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DEVELOPMENT ARTICLE

Game object model version II: a theoretical framework for educational game development

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Abstract Complex computer and video games may provide a vehicle, based on appropriate theoretical concepts, to transform the educational landscape. Building on the original game object model (GOM) a new more detailed model is developed to support concepts that educational computer games should: be relevant, explorative, emotive, engaging, and include complex challenges; support authentic learning activities that are designed as narrative social spaces where learners are transformed through exploration of multiple representation, and reflection; be gender-inclusive, include non-confrontational outcomes, and provide appropriate role models; develop democracy, and social capital through dialogue that is supported by means of computer mediated-communication tools; and include challenges, puzzles or quests, which form the core of the learning process, where access to explicit knowledge, conversations, and reflection results in the construction of tacit knowledge. It is argued that the GOM version II can be used not only to support the development of educational computer games but to provide a mechanism to evaluate the use of computer games in the classroom.

Keywords Game object model · Educational games · Narrative social spaces · Ideologies · Challenges–puzzles–quests

> "Given that games can teach people, why aren't there more fun educational games available? ... As an industry, we could be making games which take the boredom out of school for the next generation of students." DeLoura (2001, p. 6).

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Play, especially during early childhood, positively influences important psychological, sociological, and intellectual developments (Rieber, 1996; Vygotsky, 1933/1978) that might be a universally accepted mode of learning (Blanchard & Cheska, 1985). Today play is closely associated with video and computer games. Of the many types of games available it appears that educational researchers have concentrated on the simulation, and adventure genres (Amory, Naicker, Vincent, & Adams, 1999; Ju & Wagner, 1997; Quinn, 1994; Roberts, 1976). However, Billen (1993) argues that while games may influence cognitive functions and motivation, players are often removed from the 'real world'. On the other hand, Thomas and Macredie (1994) contend that games can intrinsically stimulate curiosity which may be due to the presence of challenges, elements of fantasy and challenge (Malone 1980, 1981a, b), and novelty and complexity (Carroll, 1982; Malone, 1984; Malone & Lepper, 1987; Rivers, 1990). Gameplay influences learning through visualization, experimentation, and creativity (Betz, 1995) and often supports development of critical thinking though discovery and problem solving (Rieber, 1995), object manipulation (Leutner, 1993), and goal formation and competition (Neal, 1990). Quinn (1994, 1997) argues that learning and educational practice need to combine the fun elements of games with instructional and educational system design that includes motivational, learning, and interactive components. While the relationship between play and learning is very well established, the use of video and computer games as viable educational tools by the broader society is more tenuous. Squire (2002) explains that attitudes to computer and video games range from views that they are imperative for education to views that they result in hyper-competitiveness and warped sexual values. However, authors such as Rieber (1995), Quinn (1994, 1997, 2005), Amory et al. (1999), Amory (2001), Gee (2003) and Kiili (2005a) argue that computer games offer a unique opportunity to engage learners in learning environments that could support contemporary educational practices.

Shaffer, Squire, Halverson, and Gee (2005) argue that to date, educational games have not been designed using any coherent theory of learning or appropriate research findings. However, Amory et al. (1999) and Amory (2001) propose a game object model (GOM) (Fig. 1) that is based on educational theories to support the development of educational games and is described in the next section.

The game object model

The GOM, originally presented by Amory et al. (1999) and Amory (2001), describes a relationship between the pedagogical dimensions of learning and game elements and is loosely based on the Object Oriented Programming System paradigm which includes concepts such as encapsulation, inheritance and polymorphism (http://en.wikipedia.org/wiki/Object-Oriented_Programming). The Object-Oriented Programming metaphor was selected to support

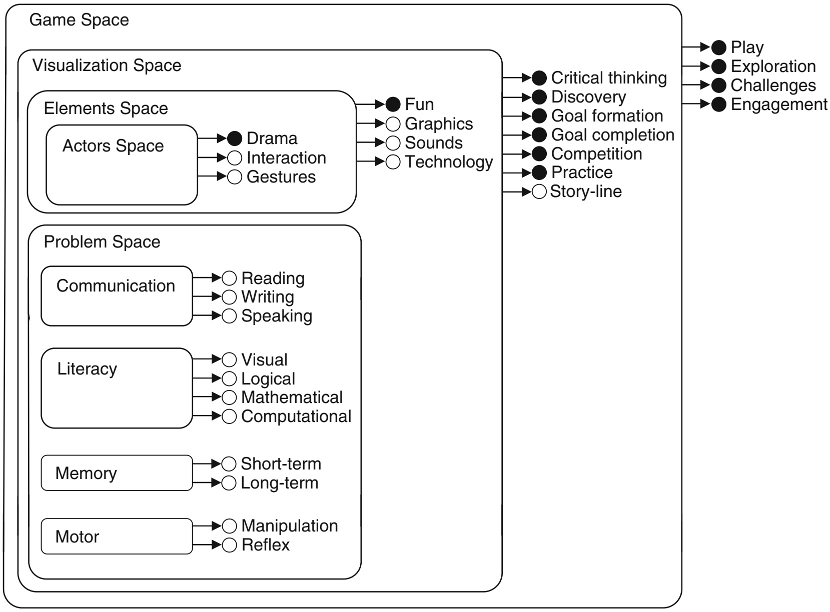

Fig. 1 The game object model (redrawn from Amory & Seagram, 2003)

the development and analyses of complicated designs, and to facilitate the understanding of complex situations. While components of an educational game design should be interrelated (act on each other), and not be seen as a linear collection of functions, such objects can be viewed as independent (and therefore less complicated) units during the development and design phases.

In the GOM (Fig. 1) Amory et al. (1999) consider an educational game to consist of a number of components (*objects*) each of which is described through abstract and concrete *interfaces*. *Abstract interfaces* refer to all pedagogical and theoretical constructs and *concrete interfaces* refer to design elements. Therefore educational game designers make use of the abstract interfaces in the conceptualization phase of game design while game developers realize these pedagogical aspects of an educational game by including the concrete interfaces into the game software and gameplay.

In the model diagram (Fig. 1) objects are represented by rounded squares and interfaces by circles linked to the objects. Objects may either be free-standing or part of other objects, in which case they inherit all the parent *interfaces*. Inner objects (which inherit all their parent interfaces) contain mainly *concrete interfaces* (represented by open circles) while the outer ones are more *abstract* (represented by closed circles). In the GOM the *Game Space* object includes the *Visualization Space* object that consists of the *Elements Space* and *Problem Space* objects. The *Elements Space* object includes the *Actor Space* object. The theoretical constructs of each object are described in the following sections.

The *Game Space* object includes four motivational *abstract interfaces*: play, exploration, challenges, and engagement (Blanchard & Cheska, 1985; Malone 1980, 1981a, b; Rieber, 1996; Roberts, 1976; Thomas & Macredie, 1994).

The *Visualization Space* includes those interfaces related to cognitive activities such as critical thinking, discovery, goal formation, goal completion, competition, and practice (Amory et al., 1999; Neal, 1990; Rieber, 1995), and includes the concrete *Story Line interface*.

The *Elements Space* object includes the abstract interfaces of fun, and drama (Malone, 1981a, b) and concrete interfaces of graphics, sound, and technology (Amory et al., 1999) and actor interaction, and gesture (Harrigan, 1999; Stanislavski, 1981). The drama, interaction, and gesture interfaces are part of the *Actor Space* object.

The *Problem Space* object includes the manipulation, memory, logic, mathematics, and reflexes concrete interfaces (Amory et al., 1999; Betz, 1995) that realize the critical thinking, discovery, goal formation, goal completion, competition, and practice interfaces (Leutner, 1993; Quinn, 1994; Saljo, 1979; Schank & Cleary, 1995) of the *Visualization Space* object.

Objectives

While the GOM has successfully been used to design academic adventure games (Amory, 2001; Amory & Seagram, 2003; Foko & Amory, 2004; Seagram, 2005), recent discourses, insights, and developments bring to the fore new notions that should be included into a framework to support the conceptualization and design principles of education games. The objectives of this paper are therefore to review developments in and insights into the use of computer games in education and to incorporate these developments into the GOM to formulate an updated, and more inclusive, version of the model (GOM II, Fig. 2) that is based on sound *theoretical arguments*. The aim of this communication is therefore to present a coherent theoretical framework for the development of educational games, and for the evaluation of the educational fitness of either educational or traditional commercial games.

The section (Game Object Model version II—theoretical concepts) includes a number of subsections: definition of computer games, authentic learning, narrative, gender, social collaboration, and challenges-puzzles-quests. Each of these subsections includes theoretical constructs and arguments, and core concepts derived from the theoretical discussions that are used to develop the GOM version II. Each section concludes with abstract and concrete interfaces derived from the theoretical discussion, and a brief description of how these interfaces informed the development and evaluation of γKhozi (Amory & Seagram, 2003; Seagram, 2005). A brief description of γKhozi is given below. Identical numerical labels are used in the text, the model diagram (Fig. 2), and the tabulated data sets (Table 1) to identify core concepts used in the formulation of the GOM version II framework. The paper then provides a summary of these derived theoretical constructs as part

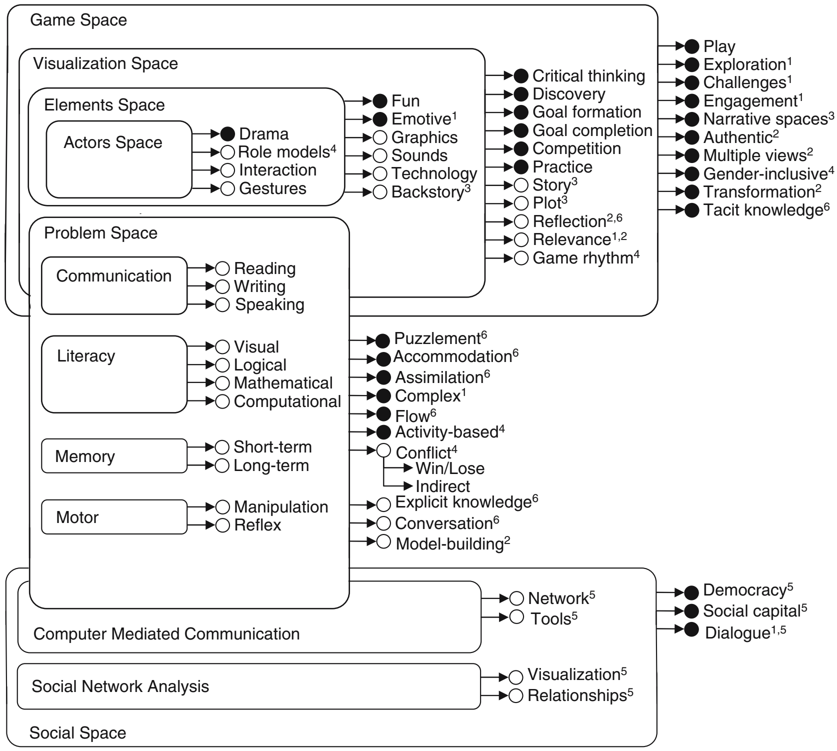

Fig. 2 Game object model version II (Core concepts: 1, Game definition; 2, authentic learning; 3, narrative; 4, gender; 5, social collaboration; 6, challenges-puzzles-quests)

of the GOM Version II framework in a section titled Game Object Model version II—summary description. The final section, Game Object Model version II—uses, suggests the version II of the model could be used in the design and evaluation of games for education.

γKhozi

The γKhozi game is designed and evaluated using the design experimental approach (Reeves & Hedberg, 2003; Reeves, Herrington & Oliver, 2004; Squire, 2003), and is an educational adventure game that explores scientific knowledge related to pertinant African diseases (HIV/AIDS, malaria, tuberculosis and cancer). Content areas related to these diseases where learners from a South African University showed poor understanding, or held misconceptions, are used as the primary learning objectives for this game conceived as a 3D-immersive microworld (Seagram, 2005). Areas not well understood by the learners included knowledge concerning the transmission, symptomatic expression, biology, and prevention of these diseases. The game is designed as an adventure game, similar to the Myst games, where the

Table 1 Abstract (•) and concrete (○) interfaces relevant to game design and their use in the development of γKhozi (Core concepts: 1, Game definition; 2, authentic learning; 3, narrative; 4, gender; 5, social collaboration; 6, challenges-puzzles-quests)

Interfaces			γKhozi development
Definition	• • • • • • ○	Exploration[1] Challenges[1] Engagement[1] Emotive[1] Complex[1] Dialogue[1] Relevance[1]	This game is based on the adventure genre similar to the Myst series where players navigate through a predetermined path and interacts with game characters in order to solve a number of complex puzzles in order that they learn about diseases (HIV/AIDS, tuberculosis, malaria and cancer) and recreate the embedded story
Authentic Learning	• • • ○ ○	Authentic[2] Multiple views[2] Transformational[2] Relevance[2] Model-building[2]	The game takes places in an African village where the player learns about a number of game characters including a doctor and nurse and about important African diseases. The player faces a number of authentic interrelated puzzles of which some are based on medical and scientific procedures (such as using a microscope or preparing a poster for information distribution) that require an understanding of HIV/AIDS, malaria, tuberculosis and cancer. It is suggested that during gameplay participants are encouraged to solve the puzzles collaboratively
Narrative	• • ○ ○ ○	Narrative spaces[3] Challenges[3] Story[3] Plot[3] Backstory[3]	There are no real-time game actors present in the environment during gameplay. However, the story is developed through the use of a realistic environment and sound scapes in which the backstory is told through the use of flashbacks where game characters either talk directly to the player or between themselves (that is a restorative narrative structure)
Gender	• • ○ ○ ○	Gender-inclusive[4] Activity-based[4] Game rhythm[4] Role models[4] Conflict[4]	Mouse actions are used as the primary device to interact in the game environment and players gain points by solving puzzles. The gender and race of each game character was specifically designed to challenge stereotype. For example, the nurse is a black male while the doctor a male of mixed-race
Social collaboration	•	Democracy[5]	No specific tools to support collaboration are built into this game but during development and testing players were encouraged to play and solve problems together. It is argued here that the building of virtual communities within games will stimulate learning

Table 1 continued

Interfaces		γKhozi development
	• Social capital[5] • Dialogue[5] ○ CMC Network[5] ○ CMC Tools[5] ○ SNA visualization[5] ○ Relationships[5]	
Challenges-puzzles-quests	• Tacit knowledge[6] • Puzzlement[6] • Accommodation[6] • Assimilation[6] ○ Reflection[6] ○ Explicit knowledge[6] ○ Conversation[6] ○ Relationships[6]	Explicit knowledge is included in the game in many forms that include books, posters, diagrams and models. Each puzzle is designed to lead the player to specific information and through the interactions with the puzzles it is argued that the player resonates between puzzlement, assimilation and accommodation. The final puzzle requires the collection of artifacts while solving all the other puzzles. Once the final puzzle is solved the player is given access to the true nature of the protagonist

players explore the environment to solve a number of related puzzles, which are directly related to the previously identified poor understanding, in order to recreate the narrative, or story.

Game Object Model version II—theoretical concepts

A definition

Theoretical constructs

Crawford (1982, ¶ 19) defines a computer game as a ‘‘simplified representation of emotional reality’’ with a sufficient accuracy to support the player’s fantasy, a key agent required to make the game psychologically real. Computer games contain formal rules where different components interact in complex ways. Rollings and Adams (2003, p. 201) suggest that gameplay consists of ‘‘one or more causally linked series of challenges in a simulated environment’’. Thus in its simplest form playing games is solving challenges in an emotive environment. However, Prensky (2005) argues that computer games familiar to most adults look similar to the ones they played as children (board games such as Scrabble, Monopoly, Mah-Jong; and simple one-dimensional content games such as Carmen Sandiego and Math Blaster), contain simple content, and are easy to complete (take an hour or less to play). This author therefore labels such games as trivial and argues that they do not support good educational practice. Computer games which require the player to learn new strategies and skills to solve ever-more complex challenges or puzzles, identify and negotiate complex relationships between simulated- and real-characters, solve ethical dilemmas, and be involved for more than 10 h are referred to as 'complex-games' by Prensky (2005).

Relevance for game design

Educational games should present *relevant*, *explorative*, *emotive* and *engaging* environments where solutions to *complex challenges* are difficult requiring multifarious *dialogues* (see Table 1 [Definition] for the associated interfaces and their use in game design) [Core Concept 1].

Authentic learning

Theoretical constructs

Introduction. Gee (2005) argues that instructional games should include skills, knowledge, and values to allow the player to experience how members of a specific profession think, behave, and solve problems (*authentic professionalism*). Shaffer (2005) suggests that such games should be based on communities of practice, reflective practices, epistemic frames (practice, identity, interest, understanding, and epistemology), and pedagogical praxis which are collectively described by Shaffer and Resnick (1999) as 'thickly authentic'. These concepts are similar to authentic task-based collaborative learning environments where tasks are relevant to the real world, are ill defined, involve complex activities that include different perspectives across numerous domains, allow for reflection and collaboration, result in the production of polished products that can be different and diverse, and include integrated assessment (Reeves et al., 2004). It could be argued that games contextualize authentic challenges within collaborative environments.

Gee (2005) presents *Full Spectrum Warrior*, a U.S. Army training simulation, as an exemplar of authentic professionalism in which the game teaches the player how to be a professional soldier. This author acknowledges that many people will object to this game because of its embedded ideology, values, and world view, but contends that real learning is always linked to ideology. Shaffer et al. (2005) report that simulations to help children cope with cancer and doctors to perform surgery more effectively are being developed by the USA Department of Homeland Security. These authors introduce three interrelated concepts that include simulations, games that teach, and ideology, which requires further discussion.

Simulations—Games That Teach. The idea that games can teach is closely allied to the concept that learning happens when participants use simulation. Recently Rieber (2004) discusses the relationship among microworlds (a constructivist construct), simulations, and modelling tools and states that "there are two main ways to use simulations in education: model using and model building" (p. 598). *Model using* relates to systems where the users manipulate a simulation designed by another, while learners have a direct role in *model building* systems. “The model-using approach to simulations has had a long history in instructional technology, particularly in corporate and military settings” (p. 598). However, model building is more closely allied to microworlds that “rely on a culture of learning in which students are expected to inquire, test and justify their understanding” (p. 598). Rieber (2004) refers to de Jong and van Joolingen (1998) who argue that the successful manipulation of a simulation does not guarantee that the learner has acquired conceptual knowledge, and that students often find it difficult to learn from simulations. Schumacher (2003) found that deep learning did not occur when MBA students acted as senior management in the Beefeater simulation and suggested that such learning could be achieved through the use of improved facilitation. Crawford (1982, ¶ 18) reasoned that games and simulations are different as “a simulation is created for computational or evaluative purposes; a game is created for educational or entertainment purposes”.

Squire and Barab (2004) show that a history simulation game can support learning, which occurs through recursive cycles of failure and revising strategies and includes collaboration and journal writing (noting major game decisions that included timed-writings to post-it notes). Shaffer (2005), in reporting the initial research related to epistemic games, maintains that such an approach requires a suitable game/simulation engine and associated system of activities that make use of the engine and includes how learners undertake the tasks, who they work with, the tools they use and the context of the learning. Such an approach appears to be very similar to the construct of authentic learning as proposed by Reeves et al. (2004) where the computer game is just one of the tools required to solve a complex problem.

Therefore, it appears that while simulations can teach simple tasks (learn from technology), real understanding may only be achieved when simulations are used in conjunction with other activities that support cognitive development within authentic settings (learn with technology).

More research needs to be conducted to evaluate the relationships between simulations and learning more fully. In order to better understand such relationships, Squire (2003) suggests that educational game research should make use of design experiments, also referred to as developmental research (Reeves & Hedberg, 2003; Reeves et al., 2004), to investigate the value of socially based microworlds that are designed to support community development, and embed a “wealth of knowledge about interface, aesthetic and interactivity issues” (Squire, 2003, p. 59).

It is interesting to note a philosophical change from the use of socially based microworlds (Squire, 2003) to the ideology-laden simulation games (Shaffer et al., 2005; Squire, Jenkins, & Holland, 2003) as appropriate examples of educational games. The following section explores ideologies that are part of all cultural artifacts.

Embedded Ideologies. According to McAllister (2004, p. 29) the computer games complex consists of “rhetoric acts within the dialectic to alter particular antagonisms according to ideological informed logics” where “*dialectics* is a way to search for truth”, and “*rhetoric* is a way to convey truths”; such ‘‘truths’’ are not absolutist but are ‘‘dynamic, non-linear and multivalent and their assemblage into logical stories that make sense in some way—rationally, emotionally, spiritually’’. Furthermore, this author suggests that such a view ‘‘brings into focus five general propositions according to which computer game scholars may begin their analyses’’ (p. 31) that include:

> ‘‘1. Computer games are comprised of rhetorical events that work to make meanings in players; 2. That rhetorical events are constructed primarily out of: (a) developers’ and marketers’ idiosyncratic, homological and inclusive ideologies and (b) players’ (or more generally, experiencers’) interactions with the system put in place by the developers, which are influenced by their own idiosyncratic, homological and inclusive ideologies; 3. The set of ideologically determined meaning-making rhetorical events that comprise a computer game is designed to transform players in some way; 4. Since all rhetorical events take place within the context of the dialectic, where various kinds of struggles are always being engaged, the rhetorical events of any given computer game are always complicit in those dialectic struggles; 5. Since dialectic struggles are never wholly discrete, any given computer game-related rhetorical event is always connected to other rhetorical events and struggles that are not game-related.’’ (pp. 31–32).

The gamework analysis of the award-winning *Black & White* by McAllister (2004) illustrates how in this game ‘‘agent/developers embedded an economic system that works enthymematically to engage agent/players while it simultaneously reinforces remarkably unimaginative understandings of both in-game and real-life social and political economies’’ (p. 142) and works on four levels: technical, narratological, philosophical, and ideological. From a technical perspective the economic system is made possible through the simplification of potential social interactions in order to easily calculate and display information. The game makes use of quests, intelligence-gathering, and training of in-game humanlike, and animal characters to advance the story and plot but is driven by ‘male breeders’ who are ‘‘more effective in this expediency-driven economy than female breeders because males aren’t constrained by the physiology of pregnancy’’ (pp. 160–161). The game works at a philosophical level by allowing the player to bring to it their own understanding (good and bad, right and wrong, effective and ineffective) of a world where they are ‘‘responsible for caring for and training humanlike characters so that they behave as one desires’’ (p. 162) in a way that is similar to being a pet owner where they, the players, influence but do not control the game economic forces. From an ideological perspective McAllister argues that players quickly learn that they must submit or be frustrated—‘‘*Black & White’s* economic force works at the ideological level by collaborating with players’ initial ideological position to create, in essence, a virtual test bed wherein they are allowed to enact variations of their ideologies through large- and small-scale exercises of virtual power’’ (p. 165). This author also contends that the "fun of a game begins with submission to *all* of its rules" (p. 166) and argues that this is the case for all games.

McAllister (2004, p. 169) argues that developers, marketers, and players can no longer ignore the "long-range implications of their work and fail to ask about the interest being served". Gee (2005) is correct in stating that learning is always related to ideology, but the perceived social and transformative power of games can only become real if educational developers design learning environments to include multiple world views to support, and transform individual idiosyncratic, homological ideologies. Such a goal is congruent with many of the characteristics (real world, ill defined, and complex problems that include different perspectives and allow different and diverse products) identified as important parts of authentic learning (Reeves et al., 2004). Hlynka (2004) suggests that learning environments need to support the development of the multiple perspectives necessary to function in a postmodern world. Authentic professionalism (Gee, 2005; Shaffer, 2005) appears to be more constrained and fails to acknowledge that such model-using simulations offer little to the ideological transformative powers that computer games, or authentic task-based collaborative learning environments, could play in the revolution of educational practice previously proposed by Gee (2003).

Relevance for game design

"Thickly authentic" or "authentic professionalism" games could be viewed as a subset of *authentic* task-based collaborative learning environments that include complex *relevant* tasks, challenges or problems, which can include *model-building* simulation where *multiple representations* (ideologies), and reflection act as *transformative* opportunities (see Table 1 [Authentic learning] for the associated interfaces and their use in game design) [Core Concept 2].

Narrative

Theoretical constructs

As "rhetoric acts" (ways to convey truths) (McAllister, 2004) form the fabric of a computer game, therefore they should be related to game narrative. In this section the relationships between gameplay, narrative, and story are discussed in order to identify elements important to the design of educational games.

The relationship between narrative and game design is a complex one, which includes Ludologists (concerned with the mechanics of gameplay), and Narratologists (who include games with other storytelling media). For Juul (2001, ¶ 44) "narratives are basically interpretative, whereas games are formal"; games can tell stories, contain narrative elements, and show narrative structural sequences; games and stories do not share the same relationship as do novels and films as there is conflict between the now of game interaction and past of narratives. The relationship between reader/story is different to that between player/game.

In an attempt to reconcile the narrative/ludology argument, Lindley (2003) introduces simulation into the debate and argues that all games can be placed within a unified heuristic triangular space where the points are defined by these three concepts (ludology, narratology, and simulation). This author defines a ludic, or ludological, game as a "goal-directed and competitive activity conducted within a framework of agreed rules" (¶ 5); narrative "as an experience that is structured in time [where] different structures then represent different forms of narrative and a narrative is an experience manifesting a specific narrative structure" (¶ 11); and simulation (prosthetic reality) as "a representation of the function, operation or features of one process or system through the use of another" (¶ 18). The relationship between gameplay and narrative can be seen as competition between cognitive resources required for immersion and engagement (engaging gameplay gestalt), and perception of complex narrative patterns. This author states that while simulations are interesting in the development of skills, they are neither games nor stories thus supporting Crawford (1982). Lindley (2003) argues that many games make use of the three-act restorative narrative structure in which conflict is established in the first act, implications of the conflict discovered during the second act, and resolution of conflict occurring in the last act (Amory & Seagram, 2003). In addition Lindley (2005, ¶ 1) reasons that well-designed games allow for personal preferences when the design includes predesigned narrative content, story potential and the influence on the "actual unfolding story created by the actions of the player". It therefore appears that educational computer games that include narrative elements are not comparable with simulations. However, model-using simulations can be viewed as a specific type of game challenge and can therefore coexist in a computer game that might include complex narrative elements such as the adventure genre.

Jenkins (2004, p. 121) discusses how the story/game discourse operates with a too narrow model of narrative preoccupied "with the rules and conventions of classical linear storytelling", and "activities and aspiration of the storyteller and too little on the process of narrative comprehension", looks at whole games and not parts where narrative elements could enrich gameplay and "assume[s] that narratives must be self-contained rather than understanding games as serving specific functions within a new transmedia storytelling environments". Through the analyses of spatial and environmental storytelling, evocative spaces, enacting stories, and embedded narratives, Jenkins (2004) argues that game designers should be considered as narrative architects.

The *Myst* game series is the most successful adventure game series ever created. Spanning 10 years five game titles (*Myst*, *Riven*, *Exile*, *Revelation*, and *End of Ages*) and four books (*The Book of Atrus*, *The Book of Ti'Ana*, *The Book of D'Ni*, and *The Book of Marrim*) tell the story of Atrius and his family as conceived and developed by Robyn and Rand Miller. The games are referred to as "story telling puzzles" (Bonus DVD, Myst V: End of Ages Collector's Edition, Ubisoft) in environments that include their own languages and cultures. *The Godfather* (first published 1969) by Mario Puzo and filmed in 1972 was developed as an interactive game released in May 2006 in which the player both experiences the original narrative but influences their own story within the game environment (Campbell, 2005). Dickey (2005) discusses how plot-based narratives (for example *Myst* and *Riven*), and character-based narratives (*Lara Croft Tomb Raider* and *Buffy the Vampire Slayer*) support gameplay. The creators of *End of Ages* and *The Godfather The Game* argue that the development of technology only now allows for the realization of complex game spaces that support transmedia storytelling concepts (Jenkins, 2004).

An example of a learning environment in which the narrative is not situated in a single form is *Quest Atlantis* which includes a 3D multiuser environment, educational quests, unit plans, comic book, a novel, a board game, trading cards, a series of social commitments, and other resources (Barab, Thomas, Dodge, Carteaux, & Tuzun, 2005).

However, while the narrative devices used in films, videos, books, and games may be different, there are a number of complex issues involved that cannot be reduced to game/story versus novel/film arguments. Sweeney (1994) discusses a general theory, cinematic cognitivism, related to narrative comprehension and interpretation based on the work of Bordwell, Branigan, and Carrol in which cinematic comprehension is defined "in terms of active viewers' ordinary psychological processes and strategies of problem solving" (¶ 1). In terms of this theory the viewer constructs the film through the interpretation and comprehension of screen images, or "viewers in their acts of narrative comprehension ... construct films" (¶ 6) and therefore a film is semantically incomplete. Therefore, in playing games the participant would create meaning from the game environment and experiences (interactions).

Lindley (2005) suggests that game players take on one of three attitudes towards drama/story/narrative: audience, performer or immersionist. However, the audience role is seen as passive acceptance of a narrative, which is incongruent with the arguments of Sweeney (1994). Instructivists believe that learning involves the flow of information into empty vessels (learners), or more specifically, passive reception of knowledge. However, radical social constructivists reject such an epistemology as they argue that there can be no ontological reality (von Glasersfeld, 1991). Is the debate between narrative and gameplay therefore a consequence of philosophical beliefs related to individual world views? Reeves and Hedberg (2003) described four major paradigms (analytic-empirical-positivist-quantitative paradigm, constructivist-hermeneutic-interpretivist-qualitative paradigm, critical theory-neomarxist-postmodern-praxis paradigm, and eclectic-mixed methods-pragmatic paradigm) used in the evaluation of interactive learning environments and argues that an eclectic-mixed methods-pragmatic paradigm offers the "most potential for enhancing interactive learning systems" (p. 36). Narrative design for educational games should therefore support an eclectic postmodern approach (Hlynka, 2004) in which a wide range of narrative devices can be selected to create immersive environments that support specific learning outcomes.

Despite the complexities associated with narrative and game design, Dickey (2005) maintains that the inclusion of narratives into learning design would enable and support fantasy that could provide occasions for reflection and reevaluation; narratives could therefore inform the design, or landscaping, of educational environments. This author contends that backstory, and cut scenes are the primary devices used to support game narratives. Here backstory "provides a dramatic content for the action and interaction" while cut scenes are story elements that are "interspersed and revealed during the course of gameplay" (Dickey, 2005, p. 73).

Relevance for game design

Educational games should be designed as *narrative spaces* where *story* and *plot* (rhetoric acts) allow players to actively construct their own meaning/understanding through the use of plot devices that can include *backstory* and *cut scenes* (see Table 1 [Narrative] for the associated interfaces and their use in game design) [Core Concept 3].

Gender

Theoretical constructs

As males and females view media artifacts from different perspectives (Cassell & Jenkins, 1998). McAllister's (2004, p. 169) gamework theory provides a way to investigate gender issues in computer games and the "hypersexualization and objectification of the human form in games is similarly problematic, as is the multitude of racial and cultural stereotypes that are designed into them (which, incidentally, Black & White has in abundance)". It is therefore important to examine gameplay and gender relationships that impact game design.

One of the obvious differences between gameplay by females and males is related to their intrinsic skills. Quaiser-Pohl, Christian Geiser, and Lehmann (2006) found three types of computer games players among a large sample of German secondary-school children that included non-players, logic-and-skill-training, and action-and-simulation. Over 80% of the non-players and logic-and-skill-training group were females and they only made up 18.3% of the action-and-simulation group. In addition these authors show that males achieved better results than females in mental-rotation tests and for females there was no relationship between computer-game experience and mental-rotation ability. Investigating the difference and style of digital games by Maltese students Bonanno and Kommers (2005) found that females preferred puzzle, adventure, fighting, and managerial games and males preferred first person shooters, role playing, sports, and strategy games. These authors argue that such choices indicate the underlying gender-related neurocognitive processes that include perceptual speed, fine motor skills, and sequenced hand movements for females and the visuospatial ability (localization, orientation, and mental rotation), target-directed motor skills and greater risk taking in males. In an educational setting Bonanno and Kommers (2005) suggest that digital games could be used to develop visuospatial skills in females and linguistic and memory retrieval skills in males. Crawford and Gosling (2005) support the concept that females play digital games significantly less then their male counterparts and argue that games are viewed as belonging to males both culturally and by the gaming industry. Both Crawford and Gosling (2005), and Bonanno and Kommers (2005) suggest mobile telephony is attractive to a female audience. However, while such findings support gender difference with respect to gameplay, and indicate sex preferences, they support a reductionist gendered view related to a female/male binary system.

Farrar, Krcmar, and Nowak (2006) in a "2 (third versus first person) × 2 (blood on/off) × 2 (sex [sic])" (p. 387) experimental design that did not probe or consider prior attitudes to violence or the transference of such intentions, found after 12 min of gameplay the obvious that "when the blood manipulation was on, participants perceived greater gore" (p. 399). A study by Sigurdsson et al. (2006) used a number of psychological tests, including the Maudsley Violence, Eysenck Personality, and Eysenck Impulsiveness Questionnaires, and the Gough Socialization Scale to investigate the relationship between personality and the involvement in violent films and computer games. These authors found that there was a strong relationship between the use of violent media and the acceptance of violence as measured by the Maudsley Violence questionnaire, and that the internal state of a person is directly related to their interest and exposure to violent games, films and videos. Such a conclusion confirms the work of Norris (2004) who showed that in the comparison of women who played computer games with women who did not play games but who were computer literate, those who played games were more aggressive themselves and that women with high masculine gender identities were more likely to use computers at work. Here the relationship between violence, gender and technology is much more complex than a binary male/female dichotomy as gender identity may play a role in game choices and gameplay. In addition predictors other than gender might influence gaming habits (Carr, 2005).

Ridgeway and Correll (2004) argue that gender is not only an identity or role learnt during early childhood, but an "institutionalized system of social practices for constituting people as two significantly different categories ... and organizing social relationships of inequality on the basis of that difference" (p. 510). Gender, these authors argue, is therefore about widely shared, hegemonic consensual cultural beliefs that are often based on stereotypes and the associated inequalities "recreated through everyday relationships" (p. 512). In addition these authors posit that the "process that links gender beliefs and social contexts is automatic sex categorization" (p. 514) that is a sociocognitive process used to label another as female or male. Such hegemonic beliefs therefore permeate throughout all societal structures including home and work environments, and cultural artifacts; and even individuals who construct alternative gender identities understand this hegemonic belief system. Therefore game designers need to understand the gender system, which can include gay men, lesbian and transgender identities, to create game environments that are not only gender inclusive, but also provide opportunities to foster more equitable understanding of human gender identities.

On a practical level, and taking into account the female/male dichotomy, Graner Ray (2004) suggests that game developers develop titles for a gender-inclusive market that include: motivation to play the game that should not be based on the killing of opponents or searching for specific game artefacts, but should also include 'useful', or activity based devices; user interface and gameplay interactions should be obvious and not hidden (for example, discovered through trial-and-error or by searching the Internet) in order to maintain the flow of the game; consequences of incorrect actions should not be fatal (death and then start again) but should rather result in penalties and be forgiving; games should not just be about 'I win/you lose' (zero-sum) binary outcomes, but more complex and indirect non-confrontational outcomes. Barab et al. (2005) use a number of devices to specifically engage girls in their Quest Atlantis that includes the incorporation of narrative and characters, multiple female role models, guides that support solidarity, the facility to customize avatars, and ability to collect objects. Specific devices were also designed to attract boys to the environment that included inquiry based and experiential activities.

However, such game design strategies do not directly address issues related to gender identities and the hegemonic narrow constructs defining women and men. It could be argued that educational designers need to include gameplay devices that incorporate the Jungian anima (the female aspect present in the collective unconscious of men) and animus (the male aspect present in the collective unconscious of women) constructs to support the development of gender-inclusive attitudes. A way to address this issue may be to use a human-centered methodology that includes detailed ethnographic inquires and participatory design to create innovative gameplay as suggested by Van der Abeele and Van Rompaey (2006).

Relevance for game design

In order for educational games to be *gender-inclusive*, more use should be made of *activity-based* (inquiry or experiential) interactions that are not 'hidden' but support the *rhythm* of the game, design *conflict* to include both 'I win/you lose' and indirect non-confrontational outcomes, and include appropriate *role models* (see Table 1 [Gender] for the associated interfaces and their use in game design) [Core Concept 4].

Social collaboration

Theoretical constructs

Most contemporary learning theories argue that collaboration is one of the most important components of learning (Duffy & Cunningham, 1996; Piaget, 1977; Vygotsky, 1933/1978). Such arguments are an integral part of complex-games (Prensky, 2005), and authentic games/learning (Barab et al., 2005; Gee, 2003; Reeves et al., 2004; Shaffer, 2005; Squire, 2003). Yet, the relationship between technology-supported collaboration and learning is not fully understood.

Steinkuehler (2004, p. 20) found that in massively multiplayer online games the focus was mainly on the activity and not the informational content—here players became engrossed in ‘‘complex, ill-structured, dynamic and evolving systems’’. This author argues that there is a need to understand contemporary online learning environments and games should be viewed not only as designed objects but also as social practice. Time, distribution of control, the nature of the task, social affinity, and development of a community to support ‘safe-for-learning’ or ‘safe-for-disclosure’ interactions are important features in collaborative environments (Jones & Issroff, 2005). The idea of long-term learning activities is supported by Veermans and Cesareni (2005) who suggest that in collaborative environments activities should be well structured and participants (learners and teachers) should understand the pedagogical underpinnings of such environments.

While it is accepted that social interactions, especially in on-line environments, are essential for the development of learning communities, it is necessary to explore the theoretical aspects of such social interactions. Here, the theory of Social Networks from the 1950s and more recently the development of Social Network Analysis (SNA) methodology allows the relationships (ties) between different participants (actors) to be described.

Social capital refers to the collective value associated with a social network and is fundamental to the building and maintenance of democracy working through information flows, norms of reciprocity, collective action, and broader identities and solidarity (Putman, 1995). Nahapiet and Ghoshal (1998) in Sorama, Katajamäki, and Varamäki (2004) suggest that social capital includes three dimensions: structural (patterns of social interactions between actors), relational (the relationships between the actors), and cognitive (shared representations, interpretations, and systems of meaning among actors) where the cognitive dimension appears to support learning and the structural dimension contributes the most to a shared understanding (Sorama et al., 2004). Social capital can additionally be defined as either preference-based (directed altruism) or cooperative (repeated interaction between pairs or groups of actors) where altruism adds more weight to a friend’s network state (Mobius & Quoc-Anh, 2004). Altruism, jealousy and fairness appear to be more important than winning (money) when playing a dictator game (Andreoni & Miller, 2002).

Social Network Analysis tools can be used to make obvious the social capital to an actor. Martínez Monés et al. (2002) show that the inclusion of SNA techniques results in a richer data set and that SNA data complements other traditional research instruments. Sha and van Aalst (2003, p. 39) argue that SNA techniques could be used ‘‘in learning communities [to] make the social structure of the knowledge building discourse more explicit’’ and in a case study investigate the indegree (where actors build on each others notes—collaborative writing), outdegree (the number of specific notes a specific actor users), and betweenness (whether an actors is a broker of information) of the network. Such an approach found that low interactivity resulted in a lack of reciprocity. Lockerd and Selker (2002) argue that while computer-mediated communication tools provide a means to develop and enrich social networks, it is important to provide network actors with tools to visualize their status within the network. The importance of visualization within social networks is highlighted by Farnham, Kelly, Portnoy, and Schwartz (2004) where the use of communication and social awareness tools allowed users to serendipitously bump into each other and thereby extend their social network.

Relevance for game design

Learning as a social practice is well established and *dialogue* is one of the corner stones of social constructivism. *Social capital* works through information flow, altruism, reciprocity, collective action, identities, and solidarity to support the development of *democracy* and is supported by Computer Mediated Communication (CMC) *tools* (including *networks*). *Visualization* of social networks (SNA) allows actors to understand their own *relationships* with a community in order to develop new *insights* (see Table 1 [Social collaboration] for the associated interfaces and their use in game design) [Core Concept 5].

Challenges-puzzles-quests

Theoretical constructs

In a review of cognitive teaching models Wilson and Cole (1991) show that such teaching approaches always include authentic problem-solving contexts. Savery and Duffy (1995) maintain that the stimulus for and organization of learning is learner ‘puzzlement’ and argue that the use of authentic problem-solving activities associated with a wide range of information (data) is essential for learning to occur in problem-based learning environments. Rollings and Adams (2003) suggest that gameplay includes a series of challenges, which forms one of the cornerstones of the GOM (Amory & Seagram, 2003; Amory et al., 1999). Therefore there is agreement that challenges, puzzles, and quests are not only important educationally but are an essential parts of a computer game. However, there are two theoretical arguments that attempt to explain how challenges, puzzles and quests operate as learning devices: the Zone of Proximal Development (Vygotsky, 1933/1978), and flow theory (Csikszentmihalyi, 1990).

Vygotsky (1933/1978, p. 86) uses the Zone of Proximal Development to describe ‘‘the distance between the actual developmental level as determined by independent problem solving and the level of potential development as determined through problem solving under adult guidance or in collaboration with more capable peers’’. Gee (2004) contends that a well-designed computer game acts as the mentor or more capable peer (‘teacher’) to move player’s from their actual developmental to their potential development level. After solving problems associated with an educational adventure computer game (Zadarh) designed to challenge misconceptions related to photosynthesis and respiration, most participants still did not understand the associated processes (Foko & Amory, 2004). On closer examination it appears that the participants reverted to their dominant learning style, rote memorization, to solve the puzzles. Here participants thought that the solution to the puzzle was important and not the process of engagement with the puzzle. This supports Jonassen and Land (2000) who discuss how students use the least demanding and most expedient approach to learning as they know that learning is about idea comprehension and memorization. However, participants showed greater understanding of the concepts when they worked in groups to solve Zadarh puzzles (Foko, 2006) suggesting that while a well designed computer game puzzle can provide the authentic context which includes information required to reach a solution, new understandings are due to social interactions between peers and technology.

Csikszentmihalyi (1990) provides a theoretical framework that argues that higher levels of performance and consciousness (a new reality) are achieved through discovery and calls the process, from problem identification through to discovery, *flow* activity. Flow consists of a number of stages that include a task that can be solved, the ability to concentrate on the task, a clear goal, immediate feedback, deep involvement, control over actions, suspension of concerns about self during problem-solving activity, and a stronger sense of self after the flow experience. Computer game challenges-puzzles-quests represent the most authentic realization of flow.

Seagram (2005) suggests that the dynamic interaction between puzzlement, accommodation and assimilation (Fosnot, 1996) needs to be taken into account in the design of educational computer game puzzles. Therefore exposure to new explicit knowledge should allow at least some degree of knowledge integration (tacit knowledge construction). Seagram argues that iteration through the puzzle process (flow) and interaction with associated information results in the formation of new (tacit) knowledge. This formulation supports Gee (2004) who argues that a computer game could act as the tutor. However, during the evaluation of the computer game γKhozi Seagram (2005) found that puzzles promote discussion (dialogue) and reflection that supports tacit knowledge production. Again the social context is important in challenge-puzzle-quest resolution. Such a conclusion is supported by

Barab et al. (2005) who argue that such environments support learning and can promote a social agenda. These authors argue that *Quest Atlantis* can advance a social commitment as it creates an immersive real-time collaborative environment that is adaptive and multidisciplinary. The importance of flow is explored in great detail through the development of an experimental gaming model (Kiili, 2005a) and use of the model (Kiili, 2005b) that could inform the design of challenges and be part of the *Problem Space* Object.

Relevance for game design

Challenges-puzzles-quests appear to be the core of learning activities associated with immersive learning environments where *accommodation*, *assimilation*, and *puzzlement* are supported through access to *explicit knowledge*, *conversations*, and *reflection* and result in the construction of *tacit knowledge* after a *flow* state (see Table 1 [Challenges-Puzzles-Quests] for the associated interfaces and their use in game design) [Core Concept 6].

Game Object Model version II—summary description

Core concepts discussed and documented in the previous section identify the new interfaces associated with the GOM version II framework (Fig. 2). The new version retains the *Game Space*, *Visualization Space*, *Elements Space*, *Actors Space*, and *Problem Space* objects of the original GOM model but introduces a new *Social Space* object. In addition, the *Problem Space* object is now inherited from both the *Visualization Space* and the *Social Space* objects (multiple inheritance). Each object of the model is discussed separately.

The *Game Space Object* includes only abstract interfaces related to gameplay (*Play*, *Exploration*, *Challenges*, and *Engagement*) and game design (*Narrative spaces*, *Authenticity*, *Multiple ideological views*, and *Gender inclusivity*) that result in social *Transformation* and development of *Tacit knowledge* (game outcomes).

Associated with the *Visualization Space* object are the cognitive development abstract interfaces (*Critical thinking*, *Discovery*, *Goal formation*, *Goal completion*, *Competition*, and *Practice*) and the concrete interfaces of *Story* and *Plot* (previously grouped together as story-line), *Reflection*, *Relevance*, and game *Rhythm*. *Story*, *Plot*, and *Rhythm* interfaces are brought to fruition through the *Elements Space* and *Actors* objects, while *Reflection* and *Relevance* interfaces are attained mainly through the *Problem Space* object.

The concrete interfaces of *Graphics*, *Sounds*, *Technology*, *Backstory*, and *Cut scenes* contribute to the *Fun* and *Emotive* abstract interfaces of the *Elements Space* object. The *Actor* object includes the abstract *Drama* interface and the concrete *Interaction*, *Gestures*, and *Role model* concrete interfaces. The *Elements Space* and *Actors Space* objects are closely allied to the *Narrative spaces* interface.

The *Social Space* object is introduced to support the development of on-line communities and to make use of the emergent technology-based social interaction to support the *Democracy*, *Social capital*, and *Dialogue* interfaces. The *Social Space* object includes *CMC*, and *Social Network Analysis* (SNA) objects. The *CMC* object support conversations (dialogues) through the *Network*, and communication *Tools* concrete interfaces. Social capital includes *Relationships*, which can be V*isualized* using SNA techniques and are therefore the concrete interfaces of the *SNA* object.

The *Problem Space* object is the most complex component in the model and includes all the interfaces of both the *Visualization Space* and *CMC* objects. In addition the *Problem Space* object (which includes mini-games, challenges, quests, and other 'problems') includes the abstract interfaces of *Puzzlement*, *Accommodation*, *Assimilation* (related to puzzle design) and *Complexity*, *Flow*, and *Activity-based* (puzzle interactions). Puzzles need to include both *Win/Lose* and *Indirect Conflict* resolutions, *Explicit knowledge*, *Conversations*, and should rather be *Model-building* than Model-using (concrete interfaces).

The GOM II therefore consists of a number of complex interrelated objects (informed by contemporary educational theories and practices) used to describe educational games that could be simplified into three major spaces (challenges, narrative, and conversation). Educational games are therefore transformative devices in which the authentic problem-solving challenges, puzzles or quests are driven and supported by narrative and conversational devices. However, this model is part of this author's own idiosyncratic, homological, and inclusive ideology and represents one of many ways of seeing educational computer game development. Therefore the model should be viewed as a means of structuring discussions and could easily be reconceived to suit different, or alternative, viewpoints.

Game Object Model version II—uses

The GOM II provides a theoretical basis for the design of educational games. Amory and Seagram (2003) previously discuss how the development of learning objectives should inform the design of specific game challenges-puzzles-quests and thereafter, the development of story and plot. These authors suggested that for educational games to be useful it is necessary to first clearly define the learning objectives and the authentic space of the game. Thereafter the story in relation to the puzzles (which realize the learning objectives) is devised. Amory and Seagram (2003) argue that the story follows the traditional three-act scenario; the navigation through the different parts of the story need not be linear. The GOM II developed here supports this conceptualization but provides a richer model to support contemporary learning practices and provides a way to conceptualize education computer video games. GOM II provides a wider variety of abstract (theoretical constructs) and concrete (practical elements) interfaces that support education games designers and developers, respectively. A simple way to use the GOM II would be to create a check list of all the necessary criteria (concrete interfaces) and to evaluate game design specification against such a check list. However, the viability and veracity of the model in the creation of complex learning environments in practice needs to be evaluated.

McAllister (2004, p. 129) argues that the design of games includes three contradictions: computer games ‘‘are an art form based on mass production’’, ‘‘often seems to encourage unhealthy kinds of play’’, and ‘‘require developers to design realistic games that aren't *really* realistic’’. This author argues that computer game reviewers perceive the solutions to these contradictions as either strengths or weaknesses, and either stress playability (on-line reviewers) or the technological criteria of graphics, sound, frame rates, and polygon counts (print-based reviewers). McAllister (2004) suggests that game reviewers need to understand the relationship of mass culture, mass media, psycho-physiological, economic, and instructional forces on industry contradictions in order to ‘‘encourage transformative work in both the computer game complex and in the dialectical struggles with which it engages’’ (p. 130). The GOM II provides a mechanism to review computer games from an educational (learning versus instruction) perspective. Evaluation of all the abstract interfaces would indicate the pedagogical fit of a specific game while assessment of the concrete interfaces would indicate how well a computer game achieves the educational objectives. For example *The Sims*, a popular game over the past few years, would score very low for the *Transformative* and *Multiple Views* abstract interfaces as the game replicates a consumer culture whereas most of the *Myst* titles would score higher for these interfaces as the games deal with developing an understanding of other cultures. While not all games include CMC tools, they could still be used in collaborative environments where more than one player can play the game on a single computer. However, the development of an evaluation instrument based on the GOM II will require the development of assessment criteria that are self-explanatory.

Conclusions

The main objective of this communication was to develop a theoretical framework for the development and evaluation of computer video games, which would be useful in the learning environment. The production of educational games is both complex, and technically challenging. The use of a model such as the GOM version II allows for the conceptualization and assessment of educational computer games based on contemporary educational ideas; in essence ‘‘the business of supporting the emergence of socio-technical structures so as to support a common intersubject experience, not simply designing technical artifacts’’ (Barab et al., 2005, p. 104). Future research should investigate the GOM version II as a tool to both develop educational games, and to evaluate the educational value of traditional computer games.

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