

An Exploratory Review of Design Principles in Constructivist Gaming Learning Environments

Roberto A. Muñoz Rosario

George R. Widmeyer

Information Systems Department
New Jersey Institute of Technology
Newark, NJ, 07102, USA

ram75@njit.edu widmeyer@njit.edu

ABSTRACT

Creating a design theory for Constructivist Gaming Learning Environment necessitates, among other things, the establishment of design principles. These principles have the potential to help designers produce games, where users achieve higher levels of learning. This paper focuses on twelve design principles: Probing, Distributed, Multiple Routes, Practice, Psychosocial Moratorium, Regime of Competence, Self-Knowledge, Collective Knowledge, Engaging, User Interface Ease of Use, On Demand and Just-in-Time Tutorial, and Achievement. We report on two pilot studies of a qualitative nature in which we test our design principles. Game play testing and observations were carried out on five Massively Multiplayer Online Games (MMOGs): RuneScape, GuildWars, Ragnarok, World of WarCraft, and Final Fantasy XI. Two educational games, Carabella Goes to College and Outbreak at WatersEdge were also observed. Our findings indicate that not all of the popular MMOGs and educational games support all of these principles.

Keywords: Design Principles, Massively Multiplayer Online Games, Constructivist Learning Environment, Information Systems Design Theory

1. INTRODUCTION

“This is so boring.” Many students who are being taught with the traditional education system echo this sentiment. Therefore, it is extremely important that the educator gives meaning to the knowledge being taught, in other words, its usefulness in real life situations. The central concept of the learning theory of Ausubel, Novak and Hanesian (1978) is the idea that meaningful learning occurs when new knowledge is consciously integrated into the ideas and concepts previously acquired by the learner. The construction and reconstruction of meanings by learners necessitates that they incorporate new knowledge with knowledge existing in their cognitive structure (Novak, 2002). This is the essence of the Constructivist view: knowledge is actively constructed within the limitations and contributions of the learning environment; it is not mechanically obtained (Liu and Matthews, 2005). Nevertheless, the limitations of the learning environment can make the learning process more difficult for students. Consequently, the instructor must also find the right tools (in addition to the right approach) to motivate students and thus to create a favorable attitude towards learning.

Playing computer games is not a new phenomenon. Since the creation of the personal computer, different genres of computer games have been created to appeal to different interests. Educational computer games exist with the purpose of teaching while entertaining users, currently providing a single player experience only. With the advent of the

Internet, a new type of computer game was conceived: The Massively Multiplayer Online Game (MMOG). A MMOG is a computer game played on the Internet capable of supporting thousands of players in its own huge virtual world. These games are currently enjoying tremendous popularity around the world thanks in part to the virtual communities created for these games with users debating several game aspects. However, very few MMOGs are *designed* to provide learning opportunities, even though many of these MMOG may offer opportunities for learning by motivated individuals. For instance, player A that wants to defeat the Green Dragon may or may not find the discussion thread on this topic. If player A does, it is because player B, for example, was sufficiently interested in this issue. The learning can occur after player B shares his or her ideas or strategies about that dragon with the rest of the community. However, the gaming environment itself may not offer many clues of how to defeat the Green Dragon. If the gaming environment could provide learning opportunities as well, MMOGs could potentially become a powerful tool for constructivist learning.

It is conceivable to somehow design educational Massively Multiplayer Online Games that have a Constructivist Learning Environment incorporated. Any game created under this philosophy will provide a new type of learning environment; we would call this environment *Constructivist Gaming Learning Environment (CGLE)*. In this new environment, MMOGs would become an instrument to offer meaningful knowledge where students

can learn, in a fun way, by doing. Additionally, constructivism can foster participation and collaboration among people through feedback from knowledge and experiences. Thus, a MMOG is the perfect place to create a visually interesting and appealing interface that supports both participation and collaboration.

This paper begins with the discussion of the Information Systems Design Theory (ISDT) proposed by Walls, Widmeyer, and El Sawy (1992). Next, we discuss the twelve design principles to be used in the Constructivist Gaming Learning Environment, which are the focus of this paper. Following that, we present our findings from two pilot studies based on our observations and game play testing of five popular MMOGs and two educational games with regards to these twelve principles. These tests were of a qualitative nature, where the presence of each of the twelve principles was assessed. Finally, we describe how this research in progress will serve as a foundation for the revision and validation of our meta-design principles through the Constructivist Gaming Learning Environment Survey.

2. BACKGROUND

An Information Systems Design Theory (ISDT) has five components: kernel theories, meta-requirements, meta-design, design methods, and hypotheses (Walls, Widmeyer and El Sawy 1992; Markus, Majchrzak, and Gasser 2002). The first component is a set of *kernel theories* from natural or social sciences that govern design requirements. We implicitly assumed that this described the roles of the people involved and the desired functionality of the designed information system. For this research, we have adopted a constructivist learning theory as our kernel theory. The next component is the *meta-requirements*, which refer to a set of generic requirements that will address a class of problems, instead of a specific problem. The meta-requirements proposed in this research are described as a set of 12 design principles. The third component is the *meta-design* that describes a class of artifacts hypothesized to meet the meta-requirements. We have not yet developed our meta-design, which is a specific IT architecture, and we have not yet specified a design method. Our premises are (1) students prefer a constructivist learning environment and (2) some MMOGs can provide such an environment. This overall structure and the specific concepts are used in this research to provide a design theory for a constructivist learning environment.

2.1 Design Principles

Gee (2003) argues that first-rate video games produce better learning conditions than many of today's schools. His book presents 36 learning principles that should be considered in using games in designing a learning environment. Ten of these principles were adopted by Bonk and Dennen (2005) as being particularly pertinent to MMOGs. A group of four students (undergraduate, masters and two doctoral students) and the faculty member leading the research project conducted a review of both sets. Table 1 shows the revisions made to the original principles to arrive at the final 12 design principles.

We dropped two principles from the list of 10 by Bonk and Dennen (2005). Our Engaging Principle (number 9)

covers their Amplification of Input principle and their Identity Principle is covered by our restatement of the Self-Knowledge Principle (number 7). We added four new ones (numbers 8, 9, 10 and 11 above) based on the game design and learning literature and on our experiences with playing online games. The resulting revised 12 design principles for a Constructivist Gaming Learning Environment (CGLE) are described and explained next.

2.1.1 Principle 1 - Probing Principle: *Learners should be encouraged to engage in cycles of action, hypothesis building, and inquiry.* Through the application of this principle, a player is encouraged to build and test hypotheses regarding solution to tasks. In this way, a learner can see for himself what does or does not work. For example, James thinks that with his current items and knowledge of the terrain, he can successfully reach his destination. While testing his hypothesis, he is ambushed by a pack of wolves; thus, it is proven false. Upon further reflection, he formulates a new hypothesis to be tested later, and repeats the process.

2.1.2 Principle 2 - Distributed Principle: *Learners should find growth and knowledge in their interactions with other learners, technology, context, objects, and tools. Concerning interactions with other learners, the automatic recording of vital information obtained from other players can be made.* The game presents a player with several avenues of interaction to achieve a goal. In-game interaction with other players can provide the most benefit to a gamer, since at least, he or she can ask other players for advice. Players also interact with objects in a specific context within the game world, and thus they learn what to do when they encounter similar objects in similar contexts. For instance, a hungry avatar is offered an apple and through the interface, she learns how to eat it. From her previous experience, she knows she can use certain objects as source of nutrition for her character, even in a different game. Lastly, how the player interacts with the technology itself can also provide opportunities for learning. For example, a player might discover that he prefers using the keyboard for most interactions, and the mouse just for a few specific tasks.

2.1.3 Principle 3 - Multiple Routes Principle: *There should be more than one way for learners to progress, encouraging them to make decisions and solve problems.* For instance, if a player needs to reach a location, the game should be versatile enough to allow several means of in-game transportation (e.g. boat, plane, horse, etc.). Furthermore, people have different cognitive styles, which allow them to tackle problems differently. However, it is not enough that the in-game tasks could be solved in myriad ways; the gaming environment must somehow encourage the user to do so. However, there are other methods of doing the problem; James wanted to solve the task in the fastest way.

Lastly, if the player is not aware of the multiple routes, then the game should provide some hints through interaction with objects (e.g. in-game books) and non-player characters (NPCs) through narrative.

2.1.4 Principle 4 - Practice Principle: *Learners should be able to spend a lot of time practicing throughout the entire game in an interesting environment.* For example, a first time

Design Principle	Revision
1. Probing Principle	Exactly as stated in B & D (Bonk and Dennen 2005)
2. Distribute Principle	The first sentence is exactly as stated in B & D. The second sentence is added for amplification.
3. Multiple Routes Principle	Exactly as stated in B & D
4. Practice Principle	Basically as stated in B & D with the addition of the clarifying phase “throughout the entire game”
5. Psychosocial Moratorium Principle	Basically as stated in B & D with the addition of the clarifying phase “for in-game activities”
6. Regime of Competence Principle	Basically as stated in B & D
7. Self-Knowledge Principle	Restatement of the corresponding B & D principle with the phase “and their current and potential capabilities” from the original statement of the same principle from Gee (2003)
8. Collective Knowledge Principle	A new principle parallel to the self-knowledge principle (number 7) that reflects the collaboration aspect of constructivist learning
9. Engaging Principle	A new principle based on our reading of Rouse (2005); specifically, his Chapter 1 on “What Players Want”
10. User Interface Ease of Use Principle	A new principle based on our reading of Rouse (2005) and the general human-computer interaction literature
11. On-Demand and Just-in-Time Tutorial Principles	A new principle based Gee's Explicit Information On-Demand and Just-in-Time principle (his number 27) and on our reading of Rouse (2005); specifically, his Chapter 1 on “What Players Want”
12. Achievement Principle	Restatement of the corresponding B & D principle with the phases “in an exciting way” and “to encourage their further participation” to better explain and amplify the concept.

Table 1. Revisions to the Bonk and Dennen (2005) Design Principles

user can spend the entire duration of the tutorial practicing how to navigate, how to interact with objects and players, etc. However, the tutorial should not be the only avenue for practice in the game. The environment should provide “safe areas” that would allow players to test certain actions before applying them to the main task. Thus, a player can practice a task without any risk to her avatar until she gets it right. The actual task may be performed afterward. Lastly, to actively encourage practice, the environment has to be interesting and provide variety of ways to keep players frequently discovering new things. For example, Julia experiments in the safe area with the two substances. Her first trial ends as a failure and her avatar’s face turn blue for five seconds. Next time, she succeeds and a cheerful tune is played.

2.1.5 Principle 5 - Psychosocial Moratorium Principle: *Learners should be able to take risks in artificial environments where there is a lower chance of real-world physiological consequences for in-game activities.* Regardless of risks that the avatar incurs, the player should not be physiologically affected by any dangerous situations in-game. For example, James’ avatar being bit by an in-game viper should not present any real-life danger to him. However, if the player uses his or her avatar to engage activities that exploit the environment in a negative way, or conduct illegal behavior then this principle does not apply.

2.1.6 Principle 6 - Regime of Competence Principle: *Learners should be challenged to push beyond their*

comfort/ability zone, but not to an extent that is unsafe or unattainable. One of the great motivating factors in MMOGs (and almost any game) is that it challenges a player’s resourcefulness, knowledge, and skill. The difficulty level of a task or challenge should depend on his character level, which should be representative of his experience and progress within the game. For instance, James completed Task B and it was determined (either by the game, or by another entity) that he was 60% successful. As a result, the game decides that the task created difficulties for the player. Therefore, James should not be allowed to advance until he gets better results in subsequent similar tasks.

2.1.7 Principle 7 - Self-Knowledge Principle: *Players should learn about themselves and their current and potential capacities.* This principle refers to what do players learn from this experience. First, users obtain knowledge and skills from completing tasks. This in turn raises their competency and prepares them for more difficult tasks, which increases their knowledge. In addition to the knowledge acquired from accomplishing the goals, there are several types of supplementary “experiences” that provide players with useful real-life insights. Some of these experiences might be classified as social, ethical, and cognitive. For example, Julia learned from her social experience that a team leader role is very enjoyable and that she is capable enough to do it. Regarding ethics, she realized she is very demanding of others to always act as ethically as possible during group work. Lastly, she determined that her

cognitive style necessitates quiet introspection of the information acquired, before being able to use it in a productive manner.

2.1.8 Principle 8 - Collective Knowledge Principle: *Players should learn from other players' experiences, building a repository of useful knowledge shared by all.* The difficulty of some tasks has prompted many players to use discussion forums in order to discover ways to complete them. Once someone finds a solution, it remains in the forum or knowledge base for other players that might experience the same or similar issues later. Successful use of this principle might require the use of adequate knowledge management tools, in order to locate the required knowledge very quickly. This is especially true when the number of players is large and the discussion forums are extremely active.

2.1.9 Principle 9 - Engaging Principle: *The game should have a compelling theme that is attractive to potential users, so that people will be drawn to play it. The game should also provide the player a way to experience a different and exciting role from what they experience in their regular life.* This principle is possibly one of the most critical non-learning game design principles. Its premise is based on a simple question that game designers must ask themselves. Does the game have a compelling theme to attract people to play it? The game designer must first know the target audience's preferences (e.g. fantasy, sci-fi, etc.). This is the most important issue this principle must address. Second, give a player an exciting or extraordinary role in the game (Rouse 2005). This will make the idea of playing an educational game more exciting and less of a chore for many students. For example, in a game for computer majors, the role of "underground infiltrator" would appeal more to a player instead of simply "network specialist".

2.1.10 Principle 10 - User Interface Ease of Use Principle: *The user interface should be user friendly and the system should be easy to navigate.* A poorly designed user interface (UI) will frustrate and anger players, regardless of the type of game. Therefore, the interface must possess the following characteristics: *ease of use, consistent, non-intrusive, flexible, and navigable.* An easy-to-use UI is intuitive and provides a mechanism for users to interact with the environment logically. For example, pressing the keyboard's down arrow (▼) must make the player's avatar move in that direction. Additionally, the interface must be consistent. For instance, all interactions with friendly NPCs must always display the same general menu options (e.g. talk, trade, etc.). Furthermore, the interface must be non-intrusive to keep the player immersed in the game, maintaining his or her suspension of belief. Thus, at a critical moment, the interface should not require of the user to go through several UI windows to achieve a goal. If that happens, the game's sense of urgency and realism diminishes. Additionally, the interface must also be highly customizable (e.g. keystroke shortcuts). Finally, the UI must be navigable with features such as an auto-map and a compass that can help players arrive at the required destination.

2.1.11 Principle 11 - On-Demand and Just-in-Time Tutorial Principle: *Game tutorials should aid players in learning the game mechanics and user interface while they are playing, exploring or interacting with the environment.*

This way, players will learn the game mechanics as well as the user interface while they are playing the game. To achieve this principle, the game designer must first create the tutorial as part of the player's character advancement in the game. The tutorial can be disguised as a "preliminary mission" to help users get into the "mood of the game". Second, incorporate into the tutorial all of the game's core aspects (conversations, interactions with the environment, etc.) to be learned. Third, include some technical interface aspects of the game most likely to be used by players (e.g. rotating the camera view). Fourth, make the tutorial provide feedback to players, when mistakes are being made; therefore, preventing or minimizing costly mistakes from occurring at a critical stage. Finally, have the tutorial reward players for successfully completing the tutorial without penalizing them for mistakes.

2.1.12 Principle 12 - Achievement Principle: *Learners should be constantly and visibly rewarded, in an exciting way, at each level of game play and skill mastery to encourage their further participation.* Games using this principle have to give exciting, visually appealing, and useful rewards that can keep players happy and wanting to play more. Exciting in-game rewards include special items, prestige, new skills and abilities. The rewards must have a visual non-textual representation and each has to be unique to keep players interested. For example, for completing task A, James has now become a member of the "Gallant Knights Guild". As such, he was awarded with a guild vest with the guild's symbol on the chest. By wearing this vest, other players that know about that guild can easily determine that he belongs to it. Furthermore, an important aspect of this principle is that rewards should occur as constantly as possible and should be given according to the task's difficulty level.

The Gameplay Research and Findings section explains how to apply the twelve principles to systems development and shows how to measure whether a resultant system satisfies the 12 principles, but first we present a test of our design theory. This model serves as the basis of the design hypotheses, which is the fourth part of our design theory.

2.2 The Design Hypotheses

Two questions need to be explored. The first is whether students would actually prefer a learning environment based on constructivist gaming learning principles and the second is how well some current online games that are specifically designed as learning environments satisfy the 12 design principles. The dependent variable is learning outcomes as measured using the Bloom (1956) taxonomy of educational objectives.

The characteristics of the technology are specified by the design principles, which have been developed based on a review of the literature as explained previously. Individual characteristics are described using a survey in two modes, asking the students their perception of the actual learning environment. A comparison of these two (Actual versus

Preferred) defines a gap (Taylor, Fraser and Fisher 1997), which captures the characteristics of the person and the context in which they find themselves. The instructional objectives can be used to measure performance, which is the dependent variable.

The Constructivist Gaming Learning Environment Survey (CGLES) used in this research is derived from the Constructivist Multimedia Learning Environment Survey, CMLES, (Maor 1999) and from the Constructivist Learning Environment Survey (Taylor, Fraser and Fisher 1997). The Taylor et al. survey has been validated in several research studies of high school science and mathematics classrooms and has been used in various studies in different countries. The Maor survey has been used in the classroom as well as a teacher development program. The usage of the CGLES enables the continual testing of the hypothesis that students prefer a constructivist gaming learning environment.

The original CMLES has the five scales of student negotiation, inquiry learning, reflective thinking, authenticity and complexity. Each scale has five survey items for each scale. Maor (1999) test the five scales for internal consistency and discriminate validity. The alpha reliability coefficients ranged from 0.77 to 0.93. The discriminate validity analysis suggested that the five scales measure “distinct, though somewhat overlapping, aspects of classroom environment” (Maor 1999, page 315). We have used the CMLES in another research and have found the alpha reliability coefficients ranged from 0.83 to 0.93 (reference removed for anonymous review).

We have modified the original survey instrument used by Maor (1999) slightly to produce the CGLES. We changed the name of the fifth scale from Complexity to Ease of Use and rewrote each of the five survey items for each scale replacing the word “class” with “game-based learning environment”. Each scale of the CGLES is designed to obtain measures of students’ perceptions of the frequency of occurrence of five key dimensions of a critical constructivist learning environment. The CGLES contains 25 items altogether, with five items in each of five scales. The response alternatives for each item are Almost Always, Often, Sometimes, Seldom, and Almost Never. The five scales and sample items are shown in Table 2.

Furthermore, the CGLES constructs have been mapped to the 12 design principles. This mapping was done by the authors of this paper as means to give credence to our design principles by relating them to the five constructs adapted from Maor (1999). It is presented in Table 3.

The premise of our design theory is that there are some MMOGs than can provide such an appropriate learning environment based on constructivist learning theory. The second question of our research-in-progress is how well some current online games satisfy the 12 design principles by exploring how some current MMOGs such as RuneScape, Ragnarok and GuildWars satisfied the design principles, which is explained in the next section of this paper. These are the student-player perceptions of the presence of the design principles in each game. This does not measure the intention of the designer but the perception of the user. The gaps that are expected in this evaluation are in the areas of the learning process principles (numbers 1 through 8), especially the collective knowledge principle (number 8).

Scale Name	Description	Sample Item
Social Negotiation	Extent to which students have the opportunities to discuss their questions and solutions to questions	In the game-based learning environment, I want to ask other students to explain their ideas.
Inquiry Learning	Extent to which students are encouraged to engage in inquiry learning	In the game-based learning environment, I want to carry out investigations to test my own ideas.
Reflective Thinking	Extent to which students have opportunities to reflect on their own learning and thinking	In the game-based learning environment, I want to think critically about my own understanding.
Authenticity	Extent to which the information in the game is authentic and representative of real life situations	In the game-based learning environment, I want to work with situations that are relevant to me.
Ease of Use	Extent to which the game playing environment is user friendly and easy to navigate	In the game-based learning environment, I want that the game space to be easy to navigate.

Table 2. Descriptive Information for each Scale of the CGLES (adapted from Maor 1999)

Survey Construct	Design Principle
Social Negotiation	Distributed (P2), Collective Knowledge (P8)
Inquiry Learning	Achievement (P12), Multiple Routes (P3), Regime of Competence (P6)
Reflective Thinking	Probing (P1), Self-Knowledge (P7)
Authenticity of the Learning	Practice (P4), Psychosocial Moratorium (P5)
Ease of Use	Engaging (P9), User Interface Ease of Use (P10), On Demand and Just in Time Tutorial (P11)

Table 3. Mapping of Survey Constructs to Design Principles

3. GAMEPLAY RESEARCH AND FINDINGS

Game play testing and observations were carried out on five Massively Multiplayer Online Games (MMOGs) and two educational games. The five MMOGs were chosen because they were played or were being played by several students that we interviewed and they are among the most popular games today (e.g. WoW, GuildWars) (Snow 2007), are part of a recognized franchise (e.g. Final Fantasy) or offer free online gameplay (e.g. RuneScape). The two educational games were chosen from the over 200 listed at Social Impact Games web site <http://www.socialimpactgames.com/>. There

were several interesting games, but we decided to download and play two of them.



Figure 1. RuneScape
Source: Student's Screenshot



Figure 2. GuildWars
Source: Student's Screenshot



Figure 3. Ragnarok
Source: Student's Screenshot

3.1 Games Studied

RuneScape (Figure 1) is a Massively Multiplayer Online Role-Playing Game [subset of MMOGs] and the name of a virtual world with monsters to kill, quests to complete and treasure to win <http://runescape.com>. By having quests and mini-games within the game, RuneScape promotes teamwork and problem-solving skills as well as rewarding persistence. There are many problems to overcome and

puzzles to unravel, testing the player's knowledge and dedication. Thus, the longest of these quests might take players several days of brain-straining, while the simplest can be completed in less than an hour. Furthermore, whatever players decide to do in RuneScape is entirely their decision: nothing is predetermined. RuneScape is the only game completely free of charge that we evaluated.

GuildWars (Figure 2) is another Massively Multiplayer Online Role-Playing Game and, similar to RuneScape, it has medieval fantasy setting with its own rich back story. It takes the best elements of today's Massively Multiplayer Online Games and combines them with new mission-based design; thus, eliminating most tedious aspects of the game <http://guildwars.com/gameplay/synopsis>. For instance, a player's party has its own unique copy of the quest map.

Therefore, long lines of other players competing for the same quest, stealing from other players is much more difficult. Another example is its dynamic quest system, giving players unprecedented freedom to make unique contributions that influence the game world. There is no monthly subscription fee, but the user must purchase the main game.

Ragnarok (Figure 3) is a Massively Multiplayer Online Game based on Norse mythology and the Korean graphic series with the same name written by Myung-Jin Lee. Users can create characters and venture off alone or in groups in far-flung fantasy worlds full of adventure. The game deals with quests for treasured parts, when collected they increase the player's powers in game. The graphical design of the environments has been inspired by mythological and historical elements from various cultures around the world. Furthermore, it features hand-drawn, Japanese-style rendered characters in realistic 3D backgrounds. Character development is provided through character levels to allow for stats adjustments, while job levels let players pick new skills that depend on the player's job class.



Figure 4. World of Warcraft
Source: [Hhttp://worldofwarcraft.com/downloads/ssott/H/images/screens/ss1217-thumb.jpg](http://worldofwarcraft.com/downloads/ssott/H/images/screens/ss1217-thumb.jpg)

In World of Warcraft (WoW, as seen in Figure 4), players assume the roles of heroes as they explore, adventure, and do quests across a vast world. Thousands of players interact with each other within the same world, by adventuring together or fighting against each other in epic battles. Players are encouraged to form friendships and alliances and compete with rivals for prestige and glory (Introduction to World of Warcraft, 2008). Players are not forced to invest many hours in the game to have fun; they

can play the game at their own pace. The quest system also provides a great variety of engaging quests with story elements, dynamic events, and flexible reward systems (reputation, money, etc.). World of Warcraft also features a faster style of play with an emphasis on combat and tactics against multiple opponents (Introduction to World of Warcraft, 2008).

Likewise, Final Fantasy (Figure 5) lets player assume roles (they are called jobs in the game), which can be changed throughout game play. Furthermore, players may also seek a secondary role at any time, but jobs that are more exciting are only available for players with a certain level of experience. Players can be assigned quests, missions, and conquests that will increase their individual reputation, as well as the influence of their respective nations. It encourages collaboration and team formation as parties has more chances of surviving than a single individual exploring on his or her own.



Figure 5. Final Fantasy XI

Source:

[Hhttp://www.playonline.com/ff11us/guide/system/imgs/im05.jpg](http://www.playonline.com/ff11us/guide/system/imgs/im05.jpg)

The educational games rated were Carabella Goes to College and Outbreak at WatersEdge. We learned about these games from the Social Impact Games web site that also lists several other potential candidates that might be looked at in the future. Carabella Goes to College (Figure 6) is about finding the right balance between privacy and convenience. As you play through the game with Carabella, you will learn how everyday activities can erode your privacy, and it provides suggestions on what to do prevent this situation. The game is played within a Web browser and it can be found at www.privacyactivism.org/carabella/.

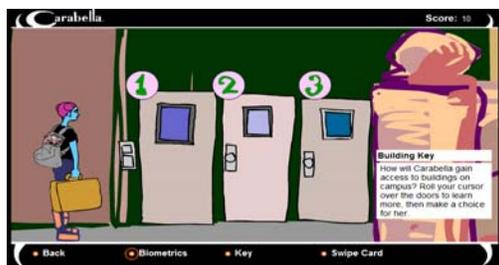


Figure 6. Carabella Goes to College

Source: Student's Screenshot

On the other hand, Outbreak at WatersEdge (Figure 7) introduces a user to the world of public health as he or she

helps discover the source of the outbreak that has hit the small community of WatersEdge and stop it before more residents get sick. This game has the additional feature of being played in Spanish. The game is played within a Web browser and it can be found at www.mclph.umn.edu/watersedge/.

3.2 First Pilot Study

In this study, we used the Amplification of Input (also one of the 10 principles used by Bonk and Dennen 2005) principle instead of the Probing principle. This principle stated, "Learners should get out of the experience more than they put in." It was after the study that it was decided to substitute this principle. The reason for the substitution was that some of what students would get from games was fun, which could be included in the Engaging principle. Furthermore, students might be getting other unintended things out of their experience (e.g. not visiting annoying relatives). On the other hand, the Probing can be used to measure specific tasks within the games.

We attempted to verify the existence of these principles within three of the most popular MMOGs: RuneScape, GuildWars and Ragnarok. We decided to test Principles 9, 10, and 11 within six hours of continuous game play, after installing the software. Three students did the game evaluations (one undergraduate, one masters and one doctoral). The criteria used included a scale of low, medium, and high to rate the degree of the 12 principles found in these three games. Each student picked a different game. One student had no previous experience playing MMOGs, whereas the other two students play these games on a regular basis. During the gaming session, students would write observations about the game's strengths and weaknesses related to the three principles. After recording these observations, they proceeded to rate the games.

As seen in Table 4, RuneScape scored high for the Engaging Principle, which means the game is very appealing. The On-Demand and Just-in-Time Tutorial principle also scored high. It was observed that the built-in tutorial walking the player through the environment and teaching such player the use of the interface was well implemented. It could help players familiarize with the game story and interface. Furthermore, it may help them to seamlessly immerse into the gaming experience as soon as possible. However, the User Interface Ease of Use had a low score. This low score occurred, because of certain issues such as the small size of the game environment window. Its size can create difficulties when moving around in the environment, especially when too many players are simultaneously on the same game map. Therefore, it becomes more difficult to click on an empty area on the screen to move around. Additionally, there are no options to increase the window's size, since the game is played within a Web browser.

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#	Principles	Level of Conformance with the Principle		
		RuneScape	GuildWars	Ragnarok
1.	Amplification of Input Principle	Low	Low	Medium
2.	Distributed Principle	High	Medium	High
3.	Multiple Routes Principle	High	High	Medium
4.	Practice Principle	High	Low	Low
5.	Psychosocial Moratorium Principle	High	High	Low
6.	Regime of Competence Principle	High	High	Medium
7.	Self-Knowledge Principle	Medium	Medium	High
8.	Collective Knowledge Principle	High	High	High
9.	Engaging Principle	High	High	High
10.	User Interface Ease of Use Principle	Low	High	Medium
11.	On-Demand and Just-in-Time Tutorial	High	Medium	Medium
12.	Achievement Principle	Medium	Medium	High

Table 4. Evaluation of Three Games using Design Principles

three games. Each student picked a different game. One student had no previous experience playing MMOGs, whereas the other two students play these games on a regular basis. During the gaming session, students would write observations about the game’s strengths and weaknesses related to the three principles. After recording these observations, they proceeded to rate the games.

As seen in Table 4, RuneScape scored high for the Engaging Principle, which means the game is very appealing. The On-Demand and Just-in-Time Tutorial principle also scored high. It was observed that the built-in tutorial walking the player through the environment and teaching such player the use of the interface was well implemented. It could help players familiarize with the game story and interface. Furthermore, it may help them to seamlessly immerse into the gaming experience as soon as possible. However, the User Interface Ease of Use had a low score. This low score occurred, because of certain issues such as the small size of the game environment window. Its size can create difficulties when moving around in the environment, especially when too many players are simultaneously on the same game map. Therefore, it becomes more difficult to click on an empty area on the screen to move around. Additionally, there are no options to increase the window’s size, since the game is played within a Web browser.

Regarding the other two games, GuildWars scored high on both Principles 9 and 10. This means that the game is very appealing and the user interface is very easy to use. However, Principle 11 had a medium score. This score shows that there is a tutorial for GuildWars, but it may be lacking some features. On the other hand, Ragnarok scored high only for the Engaging Principle, which also means that the game is very likeable. However, Principles 10 and 11 had both medium scores. The medium score for the UI indicates some difficulty using the interface, a vital aspect for any

software. Finally, Principle 11 score shows that Ragnarok has a tutorial, but it may be missing some features.

3.3 Second Pilot Study

The previous pilot study prompted the evaluation of more online games. A colleague suggested we use an interval scale from 1 (lowest) to 5 (highest), rather than high, medium, and low to improve the meaningfulness of the results. We continued to use these evaluations as qualitative information about the presence or absence of each of the design principles.

We then decided to test all twelve principles by playing these games continuously during at least six hours, after installing the software. Six gaming experts did the game evaluations of which five of them are college students (three undergraduate, one masters and one doctoral). These games were rated using the new scale to determine how strongly the principles are found in these games. The undergraduate students rated the same game, whereas the master student rated four games, and the doctoral student rated three games. The sixth person rated a different MMOG altogether. Everyone that rated the games had prior experience with MMOG, especially the undergraduate students who play their MMOG on a regular basis. During the gaming session or afterwards, the experts would write observations and reflections about the game’s strengths and weaknesses related to the twelve principles. Lastly, they rated the games.

GuildWars and RuneScape, two games previously rated, were re-evaluated with the new scale. One game, Ragnarok, was dropped since there were no experts that played that game. On the other hand, new MMOGs that were rated using the numeric scale were World of WarCraft and Final Fantasy XI. However, the data collected was not enough for a quantitative analysis. Therefore, the results presented are similarly described as in the first pilot study in terms of the 12 design principles.

3.3.1 Principle 1 - Probing Principle: Regarding the Probing principle, all MMOGs, except GuildWars, and Outbreak at WatersEdge obtained high results. In these games, the more a player advances in the game, the more opportunities there are to test different ways to achieve a goal. Conversely, Carabella and GuildWars scored very low. Carabella is linear and there is not much that the “player” can do, but follow common sense regarding what offers the most privacy. Thus, there does not seem to be much inquiry occurring. Likewise, GuildWars can have a player go through the entire game simply by following the little green arrow on their map. Thinking through situations in the game is possible, but not necessary. In other words, probing is not actively encouraged.

3.3.2 Principle 2 - Distributed Principle: Concerning the Distributed principle, Outbreak and all MMOGs, except for WoW, rated high. It is not surprising since players interact with other players and objects frequently. In many of these types of games, the primary source in-game of knowledge is to communicate with other players. Consequently, they may request hints, solution to problems, or even unwanted objects that veteran players possess. Conversely, the rating was low for Carabella; mainly, because it is a single-player experience in which there is zero interaction with other gamers while in play. Furthermore, this game did not have any objects to interact with in the first place. Before obtaining a consensus among the experts, this principle was causing some ambiguity in its interpretation. Some experts were focusing just on interactions with other learners, without paying much attention to the interaction with other objects, technology and context. Therefore, this principle was rewritten as it appears now.

3.3.3 Principle 3 - Multiple Routes Principle: The Multiple Routes principle was present in WoW and RuneScape. There are multiple ways to complete the quests in these games. Nevertheless, the main way to advance to the end game requires “immensely, hard, long, and tedious end-game raids”. In the case of Carabella, it is a similar situation; multiple alternatives can be picked as a solution. However, the answers are straight forward, making it almost impossible to select the wrong choice. The other games that had low scores were linear from beginning to end, offering little if any deviation in the manner of completing the main objectives. For instance, in GuildWars all players go through the same quests and missions to reach the same ending, even though different character classes (roles) may have slightly different quests available to them. Lastly, this principle required the clarification among the experts regarding the term “progress”. For instance, one camp of thought believed that progress was equivalent to a character only moving up to the next level (leveling-up) as the only way of advancement. After some discussion among the game experts, it was agreed that it meant advancing through leveling up, and acquiring monetary rewards, special items and awards.

3.3.4 Principle 4 - Practice Principle: The Practice principle was high among the MMOGs, and average with the educational games. Regarding the MMOGs, since all of

these were engaging, it also means that their respective environments were interesting. Since these games cannot be completed in a short amount of time, they provide many opportunities to practice different in-game skills. Players will not get bored so easily, because these environments are vast and they are continually growing, when new expansions are released. On the other hand, the educational games observed were far too short in duration. Thus, there was not much room for practice in these. In Carabella for instance, the back link can be clicked to go back to a question and try a different answer. Lastly, this principle required some clarification about the context of where the practice took place. One expert thought that the practicing occurred only during the tutorial, and nowhere else. Therefore, this principle was rewritten as it appears now.

3.3.5 Principle 5 - Psychosocial Moratorium: Concerning this principle, all the games were rated very highly; which seems that all players have come to realize the following fact. Whatever they do in game (as long as it is game related) will not physiologically affect in any way their real life persona. Some games even encourage hostile encounters between players. For instance, in WoW and GuildWars, Player versus Player (PvP) is enabled in some areas. Regardless of the outcome or whom they are fighting against, they are still physically safe in front of their computers. Some of the players even do this as a way to relieve some stress. This principle was initially unclear regarding the real-life consequences of in-game actions such as temporary account suspension or account termination. Therefore, this principle was rewritten as it appears now.

3.3.6 Principle 6 - Regime of Competence Principle: It was observed that the Regime of Competence principle had relatively high scores for the MMOGs, which mean that it was present. For instance, it was observed that in MMOGs the difficulty of quests and missions are dependent on the level of the characters partaking in the event. Furthermore, in some instances players may be allowed in areas that are difficult for their current level, but not impossible for them to succeed if they think creatively. On the other hand, some of these games, such as GuildWars, have a player level cap of 20. Once it is reached, the game does not present any more meaningful challenges to players. Therefore, it might prompt some users to begin with a new character, or move on to a different game altogether. In contrast, the educational games were rated very low, since these were not very challenging. This was due because the answers were usually common sense and the software guided players fairly well, even if mistakes were made (e.g. Carabella).

3.3.7 Principle 7 - Self-Knowledge Principle: The Self Knowledge principle was highly rated for both educational games and only for two MMOGs: WoW and GuildWars. Regarding the MMOGs, players quickly learn when they are outmatched in these fast-paced games. In this manner, players may learn discretion when deciding whether to do or to avoid doing a task, depending on the context. It may indirectly promote cooperation, since they might realize that it is necessary to team up with others to accomplish the goal. Likewise, the educational games provided self-knowledge, albeit of a different type. For instance, in the Outbreak game

there is no sense of urgency, or dreadful in-game consequences for making the wrong decision. However, the game simulates potential negative consequences that could happen in real-life. Therefore, by immersing in the role given, the player can see the task's procedure that needs to be followed and its impact. Later, he or she can reflect if this procedure and any other actions taken make sense or not. Further reflections can reveal the player if he or she has the skill and motivation to pursue a career in public health. The other MMOGs rated low, perhaps because there is nothing in the game that explicitly keeps track of how a player interacts with others (e.g. journal).

3.3.8 Principle 8 - Collective Knowledge Principle: Concerning the Collective Knowledge principle, all the MMOGs rated high. In these games, players can get much help from other players from either chatting directly with them or using online resources provided such as forums. Some games (e.g. WoW) encourage collaboration among players by joining guilds (in-game organizations) that provides benefits to members, such as obtaining help in order to complete difficult tasks. Furthermore, MMOGs also foster online communities in which players can post their character stories, screenshots, fan art, etc; thus, creating an even richer knowledge repository. Conversely, the educational games observed in this study were rated very low. These games did not have any repository; they were too short in duration and too simple to feasibly worry about one.

3.3.9 Principle 9 - Engaging Principle: All the MMOGs, except for RuneScape, scored the highest for this principle, which means the games are very appealing. While RuneScape is engaging, the game's graphic engine looks dated in comparison to the others. In contrast, the educational games were rated just below average, which means that they have some engaging qualities. However, their domain is too specific, which might only attract a limited number of users. For instance, Outbreak at WatersEdge might mostly interest people from the emergency response and public health domains. Another possible reason is that the roles are usually given to the players, instead of them choosing one. This was observed in Carabella in which the user assumes the role of a female prospective college student; there is no other role in the game.

3.3.10 Principle 10 - User Interface Ease of Use Principle: Pertaining to this principle there were different results. World of Warcraft (WoW) and GuildWars received top scores, which should not be too surprising since they are two of the best MMOGs. For instance, one expert commented that in WoW, beginner players can quickly understand its functionality and its layout is easy to read. Likewise, both educational games ranged from average to high in this principle; both were considered to have a straightforward and intuitive interface. Some minor issues might have prevented them from a higher rating. For instance, both educational games run within a relatively small area within a Web browser, instead of using the full screen. Additionally, Outbreak's font size was small, which created difficulties to distinguish between letters and numbers (e.g. the letter Z and

the number two). Lastly, RuneScape and Final Fantasy did not rate very well in this principle. Lack of customization of the UI, and unintuitive interface were among some of the issues found.

3.3.11 Principle 11 - On-Demand and Just-in-Time Tutorial Principle: This principle also scored high for all the games, except for two. Final Fantasy XI has no in-game tutorial, and there are only two online ways to learn about how to play the game. The first is either to find an online mentor, which is difficult. The second is going to the official website for written documentation. Similarly, Carabella has no tutorial to guide the player through the game. Nevertheless, the user interface is so simple that perhaps the tutorial is not needed at all.

3.3.12 Principle 12 - Achievement Principle: The last principle rated very high for two MMOGs: WoW and Final Fantasy. These games offer incentives to level up in terms of experience points, money, items, and new abilities and powers to keep users motivated to continue playing. The items and powers are usually graphically visible which sends a message to others that the player has reached a certain level. Conversely, the educational games rated low and the rewards were not visually appealing. For instance, Carabella gives points every time the user makes decisions to maximize his or her privacy. However, the significance of these points is not well understood until after the level is completed. Likewise, GuildWars, even though it is an MMOG, also rated low, but for a different reason. Once a player reaches level 20, there are no more incentives or rewards to keep playing. Therefore, games with higher upper bound levels seem that would be played longer, since there are more opportunities for different degrees of achievement. Finally, Table 5 provides a summary of comparisons between both sets of principles from both pilot studies and of the differences between some of them.

4. CONCLUSION

We evaluated five Massively Multiplayer Online Games (MMOGs) and two educational games to determine the extent to which our proposed design principles were evident. Our findings from the two pilot studies indicated that not all of the principles are supported at the same level. Most games allowed for multiple solutions to a problem, in which gamers could formulate and test their own hypotheses. All games were highly engaging to players, provided a safe environment for in-game risks, and allowed students to practice some skills. Furthermore, all games recognized the necessity of having an in-game tutorial, but some games require improvement in this area, such as using customizable tutorials. Additionally, a few games appeared to have some issues regarding their user interface. For designing the UI of games also push players to attempt difficult, but not impossible tasks. In contrast, the educational games were adequate regarding helping players acquire knowledge to improve their own self-efficacy.

There were some limitations in this study. First, the sample of games used was small; therefore, we used the evaluation to provide qualitative information. This made

Original Principle	Revised Principle	Changes
1. Amplification of Input	1. Probing	Replaced Amplification of Input, because of ambiguous and unintended gains
2. Distributed	2. Distributed	Now includes interaction with other objects, technology, and context
3. Multiple Routes	3. Multiple Routes	Clarified the meaning of game progress
4. Practice	4. Practice	Clarified the context of practice scope
5. Psychosocial Moratorium	5. Psychosocial Moratorium	Now only refers to safety from physiological risks
6. Regime of Competence	6. Regime of Competence	None
7. Self-Knowledge	7. Self-Knowledge	None
8. Collective Knowledge	8. Collective Knowledge	None
9. Engaging	9. Engaging	None
10. User Interface Ease of Use	10. User Interface Ease of Use	None
11. On-Demand and Just-in-Time Tutorial	11. On-Demand and Just-in-Time Tutorial	None
12. Achievement	12. Achievement	None

Table 5. Comparison between both Sets of Principles

the quantitative analysis of the data not feasible to publish, since no result would be significant. Future studies will need to include more games in order to provide meaningful quantitative results. The second limitation was a lack of an explicit numeric inter-rater reliability for the gaming experts. This issue was addressed by interviewing the students after evaluating the game. They explained their reasoning, which in some cases prompted the rewriting of the interpretation of several principles. A third limitation was that the game experts were a mixed group of students with different educational levels. Therefore, the differences in interpretation might be attributed to their educational levels. Lastly, there were an unequal number of educational games chosen compared to the number of MMOGs. This might cause the impression that there are not enough educational games around, even though they are not as appealing as the MMOGs. However, it is also difficult to get gaming experts to play educational games for extended hours if these are not engaging or fun to play. Since educational games usually do not get the funding that commercial games get, this situation is not surprising.

Our assumption is that the five constructs of Social Negotiation, Inquiry Learning, Reflective Thinking, Authenticity of the Learning, and Ease of Use are necessary for meaningful learning by students; meaningful as perceived by the student and as objectively measured when compared to learning outcomes. We developed a set of 12 design principles for a learning environment based on a review of the literature and revised them based on two rounds of small sample investigations of actual games. Our findings indicated that there might be a need for two different types of future research. The first is to continue to evaluate both popular games designed for fun and “serious games”, which are entertaining games designed for the purposes of learning. The second research initiative is to design specific learning objects for use in courses. We have investigated the idea of using a single gaming-learning environment for multiple courses. Advanced students would have to mentor novices enrolled in pre-requisite courses. Both of these efforts are being pursued.

System design involves specifying structure, function and behavior. Our design principles specify the structural and behavioral requirements for a gaming learning environment. The functional requirements of specific learning outcomes and pedagogical goals such as problem solving or group presentations need to be added in order to have a complete specification of the learning environment. We recognize that some educators would not be comfortable with some of our suggestions for design principles, but we know that many students take a “surface” approach rather than a “deep” approach to learning (Marton and Säljö 1997). Educators can expect to gain students adopting a deep approach to learning where students do not just memorize course materials but focus instead on understanding the course concepts because they need this knowledge to accomplish specific “quests” in the game-based learning environment. Our 12 design principles are a step toward creating a cyber-enabled constructivist environment that is engaging and encourages deep learning.

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AUTHOR BIOGRAPHIES

Roberto A. Muñoz Rosario is a PhD candidate in



Information Systems at New Jersey Institute of Technology. He holds a BS in Computer Systems Engineering from Universidad Santa María la Antigua in Panama, and a MS in Computer Science from Montclair State University. His research interests are the effective use of multi-user virtual worlds in education and game-design principles for engaging learning environments. He has published in *America's Conference on Information Systems* and *Hawaii International Conference on System Sciences*.

George R. Widmeyer is an associate professor of



Information Systems and director of the Master of Science in Information Systems program at the New Jersey Institute of Technology (NJIT) in the College of Computing Sciences. He graduated from the University of Texas at Austin with his PhD in Information Systems. His current research interests are cyber-enabled constructivist learning, multiple user virtual environments (MUVEs), and information systems design theory. He has published in a variety of journals including *Information Systems Research*, the *Journal of Management Information Systems*, and *Decision Support Systems*.



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