Experiential modes: a common ground for serious game designers

Robert L. Appelman

Indiana University, School of Education,
201 N. Rose Ave.,
IN 47405, Bloomington
E-mail: appelman@indiana.edu

Abstract: Game designers are skilled in creating environments that are fun-filled and instructional designers are skilled in creating environments that foster learning. Today's demand requires that they work together to make games that are immersive learning environments, and *experiential modes (EM)* are what both designers create to achieve their goals. This paper posits that any learning environment is a sequence of *EMs* as defined from the viewpoint of the learner, and that the starting point for designers to begin working together is at the common ground of *Experiential Modes*. By understanding the characteristics of games and simulations, specific *EM's* can be defined that will allow these learning environments to be both fun and learning.

Keywords: game and simulation development; instructional design; learning environments; experiential modes; characteristics of games and simulations.

Reference to this paper should be made as follows: Appelman, R.L. (2005) 'Experiential modes: a common ground for serious game designers', *Int. J. Cont. Engineering Education and Lifelong Learning*, Vol. 15, Nos. 3–6, pp.240–251.

Biographical notes: Dr. Appelman is a nationally recognised authority on digital production and technology education. As a faculty member for the Instructional Systems Technology Department at I.U., he has designed and delivered classes and workshops on multimedia production, message design, production management, and learning environment design. He is Past-President of the Media Design and Production Division of AECT, serves on the board of the Digital Games Research Association (DiGRA), and on the board of the International Simulation and Games Association (ISAGA). He is also Director of the Virtual Xperience Lab (VX Lab)

Experiential modes

Introduction

There is no question that games and simulations can be fun, given that this has grown to a seven billion dollar industry today, but the question of whether the fun can be learning has been enigmatic for many years (Abt 1970, Appelman and Goldsworthy, 1999; Heinich et al., 2004), thus the coining of the term 'serious games'. Now we have conferences on serious games (http://www.seriousgames.org, http://www.synergysummit.com) and we have the game development industry recognising this growing development area at their own Game Development Conference (http://www.gdconf.com/conference/seriousgamessummit.htm). What this means is that two separate cultures, the game entertainment industry and academia, are on a collision course towards each other because of the increasing demand to incorporate learning into serious games. Game designers know a lot about entertainment and fun, plus the complex development process of building immersive virtual 3D gaming environments. Academics know a lot about learning, and the complex development process of building immersive learning environments. Both are building immersive environments but for different purposes, and now they need to work together to build immersive virtual 3D learning environments that are sometimes games and sometimes simulations. Hence, the game designer's perspective elicits an exclamation that "… there's an instructional designer in my pipeline that is killing the fun!", which is often countered by an instructional designer saying ' "… yeah, it's fun, but where's the learning!".

What is needed is a middle ground where both cultures can begin to understand the values, processes, and language of the other. The goal is to create a synergistic relationship where the outcome would be an immersive virtual environment that can change people. Game designers normally are not trying to change people, but academics are, through changes in cognition and affect, or learning and motivation, respectively. Academics have always placed their role in the 'serious domain', and even bristle sometimes when games and sims are associated with what they do, but there are now centres of research forming around games and simulations that are bringing it slowly into acceptance (http://www.digra.org , http://www.game-research.com/, http://game.itu.dk/, http://www.red3d.com/cwr/games/, http://en.wikipedia.org/wiki/Video_game_studies, http://www.ludology.org/, http://www.gamasutra.com). For the academic, there has always been controversy, confusion, excitement, and passionately held opinions around the topic of games and simulations. Some say that simulations are useless non-constructive forms of entertainment, games especially are detrimental to youth, and a complete waste of time for an adult population (Bandura et al., 1961; Barmazel, 1993; Sneed and Runco, 1998; Griffiths, 1999). While others claim that only through games and simulations will we ever be able to reach the engagement, learning, and performance levels educators and trainers have been seeking for centuries, thus targeting games and simulations as the latest panacea for instruction and performance interventions (Crawford, 1984; Thiagarajan, 1994; Kamimura, 2002; Gee, 2003; Jones, 2003).

For there to be such wide-spread opinions, there must also be some element of truth feeding each point-of-view and this makes it particularly difficult for the trainer to decide if and when to use a simulation or game and to determine, which of the many modes of delivery would be appropriate to meet their training goals in specific contexts.

The first thing that usually pops into someone's mind when the word *game* is mentioned is some activity that is strictly non-work related, is done by choice, is 'fun and entertaining', and will not require any recall of the game play for future non-game use. Actually, both 'fun and entertainment' ARE primary motivators that the trainer may use to increase the engagement and focus on the topic at hand. Now that these aspects are on the table, it causes concern for many academics because entertainment variables are foreign to them. They are primary variables to game designers, and also to the learners who expect fun and entertainment variables to be highly developed in any game they encounter – even in a more formal, academic, or training context.

To move more closely to a middle ground, it might be helpful to define games and simulations according to their most basic characteristics. To a game designer it will be overly simplistic, but to the academic it should resonate with existing heuristics and language.

2 Characteristics of a game

To sort out just what a game is requires delineating the difference between what happens during an activity or game, and what outcomes resulted from the experience with that game. For instance, fun, entertainment, learning, and improved competency are all *outcomes* of a game. Game elements such as the specific tasks, consequences, and available interactions are *aspects* of a game. There are specific combinations of these aspects that are targeted at certain outcomes, and these become *characteristics* that define games from simulations.

Six characteristics are present in all games:

- challenges (goals and tasks)
- rules (that govern how the game works)
- interaction (by the user with aspects of the game)
- contrivance (modifying realism to benefit game play)
- obstacles (elements of the game encountered)
- closure (an end to the game).

3 Characteristics of a simulation (Sim)

Simulations began when people started to role-play events that occur in real life. Whenever one proceeds into an activity that somehow mirrors a process, place, or event, a simulation strategy is being used to some extent. The modality of a *sim* may extend from arrangements of people to sophisticated game-like virtual spaces and may even utilise both modalities in a blended learning context called *Mixed Reality*. There is a great degree of overlap between games and sims, but there are subtle, yet significant, differences found in the targeted outcomes and structural characteristics of a simulation compared to a game.

Six characteristics are present in all simulations:

. • challenges (goals and tasks)
. • models (that govern how the environment functions)
. • control (by the user with aspects of the sim)
. • manipulation (ability to select multiple outcomes)
. • authenticity (the degree of match to reality)
. • consequences (results of decisions made in the sim).

Simulations are receiving special attention because of the computer capabilities to create realistic models of people, places, and things. This makes it possible to use simulation strategies in a virtual mode to mirror more situations than could have been possible prior to this capability, and to even consider using virtual space to mirror interpersonal interactions and decision making. Like games, all cases of *sims* will be directed towards particular outcomes and will have certain aspects that are unique to a specific context. All will have varying degrees of the common characteristics and players will engage in interactions and activities similar to games.

4 The technology

Computing power, creation tools, and display technologies have improved to the degree that designers can now envision virtual environments that have similar attributes as the real world. Of course, we are not at the holodeck level yet, but enough of the critical elements and functionality of an environment can be made available that desired experiential levels for a learner can be reached. These capabilities, combined with new paradigms of problem-based learning strategies, now offer the instructional designer more avenues to higher level learning goals than were ever possible before. Unfortunately in this regard the technology is also a huge hurtle for instructional designers because most have never designed in three dimensions, and certainly have never built any artificial intelligence systems; however, they have used many games and simulations in their instruction (Greenblat and Duke, 1975; Thatcher, 1986; Reigeluth and Schwartz, 1989; Brant et al., 1991; Petranek et al., 1992; Savery and Duffy, 1995; Thiagarajan and Thiagarajan, 2001; de Lara and Alfonseca, 2003; Kommers, 2003; Squire and Barab, 2003; Kirk, 2004).

The one common ground that both game designers and instructional designers share is a focus on the player/learner and the experience that each has with the respective play/learning environments. This dialogue can occur without technology, but instead only refers to affordances that the technology brings to the environment. For serious game objectives, this environment becomes a 'learning environment' and is posited here as being the arena for the 'middle ground' synergy building.

5 Learning environments (LE)

Learning environments are a way of looking at technology from a broader perspective, and one that situates the discussion in the instructional design process (Hannafin and Hill, 2005). It is defined with a strong learner centred focus because an LE is defined more by how a learner perceives it than by how a designer designs it. Thus, it is not the game or instructional designer that defines it, it is the learner.

Learning Environments can be categorised on the basis of two primary criteria – the *attributes* of the environment that are created by the designer and the *learner's perceptions* of that environment while operating within it.

Learning Environment	**Learner Perceptions**

Attributes: …		**within the Environment:**	
1. virtuality	The degree of representation of persons, places, or things	***1. sensory immersion***	Engagement through visual, auditory, haptic, kinesthetic, & olfactory senses
2. infra- & super-structures *(simple to complex)*	*Infra:* hidden affordances or capabilities *Super:* real or virtual definitions of space	***2. Interaction***	Communication or contact with a person or thing
3. spatial boundaries	Real or virtual limitations of access or motion	***3. mobility***	Freedom of motion to another place
4. time boundaries	Limits of time imposed on activities	***4. sense of time***	Apperception of the flow of time
5. persons, objects, & matter	Available persons, places, or things to interact with	***5. access to information***	Available options for gathering information
6. technological affordances	Tools & processes available for use	***6. user control/ manipulation***	Options and functionality with technologies
7. content density	Scope of content relative to entry level of learner	***7. apperception of content***	Awareness of content scope
8. concreteness	Lack of abstraction of concepts	***8. cognitive change***	New understandings or perceptions of procedures, concepts, or principles
9. authenticity	Levels of congruency to real persons, places, things, or processes	***9. affective change***	New attitudes or values toward content, persons, places, or things.

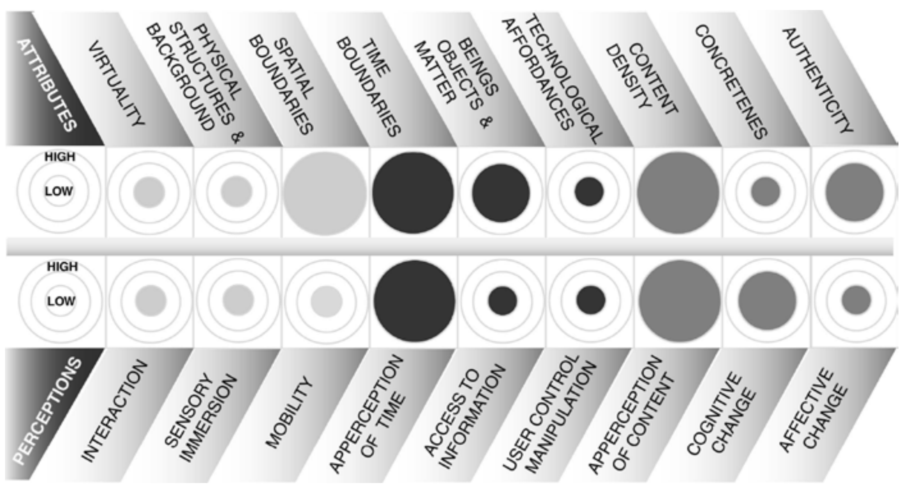
Such a definition links the LE attributes to the learner perceptions in a causal relationship. It is based on the assumption that elements and processes incorporating those attributes are placed in a learning environment for the sole purpose that the learner will engage with them. The designer of an LE also anticipates certain perceptions and cognitions of the learner while they are operating in the LE and by placing its definition based on observation and assessment, the learning environment can only be what it is demonstrated to be engaged by the learner. Too often designers ply an LE with technologies that are never fully engaged by the learner, and the failure in meeting learning goals is placed on the learner rather than a poorly conceived learning environment (Cuban, 2001).

Consistent with the old adage that one can lead a horse to water but not make him drink, a designer can introduce an environment to a learner but can not make him perceive or cognate. However, a designer can provide experiences and affordances for the learner to engage with. By assembling these modular experiences (called *experiential modes*) into particular sequences, a designer can observe the actions of the learner and assess his/her perceptions and learning. The role of the instructional designer then becomes more of a conductor who orchestrates a particular sequence of experiential modes that make up a learning environment for the learners to encounter. This is similar to a level designer of a game creating different rooms or obstacles for the player to go through and engage with.

6 Experiential modes

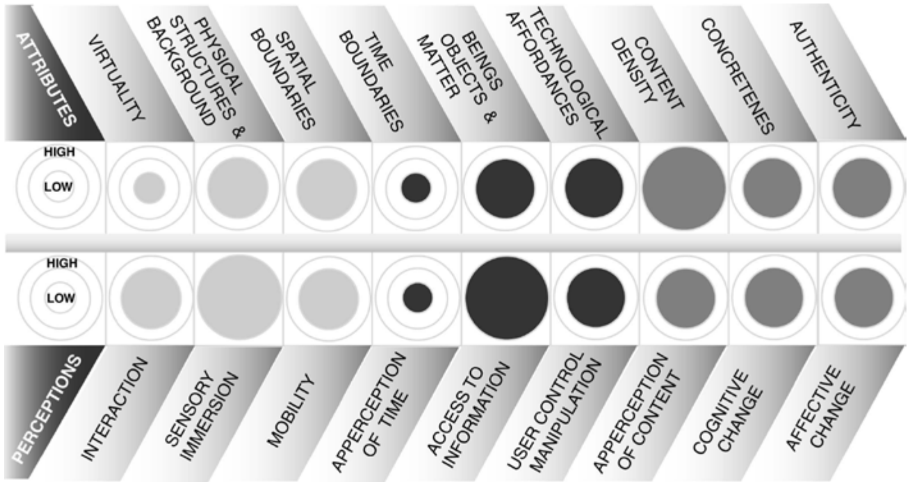
An *experiential mode* (EM) is defined through a listing of the degree and/or level of any environmental *attribute* or *perception* a learner encounters within a learning environment. The myriad combinations of degrees and levels of each attribute and learner perceptions within each learning environment create an equal number of possible experiential modes. Because of the mind-boggling number of permutations, traditional learning environments have kept a great many of these variables at a constant level. Before leaping to a virtual space, let us examine the modes found in a traditional classroom (Figure 1) with simple *superstructure* attributes of a rectangular room filled with rows of chairs (*objects*) and a presentation area for an instructor (*person*) at the front, with very few *technological affordances* for the students (more *persons*), and absolutely no *mobility* opportunities (students are pretty much expected to sit in their seats and not roam around the room). *Interaction* is highly structured with little *control* for students to *access information* other than what is made available.

Figure 1 EM in Traditional Classroom LE



Contrast the traditional modes with a more contructivist LE (Figure 2) with a similar *superstructure*, but where chairs and tables are designed to fit together in multiple combinations, and each student has a wireless laptop where group assignments are self directed and students are free to move about the room with presentations being offered by the instructor, students, using information from individual, print, and web sources alike. From a learning environment perspective the two classes differ significantly in the numbers of experiential modes present in each, with the latter emphasising increased *interactivity* with *persons*, more *control* of *content* variables, a wireless *infrastructure*, increased *technological affordances*, more *mobility* within the environment, and a different sense of *time boundaries*.

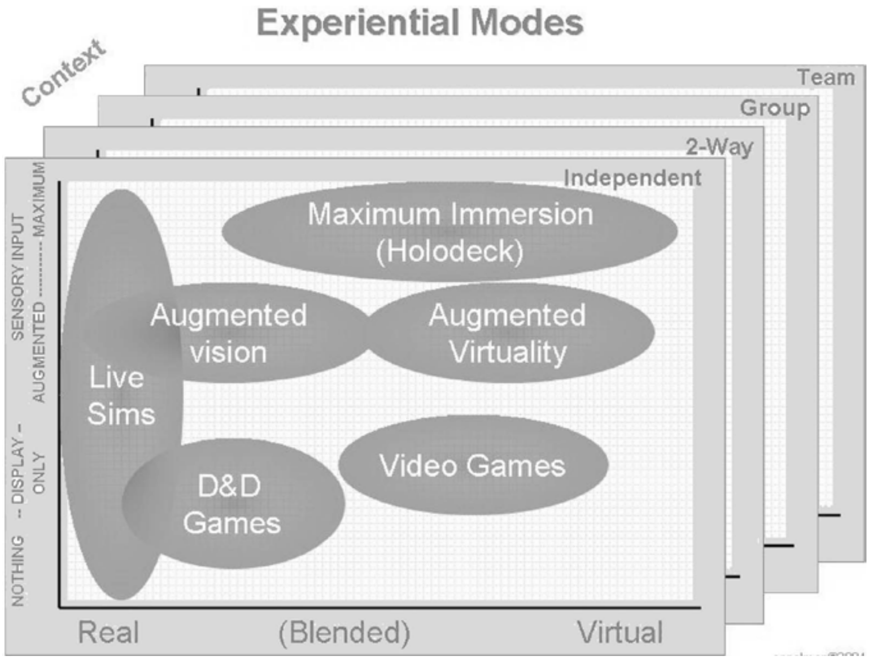
Figure 2 EM in Constructivist Classroom LE



It is no wonder that resistance is encountered when new variables are introduced into a learning environment because this places a need to challenge the traditional constants (Cuban, 2001). As the information age permeates our everyday lifestyles, the contrast between how we access and acquire information draws sharper and sharper contrasts with the relatively slow content dissemination of traditional experiential modes. This contrast is most contrasted when comparing it to the EMs of video game play of the current generation of students (Petranek, 1994; Thiagarajan, 1994; Gee, 2003; Squire and Barab, 2003). The traditional classroom is replaced by virtual superstructures beyond anything previously conceived, let alone constructed. The player can have extremely facile mobility, with capabilities to not only “leap tall buildings at a single bound” but even walk through the walls of the buildings themselves. The information flow generated through actions of the controller and by the programming of the game itself requires a level of multi-tasking that would even challenge an airline pilot. Because more of our learners are experiencing modes like these, there is an increasing demand to include more immersive experiential modes in instruction. This is not only to keep students’ attention, but also because their familiarity with multiple sensory immersion in virtual environments allows for these EM’s to be used for instruction where here to fore were not an option. These new opportunities not only allow but require that game designers begin the collaboration to build immersive virtual learning environments that offer as exciting and engaging experiences for learners as is afforded in most of the video games. Instructional designers must also join this collaboration by researching new ways to communicate in these robust environments. Timelines for development may be lengthened but comparing and contrasting attributes of the environment with possible experiential outcomes will generate new solutions and new EMs.

The matrix below displays one such comparison of an attributes of *virtuality*, as it maps against the degree of *sensory immersion* of the learner’s perceptions. An added dimension to this relationship is the multi-faceted *Context* for any LE, targeted here as a continuum of *interaction with others* from individual to team collaboration.

Figure 3 Virtuality by Sensory Immersion



Some common forms of EMs are identified on the matrix in Figure 3 and offer to orient the reader to new affordances of EMs. While most of the blended and virtual modes are less common to instruction, the ‘live sim’ area is very common and represents activities like a field trip. Visiting a zoo offers many EMs that incorporate not only visual and auditory senses, but a ride on a camel would involve haptic, kinaesthetic, and the sometimes less pleasurable olfactory senses. Zoo Tycoon, a popular video game, also offers interactions with camels, but only at a 3D image level and with some audio sound effects, placing it at a lower sensory level on the Y axis, but farther to the right because it is virtually represented. Dungeons and Dragons (D and D) games offer a high degree of interactivity and content density, but because they are represented by actual models that move on a game board, they are placed low on the sensory scale. Military war games are traditionally carried out in outdoor simulated battle grounds that offer as many sensory inputs as possible, including real explosions. This places them in the area of live sims on the matrix, but often additional technologies are included such as *heads up displays* that allow the viewer to see text and graphic displays super imposed over whatever they are viewing at any moment. If the data stream feeding this display are correlated with what the viewer is seeing, they can add additional information about the object being viewed, hence the name *augmented vision*. With the majority of architecture and manufacturing incorporating computer aided design (CAD), the designing of a virtual item before the real one is constructed, is standard practice. However, there is often the need to include real elements to situate that virtual element into its future context, and this is an instance of *augmented virtuality*. The ultimate EM is a *holodeck* envisioned by the video series Star Treck. Although such technology is not available, *holodeck-like* experiences can be achieved through wearable gloves coupled with augmented vision, CAVE augmented virtual environments (CAVEs), and experiences like the *Spiderman* theme park ride at Universal Studios in Florida. All of these include multiple sensory inputs that are coupled to the users’ actions and create maximum immersion EMs.

Learning environments for high-stakes training applications are particularly aided through this approach because it assists in the navigation through important decision-making. High-stakes applications are those found in the military, medical, and business contexts where the consequences of a bad decision have extensive repercussions (Kommers, 2003; Swartout and Michael, 2003; Raczynski, 2004; Summers, 2004).

Flight simulators are the most advanced instances of EMs with full *virtual* visual, audio, haptic, and kinaesthetic *sensory immersion*. As a frequent flyer, I am very comfortable with the costs necessary to create these extensive *technological affordances* for the pilot to experience in training. The consequence for failing in a simulator is low, and there can even be a degree of *control and manipulation* where experimentation could be used as an acceptable strategy. The critical perception, and the most difficult attribute to develop, is the *level of authenticity* of the environment. There is no point to build a simulator that does not replicate reality, unless the trainee is adequately made aware of what is, and is not, authentic. It is difficult to create an authentic simulation because all attributes must be at their highest levels.

It is equally difficult to create a virtual war game but more because of the extensive artificial intelligence (AI) that must run behind the game's functionality. That is because it is easier to train a platoon of seasoned soldiers as to how to behave and interact with a new cadet than to program this intelligence into a virtual 3D model. The good news is that with the object-oriented programming models being created, these virtually modelled soldiers are becoming smarter and smarter with each iteration. This is also aided through the increasing sophistication of military like first-person shooter games that are driving much of the adventure game market. For the instructional designer facing the challenge of porting learning goals into these immersive environments, specifying the experiential modes that the learner must encounter is the place to start. It makes very little difference if the mode is in real or virtual contexts, and a mix of these might be preferable and even phased. This is the arena of *mixed reality* training, which involves virtual, augmented, and actual realities, and never is focusing on the perception of the learner more critical. Simply knowing where a learner perceives himself/herself to be, while wearing a heads-up display and viewing the world with super-imposed graphics, is a critical experiential assessment for the designer. Sequencing and coupling learning objectives to experiential modes in such immersive environments is not only critical, it is the future of where instructional design will be centred in the years to come.

7 Design and development of LEs

The activities and processes that take place in this 'middle ground' for the design and development of learning environments should flow from macro to micro decision-making and from strategic to tactical. This flow, according to leading game designers (Rollings and Morris, 2000; Cerny and John, 2002; Bethke, 2003), is common in game design, and according to leading instructional designers is also common in most instructional development models as well (Reigeluth and Schwartz, 1989; Fleming and Levie, 1993; Appelman, 2000; Heinich et al., 2004). The strategic decisions of defining goals and outcomes are where the dialogue between the instructional and game designer begins. However, care should be taken to avoid specifying the overall LE and begin with instances of EMs that both designers can envision as successful experiences the learner could have on their journey through the eventually defined LE. As more and more of the EMs are defined, the tactical process of identifying specific attributes and perceptions of the EM can be made, and more design, craft, and programming leads can begin hammering out the micro decisions of some EMs. As each EM takes shape, the results are passed back to the instructional and game design team where each holds up their own rulers to estimate its effectiveness in the LE.

Once an EM is quantified by the tacticians and approved by the design team, then design centres can be created to execute initial prototypes of each. Each EM at this stage has a robust definition made by the designers that describes the experience the learner will have, along with a continuity description of each functionality afforded by the technology. The tactical team has identified which technologies support these affordances and also have provided the specifics on all the other attributes in the EM. By the time it hits the design centre, there is a good chance that it will move easily from technology specific design, through the tactical and operational decisions at this micro level.

Once the prototype has adequate form, then assessment of the learner experience can be initiated to compare with the desired outcomes. These results are fed back to the design team and adjustments and revisions may be negotiated with the tactical team, who in turn communicate with the design centre.

This process continues until all necessary experiential modes have been created, have initiated the appropriate experience for the learner, and sequenced into a final learning environment. Some have likened this process more to fractal generation and crystal formation than to an orderly development process. I would have to agree, but also I would have to say that I have seen some beautiful fractal and crystal patterns that are beyond anything a traditional artist could produce.

The dynamics of a learning environment that exists in an immersive virtual context can only be strategically created through a process heavily dependent upon feedback and re-direction. The micro level processes must be conceived as a series of autonomous centres that focus on excellence largely driven by the constraints of the technologies, in which they are being created. The concept of a pipeline implies linearity, which is counter to re-direction, and in fact the game designer will not find an instructional designer there, but instead will be saying 'there's an ID person on the beach with me, and we are building a castle!'.

References

Abt, C.C. (1970) *Serious Games*, Canada, Macmillan Company.

Appelman, R. (2000) 'An iterative development model: a genesis from pedagogical needs',

Int. J. Continuing Engineering Education and Lifelong Learning, Vol. 10, No. 1, pp.142–166. Appelman, R. and Goldsworthy, R. (1999) *The Juncture of Game & Instructional Design: Can Fun be Learning?*, Association for Educational Communications and Technology, Houston, TX.

Bandura, A., Ross, D. *et al*. (1961) 'Transmission of aggression through imitation of aggressive models', *Journal of Abnormal and Social Psychology*, Vol. 63, pp.575–582.

Barmazel, S. (1993) 'Video games: Asians in Canada say they promote hatred', *Far Eastern Economic Review*, Vol. 156, No. 36, p.37.

Bethke, E. (2003) *Game Development & Production,* Plano, Wordware Publishing, Inc, TX.

Brant, G., Hooper, E. *et al.* (1991) 'Which comes first, the simulation or the lecture?', *Journal of Educational Computing Research*, Vol. 7, No. 4, pp.469–481.

Cerny, M. and John, M. (2002) 'Game development: myth vs. method', *Game Developer*, June, pp.32–36.

Crawford, C. (1984) *The Art of Computer Game Design*, Osborne/McGraw-Hill, California.

Cuban, L. (2001) *Oversold and Underused: Computers in the Classroom*, Harvard University, Press, Cambridge, MA.

de Lara, J. and Alfonseca, M. (2003) 'Visual interactive simulation for distance education', *SIMULATION*, Vol. 79, No. 1, pp.19–34.

Fleming, M. and Levie, H.W. (1993) *Instructional Message Design*, Englewood Cliffs, Educational Technology Publications, New Jersey.

Gee, J.P. (2003) *What Video Games Teach us About Learning and Literacy*, Paulgrave Macmillan, New York.

Greenblat, C. and Duke, R. (1975) 'Gaming simulation: rationale, design, and applications. a text with parallel readings for social scientists, educators, and community workers, *Teaching and Training*, SAGE Publications, John Wiley & Sons Halsted Press Division, New York, pp.180–195.

Griffiths, M. (1999) 'Violent video games and aggression: A review of the literature', *Aggression and Violent Behavior*, Vol. 4, No. 10, pp.203–212.

Hannafin, M.J. and Hill, J.R. (2005) *Epistemology and the Design of Learning Environments*, in Reiser, R. and Dempsey, J. (Eds.): Trends and Issues in Instructional Technology, Prentice-Hall.

Heinich, R., Molenda, M. *et al*. (2004) *Instructional Media and Technologies for Learning*, Prentice-Hall.

Jones, S. (2003) *Let the Games Began: Gaming Technology and Entertainment Among College Students*, Pew Internet & American Life Project, Washington DC.

Kamimura, Y. (2002) 'The power of experience', *Simulation & Gaming*, Vol. 33, No. 4, pp.477–480.

Kirk, J.J. (2004) 'The making of a gaming-simulation course: a personal tale', *Simulation & Gaming*, Vol. 35, No. 1, pp.85–93.

Kommers, P. a. R., S (2003) 'Competency-based learning surgical interventions by navigating in virtual reality case spaces', *Num 3D – 3D solid digitising & modelling*.

Petranek, C. (1994) 'A maturation in experiential learning: principles of simulation and gaming', *Simulation and Gaming*, Silver Anniversary Issue, Part 2, pp.513–523.

Petranek, C., Corey, S., *et al.* (1992) 'Three levels of learning in simulations: participating, debriefing and journal writing', *Simulation and Gaming*, Vol. 23, No. 2, pp.174–185.

Raczynski, S. (2004) 'Continuous simulation, differential inclusions, uncertainty, and traveling in time', *Simulation*, Vol. 80, No. 2, pp.87–100.

Reigeluth, C. and Schwartz, E. (1989) 'An instructional theory for the design of computer-based simulations', *Journal of Computer-Based Instruction*, Vol. 16, No. 1, pp.1–10.

Rollings, A.M. and Morris, D. (2000) *Game Architecture and Design*, Scottsdale, AZ, Coriolis.

Savery, J. and Duffy, T. (1995) 'Problem based learning: an instructional model and its constructivist framework', *Educational Technology*, Vol. 35, pp.31–38.

Sneed, C. and Runco, M.A. (1998) 'The beliefs adults and children hold about television and video games', *The Journal of Psychology*, Vol. 126, No. 3, pp.273–284.

Squire, K.B. and Barab (2003) *Engaging Urban Underserved Students in Learning World History Through Computer Simulation Games*, Paper presented at The Sixth International Conference of the Learning Sciences, Santa Monica, CA.

Summers, G.J. (2004) 'Today's business simulation industry', *Simulation & Gaming*, Vol. 35, No. 2, pp.208–241.

Swartout, W.R. and Michael, L. (2003) 'Making a game of system design', *Communications of the ACM*, Vol. 46, No. 7, pp.38–40.

Thatcher, D. (1986) 'Promoting learning through games and simulations', *Society for the Advancement of Games and Simulations in Education and Training*, Vol. 2, pp.262–273.

Thiagarajan, S. (1994) 'How I designed a game – and discovered the meaning of life', *Simulation and Gaming*, Silver Anniversary Issue, Part 2, pp.529–537.

Thiagarajan, S. and Thiagarajan, R. (2001) 'Puzzle pieces', *Simulation & Gaming*, Vol. 32, No. 2, pp.263–265.