Problem-Based Educational Games: Connections, Prescriptions, and Assessment

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Abstract
The overwhelming success of the commercial game market has brought increased attention to emerging work in educational game design. Much of the existing work in educational games a strong similarity to the field of Problem-Based Learning (PBL), which has a rich history of conceptual literature as well as empirical investigations. Despite apparent similarities between the two fields, there has been no formal effort to explore the connections between them. This conceptual paper examines the basic tenants of PBL with an eye toward making prescriptive recommendations for the design and use of problem-based educational games. Examples within existing educational games are discussed in the context of PBL features and outcomes.

Introduction
PBL originated at McMaster University in the late 1960s as a response to low enrollments and general dissatisfaction with medical education (Barrows, 1996). This modern
inception of PBL came soon after a North American revival of Montessori’s work and has a strong relationship to the progressive education movement of the early 20th century espoused by Montessori, Dewey, Neill, Steiner, and Kilpatrick (Rohrs & Lenhart, 1995) among others. That said, it arose primarily out of a perceived need for medical education reform. Specifically, students felt highly motivated as residents overcoming patient problems, but struggled in the two preceding years of largely rote information with few apparent ties to their future practice (Spaulding, 1969). Briefly, PBL is characterized as an approach to learning in which students are given more control, asked to work in small groups, and most importantly acquire new knowledge only as a necessary step in solving authentic problems representative of eventual professional practice (Barrows, 1986). Since its modern inception in medical education a robust interest in PBL has resulted in use across several disciplines (Savery & Duffy, 1995) and educational levels (Savery, 2006) including: Business (Arts, Gijselaers, & Segers, 2002; Breton, 1999), economics (Garland, 1995; Son & Van Sickle, 2000), educational psychology (Steinkuehler, Derry, Hmelo-Silver, & Delmarcelle, 2002), engineering (Van Treuren & Havener, 1997), physics (Mestre, Dufrense, Gerace, & Hardiman, 1993), and social work and sociology (Heycox & Bolzan, 1991; Rangachari, 1996; Ross & McNeil Hurlbert, 2004) among others. More recently, there is a rising interest in educational computer games. This is due in part to the popularity and commercial success of games with those under the age of eighteen. Indeed, the video game industry is responsible for over 30 billion dollars in income, annually outpacing the domestic and foreign proceeds for motion pictures (Macklin, 2006). Educators have renewed their attempts to capture the attention of students by leveraging what games have to offer in learning situations. The emerging philosophy and research in educational game design has a parallel relationship to the underlying structure of PBL, even while no explicit
derivations are cited. For example, Squire (2002), Paras & Bizzocchi (2005) and Shelton (2007a) make a call for externally representing the connections between learning goals and gameplay in educational game design. This parallels PBL, which calls for a strong relationship between learning goals and the problems presented to learners (Barrows, 1985). Yet no work to our knowledge explicitly addresses the use of PBL in the context of educational games or attempts to map the relationship between educational game design and the structures of PBL. To that end, the purpose of this work is to explore the features of PBL as well as the intended outcomes of the approach in the context of educational game design. Examples within existing games will be discussed and a rubric for the assessment of PBL alignment in educational games will be presented.

Problems with Educational Game Design

Certainly, there exist numerous suggested approaches to educational game design, including those that originate from computer game theory (Crawford, 1984; Prensky, 2001), educational technology (Rieber, 1992, 1996; VanEck, 2006, June), instructional design (Appelman, 2005; Kirkley, Tomblin, & Kirkley, 2005), motivation theory (Csikszentmihályi, 1997; Malone & Lepper, 1987), learning sciences (Barab, Thomas, Dodge, Carteaux, & Tuzan, 2005; Dede, Salzman, Loftin, & Sprague, 1999; Squire, 2002), and business and industry (Aldrich, 2005). The following discussion of the challenges that educational game designers face does not adequately represent the field or all of the existing paradigms, and it is not meant to. Rather, these issues are one node of interest to theorists and designers of a nascent field of instruction.

The broad categorizations of what constitutes “computer games” and more generally computer simulations for learning are not debated in this article. Instead, a variety of computer-
based applications that include game-like elements and those that simulate real-world activity and environments are considered. Although these encompass a wide spectrum of work they are consistently referred to as educational games here. Differences between educational games and simulations exist including genre, intended audience, overall design approach and desired learning outcome. However, it is through examining both educational games and simulations that contributions can be made to the design and evaluation of educational activities. Given this broad definition, the following paragraphs discuss the three approaches that designers have taken when considering educational computer games.

One approach mirrors closely that of commercially successful computer games which motivate players by offering the challenge, interest, and gratification common to traditional video games. These games are often linked to conquer, chase, and save-the-city kinds of objectives that one experiences in Galaga, Pac-Man, or Missle Command. The modifications for instructional purposes, then, come in the form of rewards or reinforcement removal. Such would be the case of an electronic flash-card type of game that offers or takes away coins, points, or some other extrinsic reward to reinforce correct behaviors or answers and weaken incorrect ones. Generally, these games can be successful in their objectives, but are linked to less complex, memorization based tasks or motor-based skills, such as learning the multiplication tables or typing practice (Kirriemuir, 2003).

A closely associated approach involves taking commercially successful games and building instructional lessons around the traditional game play, without modifying the game itself. An example of this would be creating tasks for students within Sim City that help them learn city planning, money management, or leadership skills. This approach has proven less useful for learning purposes in part because it places a heavy burden on the instructor to guide
students through relevant tasks and assess their progress (Kirriemuir & McFarlane, 2003). This technique is also difficult to monitor, given the inherent nature of sim-games being largely random and unpredictable, creating less control for the instructor and more opportunity for off-task behavior (Squire, Barnett, Grant, & Higginbotham, 2004).

A third approach has the opposite problem. Some educational computer games are created with specific instructional objectives in mind. They have a progression, scaffolding, and built-in assessments that focus students on more complex learning issues aligned with meaningful goals. However, these games often have difficulty maintaining engagement with the learner. Students have found games of this nature to be boring or unfulfilling (Kirriemuir, 2002; Kirriemuir & McFarlane, 2003). Many corporate and training simulations are often created in this way, with the understanding that the audience has other motivations in which to engage with the simulation (e.g., career advancement, machinery upgrades, software updates, or skill certifications). These simulations therefore need not incorporate game-like elements, and are often aimed at audiences that are not motivated by computer games anyway.

A suggested approach to address these design issues has been to design educational computer games with the constraint that all game play activity embedded within the game be aligned with the instructional objectives (DeCastell & Jenson, 2003; Shelton, 2005a; Shelton, 2007b). The scenario around which the game is built can be engineered to balance authenticity with alignment to the educational task and objectives. The game uses simulated scenarios that are representative of the real-world, and the activity itself is useful for progression toward and designed around a learning goal. It is this approach that allows for alignment between PBL and educational game design. By articulating the relationship between designing educational computer games and PBL a rubric emerges that can 1) aid in the design of problem-based
educational games and 2) help establish a protocol for evaluating existing games that may or may not be useful for the intended learning objectives.

PBL Characteristics

PBL involves 1) authentic problems that are the vehicle for acquisition of procedural and content knowledge, 2) learner-centered activities, and 3) small group interactions that are 4) facilitated by teachers (Barrows, 1986). Each of these four important characteristics will be described in more depth below alongside examples of these characteristics from educational or commercial games.

Authentic Problems

Intuitively enough, authentic problems are the central focus of instructional activities in PBL. Jonassen (2000) defined a problem as the discrepancy between an initial state and a resolved state. This aligns fairly well with the work of Barrows (2002) who advocated for problems to be presented to the learner in unresolved form. It is the learner’s attempts to bring these problems to meaningful resolution that result in both conceptual as well as procedural understanding. Although Jonassen presents a useful continuum of problem types along dimensions such as structuredness, complexity, and level of abstraction (2000) Barrows focused in on problems that are somewhat ill-structured, involve multiple solution paths, and reflect the kinds of problems encountered in professional life (Barrows, 1986, 1996; 2002). Ideally, the initial state is far enough removed from the resolved state that the situation demands an examination of multiple solution paths using free inquiry, an investigation of the problem as well as the acquisition of and application of knowledge to resolve it. Problems are designed, selected, and sequenced in a way that guides student learning (Barrows, 1986). They become a vehicle for
attaining content knowledge (Savery & Duffy, 1995) that crosses several different disciplines (Savery, 2006) as well the process knowledge needed to employ it (Barrows, 1996).

An example of presenting authentic problems can be found in the educational game *Quest Atlantis* (Center for Research on Learning & Technology, 2000a). Players “go questing" by traveling through virtual environments to identify and finish tasks designed to create opportunities for learning in multiple ways.

*Figure 1 - Quest Atlantis*

*Quest Atlantis* includes interaction within 11 different worlds that each encompasses a different theme of citizenship. Each world has 3 villages that address variations of the world's theme by offering a large number of individual quests. Quests may embody activity in the virtual world or the real world, but each exercise is tied to the citizenship theme of the visited village. Villages include quests that address ecology, culture, power and health. The design of *Quest Atlantis* offers support for children “in developing their own sense of purpose as individuals, as members of their communities, and as knowledgeable citizens of the world” (Center for Research on Learning & Technology, 2000b, para.1) Although the computer-based environments that form the setting for *Quest Atlantis* missions may not be authentic, the problems and activities within the environment are quite authentic. The designers identified and embedded
seven dimensions, such as social responsibility and environmental awareness, to help children achieve the goals listed above. It is our contention that the crucial element in authenticity is the alignment between the educational task and eventual practice. If the learning environment introduces abstraction that supports the authentic nature of the task then the authenticity requirement is met. In this case, children may be reluctant to explore issues of social responsibility in a real village with real people. Still, abstractions to the environment necessitate a bridge to more authentic environment. In the case of Quest Atlantas, the developers also offer teaching supports in the form of downloadable documents, which allow students to take their game experiences home for additional work (Barab, 2006). In this way the missions within the game serve as a jumping-off point for students to take what they learned from interactions within the game context and apply them to their everyday lives.

*Learner Centered*

PBL is a self directed (Savery & Duffy, 1995) or learner centered approach to education. Specifically, learners take on primary responsibility for examining a problem and then determining what they know and what they need to learn in order to solve it. Note that instructors still have a responsibility for defining learning objectives, but these are mostly kept from students who generate their own learning objectives in response to a given problem (Barrows & Tamblyn, 1980; Savery & Duffy, 1995). The next crucial step is locating appropriate resources to fill in their knowledge gaps or investigate areas of personal interest (Barrows, 1996). Resources are broadly defined as content experts, reference books, journal articles, electronic sources and the like (Barrows, 1996, 2002). In order for this to happen, problems need to be presented prior to any pursuit of knowledge (Barrows, 1986) since a lecture based approach relies on the instructor to decide what students need to learn. Barrows claims
that instruction prior to presenting problems comes at a cost. Most notably it undermines the learner's control and may also prevent content knowledge from being structured to aid in problem solving (1986). As a final step, learners are responsible for self-assessing and peer assessing problem solving performance (Barrows, 2002; Savery, 2006; Savery & Duffy, 1995).

An example of learner centered design can be found in the Virtual Reality Gorilla Exhibit (Learning & Performance Support Laboratory, 2000), which teaches users about gorilla behaviors and social interactions (Allison, Wills, Bowman, Wineman, & Hodges, 1997). The Georgia Institute of Technology's Virtual Environments Group and Zoo Atlanta put students into the gorilla's environment in a way that supports an authentic experience but without the dangerous repercussions. The program, which allows students to roam in a simulated natural gorilla habitat, also simulates certain types of interactions with the animals. The goal of the project is to educate and help understand how gorillas function in their native environment and with other gorillas (Walton, 1996).

![Virtual Gorilla](image)

Figure 2 – Virtual Gorilla

Activity centers on student movements and actions with the virtual system, acting as gorillas from a first-person perspective. The construction of students’ own knowledge is built through the students’ game-like activity. The creators of virtual gorilla have taken great pains to
implement real gorilla-like behavior in the environment so that students, acting as a gorilla in the environment, understand what it is like in the habitat. The gorillas in the environment exhibit behaviors and actions extremely close to those in the natural environment, and it is up to the student to determine how to satisfy the needs of the beast. These needs include issues of survival, such as hunger and shelter, as well as group hierarchy and interaction with other gorillas. By searching and identifying the needs for gorilla survival, students must identify the gaps in their current understanding of what drives gorilla behaviors and attempt to resolve these issues through the investigation of cause-and-effect relationships in the environment. By reflecting on their newly acquired knowledge, students learn what it means to be a part of a social group that would otherwise be unrecognizable to them (Hay, 2006).

*Teachers as Facilitators*

Rather than disseminating knowledge, PBL instructors act primarily as facilitators, a role shift that can be quite challenging (Ertmer & Simons, 2006). Their focus is to serve as a metacognitive aid, modeling the kinds of questions students need to ask themselves in order to solve the problem (Barrows, 1996; Savery & Duffy, 1995). These questions correspond with the activities discussed above under the definition of learner centered. For instance, facilitators might ask students what their knowledge limitations or gaps are, where they could go to fill them, how the knowledge they have gleaned will help them, or how effective the group was in solving the problem (Barrows, 2002; Ertmer & Simons, 2006). In order to have the most impact, facilitators need to be content experts and they need to be formally trained as facilitators (Moust, Grave, & Gijselaers, 1990). In large part this training is necessary so that facilitators do not engage in lectures during PBL sessions, or correct the lines of reasoning that students engage in. Rather facilitators assure participation from all students, focus the discussion on the problem,
make students’ knowledge transparent, and encourage self-directed learning (Ertmer & Simons, 2006). Over time, the goal of a facilitator is to be replaced by students—slowly fading their metacognitive prompts and letting a student issue the same kinds of prompts to the group (Barrows, 1996).

Examples of facilitation in educational games are rare, but one is the Multi-User Virtual Environments or MUVEES (Harvard University, 2003). Within MUVEES, student action is mediated by a progression of data gathering and analysis tasks within the environment. Progress is monitored by an instructor who provides coaching. MUVEES are designed to be an engaging way to improve educational outcomes using multimedia and virtual environments for teaching and learning science. MUVEES enables multiple simultaneous participants to:

- access virtual architectures configured for learning
- interact with digital artifacts
- represent themselves through graphical "avatars"
- communicate both with other participants and with computer-based agents, enacting collaborative learning activities

Figure 3 – MUVEES River City
As part of the project data were collected from both students and teachers (Nelson et al., 2007). Interestingly, the students who played the game indicated that they perceived the role of their teachers as being more “facilitator-like” than those who did not play the game, in that they did not press them for their understanding. This suggests that students who played the games may have assumed more responsibility for their own learning. Further, the study indicated the teacher prompts tended to decrease over time, indicating a desirable shift towards increased student responsibility over time.

**Small Group Interaction**

PBL is typically conducted in a series of small group interactions with 5-9 students (Barrows, 1996; Savery & Duffy, 1995). This can be considered a form of collaborative independent study. After agreeing on the set of knowledge gaps collaboratively, group members distribute and then tackle the task of filling them independently. Collaboration then comes back into play when the knowledge is shared and applied to the problem (Savery, 2006). Group sessions also provide an opportunity to reflect on and critique the utility of any acquired knowledge. When a series of conceptually related problems is complete students are placed in new groups so they are exposed to a wide variety of future colleagues. Although there are certainly PBL implementations involving larger groups (Farquhar, J., & K., 1986; Jones, Beiber, Echt, Scheifley, & Ways, 1984; Polglase, Parish, Buckley, Smith, & Joiner, 1989; Rangachari, 1996) the commonly accepted practice is to keep the groups smaller.

A strong example of small group interaction comes in the educational game *Voices of Spoon River 3D* or *VOSR 3D* (Creative Learning Environments Lab, 2005). The *VOSR 3D* project involves the design, development, implementation and research of an educational interactive fiction game in a virtual 3D environment to teach poetry to 9th grade English
students. The game play combines aspects of interactive text-adventures and multi-player virtual environments that introduce students to the works of an American poet. At the same time, VOSR 3D provides an opportunity to solve puzzles, talk to ghosts, and engage in a computer-based reading adventure. Each poem encountered in the environment is an epitaph of someone from the fictional town of Spoon River. The many connections and stories to be discovered from a careful reading of the individual poems require students to work together to advance in the game’s context. So while this is a game about resolving conflicts and uncovering mysteries relating to these epitaphs, progressing in the game requires a collaborative solving of these conflicts while necessitating careful reading (Shelton, 2005, 2007a). The designers wanted to create an environment where students have access to the actual epitaph text, a supportive framework to augment the students' grasp of the material, and puzzles and challenges that encourage students to critically examine the relationships and problems expressed in the Spoon River Anthology epitaphs. A number of studies have addressed the kinds of learning that takes place in collaborative virtual 3D environments and thoughtful game play (Steinkuehler, 2004, 2006).

Figure 4 – Voices of Spoon River
PBL Outcomes

The intended outcomes for PBL include 1) effective self-directed learning skills, 2) content knowledge that is integrated and structured around problems, 2) skills for solving problems that are connected to content knowledge, and 4) an increased motivation for learning (Barrows, 1986). Each of these outcomes will be described in more detail.

**Effective Self-directed Learning Skills**

To the extent that learners take the lead in defining their knowledge goals with respect to a problem, identifying their knowledge gaps, and then selecting and pursuing resources to fill those gaps, they will develop self-directed learning skills (Barrows, 1996; Savery & Duffy, 1995). These skills include the ability to identify, select and evaluate resources, and develop an awareness for what they need to learn (Barrows, 1986). This outcome can be diminished, largely in the name of efficiency through several means. For example: Facilitators or content experts who lecture, listing narrow learning goals for students, or providing a constrained list of resources for a single problem (Barrows, 1996).

Examples of encouraging self-directed learning skills can be found in *Civilization III* (FIRAXIS Games, 2005). *Civilization III* is a computer game that leads players through a simulation of world history, politics and geography. Each student makes decisions as a leader of a large group of people that impact the course of that group within historical contexts. The decisions the student makes are not necessarily “right” or “wrong,” rather, they are choices that have real effects on the outcome of the computerized citizens of the environment. Opportunities exist within the game to reflect on which decisions are made and the consequences of those decisions—including opportunities for modifications of those decisions (Squire, 2004).
This outcome has two important features. First, integrated content knowledge arises from the cross-disciplinary nature of PBL. Since problems are selected because they represent the naturally occurring complexity of a given domain, students are forced to pull from all of the relevant sub-disciplines in order to achieve a state of resolution. In order to fully derive this benefit it is crucial for the curriculum to not drop out of PBL for various sub-disciplines (Barrows, 1996). The second outcome, structured content knowledge, is the essential core of PBL (Barrows, 1996). This concept has strong ties to three features of information processing theory, specifically prior knowledge activation, encoding specificity, and elaboration (Albanese, 2000). By asking students to move as close as possible to the resolution state of a problem before using their outside resources, they will be forced to activate their relevant prior knowledge which will assist them greatly in structuring their newly acquired knowledge (Albanese, 2000; Barrows, 1996). The concept behind encoding specificity is close alignment between the tasks of learning and the tasks of practice. By achieving this alignment, learners will be more likely to retrieve and apply (e.g. transfer) their content knowledge to future work (Albanese, 2000; Barrows, 1986). The ability to engage in transfer also depends on elaboration.
of newly acquired knowledge structures. In the context of PBL this occurs through the discussion of, reflection on and critique of knowledge that takes place in small group interactions. Engaging in this kind of elaboration allows for increased levels of understanding and more likely retrieval (Albanese, 2000).

The kind of complexity necessary for PBL to occur is certainly present in Civilization III. As stated by Wong (2001), the game steeps learners in issues of building empires, city improvements, researching technologies, and building and controlling military units. Multiple solution paths exist, including political power, military power, or production through building a spaceship. Each of these main solution states can be achieved by several possible means. While it is advisable to focus their strategy, learners still need to pay attention to all facets of the environment (e.g. military, politics, industrial production, research, etc . . . ). Although Civilization III is an excellent example in terms of knowledge integration it does not appear to embody the outcome of structured content knowledge. There are no real prompts for the kinds of discussion, reflection, and critique of newly acquired knowledge within the game.

_Problem Solving Skills Connected to Content Knowledge_

Each discipline has constituent problem-solving skills that may or may not be present in other disciplines. For the field of medical education, Barrows described these problem-solving skills as “. . . hypothesis generation, inquiry, data analysis, problem synthesis and decision-making” (Barrows, 1986, p. 481). A large part of this process is training learners to reason backwards from a hypothesis, as opposed to forwards from the given data (Hmelo, Gotterer, & Bransford, 1997). While data-driven reasoning is highly efficient, and typically used by experts, it is subject to high levels of error when employed by novices who lack relevant content.
knowledge (Patel & Kaufman, 1993). Furthermore, hypothesis-driven reasoning is useful, even by experts, when circumstances are novel.

In order to fully achieve this outcome, it is important that problems be presented in a manner that is most reflective of eventual practice. For example, if students are handed sufficient information to achieve problem resolution or the problems are simplified, then they will not be able to engage in inquiry. It is crucial that students be asked to reason from partial information or these problem solving process skills are unlikely to emerge (Barrows, 1996). This outcome also highlights the need for facilitators to not be directive. If they lecture about a problem they will likely model their own data-driven reasoning process, as opposed to the hypothesis-driven process integral to promoting problem solving skills connected to content knowledge.

As an example, reasoning skills are required to progress through facets of the game play features within Aristotle’s Assassins (Learning Games Initiative & Utah State University, 2005). Aristotle’s Assassins is a role-playing adventure set within the political turmoil of ancient Greece designed to teach period culture, philosophy, and rhetoric. The gameplay revolves around a role-playing character chosen by the player, who is guided through the environment by a series of clues that points to specific choices. The choices the player makes change the story progression, but only in ways that help make sense of the task-based activity and ancient Greek culture as a whole. For example a player’s choice of gender before the game even begins will result in radically different responses from other characters in the game. All players go though a similar storyline and have the same instructional objectives, however they are given the freedom of time and action within their own individual story, that helps make each student’s experience their own (Frushtick, 2006).
Students navigate the world by their own accord, stopping for rest and reflection at specific points. Learners are self-directed, have freedom of actions and live with their decisions which impact the environment around them. The player's responsibility is to interact with the history and mythology of Greece on a journey that in part involves a choice between democracy and aristocracy for Greece. The ability to problem solve within the environment is directly tied to the emerging complexity of their understanding of the game content, where the player is required to navigate the landscape, collect information from NPCs that is necessary to solve several puzzles contextualized around Greek culture and politics. Although Aristotle’s Assassins does present unresolved problems and asks students to reason from partial knowledge it appears to fall short in promoting hypothesis generation and the backwards driven reasoning process.

**Increased Motivation for Learning**

Motivation is a direct result of both the challenge of arriving at problem resolution as well as the relevance to future practice (Barrows, 1986, 1996). In terms of relevance, students are able to see more clearly why a specific reasoning process is necessary to learn. In addition, they have an immediate need, the solution of their problem, for pursuing relevant content.
knowledge. Since the problem is tied to future practice, the relevance of acquiring necessary content knowledge is far more transparent (Barrows & Tamblyn, 1980). In terms of challenge, students become intrinsically motivated by their growing ability to achieve problem resolution. This is a marked difference from the extrinsic rewards of a grade or standardized test, and will persist when extrinsic rewards are no longer present (Barrows & Tamblyn, 1980).

The motivation for learning with games like *Civilization III* and *Aristotle’s Assassins* mirrors those properties of traditional video gameplay. Aspects of challenge, proclivity, and uncertainty, along with certain social factors all play a role in why students gravitate toward computer gaming. Game-like activity that is aligned with learning objectives, whether it happens to be ancient Greek rhetoric or international politics is an educationally meaningful embodiment of this motivation. The moves the player makes have real consequences based on real decisions. The player *cares* about the outcome, and can enjoy their experience at the same time.

In *Civilization III*, the focus is not just on generic civilization battles, but actual conquests from history, and to control every aspect of them. For example, an early conquest involves the Phoenicians battling the Babylonians. Each game revolves around a conquest that lets the player have access to specific maps and decisions that control the growth of the virtual society. Players can go as far as creating a police force to prevent civil unrest in the cities, and make choices about ruling with love and respect or fear (Kolumbic, 2006). The game certainly holds interest through aspects of challenge. Thirdly, the game should hold levels of uncertainty, and hold rewards for accomplishing progressive tasks. In *Civilization III*, if you are a good leader your people will from time to time reward you by building and improving your palace, an extrinsic reward. As your society grows and prospers, the player is imbued with a sense of power and accomplishment, an intrinsic reward (Steinkuehler, 2003). Then there exists a level of social
interaction within the game as well that many players find fascinating. The game allows for
team-like play or adversarial, with and against strangers or friends. Many players find the social
organization and relationships of online games extremely satisfying (Steinkuehler, 2003).

Although *Civilization III* certainly presents a challenging environment, the tie to future
practice is not immediately apparent. The primary task of ruling a civilization is one that
learners are unlikely to engage in. That said, relevance may be achieved through carefully
structuring the problems that students engage in within the game. For example, the focus may
shift from ruling a civilization to brokering peace between Lebanon and Israel in a custom
scenario about current events. This need to customize the game environment underscores the
discussion above about differences between *Aristotle’s Assassins* which is an educational game,
and *Civilization III*, a commercial game that can be used for educational purposes. While
*Civilization III* may do a better job of increasing motivation to engage in the activity, that
motivation may not always be directed at learning goals. Conversely, *Aristotle’s Assassins* may
focus on learning goals to the detriment of motivation.

Assessment Rubric & Discussion

The assessment rubric below (see Table 1) is built upon the characteristics and outcomes
of PBL discussed above in the context of educational game design. Alongside each trait is a
scoring sample initiated by an expert in PBL and confirmed by an expert in educational games.
For the purposes of uniformity, if an element from the rubric was not readily apparent from the
game or the available information about the game then non-conformance was assumed.

From looking at the sample scores a couple of things are apparent. First, the overall
score, an unweighted average of all eight sub-scores, is not all that flattering (48%). Although
some game examples were chosen because they helped elaborate a principle from PBL, most
were selected because they were the best example known to the authors of a particular PBL trait. If the assumption that educational games will benefit from a PBL design is true, then this suggests some ripe areas for incorporation of PBL into future game designs. Most notably, the creation of problems that are learner centered, promote self-directed learning, content knowledge that is both integrated and structured, as well as increase motivation for learning. This last area (motivation for learning) is particularly promising since, as noted above, educational games have been described as boring and unfulfilling (Kirriemuir, 2002; Kirriemuir & McFarlane, 2003). Perhaps a PBL structured educational game will be able to provide this motivational element in a way that maintains a focus on learning. Note that it is possible these games are meeting the criteria in ways that are not anticipated by PBL. From a PBL perspective Civilization III may look poor with respect to self-directed learning because it does not explicitly prompt learners to identify and then fill in their knowledge gaps. Still, this activity may emerge from play itself. That is the highly motivational nature of the game (at least with respect to challenge if not learning) may be enough to encourage learners to go through these steps even without prompting. Thus, the best way to use the rubric may not be to make value judgments based on a summary score, but instead to take a closer look at an educational game to see if a particular characteristic is fulfilled in another way or an outcome is achieved through alternate means.

Further examination of the rubric reveals some additional recommendations for future game designs. Although each characteristic is given equal weight in the rubric it should be clear from reading the outcomes section that some portions have more far-reaching implications than others. For example, if problems do not relate closely with future practice it will likely hinder motivation for learning and the integration of content knowledge. If teachers are too directive in
their role as facilitators, they may hamper the development of self directed learning skills and problems solving skills.

Conclusions

This paper argues that educational games may benefit a great deal from incorporating the traits of PBL. The combination of educational games and PBL may help bridge the gap between the enticements of a commercial game designed purely for entertainment and an educational game that holds no allure for learners. There are two uses for the rubric: 1) to evaluate the PBL alignment of an educational game and 2) inform the design of educational games through the inclusion of PBL features.

It is important to note that the rubric should be used to determine points at which an educational game or a game design may not align with PBL, as an impetus for closer examination. That examination may reveal that an outcome is achieved through alternate means. For example, Civilization III fell well short on the outcome of structuring content knowledge because there are no functions or prompts for discussion, reflection, and critique within the game. However, these kinds of activities do take place external to the game, in player chats, discussion and newsgroup sessions, and blogs about actions and strategies. Thus a game may be able to overcome a lack of small group interactions by taking learners to an environment external to the game.

Planned future work includes the use of this rubric as a framework for educational game designs created by graduate students in an educational gaming class. This will provide a means of validating the rubric from a practitioner perspective through participant reflection papers and interviews. Further validation as well as reliability (intra-rater and inter-rater) analysis is planned by applying the rubric to several existing educational games. Finally, the rubric will be
applied to iterations of the *Voices of Spoon River* game. Each version will be used by students and empirical data on learning outcomes will be collected in part to analyze the predictive validity of the rubric.
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<tr>
<th>Trait</th>
<th>Criteria</th>
<th>Example</th>
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<tr>
<td><strong>Authentic Problems</strong></td>
<td>Problems are complex (cross-disciplinary).</td>
<td>Quest Atlantis is complex (1) and involves problems that will likely be encountered in real life (1). Although the environment is abstracted this was done in support of the authentic nature of the task and alongside opportunities for practice in a more realistic setting(1). Total = 3/5 (60%).</td>
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<td></td>
<td>Problems have multiple solution paths.</td>
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<td></td>
<td>Problems are unresolved and ill-structured.</td>
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<td></td>
<td>Problems are likely to be encountered in professional practice.</td>
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<tr>
<td>5 possible</td>
<td>The environment should approximate that of eventual practice unless:</td>
<td></td>
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<td></td>
<td>• The environment is abstracted as a design decision (e.g. a virtual world) to support the authentic nature of the task.</td>
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<td></td>
<td>• And learning is followed up with opportunities for practice in a more realistic setting.</td>
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</tr>
<tr>
<td><strong>Learner Centered</strong></td>
<td>Learners generate objectives from given (and unresolved problems).</td>
<td>Virtual Gorilla certainly presents an unresolved problem (keeping the Gorillas happy) that forces learners to generate their own learning objectives (1). It appears to fall short in a search of external resources and assessment. Total = 1/3 (33%).</td>
</tr>
<tr>
<td>3 Possible</td>
<td>Learners locate and pursue resources (content experts, reference books, journals articles) from that will assist in problem resolution.</td>
<td></td>
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<tr>
<td><strong>Teachers as Facilitators</strong></td>
<td>Facilitators model and prompt students with meta-cognitive questions that assist in problem resolution.</td>
<td>The Multi-User Virtual Environments do appear to engage in a fading of their coaching (1), although it is not clear if that coaching involves meta-cognitive prompts. Students did acknowledge their instructor took a passive role with respect to content (1). Total = 2/3 (67%).</td>
</tr>
<tr>
<td>3 Possible</td>
<td>Over time, facilitators fade their assistance and prompts in favor of students taking on the responsibility themselves.</td>
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</tr>
<tr>
<td></td>
<td>Facilitators are not directive with respect to content (e.g. they do not lecture or correct the misunderstandings of students).</td>
<td></td>
</tr>
<tr>
<td><strong>Small Group Interaction</strong></td>
<td>Learners meet in small (5-9 person) groups.</td>
<td>Voices of Spoon River 3D offers an opportunity for small group interaction (1) by requiring learners to share and discuss their findings in order to move forward in the game (1). It does not, however, promote a divide and conquer approach or enforce the reflection and critique of achievements or pitfalls. Total = 2/4 (50%).</td>
</tr>
<tr>
<td>4 Possible</td>
<td>Learners decide as a group what their knowledge gaps are in relation to the problem at hand and divide up the pursuit of knowledge to fill those gaps.</td>
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<td></td>
<td>After acquiring new knowledge, learners meet again to share and discuss their findings.</td>
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<td></td>
<td>As part of sharing their findings, the group reflects on and critiques the utility of the acquired knowledge in solving the problem.</td>
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</tr>
<tr>
<td>Outcomes</td>
<td>Description</td>
<td>Total</td>
</tr>
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<td>----------------------------------</td>
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</tbody>
</table>
| **Effective Self-directed Learning Skills** | 3 Possible  
- Learners take the lead in identifying knowledge goals.  
- Learners are responsible for identifying the gap between their knowledge goals, and their current knowledge.  
- As a consequence of filling their knowledge gaps, learners improve their ability to identify, select, and evaluate resources.  
Tied with **Small Group Interaction**, but can only occur if **Teachers as Facilitators** don’t usurp the learner’s activities.  
**Civilization III** represents a very open-ended environment for learners. It is certainly true that knowledge goals will largely come from the learner (1) but it is less clear if they are encouraged to do so, or to identify knowledge gaps, much less fill them. Total = $1/3$ (33%). |
| **Integrated and Structured Content Knowledge** | 4 Possible  
- Learners obtain a set of content knowledge that is integrated (e.g. cross-disciplinary). Note this part of the outcome will be threatened if the game drops out of PBL for select content areas.  
- Learners activate their prior knowledge by attempting to solve the problem before filling their knowledge gaps.  
- Learners benefit from encoding specificity—close alignment between the tasks of learning and the tasks of future practice.  
- Learners elaborate on their newly acquired knowledge through reflection, discussion, and critique as it is shared with the group.  
Tied with using complex (e.g. cross-disciplinary) **Authentic Problems** that relate closely to future practice and to the reflection, discussion, and critique in **Small Group Interaction**.  
**Civilization III** does quite well at presenting complex problems and integrating content knowledge across disciplines (1), it falls well short in all three facets of structured content knowledge—with the possible exception of opportunities for reflection (but this is not coupled with discussion and critique). Total = $1/4$ (25%). |
| **Problem Solving Skills Connected to Content Knowledge** | 3 Possible  
- Learners engage in backwards-driven reasoning (e.g. generating a preliminary hypothesis and reasoning back through their existing knowledge set towards the data provided for the problem).  
- Learners are presented with partial knowledge about unresolved problems, which allows them to utilize inquiry.  
- Learners take the primary responsibility for data analysis, problem synthesis and decision-making.  
Tied to **Authentic Problems** that are presented with partial information and in an unresolved state as well as **Teachers as Facilitators** who are not directive (e.g. do not lecture or correct misunderstandings).  
**Decision-making** plays a key role in Aristotle’s Assassins, as does problem synthesis and data analysis (1). Learners gain the bulk of the knowledge needed to resolve various problems in the game only during the course of play (1). Encouragement to engage in hypothesis formation and backwards-driven reasoning does not appear to be present. Total = $2/3$ (67%). |
| **Increased Motivation for Learning** | 2 Possible  
- Learners engage with problems that are relevant to their future practice as professionals.  
- Learners are challenged by the presented problems, and become intrinsically motivated by growing ability to bring problems to resolution.  
Tied to all facets of **Authentic Problems**.  
**Civilization III** presents challenging problems that allow a progression in problem solving ability (1). Since the primary task of leading a society is not likely to be the future practice of the learners, it is not all that relevant. Total = $1/2$ (50%). |

The overall score is an unweighted average across all traits (48%) in this case.
References


Barrows, H. S. (2002). Is it Truly Possible to Have Such a Thing as dPBL? Distance Education, 23(1), 119-122.


Footnote

1 While concepts from PBL can certainly be connected to the progressive education movement the specifics of those connections are subject to debate. Despite conceptual similarities, Barrows tends not to cite these theoreticians, philosophers, and practitioners when discussing the origins of his own work. We admit to side-stepping the issues around the origins of PBL and educational philosophy, in order to avoid a broader discussion that is perhaps best left to another article.