Computers & Education 51 (2008) 1729–1743

Contents lists available at ScienceDirect

Computers & Education

journal homepage: www.elsevier.com/locate/compedu

Examining the pedagogical foundations of modern educational computer games

Mansureh Kebritchi *, Atsusi "2c" Hirumi [1]

Instructional Technology, Educational Research, Technology and Leadership, College of Education, University of Central Florida, 1608 Oviedo Grove Circle, Apt 8, Oviedo, FL 32765, USA

ARTICLE INFO

Article history:
Received 2 January 2008
Received in revised form 8 May 2008
Accepted 17 May 2008

Keywords:
Educational computer games
Simulations
Interactive learning environments
Pedagogical issues
Teaching/learning strategies

ABSTRACT

This study examines the pedagogical foundations of modern educational (computer video) games. Specifically, Cooper's [Cooper, H. (1985, Mar 31–April 4). A taxonomy of literature reviews. In Paper presented at the American Educational Research Association, Chicago, IL] literature review framework was used to locate and examine relevant literature and games (published between the years 2000 and 2007) and to organize and report findings. A total of 50 articles and 55 educational games met specified selection criteria. The pedagogical foundations of the games were further investigated by contacting the authors of the games. Twenty-two games were based on established learning theories or instructional strategies and two games included basic instructional events that were not associated with any particular theory or strategy. No information regarding the pedagogical foundations of the 31 games was found or received. Analysis of the games and supporting literature revealed several patterns of practice that may be used to guide future research and development of educational games.

1. Introduction

Modern educational [computer video] games are thought to be effective tools for teaching hard and complex procedures because they (a) use action instead of explanation, (b) create personal motivation and satisfaction, (c) accommodate multiple learning styles and skills, (d) reinforce mastery skills, and (e) provide interactive and decision making context (Charles & McAlister, 2004; Holland, Jenkins, & Squire, 2003; Sheffield, 2005). "People acquire new knowledge and complex skills from game play, suggesting gaming could help address one of the nation's most pressing needs – strengthening our [American] system of education and preparing workers for 21st century jobs" (Federation of American Scientists, 2006, p. 3). Given these potential benefits, an increasing number of educators and instructional designers are developing and utilizing video games for use in K-12, higher education, and business and industry settings to facilitate the achievement of a variety of learning outcomes.

Concurrently, a growing body of literature emphasizes the importance of applying established instructional strategies and theories to design educational games and to facilitate game-based learning (Charles & McAlister, 2004; de Jong & van Joolingen, 1998; Egenfeldt-Nielsen, 2005; Garris, Ahlers, & Driskell, 2002; Gredler, 1996; Kafai, 2001; Lee, 1999; Leemkuil, de Jong, de Hoog, & Christoph, 2003; O'Neil & Fisher, 2004; Quinn 1994; Squire, 2002, 2004; Thiagarajan, 1998; Wolfe, 1997). The problem is that little has been done to synthesize information on how established learning theories and

* Corresponding author. Tel.: +1 407 366 8469; fax: +1 407 823 4880.
E-mail addresses: kebritchi@gmail.com (M. Kebritchi), hirumi@mail.ucf.edu (A. "2c" Hirumi).
[1] Tel.: +1 407 823 1760.

0360-1315/$ - see front matter © 2008 Elsevier Ltd. All rights reserved.
doi:10.1016/j.compedu.2008.05.004

instructional strategies are being applied to design educational games to guide research and practice. To delineate patterns of practice, a review of literature was conducted and the authors of identified games published between years 2000 and 2007 were contacted. Like Dickey (2005), it is believed such investigations yield valuable information for instructional designers for both traditional educational media and interactive learning environments.

2. Method

Initially, Cooper's (1985) literature framework was used to define the (a) goal, (b) coverage, (c) organization, and (d) audience for the study. The goal was to identify instructional strategies and related pedagogical foundations used to design educational games. The review had an exhaustive coverage with selection of a sample of relevant works.

The results are organized conceptually and the relevant works are presented based on the instructional strategies or the learning theories used to design each game. Cooper's (1988) procedure for synthesizing literature was then applied to (a) formulate the problem, (b) collect data, (c) evaluate the appropriateness of the data, (d) analyze and interpret relevant data, and (e) organize and present the results.

2.1. Problem formulation

The problem is that like many rapidly growing industries, advances in video game technology are far outpacing research on its design and effectiveness. Relatively little is understood about how to apply what we know about teaching and learning to optimize game-based learning. To help resolve the problem, the following question was asked: "What learning theories and instructional strategies are being used to design modern educational games (2000–2007)?"

2.2. Data collection

The purpose of data collection was to find games that were developed between 2000 and 2007 strictly for educational purposes to facilitate achievement of specified learning objectives.

"game based learning," "educational games," "game design," and "pedagogy," were used as keywords to find relevant literature on instructional game design. The research was conducted in the fields of interactive game and instructional design by searching online and paper-based journals, academic databases, information technology organization websites, academic institution websites, related conference websites and relevant publications from both fields. Appendix A shows the list of the resources that were used to collect relevant literatures for this review.

After finding articles and educational games with specified criteria, a database was developed to record contact information and documents related to each game. The game documents were reviewed to determine the pedagogical approach taken to design each game (if any). In cases where the pedagogical foundation was not explicitly mentioned, personal electronic communications to the game designers were made to seek the desired information.

2.3. Data evaluation

Based on the described procedure, 55 educational computer games, listed in Appendix B, and 50 relevant articles were found. The pedagogical foundations of 15 of 55 educational games were explicitly mentioned in related documents. The designers of the remaining 40 games were contacted by electronic mail. Nine of the 40 game designers replied and explained their pedagogical approach while no reply was received from 31 of the game designers.

Of the 50 articles that were found on educational game design, 9 described learning theories or instructional strategies used to design related games. These articles were also reviewed to find recommended guidelines for game design. The remaining articles that did not discuss specific learning theories or instructional strategies were excluded from this review, including 10 articles that focused on game components and definitions, 11 articles that focused on the advantages of game-based learning, and 20 articles that focused on game design methods from non-instructional purposes.

2.4. Analysis and interpretation

The authors of 24 of 55 games either published papers documenting their pedagogical foundations or provided information about their approaches via electronic mail. The authors of 18 of 24 of the games, who documented their pedagogical approaches, grounded their designs on established learning theories and instructional strategies. The authors of 4 games described unclassified pedagogical approaches; that is, instructional activities that were not clearly associated with a published theory or strategy. In addition, the authors of 2 games explicitly stated that no established theories or strategies were applied. No explicit information concerning the pedagogical foundations of the 31 games listed in Appendix C was neither found nor received. However, it was implicitly observed that some of the designers of the 31 games used basic learning attributes of drill and practice to teach the subjects at hands.

3. Results

As depicted in Table 1, the review of literature and games revealed five basic categories of instructional strategies and theories were used to explicitly design 24 educational games, including direct, experiential, situated, discovery/inquiry, and constructivist approaches to teaching and learning.

To characterize the pedagogical foundations of the modern educational games, a brief summary of key concepts and instructional events associated with each approach are presented along with a discussion of how each game applied the related concepts, principles, and events.

3.1. Direct instruction

A direct instructional approach was applied to design *Destination Math* to teach mathematics. One of the game representatives (personal communication, June 29, 2006) of *Destination Math* explained the pedagogy foundations of the game in the following way. Most game activities started with the introduction of a new concept. Then, the activities gave students a chance to practice newly learned concepts. During these activities students were given feedback. If the student answered incorrectly, the narrator provided a hint. If the student still did not understand, the program would eliminate some of the wrong answers to make it easier for students to find the correct answer.

This approach is consistent with direct instruction that is grounded in the behaviorist learning theory that suggests that learning occurs through stimulus-response conditioning and generates and sustains motivation through pacing and reinforcement (Hirumi, 2005). The instructional events associated with the Direct Instruction Strategy, as posited by Joyce, Weil, and Showers (1992) included:

- Orientation
- Presentation

Table 1
Educational games with explicit information ($n = 24$)

Pedagogical foundations	Educational games and related strategies
Direct instruction	Destination math
Experiential learning	Learning by doing • BioHazard • Daedalus' End • La Jungla de Optica Experiential learning • Global conflicts: Palestine Guided experiential learning • Full spectrum warrior • SLIM-ES3 Case-method teaching • Army excellence in leadership (AXL) Experiential and inquiry-based learning • Quest Atlantis
Discovery learning	Discovery learning • Discover Babylon • Gamenomics Guided discovery and inquiry-based learning • The monkey wrench conspiracy
Situated cognition	Situated learning in communities of practice • Racing academy • Fizziees Cognitive apprenticeship • simSchool • KM quest
Constructivist learning	Constructionism • SuperCharged Community supported constructionist approach • Hephaestus
Unclassified approaches	• DimensionM • Global Island • Genius series • Jr. series
No explicit pedagogical foundation	• Peacemaker • Virtual-U

- Structured practice
- Guided practice
- Independent practice

Like many traditional drill and practice programs, *Destination Math* oriented and presented learners with a mathematics concept, then facilitated learning through practice and feedback.

3.2. Experiential learning theory

During experiential learning, educators purposefully engage learners in direct [real-life] experience and direct their focus on learning reflection to increase their knowledge, skills, and values (Dewey, 1938). Experience occurs as a result of interaction between human beings and the environment in forms of thinking, seeing, feeling, handling, and doing (Dewey, 1938). This experience may take place equally in real or artificial environment. As Egenfeldt-Nielsen (2005) stated, "In today's computer games you are part of a living, breathing, simulated universe with very concrete self-sustaining experiences–getting still closer to reality" (p. 125). Computer games, which may be designed in the context of everyday life, can connect the players to every day life experience. Such concrete experience is the heart of the experiential learning approach in which knowledge is constructed, not transmitted, as a result of experiencing and interacting with the environment.

Five instructional strategies rooted in the concept of learning through realistic experiences with environment were identified. The five instructional strategies include (a) learning by doing, (b) experiential, (c) guided experiential, (d) case-method teaching, and (e) combination of experiential and inquiry-based learning.

3.2.1. Learning by doing

The Learning by Doing instructional theory, as posited by Schank, Berman, and Macpherson (1999), was used to develop *BioHazard* about environmental science (Squire, 2002), *La Jungla de Optica* about optical Physics (Squire, 2001), and *Daedalus' End* about civil engineering and engineering ethics (Li & Shresthova, 2002). These three games were developed by Massachusetts Institute of Technology (MIT). The primary goal of Learning by Doing is to foster skill development and the learning of factual information in the context of how it will be used. It assumes that learning occurs best in context of a goal that is relevant, meaningful, and interesting to students. Schank et al. (1999) posited the following instructional events to facilitate Learning by Doing:

- Define goals
- Set mission
- Present cover story
- Establish roles
- Operate scenarios
- Provide resources
- Provide feedback

The above instructional events have been used to design *BioHazard*, *La Jungla de Optica,* and *Daedalus' End.* These games have a number of common features that are directly related to the instructional events associated with the theory. The players in these three games need to achieve specified learning goals or accomplish specified missions in a context of a story. They assume roles, use resources to operate scenarios, and receive feedback to accomplish their missions.

BioHazard provides a medical emergency simulated situation where players assume the role of medical practitioners who respond to an epidemic infectious disease. The players learn about human body, medical instruments, emergency situation control, and effective resource management. Resources are provided by non-player characters. The players should allocate the resources efficiently and respond to new situations arise during the game. The players can win the game if they identify the disease, prevent further infections, and cure those already infected.

La Jungla de Optica provides a simulated adventurous environment where the players learn about basic concepts of optical physics. They apply their knowledge to solve problems arise in the game missions. The players are dropped in the fabled Jungle of Optics and should help the two main characters of the game escape from the treasure of thieves and return home. To accomplish this mission, the players use their knowledge to solve optics puzzles and complex open-ended problems. They also construct optics artifacts such as telescopes and camera and receive real time feedback and detailed analysis of their game progresses.

Daelalus' End provides a simulated virtual world where the players assume the role of civil engineers and learn about conducting civil engineering projects such as constructing dams or highways. In addition, the players learn about the effects of constructing these civil projects on the global environment. *Daelalus' End* is a multiplayer game where the players interact with each other to manage the project decision making stages and to address controversial issues related to the projects and their environmental effects. The players have to use the limited money and time efficiently in order to accomplish the missions.

3.2.2. Experiential learning

Egenfeldt-Nielsen (2005) applied experiential learning theory to develop *Global Conflicts: Palestine* to educate players about Palestinians and Israelis' conflict. Experiential learning, which is simply defined as using learner experiences to facilitate learning, has been a common ground for both traditional educators as well as designers attempting to integrate game-based learning with education (Appelman, 2005; Crawford, 1984; Gee, 2003; Prensky, 2001; Salen & Zimmerman, 2004). Like Schank et al. (1999) instructional theory, experiential learning is also based on the belief that people learn best by doing. Although the experiential learning strategy can start with didactic (passive) forms of instruction, it soon progresses to experiential (active) forms of learning. An instructional strategy, posited by Kolb (1984) that embodies the principles of experiential learning consists of the following sequence of events:

- Concrete experience
- Reflective observation
- Abstract conceptualization
- Active experimentation

Kolb's (1984) experimental theory evolves around the above four stages. The cycle starts from the concrete experience which is the base for the observations and reflections. The reflections transform experiences into abstract concepts, which stimulate new actions. The experiences from the new actions are then tested and reflected creating new concrete experiences. The cycle is then repeated. The learning process is a continuous cycle of experiencing and exploring (Kolb & Kolb, 2005a).

Global Conflicts: Palestine is a 3-D role-playing game in which the players assume the role of a journalist and collect information to write news. To design *Global Conflicts: Palestine,* Egenfeldt-Nielsen (2005) utilized Kolb's learning theory, delineating the four basic events associated with Kolb's cycle for game-based learning. The players learn about Israeli-Palestinian conflicts and some other issues in the Middle East (i.e., terrorism, human rights, border disputes) through collecting stories that are available in the game, reflecting on the stories, developing concept about the issues, and actively involving in the game activities.

3.2.3. Guided experiential learning (GEL)

Guided experiential learning has been used to develop *Full Spectrum Warrior* about war strategy and *SLIM-ES3* about military intelligence skills (Clark, 2005). It has been suggested that student-centered instructional strategies such as discovery learning, problem-based solving, experiential learning, and inquiry-based strategies did not work effectively unless additional guidance was provided for novice, intermediate, and high achieving learners (Kirschner, Sweller, & Clark, 2006; Mayer, 2004).

Based on the need for guidance, a group of designers at the Institute for Creative Technologies at University of South California has developed guided experiential learning which includes the following components (Clark, 2005).

- Solve real problems from field
- Activate relevant prior knowledge
- Demonstrate how to solve
- Apply what is learned by solving
- Integrate learning so that it reflects real field conditions

The above components could be integrated into the following steps (Clark, 2005):

- Sequence lessons
- Develop goals for each lesson
- Design each lesson with (a) motivating reasons, (b) background, (c) relevant concepts and processes, (d) job aids which are summarized key procedures for learners to use while they are in learning process, (e) demonstrations, (f) practice, and (g) feedback
- Design job aids for transfer
- Select media based on context, practice and cost
- Evaluate on four levels (a) reactions, (b) learning, (c) transfer**,** and (d) impact (Kirkpatrick, 1994)

Clark (2005) reported, based on a study, that Guided Experiential Learning was more effective than unguided-experiential learning strategy as it increased the amount of learning and decreased the learning time.

Both *Full Spectrum Warrior* and *SLIM-ES3* provide lessons with goals, reasons, concepts, processes, and procedures. These games are not "stand alone" training. They may used for demonstration, practice and feedback once their lessons reach demo and practice stage.

Full Spectrum Warrior is a first person strategy game in which the players, who are mainly soldiers, act as squad leaders and direct their fire teams to protect themselves from possible attacks. The objective of the game is to train US Army infantry troops to combat in urban situations. The game emphasizes on improving the players' critical thinking, planning and decision-making as required by US Army. The game allows the players issue orders to the game characters. The players have no weapons. Mechanical skills such as firing weapons or playing with equipments have been considered as distractions and removed from the game (Korris, 2004).

SLIM-ES3 is a simulation designed to increase soldier battlefield situational awareness in response to the need of patrol training for US ground forces in Iraq. The game provides practice in Active Surveillance and Threat Indicator Identification in an urban setting. The players self-navigate the urban area seeking to detect the threats and interact with the game characters. They work from an action menu, recording their observations, checking maps and taking pictures. Finally, they report their records and earn scores based on the numbers of identified objects in their reports.

3.2.4. Case-method teaching

Army Excellence in Leadership (AXL) is developed to teach tacit knowledge of military leadership to US Army trainees. Case-method teaching and Hollywood storytelling techniques to develop fictional leadership case studies have been used to design this game (Hill, Gordon, & Kim, 2004). In addition, software prototypes have been developed to formalize case-method teaching and engage trainees in human-computer dialogues with focus on the leadership issues embedded in the fictional cases. The training challenge in US Army is to train leaders who can function in an operating environment before experiencing the environment. Particularly, interpersonal skills such as sensitivity to others, trust, and dealing with performance problems have been considered as major leadership challenges and have become the main focus of this game.

Case-method teaching provides trainees with opportunities to analyze leader issues within the rich and realistic stories. "A case is a synopsis of the experiences, decisions and actions of others that can be studied and provide a vicarious learning experience by placing the student in the shoes of another" (Hill et al., 2004, p. 3). In *AXL* game, trainees are presented with failure leadership stories which provided opportunities for the trainees to explore alternative ways to fix the problems. Then, the trainees are guided by experienced mentors to further refine their alternative solutions. Finally, the trainees have opportunities to reflect on their learning experiences.

3.2.5. Experiential learning and inquiry-based learning

Quest Atlantis, developed by Indiana University, is a multi-user 3-D virtual environment that immerses children, ages 9–12, in educational tasks including language arts, mathematics, and social studies. It has been designed based on the combination of experiential and inquiry-based learning theories. Student achievement is measured using portfolio assessments (Barab, Thomas, Dodge, Carteaux, & Tuzun, 2005). Based on these strategies, a participatory framework has been developed in which hands-on actions and reflections are the two main components of the learning process, and the context of the learning is considered as a co-determinant of meaning. This notion that learners learn through active participation in the real world activities is the feature proposed by both experiential and inquiry-based learning. As mentioned earlier, experiential learning is rooted in four basic principles (Dewey, 1938; Kolb, 1984):

- Learning involves participation in the real-world
- There are intimate relations between experience and education
- Understandings are derived from and modified through experience
- Meaningful learning consists of action and reflection

The cornerstone of inquiry-based learning is the idea that learners learn best if the learning process involves an inquiry instead of memorization of facts (Barab et al., 2005). Inquiry-based learning promotes inquiry strategies and values essential to an inquiring mind including: process skills (e.g., observing, collecting and organizing data), active learning, verbal expression, tolerance of ambiguity, and logical thinking (Joyce et al., 1992). Joyce et al. (1992) posited four basic events for facilitating inquiry-based learning, including:

- Confrontation with the problem
- Data gathering, including verification and experimentation
- Organizing, formulating rules or explanation
- Analysis of inquiry process and development of more effective processes

In *Quest Atlantis* students from the participated schools conduct educational activities, interacted with other users and mentors, and build virtual personae in virtual 3-D spaces. The learners learn through analyzing hands-on and real world related activities (Barab et al., 2005).

3.3. Discovery learning theory

Discovery learning is, "...an approach to instruction through which students interact with their environment by exploring and manipulating objects, wrestling with questions and controversies, or performing experiments" (Ormrod, 1995, p. 442). The idea is that students are more likely to remember concepts that they discover on their own. Researchers have also found that discovery learning is most successful when students have prerequisite knowledge and go through some structured experiences (Roblyer, Edwards, & Havriluk, 1997). Discovery learning has been explicitly stated as the pedagogical foundation for two games. A third game has been designed based on the combination of guided discovery and inquiry-based learning.

3.3.1. Discovery learning

The discovery learning approach has been used to design *The Monkey Wrench Conspiracy* (M. Prensky, personal communication, June 12, 2006), a role-playing simulation game developed by Game2train, and *Gamenomics* (2006), a multiplayer management simulation game developed by Carnegie Mellon University. According to Spectre and Prensky (n.d.), the following instructional events have been used to design *The Monkey Wrench Conspiracy* game:

- Ask questions that allow mistake and offer the learning topic in a way that motivates and accommodates multiple senses.
- Provide feedback and reinforcement.
- Offer challenges, goals, and problems that are involving and relevant to the learners.
- Allow the learners to learn by performing authentic tasks.
- Apply cognitive apprenticeship method.

The objective of *The Monkey Wrench Conspiracy* is to teach industrial engineers how to use new 3-D design software. The players assume the role of secret agents dispatched to space to rescue the Copernicus station from alien hijackers. To succeed in the game, the players need to design everything for their missions, starting from designing their gun triggers to their spacewalks, bad-guys and traps.

The context of the game is motivating. The game provides a safe environment for the learners to solve problem and make mistakes without fear of failure. They can ask questions by clicking on new terms. The game models problem solving in a way that involves users' multiple senses. The game provides constant feedback and hands-on practice. In addition, the game situates the learners in an environment where they are challenged to complete game tasks to further advance in the game. The overall approach is similar to situated learning which focuses on solving meaningful and real world problems. The game has used a cognitive apprenticeship model by offering a video serving as a model that provides overviews of the tasks and detailed instruction of how to complete the tasks. In addition, coaching and scaffolding are offered in the step-by-step fashion and are faded as the players gain control over the game missions.

Gamenomics has been designed based on different scenarios and each scenario has included the following instructional events:

- Present an event that exaggerates an economic concept.
- Challenge the learner to discover that concept.
- Place the knowledge where they can find it.
- Provide rewards by overcoming obstacles, improving economic knowledge, and improving ability in the game.

The goal of *Gamenomics* is to teach basic economic concepts in an introductory economic college class. In addition, the players learn about supply-chain management. The class professors can use an interface to manipulate the market economy so that the players can observe and interact with economy and business concepts. The learners are immersed in a realistic market economy where they buy factories, produce goods and compete with each other. They are challenged by difficult economic tasks such as (a) which market to enter, (b) at what prices to buy and sell, and (c) how many units to produce. Meanwhile, they have to deal with cash flow problems, supply-chain bottlenecks, and competition from other players. Then, the game provides the learners with all necessary economic theories and guides them toward the solutions. In addition, the game rewards the learners by learning about economic knowledge and the joy of overcoming obstacles.

3.3.2. Guided-discovery and inquiry-based learning

Guided-discovery and inquiry-based learning have been combined to design *Discover Babylon,* a multiplayer-game (M. Roper, personal communication, January 28, 2007). The purpose of the game is to educate players about the Mesopotamian society where is the birth-place of written language, laws, and literature. The game provides 3-D photorealistic simulations of temple complexes that allow the user explore and discover the virtual environment.

According to Landa (1997), the instructional objectives and events in guided-discovery included:

- The students' independent discovery of the concept.
- Designate the concept.
- Framing the concept's logically correct definition.
- The independent discovery of a system of mental operations for applying the concept.
- Formulating the discovered method.
- Learning, through practicing, how to apply the method.
- Internalization of method's instructions.
- Automatization of the method's operation and insuring its complete mastery and command.

Combined with the principles of inquiry-based learning (which was noted earlier under Section 3.2.5), *Discover Babylon* applies a guided discovery and an inquiry-based approach to convey knowledge through the following features:

- Compelling simulations of real environments with contextualization of museum artifacts used by learners' avatars in the virtual environment.
- Opportunities for guided discovery and unguided exploration.
- Authentic and motivating challenges designed with Subject Matter experts (SMEs).
- Immediate feedback to learners.
- A question and answer tool that provides contextual information in a question/answer game format.
- Opportunities to learn by doing and learn through observation.
- Scaffolding (e.g., clues to learning challenges that help learners associate content and apply lessons learned in earlier levels that could be obtained through dialogue with avatars); and
- Opportunities to moderate game levels, objectives and time by offering (a) an optional higher score for people who sought out additional information, (b) a kiosk version of the game that address different learning objectives, and (c) a faster ramp-up time to meet the needs of learners who typically spends only 3–5 min at any one place.

(M. Roper, personal communication, January 28, 2007)

3.4. Situated cognition

The theory of situated cognition suggests, "...that activity and perception are importantly and epistemologically prior, at a non-conceptual level, to conceptualization and that it is on them that more attention needs to be focused" (Brown, Collins, & Duguid, 1989, p. 24). Knowledge is situated in its context, more specifically, knowledge is a product of its context, activity and culture within which it is developed and used (Brown et al., 1989). The situated cognition is rooted in the social development theory of Vygotsky (1978) in which social interaction plays a fundamental role in the development of cognition. Three games have been based on the principles of situation cognition that are grouped into two subcategories: Situated Learning in Communities of Practice and Cognitive Apprenticeship.

3.4.1. Situated learning in communities of practice

Based on the principles of situated cognition, a method of gaining knowledge, called situated learning in communities of practice has been developed in which knowledge is taught in context of real-life application and occurs in relationships with a community of practice (Lave & Wenger, 1991). A community of practice is referred to a group of people who are engaged in common interests and activities and learn through their mutual engagement in these activities (Wenger, 1998). The elements of situated learning have been defined by Stein (1998) as follow:

- Content includes higher order thinking and is situated in learners' daily experience to engage learners in reflective thinking and negotiation about the meaning of the content.
- Context refers to creating an instructional environment that is sensitive to the tasks learners should complete to succeed in practice. Context includes learners' interaction with the values, norm and culture of a community of practice.
- Community of practice refers to community through which learners reflect and form meaning. Community provides the setting for the required social interaction to see diverse perspectives of any issue.
- Participation refers to the process of interactions and dialogue among the learners in the community of the practice which result is forming meaning about the content.

Both the *Racing Academy* (Sandford & Williamson, 2004) and *Fizzees* (D. Sutch, personal communication, September 11, 2006) have been suggested to situate learning in online communities of practice within a game format. In both games, knowledge is gained through the use of higher order of thinking skills. The learning take place in simulated authentic context and players participate in online interaction and collaboration with other players, as the members of community, to improve their knowledge.

Racing Academy has been designed to teach players engineering concepts through racing and engineering realistic virtual cars. The game includes a simulated real-time vehicle dynamics system that accurately modeled how cars behaved and reacted. The simulated system allows players to manipulate their vehicle parameters. The players build and maintain their vehicles to compete in races. In addition, they monitor and analyze their performance using online data and competed as team of practitioners in a virtual community of engineers and drivers. Together, members of the community of practice develop an understanding of engineering through social negotiations facilitated by online competing, chatting and posting to a message board (Sandford & Williamson, 2004).

Fizzees (Physical Electronic Energisers) is a prototype of a game designed to teach young players healthy lifestyle. The players learn how to care for their physical health by caring for a digital pet-Fizzee. Players are challenged to act in physically healthy way to nurture their digital pet and keep it healthy. This purpose is achieved by using a dual sensor device worn by the player which measure players' data such as heart rate and accelerometer data. *Fizzees* takes a situated approach to learning that focuses upon players' personalized learning and applying learning to their daily lives. In this game, learners not only investigate and understand health requirements for their bodies and digital pets, but also apply their understandings within their daily lives and interact with other members of their community (e.g., school) through a website to compare their *Fizzees* and exchange ideas about healthy life style activities (D. Sutch, personal communication, September 11, 2006).

3.4.2. Cognitive apprenticeship

Cognitive apprenticeship is another approach based on the principles of situated learning. In cognitive apprenticeship, knowledge is situated within authentic activities and taught through interaction with instructors (Brown et al., 1989). The term "apprenticeship" used in this approach emphasizes the context-dependent nature of knowledge where learning is promoted through (a) situated modeling tasks, (b) coaching and scaffolding to complete the tasks, and (c) fading support. First, instructors make their tacit knowledge explicit by modeling their strategies to complete a given task. Second, instructors support the learners to complete the tasks and third, they encourage the learners to complete the tasks independently (Brown et al., 1989).

Modeling the authentic activities, coaching and scaffolding, and fading support have been used to design *simSchool* (Zibit & Gibson, 2005) and *KM Quest* (Leemkuil et al., 2003). *simSchool* is a simulation game that prepares educators for teaching by enhancing their classroom management skills and ability to adapt instruction to learners with different cognitive abilities. The required professional skills for educators to succeed in teaching have been embedded in the structure, rules, choices, and environment of the game. The learners are coached by the game feedback, hints, and scaffolding. As the learners advanced in their abilities, the complexity of the game increased and they moved to a new level of challenge.

In addition, several key concepts associated with learner assessment have formed the pedagogical foundations of *simSchool*. Specifically, *simSchool* organizes game tasks into four levels of difficulty in assessment and uses a conceptual assessment framework to guide a four-process architecture to assess student learning (D. Gibson, personal communication, June 28, 2006; Gibson, Aldrich, & Prensky, 2007). The game includes a database of 600–1000 realistic student profiles, including students' personality, emotional, and academic development factors. These factors functions as hidden variables. The teachers can choose different tasks for their simulated students with different variables and observe the impact of their chosen tasks on their students. The key concept is to teach the players what need to be done in the task to improve failing students' performances. Tasks are organized into four levels based on Webb's (1999) work on assessing levels of difficulty:

- Recall level, which includes the recall of information such as a fact, definition, term, or a simple procedure, as well as performing a simple algorithm or applying a formula.
- Skill or concept level, which includes the engagement of some mental processing beyond a habitual response.
- Strategic thinking level, which requires reasoning, planning, using evidence, and a higher level of thinking than the previous two levels.
- Extended thinking level, which requires complex reasoning, planning, developing, and thinking most likely over an extended period of time.

The assessment of learners in *simSchool* is based on an architecture of assessment posited by Almond, Steinberg, and Mislevy (2000) that includes cycles of interactions with administrators through the following four processes:

- The activity selection process, which is responsible for selecting tasks from a task library;
- The presentation process, which is responsible for presenting the task to the examinee;
- The evidence identification process, which detects essential features of the response that provide evidence about the examinee's knowledge, skills, and abilities; and
- The evidence accumulation process, which updates information about examinee's knowledge and skills.

A Conceptual Assessment Framework (CAF) has been used to coordinate operational processes and key interactions during the four processes. According to Gibson et al. (2007) the framework includes three main components: (a) a student model that determines the complexity of knowledge, skills, or other attributes that should be assessed, (b) a task model that specifies prompts or challenges given to the game user to elicit specific behaviors, and (c) an evidence model that specifies why and how observations in a given task constitute evidence about student model variables. The evidence model compares student model variables with the current student's scores that have been changed as a result of interaction with the task model. The score difference is used to characterize how students have changed and to control new setting and interaction for the students. Then an analysis game engine provides an output with scores and narrative to point out the impacts of the teaching tasks on different students.

KM Quest is another internet-based game that has been designed based on the cognitive apprenticeship principles (Collins, Brown, & Newman, 1989) to teach knowledge management (Leemkuil et al., 2003). The game simulates a realistic context where the learners solve practice knowledge management skills. The game includes four main phases of introduction, instruction, play, and reflection. The instructional phase includes cognitive apprenticeship of: (a) modeling in which, an expert conducts a task so that the learners observe and make conceptual framework for completing the tasks, (b) coaching which includes monitoring and observing students when they carry out the tasks, (c) scaffolding and fading which support students in problem solving process and decrease as students gain more experience, (d) articulation which includes methods of getting student articulate their knowledge, (e) reflection which allows students compare their problem solving experience with those conducted by the experts, and (f) exploration which allows students explore the problem solving on their own.

3.5. Constructivism

Constructivist learning theories posit that knowledge is built by the learner, not supplied by the teacher (Bruckman, 1998; Piaget, 1967). Two learning strategies based on constructivist principles have been identified. Constructionism has been used to design *SuperCharged!* (Hauck, Holland, Targum, & Squire, 2002) and community supported constructionist approach has been used to design *Hephaestus* (Tan, Squire, & Jenkins, 2001).

3.5.1. Constructionism

SuperCharged! designers have referred to a definition of constructionism posited by Papert (1991) and refined by Kafai and Resnick's (1996), suggesting that new knowledge could be acquired more effectively if the learners were engaged in constructing products that were personally meaningful to them.

The game designers explained that constructionism has been used to teach Electromagnetism in *SuperCharged!* by allowing the players to build their own game levels. The players can use the click and drag interface to design complex game levels that can be played or traded with other players over the Internet. The option to design complex game levels is available to all players however the ones who better understand Maxwell's laws would be able to devise the most playable game levels. This approach is aligned with constructionism notion suggested by Kafai and Resnick's (1996) in which players acquire new knowledge when they constructing their own game level which is personally meaningful to them. The game also supports the players by providing scaffolding and feedback, and assessment is done by analyzing the players' progress in the game.

3.5.2. Community supported constructionist

Hephaestus has been designed based on a community supported constructionist approach in which constructionism strategy is situated in a supportive community context (Bruckman, 1998). This approach emphasizes the importance of social aspect of learning environment. In this game players learn about mechanical engineering concepts by designing robots, colonizing the planet, Hephaestus, and manipulating environmental variables such as distance, elevation, or surface type. The players learn through iterative design processes, observing how the robot works, and modifying the robot design (Tan et al., 2001). As a community-based game, players also learn through interaction with other players, observing other players' design, and altering their designs accordingly. In addition, players may work together to design structures such as bridge, walls or trenches in the environment.

3.6. Unclassified approaches

The educational games listed under Unclassified Approaches included a number of instructional events such as problem solving, role-modeling, practice, and feedback. However, the combination of these events did not appear to constitute any specific instructional strategy that could be categorized as an established instructional strategy. The examples of these games are *DimensionM, Global Island, Jr. Series,* and *Genius Series*.

DimensionM has been developed as an immersive 3-D game to teach pre-Algebra and Algebra to middle and high school students. The game includes a series of missions aligned with standards of the National Council of Teacher of Mathematics. It gives players opportunities to practice and provides feedbacks to teach Algebra, but again, the instructional events cannot be associated with any particular learning theory or instructional strategy. *Global Island* has used role-playing method, in which players become citizens and parliamentarians of five islands to solve real-world problems through interactions with each other, debating, and voting (Danish Association for International Co-operation., n.d.). The *Jr. Series* and *Genius Series* have used the concept of role-modeling for children to develop their sense of curiosity and motivate them to become self-learners. *Jr. Series* provides a series of positive role models such as doctor, vet, scientist, or inventor to show the players the available opportunities in life and aspire them to develop the required skills for these professions, while *Genius series* provides a series of thinking role models and historical geniuses. The thought processes of the geniuses are modeled so that the players learn how to think like them. Thus, it appears that these games have employed a number of instructional principles and events, however, their approaches cannot be classified as any established learning theories or instructional strategies.

4. Discussion and conclusion

This study examined the pedagogical foundations of 24 modern educational video games. Eighteen were based on established instructional strategies and learning theories. Four games used instructional events that could not be classified as established instructional strategies. The authors of two games reported no learning theories or instructional strategies were used to design their games. No information concerning the pedagogical foundations was found or received regarding 31 games.

Eight of the 18 games with explicit pedagogical foundations were said to be based on experiential learning theories and 17 of the 18 games simulated "real world" experiences. Furthermore, 7 of the games were based on pedagogical approaches that promoted questioning and active experimentation by learners. Evidently, modern educational game designers believe that the ability to present learners with authentic problems in realistic contexts that facilitate inquiry and exploration are the primary strengths of educational games.

Furthermore, like in conventional classroom and online learning environments, it appears that learner-centered approaches to teaching and learning are gaining momentum in recent years. This trend was also observed by Dickey (2005). Seventeen of 18 games with explicit pedagogical foundations used learner-centered approaches. Direct instructional teacher-centered methods, grounded in behavioral learning theories, are giving way to more learner-centered approaches. Only one of these 18 games used direct instructional method.

The review of literature indicated a number of meta-analysis studies that examined effectiveness of educational games (e.g., Hays, 2005; Mitchell & Savill-Smith, 2004; Vogel et al., 2006). However, no meta-analysis was identified that compared the effectiveness of the games based on their pedagogical foundations. According to the learners and teachers participated in an experimental study conducted by Kebritchi (2008), games with learner-centered approaches are more effective and attractive to learners than games with basic drill and practice approaches. In addition, guided experiential strategies are suggested to be more effective than unguided experiential strategies (Clark, 2005).

The analysis also revealed that teams designing two or more games favored the use of certain strategies. For example, the Game-to-Teach group at MIT used Learning-by-Doing and constructivist strategies, the Institute for Creative Technologies at University of South California used guided experiential learning theory, and Futurelab, a British instructional game developer, used situated learning to design their games.

A number of game designers applied strategies grounded in instructional theories, but modified them according to their needs. For example, the designers of *Gamenomics* (gamenomics, 2006) and *The Monkey Wrench Conspiracy* (Spectre & Prensky, n.d.) modified discovery learning events and strategies to fit their needs. Similarly, a number of game designers combined two established instructional strategies to develop a game. For example, experiential and inquiry-base learning have been combined to design *Quest Atlantis* (Barab et al., 2005) and guided-discovery and inquiry-based learning have been combined to design *Discover Babylon* (M. Roper, personal communication, January 28, 2007). One group of designers (D. Gibson, personal communication, June 28, 2006; Gibson et al., 2007) also reported the use of a relatively innovative method approaching game design from research on learner assessments.

A number of game designers also recommended using instructional supports, which include game procedure explanations, hints, advices, and feedbacks (Alessi, 2000) within learner-centered instructional approaches such as experiential and discovery learning strategies to facilitate game-based learning (De Jong & van Joolingen, 1998; Knotts and Keys,1997; Leemkuil et al., 2003; Miller, Lehman, & Koedinger, 1999). In addition, a number of game designers (Leemkuil et al., 2003; Sandford & Williamson, 2004) suggested that (a) the process of achieving the goals even if it is fantastical should be logical, consistent and have a firm rationale, and (b) educational games must provide feedback to players. The feedback can be designed in formats of meaningful scores, replays, or measurements.

The literature is filled with articles calling for the use of established learning theories and instructional strategies to guide the design of educational games and enhance game-based learning (e.g., Dickey, 2005; Kafai, 2001; Squire, 2004). However, less than half of authors who designed the games included in this study reported the pedagogical foundations for their games. To enhance game-based learning over time, it is vital for game developers to ground their designs on established learning and instructional theories and report how related instructional events and experiences are integrated with game play so researchers can begin manipulating key variables and determine what factors have the greatest effect on learner motivation and achievement and other developers have a clear and solid foundation for informing future designs.

Appendix A

List of the resources used to find literatures on instructional game design

Resource type	Resource
Online journals	• Game Studio, International Journal of Game Research, (<http://www.gamestudies.org/>)
	• Games and Culture**,** A Journal of Interactive Media **(**<http://www.sagepub.com/journal.aspx?pid=11113>)
	• An International Journal of Theory, Practice and Research (<http://www.sagepub.co.uk/journal.aspx?pid=105774>)
	• Journal of Educational Computing Research
	• (<http://baywood.com/journals/previewjournals.asp?id=0735-6331>)
	• Game Developer
	• (http://www.gdmag.com/homepage.htm)
Academic Databases	• Educational Resources Information Center (ERIC) (<http://www.eric.ed.gov>)
	• Wilson Web (<http://vnweb.hwwilsonweb.com.ucfproxy.fcla.edu>)
	• EBSCO HOST, Research Database (<http://search.epnet.com/>)
IT and game Organization	• EDUCAUSE (<http://www.educause.edu>)
	• Futurelab (<http://www.futurelab.org.uk/>)
	• Gamusutra (<http://www.gamasutra.com/>)
	• WRT: Writer Response Theory, Explorations in Digital Character Art (<http://wrt.ucr.edu/wordpress/>)
	• Serious Game Initiative (<http://www.seriousgames.org/index2.html>)
	• USC Gamepipe Labs (<http://gamepipe.usc.edu/>)
	• The Skotos (<http://www.skotos.net/>)
	• Writing and the Digital life (<http://writing.typepad.com/digital_life/>)
	• DiGRA, Digital Games Research Association (<http://www.digra.org/>)
	• Sirlin.Net, Collection of articles, and bloges (<http://www.sirlin.net/>)
	• Idga, International Game Developers Association (<http://www.igda.org/>)
	• Ludology, online resources for videogame researchers (<http://ludology.org/index.php>)
	• elearning-review, research on elearning (<http://www.elearning-reviews.org/>)
Academic institution websites	• The Education Arcade, an MIT-University of Wisconsin Partnership (<http://www.educationarcade.org/>)
	• Simon Fraser University Institutional Repository, Dspace (<http://ir.lib.sfu.ca/index.jsp>)
	• iCampus Projects, the MIT-Microsoft alliance (<http://icampus.mit.edu/projects/>)
	• The MIT Press (<http://mitpess.mit.edu/main/home/default.asp>)
Conference websites	• DiGRA 2005: Changing Views: Worlds in Play, 2005 International Conference, Dspace (<http://ir.lib.sfu.ca/handle/1892/1318>)
	• NMC Online Conference on Educational Gaming (<http://www.nmc.org/events/2005fall_online_conf/>)
	• Federation of American Scientists, FAS, Summit on Educational Game (<http://www.fas.org/gamesummit/>)
	• Playing by the Rules, The University of Chicago Cultural Policy Center, Conference 2001, (<http://culturalpolicy.uchicago.edu/conf2001/>)
	• Serious Games Summit, Washington DC, 2005 (<http://www.cmpevents.com/GDsg05/a.asp?option=C&V=11&SessID=1018>)

Appendix B

References for all games contained in this study

A Force More Powerful (2006). Retrieved September 06, 2006 from <http://www.aforcemorepowerful.org/game/>

Adventure author. (2004). Retrieved September 06, 2006 from <http://www.futurelab.org.uk/showcase/adventure_author/index.htm>

America's Army. (2002). Retrieved May 26, 2006 from <http://www.americasarmy.com>

American Presidential Profile.(2000). Retrieved July 10, 2006, from <http://www.xfusionsoftware.com/presidents/index. html>

Army Excellence in Leadership (AXL). (2005). Retrieved December 29, 2007 from <http://projects.ict.usc.edu/axl/>

Astoversity. (2004). Retrieved September 06, 2006 from <http://www.futurelab.org.uk/showcase/astroversity/index.htm>

Biohazard. (2002). Retrieved January 15, 2006 from <http://cms.mit.edu/games/education/Biohazard/Intro.htm>

Chomp. (2004). Retrieved September 15, 2006 from <http://www.futurelab.org.uk/showcase/chomp/index.htm>

Daedalus' End. (2002). Retrieved December 28, 2007, from<http://www.educationarcade.org/gtt/Globalization/Intro. htm>

Destination Math. (n.d.) River Deep. Retrieved June 1, 2006 from <http://www.riverdeep.net/portal/page?_pageid=336,1&_dad=portal&_schema=PORTAL>

DimensionM. (2006). Retrieved December 28, 2007 from <http://www.dimensionm.com/>

Discover Babylon (2004). Retrieved January 28, 2007 from <http://www.discoverbabylon.org/index.asp>

Fizzees. (2006). Retrieved September 06, 2006 from <http://www.futurelab.org.uk/showcase/fizzees/index.htm>

Food Force. (2005). Retrieved September 06, 2006 from <http://www.food-force.com/>

Future Landscape. (2004). Retrieved September 06, 2006 from <http://www.futurelab.org.uk/showcase/future_landscapes/index.htm>

Full Spectrum Warrior. (n.d.). Retrieved December 29, 2007 from <http://www.fullspectrumwarrior.com/>

Gamenomics (2006). Retrieved May 31, 2006 from <http://etc.cmu.edu/projects/gamenomics/index.htm>

Genius Series. (2000). Retrieved December 28, 2007 from <http://www.curiosoft.com/tabone/genius_kids_games.htm>

Global Island (2002). Mellemfolkeligt Samvirke. Retrieved June 1, 2006 from<http://www.globalisland.nu/pages_intro/en/>

Hephaestus (2001). Retrieved December 28, 2007 from <http://www.educationarcade.org/gtt/documents/hephaestus>
Hazmat: Hotzone .(2005). Retrieved October 10, 2006 from <http://www.etc.cmu.edu/projects/hazmat_2005/>
Immuneattack (2006). Retrieved September 10, 2006 from <http://www.fas.org/immuneattack/>
Iya Ola. (2004). Retrieved September 10, 2006 from <http://www.futurelab.org.uk/showcase/iya_ola/index.htm>
Joint Force Employment. (2000). Retrieved June 1, 2006 from <http://www.dtic.mil/doctrine/jfe/index.html>
Jr. Series. (2000). Retrieved December 28, 2007 from <http://www.curiosoft.com/tabone/index1.htm>
Kinetic City. (2005). Retrieved July 14, 2006 from <http://www.kineticcity.com/>
KMQuest. (2005). Retrieved December 29, 2007, from <http://www.kmquest.net/index.html>
Labyrinth. (2007). Retrieved December 29, 2007, from <http://educationarcade.org/labyrinth>
La Jungla de Optica. (2002). Retrieved December 29, 2007, from <http://www.educationarcade.org/gtt/Jungle/Intro.htm>
Learning Journey. (2004). Retrieved September 10, 2006 from <http://www.futurelab.org.uk/showcase/learning_journey/index.htm>
Let's Explore the Farm (2000). Retrieved June 1, 2006 from <http://www.atari.com/atarikids/>
Mission Max. (2003). Retrieved November 06, 2006 from <http://www2.warnerbros.com/web/missionmax/ecyberlogin. jsp>
Monkey Wrench Conspiracy. (2000). Retrieved June 1, 2006 from <http://www.games2train.com/site/html/tutor.html>
Objection. (2005). TransMedia Inc. Retrieved June 1, 2006 from <http://www.objection.com/>
Pax Warrior (2006). Retrieved November 06, 2006 from <http://www.paxwarrior.com/home/>
Peacemaker (2006). Retrieved November 06, 2006 from <http://www.peacemakergame.com/>
Peter Packet (2000). Retrieved June 06, 2006 from <http://www.asklearning.com/cisco/peterpacket/postcards/>
Quest Atlantis. (2000). Retrieved December 29, 2007, from <http://atlantis.crlt.indiana.edu/>
Racing Academy. (2006). Retrieved June 13, 2006 from <http://www.futurelab.org.uk/showcase/racing_academy/racing_academy.htm>
Rapunsel. (n.d.). Retrieved December 28, 2007 from <http://www.rapunsel.org/>
Re-mission (2006). Retrieved May 31, 2006 from <http://www.re-mission.net/>
Revolution. (2005). Retrieved December 28, 2007 from <http://educationarcade.org/revolution>
Robocode (2001). Retrieved January 22, 2007 from <http://robocode.sourceforge.net/>
Shakespeare – Prospero's Island. (2006). Retrieved June 13, 2006 from <http://www.socialimpactgames.com/modules.php?op=modload&name=News&file=article&sid=220>
Size Matters. (2003). Retrieved September 17, 06 from <http://www.futurelab.org.uk/showcase/size_matters/index.htm>
SuperCharged!. (2002). Retrieved December 29, 2007, from <http://educationarcade.org/supercharged>
Stability and Support Operations—Simulation and Training (SASO-ST). (n.d.).Retrieved May 29, 2006 from <http://www.ict.usc.edu/content/view/33/86>
SLIM-ES3 (Every Soldier a Sensor). (2005). Retrieved December 29, 2007 from <https://slimes3.rdecom.army.mil/>
SimSchool (2004). Retrieved December 30, 2007 from <https://simschool.org/index.htm>
Space Mission: Ice Moon (2005). Retrieved September 10, 2006 from <http://www.futurelab.org.uk/showcase/space_mission/index.htm>
SpaceStationSim. (2005). Retrieved December 29, 2007, from <http://www.gamespot.com/pc/puzzle/spacestationsim/index.html>
Telecom Education Games: Project Connect. (2004). Retrieved September 10, 2006 from <http://projectconnect.telecom-pioneers.org/index.asp>
Virtual U. (2003). *Virtual U.* Retrieved June 1, 2006 from <http://www.virtual-u.org/index.asp>
Vmule. (2003). Retrieved September 10, 2006 from <http://www.futurelab.org.uk/showcase/vmule/index.htm>

Appendix C

Instructional games with no explicit information ($n = 31$)

- A force more powerful
- Adventure Author
- American Presidential Profile
- America's army
- Astroversity
- Chomp!
- Food force
- Future Landscape
- Hazmat: Hotzone
- Immuneattack
- Iya Ola
- Joint force employment
- Kinetic City
- Labyrinth
- The Learning Journey
- Let's Explore the Farm
- Mission max
- Objection
- Pax warrior
- Peter packet
- Rapunsel
- Re-Mission
- Revolution
- Robocode
- Shakespeare – Prospero's Island
- Size matters
- Space mission: ice moon
- SpaceStationSim
- Stability & support operations Simulation & training (SASO-ST)
- Telecom education games: Project connect
- VMULE

References

Almond, R., Steinberg, L., & Mislevy, R. (2000). *A sample assessment using the four process framework*. Princeton, NJ: Educational Testing Servicehttp://www.education.umd.edu/EDMS/mislevy/papers/FourProcess.pdf.

Appelman, R. (2005). Designing experiential modes: a key focus for immersive learning environments. *TechTrends, 49*(3), 64–74. Accessed 14.07.06<http://search.epnet.com.ucfproxy.fcla.edu/login.aspx?direct=true&db=aph&an=17903253>.

Alessi, S. (2000). Designing educational support in system-dynamics-based interactive learning environments. *Simulation and Gaming: An International Journal, 31*, 178–196.

Barab, S., Thomas, M., Dodge, T., Carteaux, R., & Tuzun, H. (2005). Making learning fun: Quest Atlantis, a game without guns. *Educational Technology Research and Development, 53*(1), 86–107.

Brown, S. B., Collins, A., & Duguid, P. (1989). Situated cognition and the culture of learning. *Educational Researcher, 18*(1), 32–42.

Bruckman, A. (1998). Community support for constructionist learning. *Computer Supported Cooperative Work: The Journal of Collaborative Computing, 7*, 47–86.

Charles, D., & McAlister, M. (2004). Integrating ideas about invisible playgrounds from play theory into online educational digital games. In M. Rauterberg (Ed.), Entertainment Computing – ICEC 2004 (pp. 598–601). New York: Springer Berlin Heidelberg. <http://commerce.metapress.com/content/qea4e988k00ugny9/resource-secured/?target=fulltext.pdf&sid=1ie0tjueepfwmcjei3hlgujo&sh=www.springerlink.com> Accessed 28.12.07.

Clark, R. E. (2005). Guided experiential learning: training design and evaluation. Los Angeles, CA: University of Southern California, Center for Cognitive Technology, Rossier School of Education. <http://projects.ict.usc.edu/itw/gel/> Accessed 2.08.06.

Collins, A., Brown, J. S., & Newman, S. E. (1989). Cognitive apprenticeship: Teaching the crafts of reading, writing, and mathematics. In L. B. Resnick (Ed.), *Knowing, learning, and instruction: Essays in honor of Robert Glaser* (pp. 453–494). Hillsdale, NJ: Lawrence Erlbaum Associates.

Cooper, H. (1985, Mar 31–April 4). A taxonomy of literature reviews. In Paper presented at the American Educational Research Association, Chicago, IL.

Cooper, H. (1988). The structure of knowledge synthesis: A taxonomy of literature reviews. *Knowledge in Society, 1*, 104–126.

C.Crawford (1984). *The art of computer game design. Berkeley, CA: McGraw-Hill/Osborne Media. Accessed 28.12.07<http://www.vancouver.wsu.edu/fac/peabody/game-book/Coverpage.html>.*

Danish Association for International Co-operation. (n.d.). Description of the global Island game. <http://www.globalisland.nu/pages_intro/en/pres/index.php> Accessed 2812.2007.

De Jong, T., & van Joolingen, W. R. (1998). Scientific discovery learning with computer simulations of conceptual domains. *Review of Educational Research, 68*, 179–202.

Dewey, J. (1938). *Experience and education*. New York: Simon and Schuster.

Dickey, M. D. (2005). Engaging by design: how engagement strategies in popular computer and video games can inform instructional design. *Educational Technology Research and Development, 53*(2), 67–83. Accessed 14.07.06<http://search.epnet.com.ucfproxy.fcla.edu/login.aspx?direct=true&db=aph&an=17029191>.

Egenfeldt-Nielsen, S. (2005). *Beyond edutainment: exploring the educational potential of computer games.* Unpublished doctoral dissertation, IT-University of Copenhagen, Netherland. <http://www.itu.dk/people/sen/egenfeldt.pdf> Accessed 31.07.06.

Federation of American Scientists (2006). *Harnessing the power of video game for learning.* <http://fas.org/gamesummit/> Accessed 29.12.07.

Garris, R., Ahlers, R., & Driskell, J. E. (2002). Games, motivation, and learning: a research and practice model. *Simulation and Gaming, 33*, 441–467.

Gee, J. P. (2003). *What video games teach us about learning and literacy*. New York, NY: Paulgrave Macmillan.

Gibson, D., Aldrich, C., & Prensky, M. (2007). *Game and simulation in online learning: Researching and development frameworks*. Hershey, PA: Idea Group Inc (IGI).

Gredler, M. E. (1996). Educational games and simulations: A technology in search of a Research paradigm. In D. H. Jonassen (Ed.), *Handbook of research for educational communications and technology* (pp. 521–540). New York: Simon & Schuster Macmillan.

Hauck, R., Holland, W., Targum, W., & Squire, K. (2002). Supercharged! May the electromagnetic forces be with you. Boston, MA: MIT/Microsoft, Comparative Media Studies Department. <http://www.educationarcade.org/gtt/documents/EM/EM.pdf> Accessed 28.12.07.

Hays, R.T. (2005). The effectiveness of instructional games: A literature review and discussion. *Naval air warfare center training system division* (No. 2005-004). <http://stinet.dtic.mil/oai/oai?&verb=getRecord&metadataPrefix=html&ide> Accessed 7.10.07.

Hill, R. W. J., Gordon, A. S., & Kim, J. M. (2004). Learning the lessons of leardership experience: tools for interactive case method analysis. In *24th Army Science Conference*. Orlando, Fl; December 2004. <http://www.ict.usc.edu/component/option,com_pubdisplay/Itemid,69/> Accessed 2.08.06.

Hirumi, A. (2005). *Grounded instructional strategies*. The Joint ADL Co-Lab (JADL). <http://www.itesm.mx/va/dide/docs_internos/docs_enc/hirumi/h01strategies.pdf> Accessed 28.12.07.

Holland, W., Jenkins, H., & Squire, K. (2003). Theory by design 2003. In B. Perron & M. Wolf (Eds.), *Video game theory*. Routledge.

Joyce, B., Weil, M., & Showers, B. (1992). *Models of teaching* (4th ed.). Boston: Allyn and Bacon.

Kafai, Y. B. (2001). *The educational potential ofelectronic games: from games-to-teach to games-to-learn*. <http://culturalpolicy.uchicago.edu/conf2001/papers/kafai.html> Accessed 13.02.06.

Kafai, Y., & Resnick, M. (1996). *Constructionism in practice: Designing, thinking, and learning in a digital world*. Mahwah, NJ: Lawrence Erlbaum.

Kebritchi, M. (2008). *Effects of a computer game on mathematics achievement and class motivation: An experimental study*. Unpublished doctoral dissertation, University of Central Florida, Florida.

Kirkpatrick, D. L. (1994). *Evaluating training programs: The four levels*. San Francisco, CA: Berrett-Koehler.

Kirschner, P. A., Sweller, J., & Clark, R. E. (2006). Why minimal guidance during instruction does not work: an analysis of the failure of constructivist, discovery, problem- based, experiential, and inquiry-based teaching. *Educational Psychologist, 41*(2), 75–86. Accessed 30.07.06<http://projects.ict.usc.edu/itw/gel/>.

Knotts, U. S., & Keys, J. B. (1997). Teaching strategic management with a business game. *Simulation & Gaming: An International Journal, 28*, 377–394.

Kolb, D. A. (1984). *Experiential learning: Experience as the source of learning and development*. Englewood Cliffs, NJ: Prentice-Hall.

Kolb, A. Y., & Kolb, D. A. (2005a). Learning styles and learning spaces: Enhancing experiential learning in higher education. *Academy of Management Learning and Education, 4*(2), 193–212.

Korris, J. (2004, December). *Full spectrum warrior: How the institute for creative technologies built a cognitive training tool for the Xbox.* In Paper presented at 24th Army Science Conference, Orlando, Fl. <http://ict.usc.edu/files/publications/korris-fsw-asc.pdf> Accessed 27.04.08.

Landa, L. N. (1997). Landamatics instructional design theory and methodology for teaching general methods of thinking. In C. M. Reigeluth (Ed.), *Instructional-design theories and models: A new paradigm of instructional theory* (pp. 341–369). Mahwah, NJ: Lawrence Erlbaum Associates.

Lave, J., & Wenger, E. (1991). *Situated learning: Legitimate peripheral participation*. Cambridge, UK: Cambridge University Press.

Lee, J. (1999). Effectiveness of computer-based instructional simulation: A meta analysis. *International Journal of Instructional Media, 26*(1), 71–85.

Leemkuil, H., de Jong, T., de Hoog, R., & Christoph, N. (2003). KM Quest: A collaborative internet-based simulation game. *Simulation & Gaming, 34*, 89–111.

Li, Z., & Shresthova, S. (2002). *Design document for Daedalus' End: Civil and environmental engineering in the context of development ad globalization*. Boston, MA: MIT/Microsoft, Comparative Media Studies Department. <http://www.educationarcade.org/gtt/documents/Global/Global.pdf>. Accessed 28.12.07

Mayer, R. E. (2004). Should there be a three-strikes rule against pure discovery learning?. *American Psychologist, 59*(1), 14–19. Accessed 26.06.06<http://projects.ict.usc.edu/itw/gel/>.

Mitchell, A., & Savill-Smith, C. (2004). *The use of computer games for learning.* <http://www.m-learning.org/archive/docs/The%20use%20of%20computer%20and%20vid eo%20 games%20for%20learning.pdf> Accessed 23.07.07.

Miller, C. S., Lehman, J. F., & Koedinger, K. R. (1999). Goals and learning in micro worlds. *Cognitive Science, 23*, 305–336.

O'Neil, H. F., Jr., & Fisher, Y.-C. (2004). A technology to support leader development: Computer games. In D. V. Day, S. J. Zaccaro, & S. M. Halpin (Eds.), *Leader development for transforming organizations* (pp. 99–121). Mahwah, NJ: Lawrence Erlbaum Associates.

Ormrod, J. (1995). *Educational psychology: Principles and applications*. Englewood Cliffs, NJ: Prentice-Hall.

Papert, S. (1991). Cambridge, MA: MIT Press. Accessed 2.08.06 http://www.papert.org/articles/SituatingConstructionism.html.

Prensky, M. (2001). *Digital game-based learning*. New York: McGraw-Hill.

Piaget, J. (1967). *Six psychological studies*. New York: Vintage Books.

Quinn, C. N. (1994). Designing educational computer games. In K. Beattie, C. McNaught, & S. Wills (Eds.), *Interactive multimedia in University Education: Designing for change in teaching and learning* (pp. 45–57). BV Amsterdam: Elsevier Science.

Salen, K., & Zimmerman, E. (2004). *Rules of play*. Harvard, MA: MIT Press.

Sandford, R. & Williamson, B. (2004). Racing academy: A futurelab prototype research report. Futurelab. <http://www.futurelab.org.uk/resources/documents/project_reports/Racing_Academy_rese arch_report.pdf> Accessed 15.12.07.

Schank, R. C., Berman, T. R., & Macpherson, K. A. (1999). Learning by doing. In C. M. Reigeluth (Ed.), *Instructional-design theories and models: A new paradigm of instructional theory* (pp. 633–651). Mahwah, NJ: Lawrence Erlbaum Associates.

Sheffield, B. (2005). What games have to teach us: An interview with James Paul Gee. *Game Developer. San Francisco, 12*(10), 4–9.Accessed 28.12.07 <http://ucfproxy.fcla.edu/login?url=http://proquest.umi.com.ucfproxy.fcla.edu/pqdweb?did=924550961&sid=1&Fmt=4&clientId=20176&RQT=309&VName=PQD>.

Spectre, M., & Prensky, M. (n.d.). Theoretical underpinnings of game-2-train approach. <http://www.games2train.com/site/html/theory.html> Accessed 07.07.06.

Squire, K. (2001). *Design document for La Jungla de Optica*. Boston, MA: MIT/Microsoft, Comparative Media Studies Department. Accessed 28.12.07 <http://www.educationarcade.org/gtt/documents/jungle/jungle.pdf>.

Squire, K. (2002). *Biohazard education at the speed of fear*. Boston, MA: MIT/Microsoft, Comparative Media Studies Department. Accessed 28.12.07 <http://www.educationarcade.org/gtt/documents/biohazard/biohazard.pdf>.

Squire, K. (2004). *Replaying History: Learning World History Through Playing Civilization III.* Unpublished doctoral dissertation, Indiana University, Indiana. <http://website.education.wisc.edu/kdsquire/dissertation.html> Accessed 02.02.06.

Stein, D. (1998). *Situated learning in adult education*. ERIC Clearinghouse on Adult Career and Vocational Education Columbus OH. (ED418250).

Tan, T., Squire, K., & Jenkins, H. (2001). Design document for Hephaestus. <http://www.educationarcade.org/gtt/documents/hephaestus/hephaestus-storyboard.pdf> Accessed 27.12.07.

Thiagarajan, S. (1998). The myths and realities of simulations in performance technology. *Educational Technology, 38*(4), 35–41.

Roblyer, E., Edwards, J., & Havriluk, M. A. (1997). *Integrating educational technology into teaching*. Merrill, NJ: Upper Saddle River.

Vogel, J. J., Vogel, D. S., Cannon-Bowers, J., Bowers, C. A., Muse, K., & Wright, M. (2006). Computer gaming and interactive simulations for learning: A meta-analysis. *Journal of Educational Computing Research, 34*(3), 229–243.

Vygotsky, L. S. (1978). *Mind in society*. Cambridge, MA: Harvard University Press.

Webb, N.L. (1999). Alignment of science and mathematics standards and assessments in four states. National Institute for Science Education, University of Wisconsin-Madison Council of Chief State School Officers, Washington, DC. <http://www.ccsso.org/content/pdfs/AlignmentPaper.pdf> Accessed 26.06.06.

Wenger, E. (1998). *Communities of practice: Learning, meaning, and identity*. Cambridge University Press.

Wolfe, J. (1997). The effectiveness of business games in strategic management course Work [electronic version]. *Simulation & Gaming Special Issue: Teaching Strategic Management, 28*, 360–376.

Zibit, M., & Gibson, D. (2005). simSchool: The game of teaching. Innovate, 1(6). http://www.innovateonline.info/index.php?view=article&id=173 Accessed 28.12.07.