was 4.77 times, and the median times played was 4. One item of interest is that the student who expounded the most on the game being dry and lacking depth, played the game the second largest number of times

(Student 15). He also played the game four more times after winning it, showing that his motivation to play the game likely came from a desire to have the highest score in the class. This was also the likely motivator for the student who played the game the most times (Student 11) and did have the highest score in the class; he was also the most positive voice regarding how engaging the game was to play. Seven of the thirteen students who reported their scores never successfully completed the game. This was likely due to a key problem with feedback in the game as well as inadequate instructions for the game, both of which will be discussed in detail later in this chapter.

Student engagement with topic through perspectives of SAD as a career. Another key goal for *Lifecycle* and the SAD course as a whole was not only to help computer information technology students to understand SAD concepts and skills, but also to help them understand what a systems analyst's responsibilities are, in case they chose to pursue a career as an analyst. The GATE theory looks to foster engagement with a topic. While *Lifecycle* was implemented towards the end of the semester to largely serve as scaffolding of previous instruction and to highlight important concepts for students, it was also meant to further help students understand the role of an analyst. Therefore, another test of engagement for the game as well as the course as a whole was students' perspectives on a career as an analyst, and their understanding of what an analyst's responsibilities are.

A pleasant surprise for the researcher was that the students unanimously recognized the benefits that having the skills of a systems analyst brings to an information technology project. Also, a strong majority of the students expressed some interest in a potential career as an analyst, despite the fact that they were required to take the course. One student noted his plans to be a systems analyst after graduation:

> Yes, that's probably what I'll go into after graduating. I like software development, and don't mind being in charge. I was a supervisor for 6 years on a previous job, and I was good at it. But, I don't imagine that the role of systems analyst is an entry level position, mind you. This course seems to provide some of the fundamental knowledge required for the systems analyst as well as the developer (Student 11, reflection assignment).

Other students noted their interest in the career and how they had already started applying the tools and skills learned in the class:

> Yes, I've always thought of a career in systems analysis when I was studying. This class further encourages that and I'm thinking about the possibility of doing analysis when I get more experience in the software industry. Also I would most definitely use the Use Cases [sic] as a basis model for every software I [in]tend to make in my lifetime from here on in (Student 7, reflection assignment)!

The professional analyst also noted benefits of the course in his career: "I use all the knowledge that I have learn[ed] in class. I have actually started implementing a few things I picked up in class that we didn't do before" (Student 14, reflection assignment).

For those students who did not intend to become systems analysts, all of them indicated their recognition of the benefits of the skills and knowledge learned from the course in their future careers: "I will definitely take the knowledge that I've learned through Systems and Analysis Design because these concepts are not just involved with system designing, but they can be used throughout all kinds of computer areas" (Student 8, reflection assignment).

Another student noted that, even though he did not expect to use the knowledge in his career, he did intend to apply it in the computer work he did non-professionally:

> I don't believe I will be able to incorporate this knowledge into any career that I am hoping I will get, but I have used it already in some of the programs I have written. I even somewhat planned out some sites I will be doing this summer.

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> Since I will not be programming much for any job I do, or even creating sites, I doubt I will be able to use this much in my career, just in my hobbies (Student 5, reflection assignment).

Despite the overwhelming enthusiasm expressed for a required course, one consistent theme amongst a number of students when discussing the coursework as a whole was the dreariness of working through so many models during the project-work. One aspect of the GATE theory not fully embraced in the SAD course is providing learners some choice in selecting goals. This was not included in the game due to scope constraints; however, student complaints regarding the sheer number of models required in the course during the project work was convincing that some choice in the course itself should be allowed in the future. This is particularly true as most real-world systems analysts might not model minor business processes, and the course requires the students to model all processes, not just the major ones.

Tentative recommendations

The contention of the GATE theory that designers should not be dismayed by not being able to match commercial games in graphics quality was supported by the interview data. When identifying what aspects of games in general were important for engaging them, a number of students mentioned nice graphics as something attractive to them, but it was discussed as something beneficial and not necessary: "[Graphics are] mostly not that important but in certain games you really need it" (Student 1, interview).

None of them emphasized graphics as a very important part of determining how engaging a game is.; although, one student identified good graphics as "a plus" (Student 6, interview). In fact, a number of them refuted graphics as terribly important:

> There's [sic] some games that I've played where the graphics would be deemed awful, but the gameplay was really good….I don't know, the mechanics are good,

-

and it's just, I wouldn't say simple, but it's quick to get into and then mastering it is really hard. But, no, the graphics are horrible (Student 3, interview).

Another student echoed this:

"Graphics are important up to a point and then it becomes, that's pretty. I want to really play a game, not sit and watch pretty pictures. I played Asheron's Call for a long time, which was done by Microsoft, and the graphics weren't that great…. I mean, you could take for instance, the [Nintendo] Wii. It is definitely not the graphics machine out right now, and it's selling better than the other two. So, you can only say so much for graphics until it comes to a point to where's the playability, and playability is on top (Student 14, interview).

Results regarding engagement were largely positive, and very positive when taking in account the overall impact of the course and the game on student perspectives towards SAD as a potential career. However, students expressed mixed responses towards competition, as it was very important for some students and not important at all for others. This raises the issue that multiple approaches to engagement are important in a game as competition alone is not enough.

Students also noted that receiving the identical textual feedback each time they played the game negatively impacted their engagement as the game and allowed them to play through the game very quickly, without reading the screens as they had read them before.

In generating data to evaluate the forms of engagement that the GATE theory advocates, ten students identified aspects of commercial entertainment games that were most important for the game to be engaging (see Table 1). The most frequently identified aspect was gameplay with seven students identifying it, followed by story with four identifying it. Gameplay meant different things to different students. One student identified gameplay with speed and ease of play:

> I like the instantaneous playing…. And really, if it keeps my attention. My thing is I don't like to sit there and wait for it to load, or walk around the map a long time. I like something that's [snaps fingers twice] continuous or something like that (Student 9, Interview).

He later again identified speed and ease of play as most important, even after previously mentioning realism and story. He highlighted the importance of speed:

> I like the story line, but if I could find something where instead of having to walk half the map, if I could teleport if I know where I'm going, just go ahead and get there instead of having to do the walking part (Student 9, interview).

Table 1.
Student perspectives on what makes games engaging

Student	Story	Gameplay	Depth	Custom-ization	Social-ization	Realism	Interface
1	X	X					
5	X						
13		X				X	
9		X	X		X	X	
6				X		X	X
15		X	X		X		X
7		X					
3		X					
14	X	X					
12	X		X	X	X		

A number of students discussed gameplay in terms of how easy it was to get into a game and enjoy it: "When I'm playing a video game, I don't want to stress out too much…. I'd like to just, video games are there to relax, you know" (Student 13, interview)?

This was echoed again by another student: "If it doesn't get right into the gameplay, if you are watching two hours of cut scenes before you actually get to gameplay, you're gonna probably turn it off and find something else" (Student 14, interview).

Four students focused on a strong story as a key element of making a game engaging: “A lot of the time I can, I usually get into the story a lot better than like with Dragoon or something like that. So story has a lot to do with it…. I don’t know, mostly story, I’d say” (Student 5, interview). Story was strongly echoed again by another student: “Content is huge, probably the top of the list….So you can kind of get lost in the storyline” (Student 14, interview). Story relates to the GATE theory’s focus on the context comprising the game as well as issues of fantasy and curiosity as players will want to know how the story ends.

Three students emphasized the depth of games as a key attractive feature, including interestingly enough both an offline role-playing game (RPG) player, and a massively multiplayer online role-playing game (MMORPG) player. A focus on depth of content could be seen as reflecting the GATE theory’s focus on curiosity, immersion, fantasy and realism. The offline RPG player did not enjoy MMORPGs but enjoyed the depth of the RPGs he plays: “The depth probably, the storyline, and a lot more content. I mean, it takes hundreds of hours to beat a lot of them” (Student 12, interview). This contrasted with the MMORPG player who felt that the ever changing MMORPG worlds offered vastly superior depth to offline RPGs:

> Um, they’re just dynamic. You know, you can be in the same place twice, and you won’t have to do the same thing. Or talk to the same people. Cause, like, you know in a Final Fantasy game for instance, you know if you leave a town and go back in, everything’s the same (Student 15, interview).

The importance of socialization was noted by three students; all identified MMORPGs as a favorite genre. One stressed how he it was important for him to be able to play online with his friends as he does not see them as much as he would like. Another stressed the increased dynamics and realism of playing with other people:

> You know it's kind of nice to have the interaction with other people. Get to see all the idiots out there in the world and laugh at them and go about and do your own thing! [laughs]. So, but, ugh, socialization makes the game really, because you're not playing with bots. You actually have a living, breathing human being on the other end who has living breathing reactions, and they're not perfect (Student 14, interview).

Realism was also highlighted by three students, and two students stressed customization. Two students noted the importance of an easy to use interface, with one highlighting it repeatedly and placing its importance near the top of important features for a game:

> Interface is another thing. If it's got an attractive, easy to use, you know I'm getting older, and interface is starting to become a huge thing….the [Nintendo] Wii has the playability, and anybody can pick up a console or a joystick and play….to master a move, you just wave a wand, and you can do it. Again it's the user interface that takes priority in this (Student 14, interview).

These findings both reinforce the complex, challenging, and unpredictable nature of the creative process of creating an engaging game and provide some guidance for what current approaches found in commercial games that the students find engaging. Student responses reflect the GATE method by focusing on such issues as the importance of story, realism, and customization. However, student responses also identified some aspects of engagement which the GATE theory does not overtly include, such as socialization and ease of play. These elements should be highlighted in the GATE theory as they clearly also play a large role in how engaging a game is.

1.8 Design and Develop the Game through an Iterative Process which Includes Cycles of Prototyping, Evaluation, and Redesign

What Happened?

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Initial prototype. The researcher designed Lifecycle, creating design documents that specified player actions, feedback, and an underlying rule-base and scoring process (see Appendices B, C, and F). An undergraduate student intern was found in Spring 2005 to work on developing the game for one semester using Macromedia (now Adobe) Flash in exchange for course credit. Prior to starting development, a paper prototype of the game was created and tested to evaluate and refine the underlying rule system. The researcher and the developer met numerous times throughout the semester to discuss the progress of the development. It was determined to initially focus solely on the critical aspects of the game and to implement other features (such as a high score board and a log of chosen actions) after the critical features were functioning correctly. At the conclusion of the semester, the student developer had completed the majority of the game but had been unable to work out all of the errors, leaving a prototype, but one that did not really function as intended (see Figure 6).

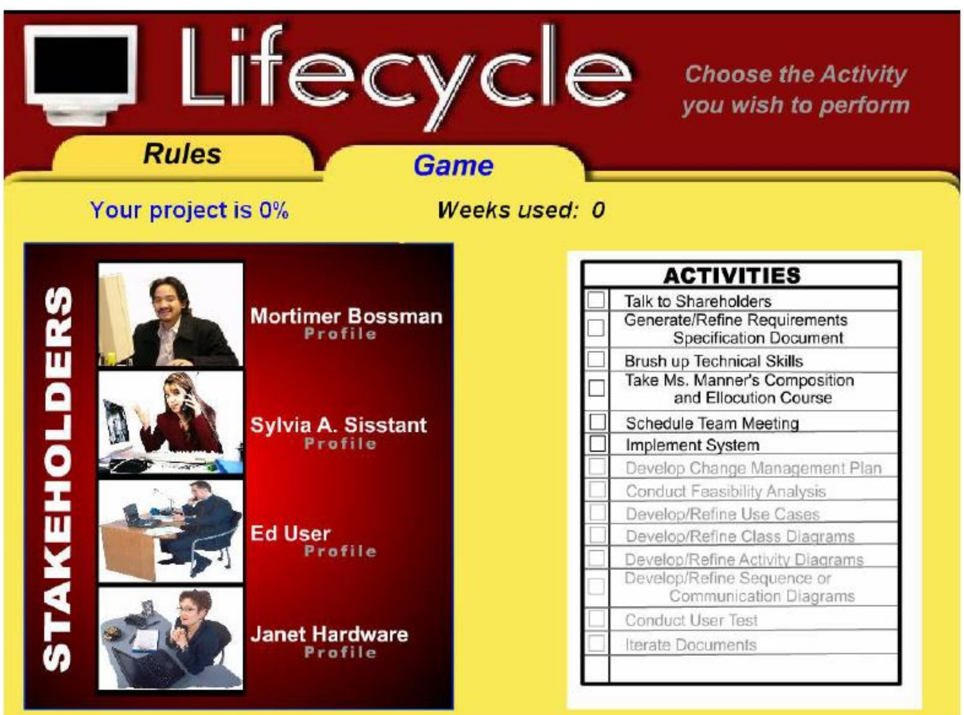

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Figure 6. The first Flash-based prototype of *Lifecycle*.

Second prototype. A second undergraduate student intern could not be found the following semester; however, one was found in the Spring 2006 semester to complete development of the game for course credit. He ultimately decided that it would be easier to start afresh rather than try to understand and correct the previous intern's code. Furthermore, this intern seemed more capable in terms of his understanding of coding in Flash, and additional features of the game were discussed to enhance player enjoyment. These included making the game more visually dynamic; the interface would now be a desk in an office with the primary interaction coming through a PDA computer on the desk (see Figure 7). There was also a desire to allow for more player customization, such as customizing a nameplate on the desk in the game as well as inserting a picture in a photo frame. The desk was to be interactive, with players able to crumple up and throw away papers, doodle on pages, open the drawers of the desk, and perhaps even play mini-games such as swatting a fly, or tic-tac-toe. These elements supplemented the addition of a high score board and a player action log, which were missing from the first prototype. It was again decided that the important functionality of the game should first be completed.

Figure 7. Completed version of *Lifecycle*, office desk screen.

Ultimately, much like the first intern, time ran short, and the intern was unable to fully complete the game in a single semester; however, as he was close, he agreed to finish up the last few required elements early in the following semester and correct any bugs that were found in play-testing. The researcher implemented a pilot study of the incomplete game in his course at the conclusion of the Fall 2006 semester. The game largely functioned but had scoring issues which undermined some of its effectiveness. The intern corrected these bugs early in the Spring 2007 semester, and brief instructions for students to take a screen shot and email it to the instructor were included on the final score screen (see Figure 5). However, additional desired functionality, such as a high score board and all of the interactive features of the desk, were never completed

What Did and Did Not Go Well?

Limited resources for development. A major challenge in the design and development of *Lifecycle* was the limitations posed by a lack of budget for developing the game. The reliance on student interns meant that the game would necessarily require a limited scope. Despite this limited scope, the development of *Lifecycle* took considerably longer than the originally intended one semester.

The first student intern did not successfully complete the game; although she came very close but was unwilling to work beyond the semester. A new intern was not able to be found the following semester. This alone pushed the development time to over a year, and the second intern felt compelled to start the game from scratch, resulting in an entirely new development cycle.

One key design feature left out of the current version of the game was an instruction manual which was to be placed within the drawer of the desk in the game. As will be discussed in the later section on results from implementing the game, the lack of this feature in the game resulted in considerable confusion for the players, and its omission was more problematic than originally suspected.

The lack of end users in all testing. Related to these omitted features are the bugs that still remain in the game despite frequent testing by both the researcher and the student intern, as called for by the GATE theory's process of design, evaluation, and redesign. It is clear that involving end users in the testing is a much more effective means of identifying game errors. While the researcher was aware of this conceptually, the point was really driven home during the final implementation of the game as one of the errors in particular caused some problems with the students' learning experience. This error will be discussed in more detail in the section in this chapter reporting on the results of the implementation.

Confirmation of instructional design theory development methods. What did go well in the game's design and development was that despite the fact that the development of the game ultimately took nearly four semesters worth of calendar time rather than one, the fact that the second intern was able to complete the game, albeit with some remaining bugs, in one semester showed that the researcher's scope and feasibility analysis were fairly on target. Furthermore, with this feasible scope in mind, the researcher was able to design the game in such a way as to tie it in well with the rest of the course to allow for the course and game to complement each other. This helped to make up for the limiting aspects of both the game and the project-based instruction of the course as a whole. This holistic focus on not just the game design, but on how it was to be implemented and the context in which it would be implemented, further support the importance of the recommendations in the instructional design theory which calls for these considerations.

While a few bugs still remain in the current version of the game, the iterative cycle of prototyping, evaluating, and redesigning the game did continue up until the implementation of the game described in this study. The early creation of a paper prototype of the game proved extremely helpful in testing and redesigning the game early on, as recommended in the theory.

Corrections were made following the evaluation of the paper prototype as well as the pilot implementation of the game. The paper prototype evaluation showed that the original 30 week time period specified in the game's design document was not only too difficult for players but also did not allow for enough aspects of the game to be explored. The game design was therefore modified to provide a 50 week development period.

The pilot implementation of the game was conducted in the course the previous semester. It not only found some errors with the scoring in the game but also provided some confirmation of the realistic nature of the game as two students who worked professionally as analysts provided positive comments regarding the general structure of the game; although bugs in the game prevented a full exploration of student perspectives on the game.

Minor tweaks continued to be made to the game's underlying structure, changing scoring aspects and actions results from the original design documents (see Appendices B and F). These tweaks largely dealt with trying to adjust the game to an appropriate difficulty and cleaning up game bugs. This confirmed the recommendations in the instructional design theory for iterative cycles of design, prototyping, evaluation, and redesign to allow for corrections of this sort to be made.

Tentative Recommendations

Tentative recommendations based on these results focus primarily on the importance of the designer having a firm understanding of available resources when designing the game and of how it is to be implemented. Limited scope of the game can be addressed by paying equal attention to how it will be implemented. Furthermore, the problems with the first intern drive home the point that the more restricted the resources available, the more careful the designer needs to be in being as involved as possible in the building of the game. Again, making the state of the game as it is played transparent so scoring values can be checked against the formal game rules for accuracy is very important.

The importance of testing with end users whenever possible was driven home by the bugs which remained in the version of the game implemented for this study, despite repeated testing by both the student intern and the researcher. Ultimately, however, the researcher found a great deal of confirmation for the specific recommendations for how to apply the first method of his instructional design theory.

Summary of Tentative Recommendations for Method 1 of the Theory

This section of the chapter has provided details on the design of the game and implementation of the educational game *Lifecycle*. In doing so, it has analyzed the process of designing the game, relying on the researcher's experience, design documents, and student feedback. While a great deal of positive feedback on the design process was found, some room for improvement to the theory was identified. A summary of recommendations for improving the GATE theory include providing guidelines for:

- Evaluating learning goals and reaching consensus on a design team.
- Incorporating more student feedback in the early context and learning goal defining stages.
- Providing additional guidance on cost-benefit and feasibility analyses.
- Illustrating examples of implementation types for different learning environment contexts.
- Making transparent testing prototypes to confirm the logic of the game is accurate.
- Considering aspects of socialization and ease of use when designing for engagement.
- Testing with end users whenever possible.

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(2) Prepare Learners to Benefit from Game and Implement Game as Designed

The second method of the GATE instructional design theory is to prepare the learners to benefit from the game and implement the game using the supporting implementation structure previously designed in method 1.6. *Lifecycle* was presented to the students of the course towards the end of the Spring 2007 semester, upon completion of the final required model for the students' intermediate project and prior to the beginning of the final project. This section describes what happened during the preparation of the students to play the game, as well as what did and did not work well and recommendations for the theory based on these experiences.

2.1 Prepare the Students for Reflection and Analysis

What Happened?

Students were prepared for the implementation of *Lifecycle* starting on the first day of the course, when they were told that they would be playing an educational game and evaluating it as well as their own learning. The game itself was of course not introduced until near the end of the semester. When the game was first introduced to the students, they were told that they would be playing the role of a systems analyst and should try to utilize the skills and knowledge they had learned in class to plan their strategy for winning the game.

As mentioned in the previous section on designing the game, a log of player actions was designed into the game so students could review what choices they had made as they played the game. This was done to allow students to better reflect on and analyze the choices they had made. This log was also highlighted by the researcher, who told the students that they could use the log to reflect back on what actions they were choosing as they played the game.

Students were also directed to save the final screen each time they played the game and email it to the researcher who would be posting high scores online in the course management system. Students were directed to play the game at least once but encouraged to play as often as they would like. They were also told they were free to play in teams if they so desired.

Furthermore, students were given a reflection assignment prior to the introduction of the game and before they had played it which directed them to reflect upon the strategies that worked well for them (see Appendix D). This assignment was to be completed after they had finished playing the game and prior to the in class debrief.

What Did and Did Not Go Well?

While students were eager to play the game, and all students completed the reflection assignment, student written responses on the reflection assignment were largely rather concise and did not display the level of reflection and insight the researcher had hoped for. The reflection assignment, while providing positive information, was typically completed rather succinctly and without a great deal of evidence of strong, critical reflection. This resulted in the students not perhaps being as prepared for the class debrief as would be preferred, and while again valuable information was obtained, too often the class debrief turned to specifics of the game, rather than to a detailed reflection on the embedded learning in the game and the students' own meta-cognitive processes and strategies when playing the game.

Additionally, the students largely agreed that they paid little attention to the gameplay log in the game. One student noted that the inability to examine the log after the game concluded made the log difficult to use. The log was originally intended to be available to be emailed to the players along with their score for the game, but this feature was not included in the final design.

A number of students did note that they utilized strategies learned in the course to plan their strategies for playing the game, however, and this was a positive.

The results of presenting the game to the students highlight the researcher's now recognized lack of tight adherence to the sub-methods of presenting the game. Outside of designing *Lifecycle* with the existing project-based class structure in mind, the researcher based his planned implementation structure on his own experience as a student playing the *Diffusion Simulation Game* discussed earlier in this chapter. In that experience, graduate students played the game individually, and the class met to debrief the experience. While a written reflection on the experience of playing the game was required of the students, this was the only additional reflection required of the students prior to the class debrief.

Tentative Recommendations

Providing a rubric, or perhaps more detailed instructions for the reflection assignment likely would have promoted more effort on the students' parts at reflecting on their gameplay experience. Computer and information technology students are somewhat notorious in their disdain for writing assignments, and the researcher should have recognized this and compensated for it. These issues reinforce the importance of following the GATE theory's methods, preparing the students for reflection and providing explicit instructions for recognizing and maximizing learning in the game. As mentioned in the first method's section on designing the implementation structure, examples of implementation approaches could strengthen the usefulness of the GATE theory and would prove helpful for this sub-method as well.

2.2 Provide Explicit Instructions for Recognizing and Maximizing Embedded Learning Opportunities

What Happened?

In addition to the reflection assignment and the highlighting of the in-game log described in the previous sub-method, a written introduction to the *Lifecycle* game was provided when the game was first started by the students and also highlighted by the researcher when the game was introduced. This introduction presented the overall context and goals of the game. However, additional, more specific instructions were originally designed that defined what each of the actions in the game was and meant, which would have provided important clues to the students as to how the components of the game were related (see Appendix E). The researcher designed these instructions by defining the terminology used throughout the course, in order to scaffold student understanding of these terms as well as reduce any confusion that might arise due to the primarily text-based feedback and interface system the game used. Terms were not only defined but clues towards how the underlying concepts in the game related to each other were also provided in some of the definitions. These definitions were again based on the researcher's knowledge of the topic.

What Did and Did Not Go Well?

As previously mentioned in method 1.8's discussion of limited resources for development in this chapter, *Lifecycle* was originally planned to have more detailed instructions for the game inside the desk drawer in the game. On one level, this would have, in one small way, addressed the lack of interactivity, which a number of the students commented on, several of them specifically mentioning the desk: "The whole desk idea; there's nothing going on with the desk except the palm pilot" (Student 9, class debrief). More importantly, it would have addressed the most problematic issue with the game, which was student confusion over what the game action "implement" meant.

This was a significant mistake by the researcher, as in class, in describing the phases of a systems development lifecycle, sometimes implement was listed as a separate step from development, and sometimes it and development were listed as a single step following design. The analysis and design process, commonly referred to by the acronym ADDIE, representing analysis, design, development, implementation, and evaluation, does not have a standard list of phases. However, in reviewing the course's presentation slides on the process, implement was listed as a separate phase from development.

Therefore, the choice of the term implement as an action was perhaps a poor choice. However, the inclusion of the original game instructions in the game would have largely mitigated this choice, as it reads:

> Implementing the system means actually developing (building, coding, etc.) working elements of the system. The speed at which working components of the system can be built as well as the quality of what you develop is dependent on how well you understand the system that is to be developed; therefore, how many weeks it takes you to implement a portion of the system depends on your knowledge of how the system will work (*Lifecycle*: information and feedback details for players design document).

Some students clearly had the concept that implementing the system meant turning it over to the client for deployment, and some of them never corrected their understanding of this idea. This incorrect understanding of the concept (in terms of the how the game functioned) was further exacerbated by poor feedback in the game, which will be discussed later in this chapter. The combination of the two resulted in great confusion as to how to actually win the game, as a number of students never understood the need to complete the implement action numerous times in order to successfully complete the game. This is well illustrated in the following exchange:

> Student 4: That's kind of what I was thinking, like finish up as much of the diagrams as possible, then the, the project was actually giving the software to the customer, I thought. I didn't know.
>
> Student 14: Yeah, see I thought implement meant, the first two times I went through, I thought implement meant…
>
> Student 4: You're done.
>
> Student 14: …I'm ready to send this to the real world to be done.
>
> Student 4: Right.
>
> Student 14: And then, when I saw the little blue progress [bar], I was like, 'this is as good as I did?' and then I didn't realize the game wasn't over yet because I still had time. I was way ahead of the cue-ball there on that one. I was like, 'now what?' And I thought it was locked up. I was like, 'Well, nice bug you threw in there!' [laughs]. Then I realized, 'Oh, that implementation doesn't mean I'm done; I'm ready to submit for the final world to finally take hold of this thing. It's keeping on going.
>
> Student 4: What exactly did it mean?
>
> Student 11: Writing code.
>
> Student 4: So, you wrote the, you're writing the code?
>
> Researcher: Right, you're starting to build it.
>
> Student 4: Oh, so you're not submitting it to the end user?

Researcher: Right.

Student 4. Ohhh. So you would do your testing after you implemented… (class debrief).

This shows how a number of students were greatly confused by the implement action and its absolute importance in successfully finishing the game. By waiting to implement at the end of the game, students were also not unlocking the conduct user test action, which was mentioned at the end of the above quotation. In examining the gameplay video of the thirteen students who had their first interaction with the game recorded, nine of the thirteen students did not successfully conduct the implement action in the first half of their moves playing the game. Two of the thirteen never tried to implement during their first attempt at the game. This totals eleven of the thirteen students observed playing the game who did not implement early in the game. One student (Student 5), implementing late, realized from the implement bar that he had more to go, and continued implementing for the rest of his few remaining actions, narrowly missing successfully completing the game on his first attempt, which none of the thirteen students did.

It should be noted that the researcher did not expect that many, if any, students would successfully win the game on the first try, given his intended difficulty level for the game. The student who nearly won the game on his first attempt noted his confusion with what implement meant: “Like, what was it for the implement? Like, I didn’t know you had to click that more than once kind of thing. So I never clicked it until I thought I was done with everything else” (Student 5, interview). He did successfully complete the game on his next attempt, according to his reported scores.

This confusing aspect of the game had an immense impact on the students' abilities to understand the game. For example, one student in the class actually did some professional SAD work and noted his confusion with not winning the game: "Yeah, the game made me kind of question if I really knew what was going on, actually. I mean, I never did succeed in it, but yet, I do it every day, and I succeed just fine" (Student 14, class debrief). It should be noted that he only played the game twice, and scored quite high both times; although did not successfully complete implementation.

Tentative Recommendations

Again, feedback on this sub-method provided specific information on how to improve the game that was used in this study. However, as the methods in the GATE theory recommend the very issues which were not done well in this implementation due to design constraints, those results support the guidelines in the theory that were not followed. Furthermore, what is highlighted in these results is the importance of supporting the lack of any design features in the game by supplementing the gaps with additional out-of-game features. In this instance for example, paper instructions would have worked just as well, and there was no reason to not provide them to the students simply because the game design timeline ran a little short and not all features could be included. Therefore, the GATE theory should strongly emphasize the need to compensate for any game development restrictions with additional out-of-game support to compensate for any exclusions.

2.3 Provide learners control in choosing actions and/or selecting their own goals through linked modules or "episodes", depending on scope

What Happened?

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As described in method 1.7 on designing engagement, the researcher designed significant player choice into the game. However, as described in method 1.1, given the limited scope of the game, the researcher did not design learner choice of goals through modules into the game. Learners could of course choose their own goals within the restrictions of the game, so players might try to implement the game in as short a period of time as possible or with the highest possible quality, instead of simply trying to achieve the highest score, which is based on a combination of these factors.

What Did and Did Not Go Well?

Students were required to play the game one time but were otherwise allowed to play the game as many times as they liked. Again, students were given control over what name was given to the systems analyst in the game. A number of students did choose to play under player names different than their own. In fact, the two who played the game the most times were the only two students who played the game with names different than their own (Student 11, score sheet; Student 15, score sheet). Another student mentioned trying to "break" the game after he had won it (Student 5, personal communication).

Tentative Recommendations

The limited scope of the game *Lifecycle*, implemented in this study provided a relatively limited number of choices for students playing the game. Furthermore, it did not implement the option of supporting multiple modules for players. Some students mentioned the desire for additional customization, even mentioning allowing for customized music in the game, but in following the theory, the researcher did design choices included in the game that allowed for a great variation in student scores and experiences with the game. Future instances of the theory should certainly include multiple linked modules so additional feedback can be gathered on this sub-method and opportunities for improvement identified.

Summary of Tentative Recommendations for Theory

There were several strong lessons learned from results dealing with preparing students to maximize learning with the game which will be presented here prior to drawing conclusions for recommendations for the GATE theory itself. The researcher made a number of mistakes in how he chose to prepare his students. Chief amongst these was not better supplementing the shortcomings of the game due its resource limitations. Simple paper-based instructions could have been provided to the students to make up for the exclusion of the instructions from the game by the developer. This would have likely greatly increased the effectiveness of the game for the students, as well as given them a more positive view of the game by reducing their confusion.

Also, the researcher made a mistake in not closely adhering to the recommended sub-methods in the GATE theory for presenting the content. Given his past experience in a class of graduate students reflecting on their experience with an educational game, he expected his undergraduate students to reflect in the same manner, rather than being more precise and directed in preparing them to reflect and providing better guidance in recognizing their own learning.

The following recommendations were made for improving the second GATE method of presenting the game:

- Provide specific examples of different implementation structures for various learning environment contexts.

- Emphasize the need to support with out of game supplements any gaps between the original design and the finished design due to development limitations.

(3) Provide Feedback

The final GATE theory method is presented here, detailing how feedback was provided within and outside of the game, how learner interaction was encouraged, and how learners were able to demonstrate their knowledge.

3.1 Feedback Should be Provided Within and Outside the Game in a Natural Way that Fits with the Context as well as the Learning Goals

What Happened?

The majority of feedback was embedded within the educational game, *Lifecycle*. The researcher focused again on trying to provide feedback in a way that was realistic with the game's context. Feedback was therefore provided on player actions and the game's response via natural interfaces. A calendar on the player's desk highlighted how many weeks were left to complete development of the project. If players wanted feedback on the quality of the system being developed, they could conduct a user test. Final feedback in the game was given by providing a final score and the value of the variables that composed that score, such as quality rating and customer satisfaction.

As recommended by the theory, additional feedback was provided outside the game in a class debrief session after the students had played *Lifecycle*. The researcher acted as the moderator for the debrief, directing students to discuss what strategies seemed effective in the game and what that might imply for systems analysts in the real world. Students were also asked to discuss what strategies did not work well and why that might be. The researcher also asked students to discuss what aspects of the game seemed realistic and which did not, and why. Students also were asked to make recommendations for improving the game and justifying their recommendations by explaining how it would better capture important lessons for novice systems analysts.

What Did and Did Not Go Well?

As mentioned previously in this chapter, the researcher was heavily influenced by his own positive experience learning from an educational game in graduate school. In that experience, students played the game individually before debriefing their experiences as a class. When the researcher presented *Lifecycle* to the students, they were not told to play *Lifecycle* alone, but were allowed to play as they would like to; however, they were not *encouraged* to play the game in small groups. This resulted in lack of interaction between the students reducing the opportunity for them to gain further feedback outside of the game on their chosen strategies by comparing results with other students or playing the game together.

As previously mentioned in this chapter, there were also some feedback problems in the game due to development flaws. Perhaps the most egregious of these problems was in regards to the implement system action. As described earlier in the chapter, there was already some student confusion regarding what the term “implement system” meant. The problem with the feedback for the implement system action was that the initial instance of implementing the system produced no change in the progress bar representing how much of the system had been successfully implemented (see Figure 8 and Figure 9).

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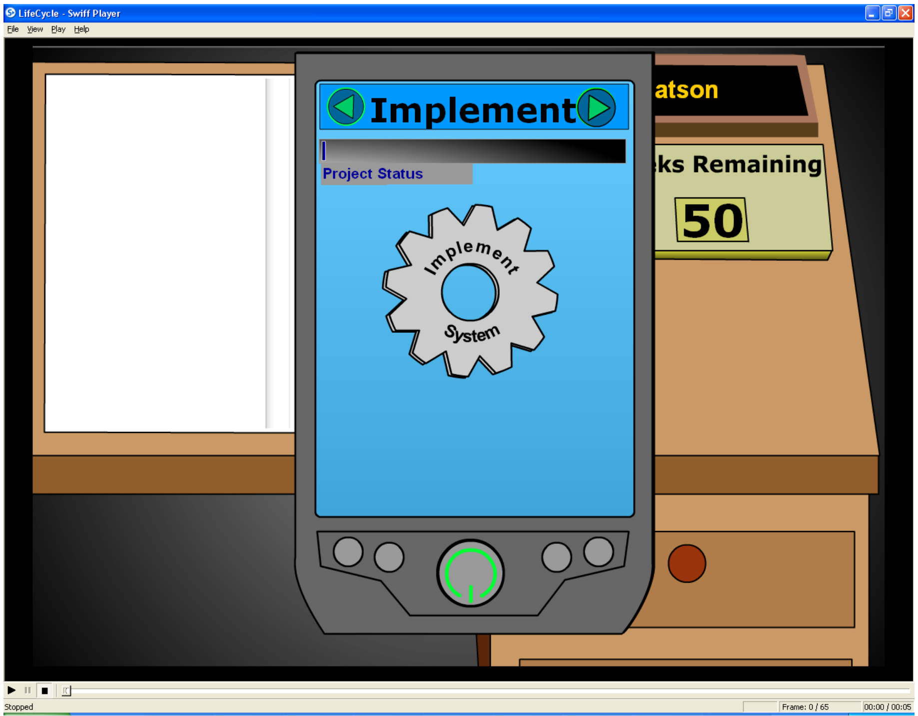

Figure 8. The implement system screen from *Lifecycle* prior to conducting the implement system action.

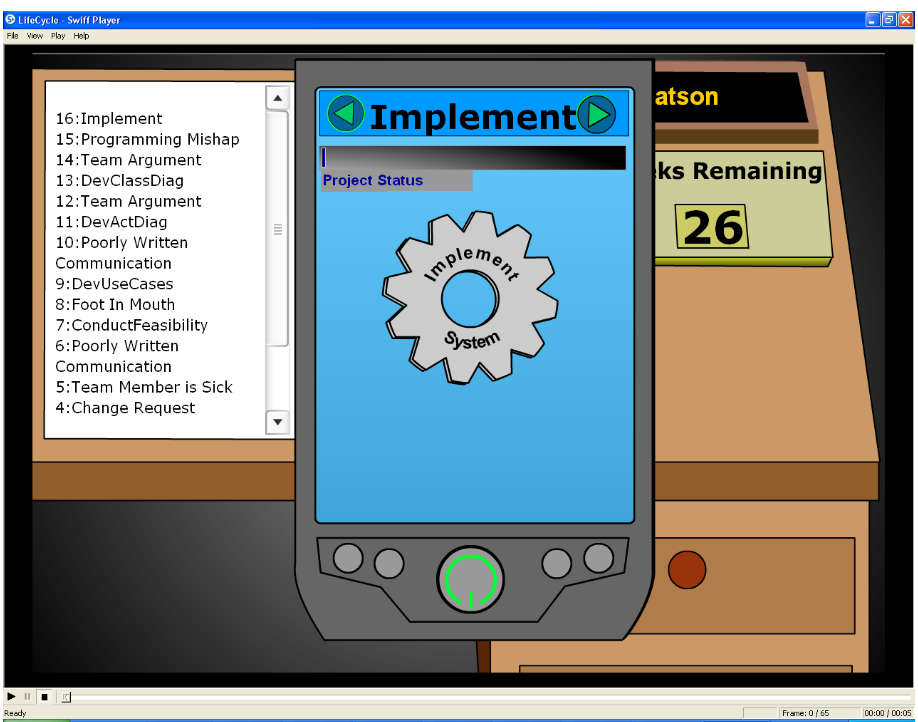

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Figure 9. The implement system screen from *Lifecycle* after successfully conducting the implement system action one time.

This resulted in students not receiving any feedback on what the implement system action was doing. For students who thought that they only had to do this action one time, they received no feedback that in reality multiple activations of this action were required.

An additional feedback problem was that, as previously mentioned, the scoring system was incorrect. In order to receive a final score at all, the students should have had to successfully implement the system to 100%. Otherwise, while they could still receive a rating of what their business knowledge and client satisfaction scores were, they should not have been given a final score. This resulted in students receiving very high scores, even while they were being fired. Students were confused by this, not understanding what they had done wrong, that they had not fully implemented the system. Again, coupled with the previous issues regarding implementing the system, this created something of a perfect storm of confusion for some students. As one asked when successfully completing the game was brought up in the class debrief: “[What] is successfully, because I have 1800 and still lose!” (Student 2, class debrief).

Besides these problems, there was a general sense among students that the game did not provide enough feedback. For feedback on some scoring variables, such as client satisfaction and quality, players were required to do actions, such as user testing for quality and meeting with the secretary for client satisfaction. As some students did not do these actions while playing the game (user testing did not become available until after the first time the player did the implement system action), they were never able to find out how to see this feedback.

A number of students also mentioned that the end screen could provide better feedback, as they were uncertain what the scores meant, what was good, and what was bad.

Students also expressed some confusion as to how much development of the analyst skills was enough. This was in part because each time a player trained a skill, it only reduced the chance for the associated random impact to occur, but there was always still a possibility of it occurring again. This resulted in frustration for some of the students and confusion as to how many times they had to train a task:

> You should put something on the desk like a rank consisting of what level you are, if you're a tech, what level you are for this, what level you are for that. And then, like, also how you're doing on the project. That way you could understand that you're supposed to level up, and that you do, and then you can actually use that screen (Student 9, class debrief).

Students also demonstrated confusion regarding what the iterate documents action did, due to a lack of feedback. Iterating documents actually gave the benefit of doing the revise document action for each of the documents, but in only two weeks, instead of the four weeks it normally took to revise each of them. In the debrief, none of the students seemed certain of what impact the action had. After the researcher explained the action, one student remarked:

> That would probably have been the difference from me succeeding and failing. Because I would literally go … ok, I need to start here again and revise this. Now I have to revise this because this changed and back and forth, back and forth, back and forth. When all I would have had done was go [makes clicking motion] done! [laughs] (Student 14, class debrief).

Additional evidence of problems with feedback as well as likely a poor design decision was that a number of students over inflated the importance of conducting team meetings. In terms of the game's structure, the only impact of having a team meeting was it reduced the chance of the random event of team argument occurring. With students' conception of real-life work on their projects, they knew they met frequently to discuss and go over the system models, and therefore, accordingly conducted the team meeting action very frequently. With no feedback on what the background result might be from this action, many of them placed very high importance on the team meeting action, importance not reflected in the game's actual structure:

> I think I was lacking in feedback to say you should have more meetings. I didn't really pick up on things that would correct my strategies. I was just trying different things, and it seemed like to be successful on something like that, you'd have to have a lot of meetings. I tried to have a lot of meetings, and it was just hard for me to develop a strategy (Student 4, class debrief).

Several students also mentioned feedback issues which were originally designed for the game but were not built into the final game. One of these was that the log of player actions from the game was not available to look at from the end screen, as originally intended: "I'd like to be able to go back and see what the last screen showed. Or multiple ones, it's got the whole list over there. If you could go look at them, that'd be great!" (Student 11, game debrief). Another student mentioned wanting to have the high score screen in the game so he could better interpret how well he had done immediately after finishing the game. This was also a planned design that was not built into the game.

Another smaller issue regarding feedback was that, for the students not carefully reading the screen, the similarities in design of various feedback screens confused them: "Speaking of those pop-up things, it'd be nice if like the negative ones were red and like, the positive ones, which I didn't realize for a while that there were some positive ones, were like, a different color. Uh, like green" (Student 14, class debrief).

Finally, there was another bug in the game discovered by observing the recorded video of students playing the game that the Ed User stakeholder would sometimes inexplicably state that he had nothing further to tell the analyst on only the second time the player met with him. This message should not have been displayed until several meetings later, and when this error occurred, if the player met with him again, the correct message would be displayed as if the second error-producing meeting had never occurred. While no students mentioned this, it certainly would have added to their confusion.

Tentative Recommendations

Overall, feedback was a common theme when students were discussing being confused or making recommendations for improvement to the game. The researcher expected this to some degree because, as described by one of the students, the game is a puzzle to a degree. With a somewhat simple scope and underlying rule structure, a certain level of mystery as to how the game functions was felt to be necessary to keep the game challenging, as challenge is an important component to engagement in the GATE theory. That being said, other issues in regards to game bugs, and the lack of instructions likely made the game much more difficult and confusing than intended. This likely explains the higher than desired number of students who never won the game.

Student recommendations for changes to the feedback system are compelling; however, these should likely be evaluated after all bugs from the game are removed and original designed feedback elements are fully implemented into the game before drawing further conclusions.

As for recommendations for the theory, the theory recommends feedback within and outside of the game. However, it could be strengthened by noting the value of synthesizing and not segmenting this feedback. In this design instance, students played the game, receiving the feedback from the game. They then received additional feedback through the class debrief. However, feedback from their peers and instructor would have been more impactful if they then were able to go back to the game and play again, based on the feedback they had received.

Furthermore, the theory should highlight the importance of ensuring that enough feedback has been provided and that feedback is frequent and provided for all actions available in the game.

3.2 Learner Interaction Should Be Incorporated and Encouraged, Whether Within or Outside the Context

What Happened?

During the design process, the researcher did consider making a multi-player option in the game. However, due to the limited development time and resources, this idea was quickly scrapped, so no learner interaction was built into the game itself; although, of course students were capable of playing the game together with one student advising another who interfaced with the game.

When the researcher introduced the game to the class, students were encouraged to play the game as they would like, including together in pairs. However, class time was not allotted for students to play the game, and outside of their initial time playing the game, students were free to play the game in the manner of their choosing.

What Did and Did Not Go Well?

Ultimately, none of the students played the game together in groups but instead all played as individuals. This perhaps should not have come as a surprise as the researcher's seven years of experience with computer information technology students shows that the students often seem more eager to interact with their computers than their classmates and considerable arm twisting and reminding is often necessary for the students to work together. This arm twisting and reminding was not given for playing *Lifecycle* in groups, and therefore none of them did.

This reflects a clear lack of adherence to the sub-method for providing feedback which indicates the importance of encouraging learner interaction. While the students did interact in the class debrief, this was likely not as valuable as playing the game together might have been for the students. Furthermore, with 15 students participating in the class debrief, despite the researcher's best attempts at involving everyone in the class debrief, some students were naturally much more vocal than others, and some students made very few comments, even when prompted.

Tentative Recommendations

It is clear that the lack of social interaction amongst the students playing the game removed one additional avenue for feedback from them. This further strengthens the importance of the theory's guideline for incorporating student interaction. The implication for the GATE theory is that multiple opportunities for learner interaction regarding both the playing of the game and reflection on the game play experience should be structured into the game implementation structure.

3.3 Learners should Demonstrate their Understanding of Themes, Topics, and Concepts through Varied and Multiple Performances, within and outside the Game

What Happened?

As the researcher largely designed *Lifecycle* to supplement and scaffold other instruction in a project-based course, students were able to demonstrate their understanding of the topic through multiple performances. This included documenting fictional systems with the models utilized in the game, both before playing the game and following the game in the course's final project. Additionally, the reflection assignment and class debrief following the game allowed for students to verbalize their understanding by identifying successful strategies in the game.

What Did and Did Not Go Well?

***Student learning in* Lifecycle.** As an educational game, it is of course particularly important to identify evidence of learning that occurred through students playing *Lifecycle*. One way learners demonstrated their understanding was through the strategies they utilized when playing the game. By examining evidence of students' learning strategies to succeed in the game, if the game is correctly designed and learning opportunities properly embedded, then an improved understanding of the game can represent evidence of learning.

One example of this was students recognizing the relationships between meeting frequently with the stakeholders during the design process, and client satisfaction:

> Student 15: Uh, if you talked to the client and all the people, your uh….
>
> Several People: Customer satisfaction.
>
> Student 15: Customer satisfaction goes up (class debrief).

Another example of this was recognizing the importance of technical, communication, and group work skills, as well as the importance of managing scope creep through change management:

> Since I've kind of gotten an idea, like I lost turns for the not doing the eloquence thing and the techies didn't talk to somebody well and lost customer satisfaction. So probably try to do more of the tech skills training and eloquence and just try to get a better flow for the meetings. And moving on to things, because I'd like meet with somebody and he'd have nothing to say. And then I'd go on, and like I should have done the change of management earlier because the scope creep came up and it was either lose satisfaction or lose 1-4 weeks" (Student 3, interview).

The student's use of terms such as scope creep and change management was satisfying evidence of the student demonstrating usage of SAD terminology and concepts represented in the game. Several students also noted how their strategy for playing the game was guided by their experience in class of following a specific SAD process through application of UML models:

> Student 11: Well, it was just like this class.
>
> Student 14: Uh, yeah, I was just going to say, it was basically the order we had in this class. We went through this first, and then we went through this and this, and it seems like when we complete them, that's the order we go [in] (class debrief).

Another student referred to this, stating "I started actually going through the UML phase, which is, started doing the use cases first and then just figured out what comes next and then did that. And I was always refining them" (Student 7, interview). This student also noted that he applied the concept taught in class of iterative design, meaning the importance of refining models as the analyst documents more of the system and gains a stronger understanding of its requirements and design. One student noted the effectiveness in scaffolding what was taught previously, saying "Yeah, it was like class. I mean, I think you could learn a lot from playing the game" (Student 12, interview).

Students also demonstrated an understanding of both what a systems analyst must do and what skills are important to an analyst:

> Communication and planning are the most important skills for a systems analyst. Concerning communication, an analyst must be able to speak on both a technical level and a personal level depending on the situation and must be able to translate between the two. The planning required in the field is to take what the client wants and include that in documents for the programmer to use in the actual program (Student 15, reflection assignment).

Another student demonstrated an excellent grasp of the role of an analyst:

> A systems analyst leads a team of software developers. He must communicate with management, the users, and the hardware people. He must generate a good blueprint for the software and lead the team in building it, all the while working with the end users to ensure customer satisfaction (Student 11, reflection assignment).

Finally, another student demonstrated an excellent grasp of the importance of both communication and technical skills for the analyst so he as able to speak two languages, both that of his programmers and that of his clients:

> A system analyst is the person who is the middleman for the client and the actual programmer/technician. He does the initial designing of the system by taking the requirements of the customer and then breaks it down to language the programmer/technician can understand and vice versa. He also communicates to the customer on the progress and what the programmer/technician is doing in terms they can understand.

As for student perspectives on the educational value of the game, they were largely positive: “it’d be hard to effectively educate someone using a video game, I think while keeping their interest. But this had, you know, no problem in doing it. I’d be definitely interested. I’m mad I got fired” (Student 12, interview). Another student echoed this, saying: “But something like this I could see in a teaching environment, how it could definitely help” (Student 5, interview).

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Student perspectives on the use of educational video games. Students largely had a positive perspective on the use of educational video games. Not a single student commented that they would prefer to not play educational video games; although the non-native female was uncertain about their use due to her lack of experience in playing educational games: “I’m just curious because I don’t know; I haven’t played in so long. I don’t know [if] I’m good at that or not” (Student 2, interview). Furthermore, one student did say while he was open to educational video games, he preferred lectures: “I would like it, but more a lecture, I would prefer that” (Student 1, interview).

One student had a very positive outlook on the potential of educational video games in both the workplace and especially in the lower and middle K-12 grades; however, his only experience with an educational video game was playing *Lifecycle*:

> I think I could welcome that…especially when you get down in the grade school, lower high school level because attention spans are short, and games definitely hold attention spans. So anytime you can maintain attention span you need to use it, and the best way to use it is with a game. And you can definitely teach a lot with one (Student 14, interview).

This idea was succinctly echoed by another student: “I think [playing educational video games would] be alright. I hate lectures” (Student 6, interview).

While none of the students interviewed were unreceptive to the use of educational video games in their classes, quality was a concern: “It really depends on the quality of the game, because, for example at work right now, they have kind of a video game that’s really [a] minimal[ly] interactive kind of video game. It’s probably the worst training I’ve ever received, ever” (Student 5, interview).

While many students had positive perspectives on the use of educational video games, they were nearly universal in not feeling comfortable with being assigned a grade based on their performance in a game. One student did mention that, depending how the application of the game in the course was structured, he could see it being used for grading too but only if he had the opportunity to interact with the game as part of the overall class and had a chance to fully understand how the game works: “I would not mind having a grade based on the game if I totally understood the mechanics of the game” (Student 4, class debrief). His description of how it should be applied is a good description of the need for additional support outside of the game itself:

> Now, if you could incorporate like, you stopping the game at certain points and saying, ok, where are you at, what are you thinking, and this is where you’re messing up. Or you should try this differently, or this is what you’ve learned from doing this, then that might do well. So, I’d probably say if the instructor gives an opportunity to interact with each other during the game, then it would probably be good (Student 4, interview).

Tentative Recommendations

There was significant evidence of student learning through playing the game as well as through the other projects incorporated in the coursework throughout the semester. Having designed *Lifecycle* to tie in naturally with these other performances of understanding, there was a very satisfying connection between these different student performances.

In terms of improving learning performances, it seems that a wonderful opportunity for a game-based performance would be having students demonstrate to peers or the instructor precisely what their gameplay strategy was and why, either using recorded gameplay video, or by playing through the game live in front of others. The theory could be improved by highlighting the greatly improved opportunity for increased learning by having students demonstrate understanding in this fashion. A public performance of this type could also be a great motivator for students to further explore the game; although the associated pressure that can come from public performances, even in front of only one other person, could be detrimental to some students and would need to be treated with care.

Summary of Tentative Recommendations for Theory

This section described the results about providing feedback to students and generating feedback from them, in accordance with the directives of the third and final GATE theory method: provide feedback. Similar to the second method, there were some significant problems with how this was done in this study. Feedback problems within the game caused some confusion amongst students, causing many of them to never successfully win the game and negatively impacting engagement with the game. Furthermore, learner interaction was limited, rather than maximized. A summary of recommendations for improving the GATE theory based on these results follows:

- Emphasize that feedback internal and external to the game should interact and inform each other, so lessons learned in the game can be implemented outside of the game, and vice versa.
- Illustrate the importance of ensuring that enough feedback has been provided, and that feedback is frequent and provided for all actions available in the game.
- Highlight that multiple opportunities for learner interaction regarding both the playing of the game and reflection on the game play experience should be structured into the game implementation structure.
- Stress the benefits of having learners demonstrate their understanding by walking through their gameplay strategies in front of peers or their instructor.

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- Note the risk of harming engagement by evaluating student performance in the game.

Conclusions

This chapter provided the results from implementing the GATE theory in the form of the educational game, *Lifecycle,* in an undergraduate course on systems analysis and design. Results showed quite a few positive results, which highlighted strengths of the GATE theory, including its potential for engaging students with a topic. The students' self-reported engagement with the topic of SAD and common consideration of the area as a potential career path were highlights of the study's results.

Additionally, the fact that the researcher was able to successfully design an educational video game by himself and have it developed in a single semester (after an initial false start) with no budget was highly encouraging. The fact that students agreed with the GATE theory's contention that strong graphics, while nice, are not required for engagement was another promising confirmation.

This chapter also identified numerous opportunities for improving the GATE theory. These are summarized below:

- Providing guidelines for evaluating learning goals and reaching consensus on a design team.
- Incorporating more student feedback in the early context and learning goal defining stages.
- Providing additional guidance on cost-benefit and feasibility analyses.
- Illustrating examples of implementation types for different learning environment contexts

- Making transparent testing prototypes to confirm the logic of the game is accurate.
- Considering aspects of socialization and ease of use when designing for engagement.
- Testing with end users whenever possible.
- Provide specific examples of different implementation structures for various learning environment contexts.
- Emphasize the need to support any gaps between the original design and the finished design due to development limitations with out of game supplements.
- Future instances of the GATE theory are needed which implement multiple game modules and support greater learner choice and goal setting.
- Emphasize that feedback internal and external to the game should interact and inform each other, so lessons learned in the game can be implemented outside of the game, and vice versa.
- Illustrate the importance of ensuring that enough feedback has been provided, and that feedback is frequent and provided for all actions available in the game.
- Highlight that multiple opportunities for learner interaction regarding both the playing of the game and reflection on the game play experience should be structured into the game implementation structure.
- Stress the benefits of having learners demonstrate their understanding by walking through their gameplay strategies in front of peers or their instructor.
- Note the risk of harming engagement by evaluating student performance in the game.

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The final chapter will offer final conclusions from this study, identify limitations of the study, and make recommendations for future research.

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CHAPTER 6: CONCLUSIONS

Introduction

This chapter presents final conclusions regarding implications from the study for the GATE instructional design theory. It then describes limitations for the study before offering recommendations for practitioners and future research. Finally, a brief summary of the study will be presented.

Implications for GATE Instructional Design Theory

As previously mentioned, the purpose behind this study was to evaluate the GATE instructional design theory by examining a designed instance, the educational game *Lifecycle*. The results of this study have provided a number of implications for the GATE theory as discussed in the previous chapter some of which will be highlighted in this section.

Students who participated in this study held a positive but guarded perspective towards the use of educational games. One key finding was that the students strongly resisted the notion of being graded on their performance in a game. However, the students did not have an issue with being graded on an assignment related to the game, such as their reflection assignment. It seems likely that learner attitude towards the use of an educational game could be turned negative if the learners feel pressure to perform in the game. The focus on extrinsic reward, such as grades, could increase immediate engagement with the game but might damage long-term engagement with the topic, which is the driving goal behind the GATE theory. It is therefore recommended that educational games developed with the GATE theory should encourage a play experience which is intrinsically rewarding.

While *Lifecycle* was successfully developed with limited resources, the process was not without problems. The experience of having the game developed by students drove a couple of points home. First of all, it is very important to have a firm grasp of available resources in determining the scope of the game's design. While the GATE theory stresses that designers should not limit their designs initially, it is important to be realistic once the feasibility of the ideal design is analyzed. Another important lesson is to leverage available resources outside of the game to make up for any limitations in the game's scope. The mistake in not providing game instructions outside of the game itself once they were not included in the game design was a damaging oversight.

While the students in this study would have preferred greater depth in the game's design, the lack of greater depth did not make the game's current design ineffective, as shown in the results chapter. Obviously, engagement could likely be improved if *Lifecycle* had a million dollar budget and a large development team; however, student response to it in this study supported the GATE theory's claims that educational games can be effective and engaging despite severely limited resources for development.

Additional elements of the GATE theory were reinforced and emphasized by the results. Despite the GATE theory stressing the importance of an equal focus on the supporting implementation structure, it can be very easy for a designer to place a greater focus on the design of the game, due to the inherit complexity and difficulty in designing and developing the game. This was represented in this study by the lack of focus on having students socially interact more regarding the game and the lack of better guidance in preparing the students to reflect on the learning experience. The GATE theory calls for a strong analysis of the learning opportunities available through playing the game, and it

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is very important that a firm understanding exists for the designer of how to maximize these opportunities. By spending more time in documenting these opportunities, much like the design of the game itself is documented, it is more likely that the supporting implementation structure's quality would be improved.

Another important recommendation for the GATE theory is the inclusion of a fourth method: evaluate effectiveness of the game. It is clear that areas for improvement of *Lifecycle* were identified through this study, and it would make good sense to explicitly state the need to evaluate the impact of, and identify aspects of, improvement through a summative evaluation beyond the formative evaluations recommended in method 1.8. This would entail evaluating evidence of learning and engagement resulting from the implementation of the game and identifying improvements not only to the game but also to the game's implementation.

An example of this would be identifying knowledge gaps presented in the game, areas where additional knowledge of the embedded topic or theme could improve player performance in the game. The structure should illustrate how students should be encouraged to identify and utilize available resources outside the game in order to improve their knowledge and gameplay strategies. Furthermore, the structure should detail how reflection time should be provided for students so that they do not fall solely into trial-and-error or guess-and-check approaches to solving the problems presented by the game, but instead take time to reflect on their choices and strategies.

Finally, it is important to recognize the learner-centered focus of the GATE instructional design theory and to understand the limitations of applying it within a non-student-centered environment. The effectiveness of applying a student-centered approach in isolation is limited, as opposed to introducing it within an already learner-centered environment which can maximize its impact. The project-centered approach of the course in which *Lifecycle* was introduced was learner-centered to a degree. However, greater support for learner choice in the selection of learning goals and performances is certainly available and would likely have further enhanced the effectiveness of *Lifecycle* and its implementation within the course.

As the game designed for this study was also meant to eventually be used in online versions of the course, it would be important to revisit the GATE methods to address the special requirements demanded by this situationality. For example, implementation structure and methods related to preparing students would require revision to address the special needs of an online environment.

Furthermore, as further discussed in the next section, the specific nature of the students in this study highlight other potential situationalities which could impact theory methods and need to be further studied.

Limitations

A number of limitations exist for this study. As a designed case, this study describes a very specific context, a single case. It is risky to generalize too much from a single case study; there is therefore a strong need for additional studies on design instances of the GATE theory. The students in this study were undergraduate computer information technology majors. This could certainly influence their perspectives on and experiences with video games and educational video games, as these students clearly have very positive views of technology being computer information technology majors.

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Furthermore, the makeup of the class in this study was largely male, and female perspectives were limited in this study. It would have been preferred to have a more equal mix of genders in the class to allow for a better opportunity to explore potential gender-related issues. The theory stressed the importance of conducting a learner analysis but does not specifically address gender issues, an issue given considerable attention in media studies regarding commercial video games (Agosto, 2004; Beasley & Standley, 2002; Beavis & Charles, 2005; Hartmann & Klimmt, 2006; Lucas & Sherry, 2004; Taylor, 2003). Given the restricted numbers of not only female, but also non-native speaking students, and non-traditional students, additional studies would be beneficial to identify possible recommendations for the GATE theory in regards to its utility for learners in these groups.

Additionally, the use of a single focus group somewhat weakened the gathering of the data for this study. In a focus group of this size, the discussion was largely conducted by a sub-set of the overall group. About half of the students in the focus group were strong participants, while an equal number did not contribute as much to the discussion. Despite the researcher’s best efforts at involving all participants in the discussion, there were a few students who were essentially non-participants in the focus group. While this limitation was somewhat mitigated through triangulation of data by using written reflections and individual interviews, it would be recommended in future studies to instead conduct multiple, smaller focus groups to encourage more active participation by all participants.

The limited resources available for the development of the game in this study did not allow for all recommended methods of the GATE theory to be included in depth; therefore, they could not all be fully evaluated. Player choice in setting game objectives and demonstrations of learning was limited, for example. Additionally, the game itself was limited in how many themes it could introduce. The impact of further integration of additional themes or topics remains an unknown.

Another limitation of this study is that it represents a single iteration of formative research. Errors were identified in the game during the study, errors which negatively impacted the effectiveness of the game and the ability to identify improvements for the theory. The instructional theory could be better evaluated with additional cycles of formative research on the game, correcting identified issues and leveraging emerging data to better understand implications for the theory.

Finally, this study focused largely on implementing the GATE theory and conducting formative research on the designed instance and thereby formative research on the theory itself. While it did gather both qualitative and quantitative data which comment on student engagement and learning, this study cannot make claims as to the effect of the implementation of the game on student learning or engagement with the topic. These are areas which would be well suited for future research as discussed later.

Recommendations for Practitioners

While this study represents a single case of implementing the GATE theory, it should serve as support for practitioners to use the GATE theory to design, develop, and implement an educational game. One strong recommendation emerging from this study is to spend considerable time identifying the potential benefits of utilizing an educational game for the specific context in which it will be implemented, as it is a challenging and time consuming endeavor, and one which does not guarantee learner engagement. There is evidence of many commercial video games on the market which are not engaging to players, so it is certainly a challenge to create an engaging and educational video game. However, this study shows that it is possible, and that the GATE theory does help guide the design and implementation processes.

The researcher stresses the importance for any designer or developer involved in the creation of an educational game to have a firm grounding in popular video games, both current and past. Creating an engaging game is a creative process, and it is important to identify aspects of games that can help foster engagement. However, if it were as simple as mimicking past game aspects, more games would be engaging. Instead, it is important to create a creative design environment and evaluate prototypes early and often. Most likely, with a game of any substantial scope, a team of designers and developers is necessary. It is important that the focus of this team remain not only on engagement, but also on education. It is also important that its focus is not solely on the game but also on its intended implementation context.

Recommendations for Future Research

Additional case studies should be conducted, particularly cases in different educational settings, including K-12 and corporate training courses. In particular, future instances of the GATE theory are needed which implement multiple game modules and support greater learner choice and goal setting, as these elements while not ignored, were not strengths of the design instance in this study due to resource and scope limitations. Case studies should also be conducted to evaluate games of different scopes and different approaches to implementation. For example, in this study the game was introduced very late in the course, and learner interaction with the game only took place over a single week. Additional case studies should also be conducted on off-the-shelf games as well as modifications (mods) of off-the-shelf games.

By conducting additional case studies, the GATE theory can be expanded to identify different situationalities and provide more appropriate and specific methods for them. For example, as mentioned in this chapter's section on limitations, studies examining the use of the GATE theory with learners with a less positive viewpoint of technology than computer majors, or focusing on female, non-native, and non-traditional students would be helpful.

Case studies should be compared to each other, particularly cases which implement the same game and supporting implementation structure, but in different contexts, such as a case where a game is implemented by the original designer and another case where the same game is implemented by an instructor utilizing the artifacts of the previous study.

Finally, as this study did not seek to strictly measure the impact on student learning and engagement of implementing an educational game designed with the GATE theory, future studies more strictly measuring the impact of educational games designed using GATE would be beneficial.

Summary

In chapter 1 of this study, the researcher argued that better guidance for the process of designing, developing, and implementing an educational video game was needed. Chapter 2 offered an overview of existing literature on educational video games, how they are categorized, and what existing educational video game design models are available. Chapter 3 presented the researcher's own Games for Activating Thematic Engagement (GATE) instructional design theory and described its values and methods in detail. Chapter 4 presented the methodological framework for this study, based on the formative research method for improving an instructional design theory. Chapter 5 summarized the results of the study, stressing adherence to the GATE theory's methods and making recommendations for improvement. This final chapter has offered conclusions and other thoughts regarding the study, its results, and recommendations for practitioners and future research. It is hoped this study will not only demonstrate the potential which educational video games hold for instruction but also illustrate to the everyday instructional designer or teacher that the time to reach their students in learner-centered, engaging ways is now, and that the design and application of educational video games is already within their reach.

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APPENDICES

Appendix A: Student self-reported game score results

Student Self-reported Game Scores (ranked by average time playing video games per week)

	Student 10#&	**Student 4%**	**Student 2&+**	**Student 1*+**	**Student 5**	**Student 8&**	**Student 13+**	**Student 9**	**Student 6**	**Student 11%**	**Student 15**	**Student 7**	**Student 3***	**Student 14%**	**Stude 12**
1	1185	435	870	840	935	1530	570	885	1225	1745	1070	1015	970	1590	1095
2	1485	1415	1310		**885**	1015	**1510**	1480	**1095**	1060	1745	1820		1745	1200
3		1115	1105		362.5	1545		1200	**1260**	1825	1625	1225			
4		915	1835		318.75	**1735**			**1820**	1215	1625	1550			
5		965	1515		300					1250	**1575**	1735			
6		492.5			290					1805	**1140**	1190			
7										**1295**	**1700**				
8										**1225**	**1775**				
9										**1140**	**1745**				
10										**702.5**					
11										**1840**					
12															

& female student
% non-traditional student
+ non-native student
# this student did not report average video game playing time per week
* this student did not report game scores, available score is from game played during interview session

Appendix B: *Lifecycle* notes

Factual knowledge
SDLC
OO concepts, terms
→ Stakeholders

competition (scoring) resources?
quality
timeliness
stakeholder buy-in

Conceptual
business knowledge
Change management
feasibility

random impacts
new product on market - good or bad

what diagrams are good for what.
the use of iterations
communicating w/ programmers
business knowledge

teamwork goals like LOTR game
Customer satisfaction scoring (needs vs. wants) time & resources (bonus tracks)
draw a superhero programmer card & move forward spaces
prototype
usability test
involve users card

time (cost) quality user satisfaction Proj Development business knowledge ~~project~~

Goal - complete w/ highest quality, satisfaction in lowest time

Stakeholders

- Ed ~~Joe~~ User
- Mortimer Bossman
- ~~Hare~~
- Janet Hardware
- Sylvia A~~...~~ Assistant
- Joe Tester.

Create log

random occurrences

team argument

stakeholder unavailable

team member sick

-

Pressures — Time, quality

Score - Customer Satisfaction

represented by cubicle

- ~~pressure~~ stakeholders involvement

analyst business knowledge understanding problem

Player actions identify stakeholders & requirements

- get Change management plan signed (can't do until met w/ business

- Program (Implement)

~~w/ Complete (time based)~~ on complete - unlocked by req spec.

- Meet w/ stakeholders (talk to) - ri

- ~~Email~~ Schedule workshop

- Management Confrontation (requires management buy-in) - ~~unlocked~~ w/ ~~req~~

- Feasibility Study (increases management buy-in) - unlocked w/ req spec

- Training (less beneficial w/ less testing & user buy-in; More training required = less cost satisfaction) - not action

- Research existing technology
  - Can ~~increase time~~ result in no gain
  - can result in some gain
  - Can result in many gains

- test (less beneficial prior to ~~stakeholder~~ end-user involvement)
  - More beneficial after analysis
  - Can result in ignoring requirements early on knowing satisfaction (gain turns lose (customer satisfaction))

- Schedule team meeting (brainstorming - reduce chance of team conflict & has chance of boosting problem understanding)

- Miss Manner's School of communication - reduces chance of foot in mouth & poor grammar has chance of free turn)

Can iterate (lessens returns) improves quality — Reward ~~Fears~~ (Goals)

Requirement specs -

Usecases -

Class Diagram - activity diagram -

Sequence Diagram (before coding) (must've completed previous diagrams

gain stakeholder involvement

cards

Noir - Systems analyst

Random events

Chance of tech mis-understanding - lose 1 turn remaining tech knowledge

- Foot-in-mouth
- poor grammar & typos
- Super programmer
- programming disaster

- Change request

- ~~Firm methodology~~

- re-examine schedule (will take longer)

-

Actions: Cost

Meet w/ stakeholder 1

Sylvia Assistant (unlocks Bossman - 25% chance of revealing satisfaction rate. . raises bus knowledge 50%) → most beneficial in planning

Bossman (unlocks Ed & Janet), unlocks Change management, reduces % of change request 15% each meeting, . unlocks management confrontation
- raises business knowledge - 15%

Ed User - raises business knowledge - 30% — most beneficial in requirements
unlocks user test, increases satisfaction 10% each mtg
increases

Janet - no benefit in requirements, — most beneficial in design

Iterate unlocked after ~~[illegible]~~ completing, then cost reduces each iteration
% chance of benefit reduces w/ each iteration
L must iterate each individual tool. Don't have to "finish" w/ one tool to do another. - never know when done.

Func req
keep a
generate a log w/ user email (text or web file)

30 moves, weeks

test (get user (quality) feedback ✓

- can't test until use-cases complete
- → more complete the documents, more successful
- testing prototype
- testing final version
- increases stakeholder buy-in if 3rd time or more
- decreases " " if late in process

Add member to team

- takes time
- adds % chance of team argument

-

Appendix C: *Lifecycle* description and rule structure document

Lifecycle: Game and Rules Description

Introduction:

Lifecycle is an interactive simulation game which seeks to develop an understanding of Systems Analysis and Design (SAD) concepts using the UML methodology. Players will play the role of a systems analyst in charge of a development team. The development team is seeking to develop a quality product for the Client Corporation using very various UML tools to document the system's requirements and design specifications. Players will be scored based on the quality of the system, time spent developing the product, and customer satisfaction. Other variables will be stored which will impact the scoring of these key variables. The goal of the game is to develop the highest quality system, in the least amount of time, with the highest customer satisfaction. The game will produce a log of the player's name, player actions throughout the game, and the player's final score. The game will support emailing this log to the player. The final score is determined by points from three variables:

(TimeScore + QualityScore + ClientSatisfactionScore) = Final Score.

Variables:

Time: The player has a maximum of 50 weeks to complete the project. *If the project is not completed in that time, the player will be fired as an analyst and no points will be awarded for the game.* For scoring purposes, 0 points are awarded for completing the project in 50 weeks, and 10 points are awarded for each week fewer than 50 that the player completes the project in. Therefore, the player is awarded 10 points for completing the project in 49 weeks, 20 points for 48 weeks, 30 points for 47 weeks, etc.

(50 – WeeksSpent) * 10 = TimeScore

Quality: Quality is the most important scoring aspect of the game, being worth the most points of the three scored variables and having a direct impact on user satisfaction. Quality Percentage points are gained as a result of player actions, as described in the action section of this document. *During the game, the quality score is only revealed when the player conducts testing as an action*. Quality is measured as a percentage rating. The final points scored for quality is determined by applying the quality percentage to 1000 points:

(Q% * 1000) = QualityScore

Client Satisfaction: Client Satisfaction is the second most important scoring aspect of the game, being worth a potential 1000 points. Client Satisfaction Percentage points are gained as a result of player actions, as described in the action section of this document. *During the game, the Client satisfaction score is only revealed when the player conducts user testing or talks to a stakeholder as an action.* Client satisfaction is measured as a percentage rating and is impacted by the quality of the system. The Client Satisfaction Percentage points are lowered or raised depending on the Quality Percentage points.

(Q% * 500) + (CS% * 500) = ClientSatisfactionScore

-

Business Knowledge: Business knowledge is a percentage rating that identifies the player's understanding of the system and the business problem it is trying to solve. This score is never revealed to the player, but is used to measure the impact of various activities throughout the process. It has a direct impact on the success or failure of the different activities. The state of the business knowledge is alluded to through conversations with stakeholders but never quantifiably defined to the player.

Project Status: Project status (PS) is percentage rating that identifies how much of the project has been completed. The implement activity adds to the project status based on a number of factors as described in the actions statement later in this document. One completion of an implement activity results in gaining 5% in the **project status bar**. A player only successfully receives a final score if the player has completed (100%) the Project as indicated by the project status bar.

Stakeholders:

The stakeholders are a means of revealing information about the Player's current score as well as opening up new player actions and access to other stakeholders. The talk to stakeholder action must be used in order to interact with stakeholders. The result of interacting with specific stakeholders is listed under the player actions section. All stakeholders are initially available to try and talk with, but certain stakeholders must be met prior to them being willing to talk with the player:

1. Sylvia A. Sisstant: Sylvia is the Executive Assistant to Mr. Bossman. Meeting with Sylvia for the first time results in the following message: "Sylvia is glad to have finally met you and feels she has a much better understanding of what you're trying to do with the new system. She says that she'll try to make sure that Mortimer finds the time to meet with you and gives the system the attention that it needs. You come away with the meeting very impressed with Sylvia's knowledge of what actually goes on inside the department." *This action increases the customer satisfaction percentage (CSP) 5% for each of the first **two** times Sylvia is met with*.

   Subsequent meetings from the first will generate the following message: "Sylvia is glad to talk with you again. While she can't know for sure, she says that the general mood around the office is: very bad/not very good/wait-and-see/positive/very impressed." The feedback will be based on the current Customer Satisfaction Rating: 0-20% = very bad, 21-40% = not very good, 41-60% = wait-and-see, 61-80% = positive, 81-100% = very impressed.

2. Mortimer Bossman: Mortimer is the Executive in charge of the Client Corporation department that this information system is being developed for. If the player tries to talk with him prior to talking with Sylvia, the following message is generated (and the player still uses the 1 week cost for trying the activity): "Mortimer doesn't seem to be returning your emails. Perhaps it would be better to try and talk to his assistant first and schedule some face-to-face time…."

   Meeting with Mortimer unlocks the Development Change Management Plan

-

activity. It also unlocks the ability to meet with the stakeholders Ed and Janet. The following message is given after meeting with Mort: “Mortimer ‘(Just call me Mort!)’ is very pleased to finally have a face to put with the name, and you have a long conversation about the goals of the system and the history behind the decisions that led to the system proposal. He answers all of your questions that he can and gives you full access to Ed User and Janet Hardware, who should be able to help you out with any other questions you have with the system as Mort seems to think they will be most impacted by the new system as it is being developed for Ed’s department and Janet’s department handles administration of most of the company’s network, databases and other technical issues.”

Meeting with Mortimer increases BKP 5% on the first meeting and another 5% BPK will be gained at the second meeting. The second meeting displays the following message: “Mort is pleased with your progress and feels you’re able to speak his language now. He has some notes for you of things he forgot to mention the last time you met that might be of help.”

Any additional meetings that do not result in gain show the following message: “Mort says it’s good to see you again and hopes things are going well with the project. He doesn’t really have much to add at this point, but he’ll definitely be on the lookout for anything that might help you for future meetings.”

3. Ed User: Ed User is an employee of Client Corporation who will be using the new system once it is developed. The player cannot meet with Ed until they have first met with Mort. The **first** time the player meets with Ed, the following occurs:

    - *The user testing action is unlocked.*
    - *BKP is increased 15%.*
    - *CSP is increased 25%.*
    - *The following message is given:* “Ed at first seems hesitant to talk with you, but once he realizes that you are really interested in hearing his thoughts on the new system, he becomes excited and quite animated in describing exactly what he needs the new system to do for him and his co-workers. When asked, he says he would be very happy to help out with testing the new system.”

    The next ***two*** *times (the second requires the player first completes the use case activity) that Ed is met with adds an additional* ***5% BKP*** *and results in the following messages, one for each meeting, given sequentially:* “Ed likes your idea about trailing him as he does his job, and after spending the day watching him work, you both were able to generate some insights for the new system.”

    “Ed doesn’t think he has much more he can tell you about his job and what he needs the new system to do, but after some skillful questioning, looking over the documents you’ve so far prepared, and drawing up a few potential sketches of how you are currently envisioning the system working, you think you might have cleared up a few things you were uncertain about."

Any additional meetings with Ed result in the following message: "Ed doesn't think he has anything additional to tell you off the top of his head, but he'll be sure to let you know if he thinks of anything or help you out with any user testing you need."

4. Janet Hardware: Janet Hardware is one of Client Corporation's primary IT professionals. She has worn a number of hats within the IT Department, including both Network and Database Administrator. Her boss, CC's Chief Information Officer, values her most because she helps him understand everything that goes on within the department. Janet is not available to talk to until the player has met with Mortimer. The **first** time the player meets with Janet, the following occurs:

    - *CS is increased by 15%.*
    - *BKP is increased by 10%.*
    - *The following message is displayed:* "Janet is very busy, but apart from occasionally being interrupted by phone calls, she is happy to work with you. You talk about your ideas for the system and how that might impact the IT department. You find her very knowledgeable, and she has some very good information about the information the system will use and how best to handle that information. She also has a clear understanding of the company's current available hardware.

    The next time the player meets with Janet, BKP is increased by an additional 5% and the following message is displayed: "Janet has some additional thoughts for you based on your past discussions."

    Any additional meetings with Janet result in the following message: "Janet doesn't really have anything to add at this point. She thinks you seem to have a pretty good handle on what data the system is collecting and what is done with it, but she'll be sure to let you know if she thinks of anything that might prove helpful."

Player Actions:

A. Initially Available:
    1. Talk to Stakeholder (Cost: 1 week to talk to one stakeholder): See stakeholder descriptions for result.
    2. Generate/Refine Requirements Specification Document (Cost: 1 week): Increases BPK by 10%. It increases Q% by 5% the second time it is done.
    3. Brush up technical skills (Cost: 1 week): Reduces chance of Technical Miscommunication Random Impact by .5 each time this action is used (multiply TM% by .5).

-

4. Take Ms. Manner's Composition and Elocution Course (Cost: 1 week): Reduces chance of Foot in Mouth and Poor Written Communication Random Impacts by .5 each time this action is used (multiply FM% and PWC% by .5).
5. Schedule Team Meeting (Cost: 1 week): Reduces chance of Team Argument Random Impact by .5 each time this action is used (multiply TA% by .5).
6. Implement System (Cost: variable. See Table 1 in Appendix)

B. Unlocked by Stakeholders:
   1. Develop Change Management Plan (Cost: 1week, only can be done once): unlocked by meeting with Mortimer. Replaces lost weeks of Change Request Random Impact with the following message: "A request for changes to the original system requirements has been submitted, but since you've come to an agreement with Mortimer as to how these requests will be handled, the changes will not impact your overall deadline. While it will take you longer to get the system complete now, Mortimer understands this and will not count it against you. You do not lose any weeks of production time."

C. Unlocked by Actions
   1. Conduct Feasibility Analysis (Cost: 1 week, **can only be done successfully once**): unlocked by Generating Requirements Specification Document. If have met with Mortimer, then increases customer satisfaction by 10%. No effect if have not.
   2. Develop/Refine Use Cases (Cost: 1 week): unlocked by Generating Requirements Specification Document. Increases Q% by 5% the first time this action is utilized and then 4,3,2,1, and 0% for each additional utilization. Note: this is whether the individual activity is utilized or the Iterate documents activity is utilized. BKP% is increased by 10% the first time this action is conducted, 20% if Ed is first talked to. The second iteration results in an increase of 5% BKP, 10% if Ed has been talked to.
   3. Develop/Refine Class Diagrams (Cost: 1 week): unlocked by Generating Requirements Specification Document. Increases Q% by 5% the first time this action is utilized and then 4,3,2,1, and 0% for each additional utilization. Note: this is whether the individual activity is utilized or the Iterate documents activity is utilized. BKP% is increased by 5% the first time this action is conducted, 10% if Janet is first talked to. The second iteration results in an increase of 3% BKP, 6% if Ed has been talked to.
   4. Develop/Refine Activity Diagrams (Cost: 1 week): unlocked by completing Develop Use Cases. Increases Q% by 5% the first time this action is utilized and then 4,3,2,1, and 0% for each additional utilization. Note: this is whether the individual activity is utilized or the Iterate documents activity is utilized.
   5. Develop/Refine Sequence or Communication Diagrams (Cost: 1 week): unlocked by completing Develop Use Cases ***or*** completing Develop Class Diagrams. **If Use Cases have been developed first, then the action will be sequence diagrams, if it is class diagrams that have been developed**

first, then it will be communication diagrams. Increases Q% by 5% the first time this action is utilized and then 4,3,2,1, and 0% for each additional utilization. Note: this is whether the individual activity is utilized or the Iterate documents activity is utilized.

D. Unlocked by Actions AND Stakeholders
    1. Conduct User Test (Cost: 2 weeks): unlocked by Meeting with Ed ***and*** Implementing System (to any percent, does not need to be complete). Reveals Q%. Increases BKP 5%.
    2. Iterate Documents (Cost: 2 weeks): unlocked by Meeting with ALL stakeholders and Developing Use Cases, Class Diagrams, Activity Diagrams, and Sequence or Communication Diagrams. This provides the benefit of having conducted each of the Develop document actions but in less time, so in the cost of 2 weeks, it provides the benefit of having done each of these steps individually. However, each of these must've been completed on their own individually.

Random Impacts:

There is a 50% chance each move that one of the following impacts will occur. The percentage change of this is adjusted by some of the activities that can be taken by the player. This typically will result in a cost or gain of weeks of Production Time. **Some of these impacts have a reduced chance of occurring due to player actions or only occur if the player attempts a particular action that week. For example, if the programming mishap is rolled, but the player is not implementing that turn, then there is no penalty, and the player is never made aware of this occurrence. If the technical miscommunication is rolled, and the player has done the brush up on technical skills action, then there is only a 50% chance that the miscommunication will happen if the technical miscommunication impact randomly occurs. If the technical skills action has been taken twice, then there is a 25% chance it will happen, if it has been taken three times, there is a 12% chance, etc.**

1. Technical miscommunication: Lose 1-2 weeks
2. Foot-in-mouth: Lower CSP by 5 or 10%
3. Poorly written communication: Lower CSP by 5 or 10%
4. Super programmer: gain 1-2 weeks of PT if implementing this turn.
5. Programming mishap: lose 1-2 weeks of PT if implementing this turn.
6. Change request: Player has choice of losing 1-4 weeks of PT or lowering CSP 10%.
7. Team argument: Lose 1 week of PT.
8. Stakeholder becomes unavailable (lose 1 week PT if tried to meet with any stakeholder that week).
9. Team member sick (lose 1 week PT).

Appendix: Data Tables

Table 1.

BKP	# weeks to gain 5% of PS.	To determine Q%
0-9	10 weeks	1/4

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10-19	5 weeks	1/4
20-29	4 weeks	1/2
30-49	3 weeks	1/2
50-69	2 weeks	1x
70-79	1 week	2x
80-100	.5 week (1 week completes 10%)	2x

Table 2.

Q%	**Effect on CSP**
0-20	¼
21-40	½
41-70	1x
71-80	2x
81-100	3x

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Appendix D: Student written reflection assignment

CIT 213 Homework 5

1. In the game, you are a systems analyst. Based on your experience in the game and the course, what are some of the skills, knowledge, and values you think are important for a good systems analyst to have?

2. What strategies or tactics seemed to work well for you in the game?

3. Imagine you are describing to a parent or grandparent what a system analyst does and write your description below:

4. Does the game realistically represent a system analyst's experiences in designing and developing a system? Why or why not?

5. After your experience with this course and the game, would you ever consider a career as a systems analyst or incorporate the knowledge gained in another career? Why or why not and if yes, how would you use that knowledge?

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Appendix E: *Lifecycle* output document

Lifecycle: Information and Feedback Details for Players

Introduction: *Lifecycle* is an interactive simulation game which seeks to help you develop an understanding of Systems Analysis and Design (SAD) concepts using the UML (the Unified Modeling Language) methodology. The concept of SAD is that more time is spent analyzing and documenting exactly what the system must do before actually building the system, which, if done well, increases the quality of the system and improves its quality. You will play the role of a systems analyst in charge of a development team. The development team is seeking to develop a quality product for the *Client Corporation* using very various UML tools to document the system's requirements and design specifications. You will be scored based on the quality of the system, time spent developing the product, and customer satisfaction. The goal of the game is for you to develop the highest quality system, in the least amount of time, with the highest level customer satisfaction. You will do this by choosing from different actions that are available to you and deciding how to spend your team's time. You have been given a maximum of 50 weeks to complete the project. Can you prove your abilities as an analyst? If so, you will have to understand and manage the system development *Lifecycle*!

Action descriptions:

1. Talk to Stakeholder:
   Stakeholders are people who will be impacted in some way by the system you are developing. Talking to stakeholders allows you to get their insights on the system and how it will affect them.
2. Generate/Refine Requirements Specification Document:
   A requirements specification document is essentially your description of what the system must be able to do after you've completed it. This is used to help verify that your understanding of system functions and restrictions match your clients' understanding of the system.
3. Brush up technical skills:
   As a systems analyst, it is important that you are able to communicate well with both the programmers on your development team and your clients. Brushing up your technical skills will help to ensure that you are able to understand and communicate well with the programmers on your team.
4. Take Ms. Manner's Composition and Elocution Course:
   As a systems analyst, it is important that you are able to communicate well with both the programmers on your development team and your clients. Taking this course will help to ensure that you are able to speak and write well to whoever you may be communicating with, client or team member.
5. Schedule Team Meeting:
   This gathers your development team into one place so everyone can be sure that they are on the same page and understand the development process. Furthermore, it helps the team as a whole with communication and can help reduce the chance of conflict between team members.

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6. Implement System:
   Implementing the system means actually developing (building, coding, etc.) working elements of the system. The speed at which working components of the system can be built as well as the quality of what you develop is dependent on how well you understand the system that is to be developed; therefore, how many weeks it takes you to implement a portion of the system depends on your knowledge of how the system will work.
7. Develop Change Management Plan:
   A change management plan is essentially a document in which you outline how you will handle any requests that come to you from the client that are different from the original, agreed-upon specifications. The client will sign off on this plan, so everyone understands that any requests for changes to the system after you start designing and developing it, will likely result in more time and money being required. This can help fight scope creep, meaning creating a system with features that do not aid in accomplishing the goals of the system. It can also help to prevent conflicts with the client who might otherwise not understand how problematic it can be to change the system requirements in mid-development.
8. Conduct Feasibility Analysis:
   A feasibility analysis takes an initial look at the proposed system and determines if it makes sense (financially as well as business sense in general) to go ahead and develop the system as it is planned.
9. Develop/Refine Use Cases:
   Use Cases are composed of scenarios and diagrams which describe how the system will function from the users point of view. In other words, it describes through a simple narrative what the user will do in a given function of the system, and how the system will respond to the user actions. This is a key component of the UML methodology and helps ensure that both end-users and developers have an accurate vision of how the system will work by describing the process-view of the system. While Class Diagrams are the fundamental diagram for describing structure, Use Cases are the fundamental UML building block for describing process.
10. Develop/Refine Class Diagrams:
    Class diagrams are a very important document in UML. They describe the system in structural terms, defining what data (objects) the system will use, and how those objects relate to each other. A class is a collection of objects that share common attributes, and this diagram identifies what classes the system contains and how they share data. While Use Cases are the fundamental UML building block for describing process, Class Diagrams are the fundamental diagram for describing structure.
11. Develop/Refine Activity Diagrams:
    Activity diagrams are another process-oriented diagram which help to build on use cases by describing the workflow of a particular function. In other words, they allow the reader to see the systems execution as it responds to different conditions and events.

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12. Develop/Refine Sequence or Communication Diagrams:
    These two diagrams are often used inter-changeably. If the development team focuses on use cases as the primary document, then sequence diagrams are often created to help refine the process-view. If the focus is on class diagrams, then communication diagrams are used to help refine the structural view. Sequence diagrams focus on identifying what messages are sent between what objects in what order, as well as which messages belong to which objects. The sequence of the messages and which objects they originate from are the focus of sequence diagram, as well as assigning use case functionality to classes.
    Communication diagrams are very similar to sequence diagrams in what they do; however, their focus is on identifying the objects involved and less on the sequence of the messages. The key here is to identify classes and how they communicate; although, sequence is also an issue.
13. Conduct User Test:
    Conducting a user test is the only way to get true feedback on the quality of the system. The system does not need to be completed before testing; however, some element of it must be implemented so that it can be tested. Testing the system as you develop it not only helps you determine its quality but also helps you understand how to improve the system as you develop it.
14. Iterate Documents:
    UML (Unified Modeling Language) is an object-oriented approach to systems analysis and design (SAD). As opposed to the structure approach of SAD, the OO approach works through iterations, which essentially means the analyst is not expected to get everything right the first time around but instead revises the documents and repeats the cycle of analysis, design, and implementation as many times as necessary in order to reach the required quality levels and complete the system. Iterating your documents as an action allows you to do a complete iteration of revising your documents. This reflects revising your documents as you go along which gives you the benefits of revising the documents in less time than revising each document individually.

Action Responses:

1. Talk to Stakeholder: See Stakeholder descriptions in game description document.
2. Generate/Refine Requirements Specification Document: 1st time- “You have clearly described exactly what the system is responsible for doing as well as any restrictions on how it should function. This will help you fight scope creep as you now have a better understanding of what the system must do in order to meet its goals.
    2nd time- “You have revised the requirements specification document to more clearly define exactly what the system must do. You feel comfortable that you have a pretty good understanding of what the system must be able to do.”

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3rd time- “Other than a few cosmetic changes, the document did not need much changing.”

3. Brush up technical skills: 1st time-“You took some time to refresh your own technical skills. This should help you in communicating with the programmers on your team to be sure that you’re all on the same page, and you’ve identified the best way to implement the system.”
   Future times- “It never hurts to make sure you’re up on your technical knowledge! You feel more confident in your ability to translate the system into technical specifications.”
4. Take Ms. Manner’s Composition and Elocution Course: 1st time- “As an analyst, you are responsible for communicating with everyone from the client, to the end users, to your programmers. It’s important to be a good communicator, and you feel your practice will pay off!”
   Future times- “Dot those I’s and cross those T’s! Best to keep your feet on the ground and out of your mouth!”
5. Schedule Team Meeting: All times- “Your team members meet and you feel that everyone had a chance to air their concerns and be sure that they were on the same page.”
6. Implement System: “You developed X% of the system.”
7. Develop Change Management Plan: **only can be done once** -“You feel that Mort and you have a good understanding now of how any requests to change the system specifications will be handled. He’s signed off on your plan, and you feel prepared to deal with any requests if they should come in.”
8. Conduct Feasibility Analysis: **can only be done successfully once**.
   Successful-“Mort feels very confident about the results of the feasibility analysis and your ability to actually make this thing work! Good job!”
   If unsuccessful-“Well, you’ve convinced yourself that you can do it, but who else might want to know?!”
9. Develop/Refine Use Cases: “You’ve completed/revised a thorough description of how the user will interact with the system. You’ve not only improved your own understanding of how the system processes will work, but you also have a good tool for communicating this to everyone else who is involved.”
10. Develop/Refine Class Diagrams: “You’ve completed/revised a thorough description of what classes the system will be composed of and how they will interact. You’ve not only improved your own understanding of how the system will structurally work, but you also have a good tool for communicating this to everyone else who is involved.”
11. Develop/Refine Activity Diagrams: “You’ve completed/revised a thorough description of the workflow of how the system will be executed. This can be used to help refine previous documents.”
12. Develop/Refine Sequence or Communication Diagrams: “You’ve completed/revised a thorough description of classes and their methods. This is helpful for refining your previous documents, and you’re moving steadily closer to effective implementation.”

13. Conduct User Test: “Nothing beats actually seeing a user interacting with the system to see if it’s working or not! The test revealed the current quality of the system is (based on Quality Percentage): 0-20% = very bad, 21-40% = not very good, 41-60% = ok, 61-80% = good, 81-100% = excellent! And you have a better understanding of what needs to be done to improve the system.”
14. Iterate Documents : “You refine your previous documents, catching errors, making improvements, and further developing your understanding of the system, which is sure to carry over to its quality in implementation.”

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Appendix F: *Lifecycle* rule structure breakdown

Lifecycle Results and Actions Breakdown

Mort:
1. BKP + 5
2. CSP + 5

Ed:
1. BKP+15, CSP+20
2. BKP+5
3. BKP+5

Sylvia:
1. CSP+5
2. CSP+5

Janet:
1. BKP+10,CSP+15
2. BKP+5

Requirements Spec:
1. BKP+10
2. Q+5

Feasibility Analysis:
1. CSP+10 (if have met with Mort)

Usecase:
1. BKP+10(if have talked to Ed), +5 (if haven't talked to Ed); Q+5
2. BKP+6 (if have talked to Ed), +3 (if haven't talked to Ed); Q+4
3. Q+3
4. Q+2
5. Q+1

Class Diagrams:
1. BKP+10(if have talked to Janet), +5 (if haven't), Q+5
2. BKP+6 (if have talked to Janet), +3(if haven't), Q+4
3. Q+3
4. Q+2
5. Q+1

Activity:
1. Q+5
2. Q+4
3. Q+3

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4. Q+2
5. Q+1

Sequence/Communication:

1. Q+5
2. Q+4
3. Q+3
4. Q+2
5. Q+1

User Test:

1. BKP+5, Q+10
2. BKP+4, Q+8
3. BKP+3, Q+6
4. BKP+2, Q+4
5. BKP+1, Q+2

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  - CIT 102 *Discovering Computer Technology*,
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  - CIT 325 *Human-Computer Interaction*
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- Co-designed/taught CIT 499/TCM 399 *User Interface Design*
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PROFESSIONAL EXPERIENCE

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Web Design and Usability Consultant

- Composing Web copy and analyzing Web site usability.
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1999 - 2000 *Indiana Review* Bloomington, IN

Webmaster

- Internship as Web Developer with *Indiana Review* literary magazine. Creation of multiple styles and graphics before final development of site. Submission of site to search engines. Creation of updating manual for staff.
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1997 - 2000 *Indiana University Writing Tutorial Services* Bloomington, IN

Graduate Composition Tutor

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PUBLICATIONS

Watson, S.L., Watson, W.R., & Reigeluth, C.M. (in press). Systems design for change in education and training. In J.M. Spector, M.D. Merrill, J.J.G. van Merrienboer & M.P. Driscoll (Eds.), Handbook of Research on Educational Communications and Technology (3rd ed.). Mahwah, NJ: Lawrence Erlbaum Associates.

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Watson, W. (2006). *Interactive Digital Storytelling: Synthesizing Storytelling Theory, Training Theory, and Video Game Design Theory.* Paper presented at the "Storytelling as an Instructional Method: In Search of Theoretical and Empirical Foundations" workshop for the Air Force Research Laboratory, Phoenix, AZ.

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GRANTS

Jerrold E. Kemp IST Fellowship Award from Indiana University Department of Instructional Systems Technology, May 2007 – May 2008, $3600.

Design and Development of Instructional Video Games, Lecturer's Development Grant from IUPUI Office of Professional Development, May – August 2006 $5000.

Learning Communities- A Look from the Senior Year and Beyond, Faculty Fellowship from IUPUI University College, August 2005-August 2006, $5000.

Linking and Redesign of Computer Fundamentals Courses, Special Focus Grant for Gateway Courses from the IUPUI Office for Professional Development, August 2003-August 2004, $5000.

SERVICE

2006 – current, Communications Officer for Systemic Change Division of Association for Educational Communications and Technology

2006 Member of the School of Engineering and Technology's Freshman Learning Community Committee

2005 Member of the School of Engineering and Technology's Honors Program Committee

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2005 Member of the Department of Technical Writing's Search Committee

2004-2005, Grant Writing Consultant for IUPUI School of Engineering and Technology

2004-2005, Judge for Association for Indiana Media Educators State Media Fair

2003–2007, Member of the IUPUI Gateway Group, the Hesburg Award winning group composed of faculty and administration devoted to

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2003 – 2006, School of Engineering and Technology Faculty Senate Representative for Department of Computer and Information Technology

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