

Association for Information Systems AIS Electronic Library (AISeL)

AMCIS 2007 Proceedings

Americas Conference on Information Systems
(AMCIS)

12-31-2007

Fun, Simple and Instructive: Towards a Design Theory for a Constructivist Gaming Learning Environment

Roberto Muñoz Rosario
New Jersey Institute of Technology

George Widmeyer
New Jersey Institute of Technology

Follow this and additional works at: <http://aisel.aisnet.org/amcis2007>

Recommended Citation

Muñoz Rosario, Roberto and Widmeyer, George, "Fun, Simple and Instructive: Towards a Design Theory for a Constructivist Gaming Learning Environment" (2007). *AMCIS 2007 Proceedings*. 478.
<http://aisel.aisnet.org/amcis2007/478>

This material is brought to you by the Americas Conference on Information Systems (AMCIS) at AIS Electronic Library (AISeL). It has been accepted for inclusion in AMCIS 2007 Proceedings by an authorized administrator of AIS Electronic Library (AISeL). For more information, please contact elibrary@aisnet.org.

Fun, Simple and Instructive: Towards a Design Theory for a Constructivist Gaming Learning Environment

Roberto A. Muñoz Rosario and George R. Widmeyer

New Jersey Institute of Technology

Email: ram75@njit.edu, widmeyer@njit.edu

Abstract

Creating a design theory of Constructivist Gaming Learning Environment necessitates, among other things, the establishment of meta-design principles. These principles can potentially help designers produce games, where users achieve higher levels of learning. This paper focuses on three key design principles important in this context: Engaging, User Interface Ease of Use, and On Demand and Just-in-Time Tutorial. Game play testing and observations were carried out on three Massive Multiplayer Online Games (MMOGs): RuneScape, GuildWars, and Ragnarok. Our preliminary findings indicate that not all of the popular MMOGs support all of these principles. This research in progress will lay the foundation for the validation and revision of meta-design principles through the Constructivist Gaming Learning Environment Survey.

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

Introduction

“This is so boring.” This sentiment is echoed by many students that are being taught with the traditional education system. 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 et al. (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 in 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 to 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 tastes. 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). An 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. Game designers for these popular games have managed to spark great interest and desire to play these games. Furthermore, these games have virtual communities with users debating different aspects of the game. 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 System Design Theory (ISDT) proposed by Walls, Widmeyer, and El Sawy (1992). This theory has several components for an information systems product design: kernel theories, meta-requirements, meta-design, and design hypotheses. Next, we will discuss three key meta-design principles to be used in the Constructivist Gaming Learning Environment. These principles are the main focus of this paper: Engaging, User Interface Ease of Use, and On Demand and Just-in-Time Tutorial. After that, we will present our research-in-progress findings from our observations and gameplay testing of three popular MMOGs with regards to these three principles. 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.

Design theory

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.

Design principles – the Meta-Requirements

Gee (2003) argues that good 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 review of both sets was conducted by a group of four students (undergraduate, masters and two doctoral students). This resulted in a revision to some of the Bonk and Dennen (2005) principles, and the addition of three new ones (numbers 8, 9 and 10 below). The resulting 12 design principles for a Constructivist Gaming Learning Environment (CGLE) are:

- **Amplification of Input Principle:** Learners should get out of the experience more than they put in.
- **Distributed Principle:** Learners should find growth and knowledge in their interactions with other learners, technology, context, objects, and tools; automatically recording vital information obtained from other players.
- **Multiple Routes Principle:** There should be more than one way for learners to progress, encouraging them to make decisions and solve problems.
- **Practice Principle:** Learners should be able to spend a lot of time practicing in an interesting environment.
- **Psychosocial Moratorium Principle:** Learners should be able to take risks in artificial environments where there is a lower chance of real-world consequences.
- **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.
- **Self-Knowledge Principle:** Players should learn about themselves and their current and potential capacities.
- **Collective Knowledge Principle:** Players should learn from other players' experiences, building a repository of useful knowledge shared by all.

- **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.
- **User Interface Ease of Use Principle:** The user interface should be user friendly and the system should be easy to navigate.
- **On-Demand and Just-in-Time Tutorial Principle:** Game tutorials to aid players in learning the game mechanics and user interface while they are playing, exploring or interacting with the environment.
- **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.

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

Task and Individual Fit – the Design Hypotheses

There are two questions that 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 research approach is based on the widely-referenced model of task-technology fit (Goodhue and Thompson 1995) as shown in Figure 1. There are two types of fit evident in Figure 1. There is the fit between the task and the technology and the fit between the individual and the technology. The first type is the perspective of fit as matching and the second type is the perspective of fit as moderation (Zigurs and Buckland 1998). Both of these fits are explored in this research. The dependent variable is learning outcomes as measured using the Bloom taxonomy of educational objectives.

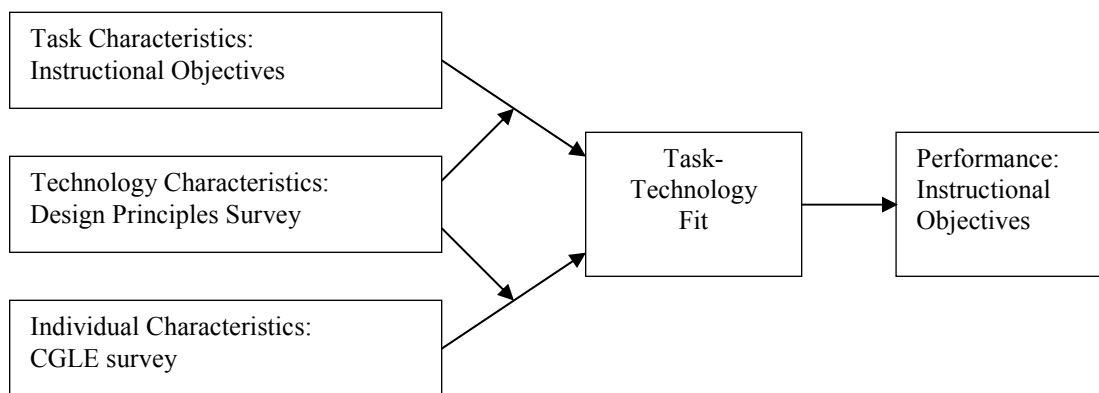


Figure 1. The Technology to Performance Chain (modified from Goodhue and Thompson 1995)

The Task can be measured by a set of instructional objectives mapped to the six levels of the Bloom (1956) taxonomy (Remember, Understand, Apply, Analyze, Evaluate, and Create). This is a standard way of categorizing instructional objectives and it has been used as a metric for specifying depth of knowledge in the design of information systems programs. 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 they are in and asking their preferred learning environment. A comparison of these two (Actual versus Preferred) defines a gap (Taylor and Maor 2000), 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 (Maor 2000) 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 and in a teacher development program. The usage of the CGLES enables the continual testing of the hypothesis that students prefer a constructivist gaming 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 are: Student Negotiation, Inquiry Learning, Reflective Thinking, Authenticity, and Ease of Use. We have modified the original survey instrument used by Maor (200) slightly to produce the CGLES. This is shown in Table 1.

Table #1 Descriptive Information for each Scale of the CGLES (adapted from Maor 2000)

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 can 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.

We are in the process of developing our CGLE survey and plan to pilot test it in two information systems courses to be offered in the next semester.

The second 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).

Gameplay Research and Findings

In this preliminary study, we focus on design principles nine, ten, and eleven: *Engaging*, *User Interface Ease of Use*, and *On-Demand and Just-in-Time Tutorial*. These three principles are not directly tied to learning. Nevertheless, they would provide vital features to game design; supporting a Constructivist Gaming Learning Environment. Games that fulfill Principle #9 will attract students to the learning environment. After all, a game that doesn’t attract players will never be played, no matter how well designed everything else is. On the other hand, Principles #10 and #11 would keep students using the learning environment. Any game designed using these two principles would help players immerse into the game seamlessly, with a minimum of effort and frustration. In this section, we will proceed to explain these three principles.

Principle #9: Engaging

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? To fulfill this principle, the game designer must follow two basic steps. First, know the target audience's preferences. This is the most important issue that this principle must address. Would the audience prefer a science fiction game or a medieval fantasy game? Let's say that the game to be designed is for medieval history major students. They would be more inclined to play a medieval fantasy game, rather than a science fiction game. Another aspect of this principle relates to the role of the player. Usually, when a person plays a game, he or she doesn't assume the same job he or she has in real life. As a form of escapism from daily routine, a person wants to have an exciting role (Rouse 2005) with actions that could potentially affect the learning environment dramatically. In other words, the person wants to have fun, with actions that will have consequences in a safe and virtual environment. This brings us to the second basic step to fulfill this principle: give a player an exciting or extraordinary role in the game. This will make the idea of playing an educational game more exciting and less of a chore for many students. Therefore, players will be learning at the same time they are having fun. For example in a game for computer majors, the role of "underground infiltrator" can be assigned to a player instead of simply "network specialist". It will pique a potential player's curiosity and will increase the likelihood of him or her playing the game.

Principle #10: User Interface Ease of Use

Whereas games adhering to the Engaging Principle attract players to them, it is the correct implementation of the ***User Interface Ease of Use Principle*** that keeps users playing them. Regardless of the nature of the game, attempting to succeed at a very difficult stage of the game and simultaneously struggling because of a poorly designed user interface, will frustrate and anger players. Therefore, the interface must possess the following characteristics: *ease of use*, *consistent*, *non-intrusive*, *flexible*, and *navigable*. An easy-to-use user interface is intuitive and provides a mechanism for users to interact with the environment in such a way that it makes logical sense to them. For example, pressing the down arrow (▼) on the keyboard must make the player's avatar move in that direction rather than open an inventory window. In addition, the interface must be consistent. For instance, every friendly non-player character upon being clicked must always display to the player the same general menu options (i.e. 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. For example, let's say the player needs to use an item at a vital juncture of the game. However, to access it, the user must traverse through several UI windows; thus, diminishing the sense of urgency of that action within the game. Additionally, the interface must also be flexible; the player must be able to customize the interface (keystroke shortcuts, camera angle, etc.). For example, the player may want to press ***Ctrl-S*** to save his or her progress instead of pressing ***F10***. Finally, the user interface must be navigable; a critical feature for games with a considerable amount of exploring. Features such as an Auto map and a compass can help players arrive at the required destination. All of these characteristics will contribute to a robust user interface that will be easy to use for the player.

Principle #11: On-Demand and Just-in-Time Tutorial Principle

Nowadays, a player wants to start playing a game as quickly as possible. However, a player can get discouraged when he or she realizes that the game comes with a big manual of how to play it. If the documentation contains errors, players might get confused and frustrated while they are attempting to play the game. Instead of forcing players to read dozens of pages on how to get into the game, game designers should create tutorials as part of the game itself. 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 follow five steps. First, create the tutorial as part of the player's character development or advancement in the game. The tutorial can be disguised as a "preliminary mission" to help users get into the mood of the game. Second, it should incorporate into the tutorial all of the game's core aspects (conversations, interactions with the environment, combat, etc.) for a player to learn. Thus, the user learns about both the game's purpose and how to interact with the virtual game world. Third, it should include some technical interface aspects of the game most likely to be used by players (i.e. rotating the camera view and saving the player's progress). Fourth, the tutorial should provide feedback to the player, when mistakes are being made. Therefore, this will prevent or at least minimize costly mistakes from occurring at more important stages of the game. Finally, the tutorial must reward the players for successfully completing the tutorial without penalizing them for mistakes. After all, the tutorial is part of the player's learning process of understanding the game's purpose and interacting with the virtual environment.

Preliminary Findings

In our preliminary research, we have 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 was 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.

RuneScape is a Massively Multiplayer Online Role-Playing Game [subset of MMOGs] and also 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 a player decides to do in RuneScape is entirely their decision: nothing is predetermined. RuneScape is the only game completely free of charge that we evaluated.

Guild Wars is another Massive Multiplayer Online Role-Playing Game and, similar to RuneScape, it has a 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 accomplishments that influence the game world. There is no monthly subscription fee, but the user must purchase the main game.

Ragnarok 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.

Table # 2 Evaluation of three Games using Meta-Design Principles

#	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.	<i>Engaging Principle</i>	High	High	High
10.	<i>User Interface Ease of Use Principle</i>	Low	High	Medium
11.	<i>On-Demand and Just-in-Time Tutorial</i>	High	Medium	Medium
12.	Achievement Principle	Medium	Medium	High

As seen in Table #2, 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 immerse seamlessly into the gaming experience as soon as possible. However, the *User Interface Ease of Use* had a low score. This low score was due, 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 the *Engaging* and the *User Interface Ease of Use* principles. This means that the game is very appealing and the user interface is very easy to use. However, the *On-Demand and Just-in-Time Tutorial* principle had a medium score. The score for the *On-Demand and Just-in-Time Tutorial* principle 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, both the *User Interface Ease of Use* and the *On-Demand and Just-in-Time Tutorial* principles had medium scores. The medium score for the User Interface indicates some difficulty using the interface, a vital aspect for any software. Finally, the On-Demand and Just-in-Time Tutorial principle score shows that Ragnarok has a tutorial, but it may be missing some features.

Next Step – Testing Games as Learning Environments

None of the currently popular MMOGs were designed as learning environments; therefore, we need to look at some other online games that were designed as learning environments. We have identified an initial set of games using the Social Impact Games <www.socialimpactgames.com> web site as a source of candidates. Three of these are shown in Table 3.

Table # 3. Some Games as Learning Environments

Game	URL	Description
Carabella Goes to College	www.privacyactivism.org/carabella/	This game 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.
Outbreak at Watersedge	www.mclph.umn.edu/watersedge/	This game introduces you to the world of public health as you help discover the source of the outbreak that has hit the small community of Watersedge and stop it before more residents get sick.
Virtual-U	www.virtual-u.org	Virtual U provides students, teachers, and parents the unique opportunity to step into the decision-making shoes of a university president. Players are responsible for establishing and monitoring all the major components of an institution, including everything from faculty salaries to campus parking.

None of these games are MMOGs. Comparing them against the 12 design principles will help in validating the design principles but it will only provide minimal guidance on the on the architecture for an MMOG that enables a constructivist learning environment. We are planning on developing our own game as an instance of the meta-design characteristics of the information systems design theory.

Conclusion

We evaluated three Massively Multiplayer Online Games to determine the degree of presence of our proposed meta-design principles. Our preliminary findings indicated that not all of the principles are supported at the same level. Whereas all games were highly engaging to players, two of the games appeared to have some issues regarding the user interface. This can make playing the game more difficult for people. A possible solution might be some form of usability testing while

designing the user interface. All games recognized the necessity of having an in-game tutorial, although two of them might have left out some important aspects. A possible solution might be a customizable tutorial in which a player can choose which features to include before using it. Thus, game designers would not have to assume what the users need to know.

This research will serve as the basis for the validation and revision of our twelve meta-design principles through the Constructivist Gaming Learning Environment Survey. Through this survey, we will be able to compare the degree of satisfaction between the student's actual and preferred learning environments. Thus, we can create a set of meta-requirements in addition to further refining of our principles. None of the current educational games are MMOG, so there is a great opportunity to create a new kind of educational tool that will help future generations. The Information Systems Design Theory provides the framework to create these types of games. Thanks to the MMOG philosophy, this tool could reach a global audience at all levels of education fostering participation and collaboration among all its users.

References

- Ausubel, D. P., Novak, J. D., and Hanesian, H. *Educational Psychology: A Cognitive View*, New York, Holt, Rinehart, and Winston, 1978.
- Bloom, B.S., Englehart, M.D., Furst, E.J., Hill, W.H., and Krathwohl, D.R. *Taxonomy of Educational Objectives: Book 1 – Cognitive Domain*, New York: Longman, 1956.
- Bonk, C.J., and Dennen, V.P. *Massively Multiplayer Online Gaming: A Research Framework for Military Training and Education*, Technical Report 2005-1, Advanced Distributed Learning Initiative, Office of the Under Secretary of Defense for Personnel and Readiness, 2005.
- Gee, J.P. *What Video Games Have To Teach Us About Learning And Literacy*, Palgrave, NY: MacMillan, 2003.
- Goodhue, D.L., and Thompson, R.L. "Task-Technology Fit and Individual Performance," *MIS Quarterly* (19:2), 1995, pp. 213-236.
- Liu, C., and Matthews, R. "Vygotsky's Philosophy: Constructivism and its Criticisms Examined," *International Educational Journal* (6:3), 2005, pp. 386-399.
- Markus, M. L., Majchrzak A., and Gasser, L. "A Design Theory for Systems that Support Emergent Knowledge Processes," *MIS Quarterly* (26:3), 2002, pp. 179-212.
- Maor, D. "A Teacher Professional Development Program on Using A Constructivist Multimedia Learning Environment," *Learning Environments Research* (2:3), 2000, pp. 307-330.
- Novak, J. "Meaningful learning: The essential factor for conceptual change in limited or inappropriate propositional hierarchies leading to empowerment of learners," *Science Education* (86:4), 2002, pp. 548-571
- Rouse, R. *Game Design: Theory & Practice*, Plano, TX: Wordware Publishing, 2005.
- Simon, H. *The Sciences of the Artificial*, Cambridge, MA: MIT Press, 1981.
- Taylor, P.C., Fraser, B. J., & Fisher, D. L. "Monitoring Constructivist Classroom Learning Environments," *International Journal of Educational Research* (27:4), 1997, pp. 293-302.
- Walls, J.G., Widmeyer, G.R. and El Sawy, O.A., *Building an Information Systems Design Theory for Vigilant EIS*, *Information Systems Research* (3:1), 1992, pp. 36-59. .
- Zigurs, I., and Buckland, B.K. "A Theory of Task/Technology Fit and Group Support Systems Effectiveness," *MIS Quarterly* (22:3), 1998, pp. 313-334.