Technology Enhanced Problem Based Learning

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Abstract
Problem based learning (PBL) pedagogy aims to provide context-rich academic situations where students can work together and demonstrate authentic application of knowledge. This paper seeks to address a recurrent problem in education related to the implementation of PBL pedagogy that students are often disengaged from active collaboration, fertile discussion, physical interaction around emerging group artefacts, and reflection. The success of PBL implementation depends on both the selection of learning activities and development of appropriate infrastructure - learning spaces in which the activities can take place. Yet, the technologies often comprising the PBL learning space in the university classroom (e.g., projector, laptops, vertical smart board) and the way they are being used by instructors and learners seem to hinder the successful implementation of PBL.

Key words: problem based learning (PBL), pedagogy, technologies
1 Introduction

A common barrier in acquiring knowledge presented in class is that students are often disengaged from active collaboration, fertile discussion, physical interaction around emerging group artefacts and reflection. Problem based learning pedagogy aims to provide context-rich academic situations where students can work together and demonstrate authentic application of knowledge. In PBL, learners in small groups are confronted with simulated, contextualized, real-world problems as a venue to develop content knowledge and problem-solving skills. This approach in education methodology is considered one of the best ways to provide context-rich academic situations where students apply their knowledge in the context of future tasks (Koschmann et al., 1994; Savery & Duffy, 1996; Greening, 1998) and it is also illustrated along the decades that PBL can deepen students’ understanding, flexibility in application and transfer of knowledge (Bednar et al., 1992; Koschmann et al., 1996; Koschmann et al., 1994).

Even though PBL has been used for over 30 years in multiple disciplines as an educational instructional approach, the use of technology was limited and sedated. Through the increased development of technology we can find few of its forms in the educational setting and learning system. The success of PBL implementation depends on both the selection of learning activities and development of appropriate infrastructure – that is, learning spaces in which the activities can take place. Yet, the technologies often comprising the PBL learning space in the classroom – and most importantly, the way these technologies are being used by instructors and learners – seem to hinder the successful implementation of PBL. Therefore we seek to investigate the current use of technology in PBL and suggest ways to support and expand it.

The 24-month research bilateral project between Cyprus and Slovenia will join forces between two European research institutions Cyprus University of Technology and Jožef Stefan Institute to develop and deliver a framework comprising the construction of creative, multi-modal information spaces ideal for the implementation of PBL in the university classroom. The project has the potential to revolutionize the practice of PBL in higher education, helping instructors to successfully implement PBL pedagogy and allowing learners to be more engaged in the process of problem solving. Ultimately, the project will contribute to the existing body of knowledge in the fields of HCI, learning technologies, computer supported collaborative learning and is expected to guide further research in these fields.
2 Existing knowledge in the field of PBL

The beginnings of PBL goes over 40 years ago, around the 1960s. It first appeared as an innovative learning approach in the medical education and more specifically in health sciences curricula. It emerged from the need to invent a new educational methodology, since the traditional teaching and learning methods fail to prepare medical students for problem-solving for clinical studies. As stated by Barrows (1986), the trigger for the development of PBL was the necessity to make medical and clinical courses more interesting and relevant to professional practice where students would be able to explore resources, gather information and learn from realistic examples or patient cases. PBL has been defined as:

- an instructional and curricular learner centered approach that empowers learners to conduct research, integrate theory and practice and apply knowledge and skills to develop a viable solution to a defined problem (Savery, 2006).
- an instructional method that initiates students learning by creating a need to solve an authentic problem. During the problem-solving process, students construct content knowledge and develop problem-solving skills as well as self-directed learning skills while working toward a solution to a problem (Hung, Jonassen & Liu, 2008).

The term PBL though does not refer to a specific educational method, but an approach to learning. Therefore we perceive crucial to identify the characteristics of this broad learning approach. Barrows (1986) indicated that the common denominator of the different forms of PBL is the “use of problems in the instructional sequence”. Furthermore, he defined a set of PBL objectives of primary importance. Barrows though, determined these objectives in terms of medical education and clinical context, but also indicated that are also applicable in all technical and applied schools. These objectives include the structuring of knowledge, to ease the recall and application of gained knowledge by the students and advance of motivation to enhance student learning. Furthermore, problem-solving and self directed learning (SDL) were also indicated as highly important skills that students should develop during a PBL curriculum. Students should be able to identify a problem, synthesize information and take decisions through repeated application of knowledge in the context of future tasks. In addition, SDL would offer the student the ability to identify and properly evaluate gathered information. In addition, collaborative learning is also one of the critical components for PBL; students working in small groups to solve the given problem and build knowledge by interacting with each other (Hung, 2011; Savery, 2006). Finally, it is also important to denote that PBL promotes student centred learning and therefore tutors have taken a new role in facilitating PBL session.

3 Technology in PBL

Traditional ways of implementing PBL are constructed in small face to face groups, while the tutors work as the facilitator of the discussion among learners (Hung, Jonassen & Liu, 2008). While initially tutor provided the sources of required knowledge, with the growth of technology and appearance of other medium for resourcing such as digital libraries, imaging and interactive videos, PBL had taken a new turn into actively involving technology to support students’ learning. For example, interactive videos were enrolled in PBL classrooms as additional learning materials. In addition, instead of using the traditional role playing learning techniques in health science, computer simulation tools had been developed to support learning.
The continuous evolution of technology, the appearance of internet and the need to evolve educational methodologies, lead to the appearance of new and innovating ways to involve technology in learning. Authors of one of a previous review (Hung, Jonassen & Liu, 2008) categorized the use of technology in two different paths. One of them is the combination of PBL with distance or online learning. The popularity of internet offered to PBL better access to resources and web environments were mainly used for the organization of courses. The second trajectory identified by the authors was the use of multimedia in PBL. Multimedia can be identified as the use of multiple mediums for communicating and transferring information, such as text, sound, video etc. Empirical studies have indicated that the multimedia learning model can result into improved knowledge integration comparing to simple textual modes of learning (Doolittle, 2002). While previous studies have explored PBL from the perspective of educational performance or implementation aspects (Hung, 2011), our investigation was targeting the current studies of PBL curriculum designs, which have embedded forms of information technologies and the latest advances in technology.

3.1 Online PBL environments
The use of technology in PBL curriculum was progressed by offering fully online PBL sessions and environments for learning. Such environments were developed to satisfy the need for distance learning. Online PBL offered a space for sharing and studying material online as well as communicating through emails initially and afterwards chat and blogs. We have seen though several forms of synchronous or asynchronous communication tools such as, WebCT (Schell & Kaufman, 2007), Blackboard (Gürsul & Keser, 2009), Blogs and Wikis, MSN (Lo, 2009) or even developed their own tools for online PBL such as LdShake (Hernandez-Leo et al, 2011) and an e-Forum (Chanlin, Chen & Chan, 2009).

Both synchronous and asynchronous communication tools were elaborated within online learning environments. Asynchronous communication (AC) tools have been defined as the ability to post messages or comments electronically in a web space so that others can read them when they access that space at their own time (Nelson, 2010). This communication format offered high flexibility for learners to communicate but also hindered the need for person to person communication. A study on asynchronous interaction, focused on improving communication by providing automatic labels on postings (Chanlin, Chen & Chan, 2009). Synchronous communications (SC) on the other hand, can be perceived as the real-time communication among learners which requires an online status at the same time. Therefore it can offer a more immediate and simulated peer to peer communication.

Moreover, in a study by Lo (2009) on the investigation of Wikis, Blogs and MSN performance in online PBL curriculum results showed that between Blog (AC) and MSN (SC), students preferred to communicate in real-time. It is interesting to notice that even within the Blog, communications were left unfinished when a member could not continue the discussion. Author make some suggestions to researchers, in order to take into consideration blended learning since online learning classrooms offers a sense of unreality, distance towards the virtual elements and depends on learners’ commitment to the course. Similar step towards blended PBL was also presented by Bridges et al. (2010) since asynchronous communications and in-class use of computers failed to support the necessary group discussion and interaction. In result, curriculum designers suggested a blended PBL approach to enhance collaboration.
3.2 Blended PBL

This hybrid PBL form is trying to bring to the forefront, face-to-face PBL and the co-located element by blending it with online and web environments, the so called blended PBL. The idea was to include both the advantages of face-to-face learning and online technologies and avoid any disadvantages. There are mainly two trajectories that studies have followed to approach this combination: (1) which form has the leading role in learning? and (2) is it a traditional PBL with online communication elements or an online course with periodical physical meetings?

The structure of blended PBL that mostly appears in studies and seems to prevail keeps the structure of PBL traditional curriculum but also offering the ability to use online communication tools and online environments to share material. Donelly (2010a) defined blended PBL as face-to-face tutorials with online support. In his studies with blended PBL he used technology in forms of online reflective journals, synchronous and asynchronous communication tools such as WebCT. His evaluations were focused on the harmony between face-to-face and online PBL elements (Donelly, 2010b) and the performance of online environments in such an innovating educational approach (Donelly, 2009).

Weekly two hour instructional PBL sessions which were followed by online discussions through AC and SC were also developed by a number of other researchers such as Yeh (2010) – on forming online communities, Lou et. al. (2010) – on vocational students performance - and Bozic and Williams (2011) on training educational psychologists. Lou and his colleagues (2010) suggested that more interesting content is required to be developed for learning online such as animations and educational games to attract student’s attention and increase their motivation. Bozic and Williams (2011) additionally indicated that their results showed that engaging students in roles or taking sides served as a stimulus for their engagement in the learning environment.

The second trajectory followed by studies, is to retain the leading role of the blending to online environments and their tools and embrace traditional PBL with face-to-face reflection sessions. Within the papers under study, we identified different approaches. Woltering et al (2009) presented a study where each team ought to have at least two physical meetings in the duration of the course for reflection and feedback. This setting leaves the decision and planning of physical meetings to groups. On contrary, a study by Hoic-Bozic (2009) implemented a blended PBL structure, with main focus on online environment while the first two PBL sessions were conceptualized in face-to-face settings.

3.3 PBL within multimedia, games and virtual worlds

The second pathway in the use of technology in PBL as presented in a previous review (Hung, Jonassen & Liu, 2008) is the use of multimedia. It has been proven with empirical studies that the combination of words with pictures in learning can perform better that the textual form (Doolittle, 2002). Earlier in the review we have annotated the use of multimedia for resourcing (Zhang et al., 2011) and also in online environments (King et al., 2010).

3.3.1 Games

A closely associated approach is the use of games and game elements within a PBL curriculum. As the evolutionary form of multimedia, games can also capture the attention and retain the engagement of players. The rising use in PBL can be partially reasoned by their wide popularity and spread in younger communities (Walker & Shelton, 2008). Besides their
popularity and the ability to enhance motivation, games could also offer a virtual space where learners could engage in problem solving waving the confrontation of their decisions’ consequences (Deteriorating Patient Medical Simulations, Flight simulations).

There have been efforts to understand game elements that would lead to the improvement of educational approaches, by adopting features that further enhance students’ engagement. Warren and his colleagues (Warren et al., 2012) studied game elements with the aim to redesign a course by adopting the discovered elements. The target was to engage students even more in the course and improve learning and engagement. Generally, the study yielded mixed results, even though students' satisfaction levels were significantly higher compared to satisfaction levels before the course redesign. Likewise, Echeverri and Sadler (2011) made an effort to examine the use of gaming environments as a medium for PBL courses. Preliminary analysis indicated that knowledge is acquired with the game based approach, while the game used was a combination of First Person Shooter (FPS) and Role Playing Game (RPG). In a more recent study, researchers applied a PBL game approach online. More specifically, they implemented an online board game with problem solving activities and mini games, suitable for multiple players which had to compete with each other. The interesting part that questions the determination of the study as a PBL design is the inexistence of collaboration between students, but instead the feature of the competition. Even though, the study reported significantly high levels of flow, interest and acceptance of the web-based problem solving game.

3.3.2 Virtual worlds

The advance of game industry and the widespread use of online multiplayer games brought to the educational world a new potential. Savin-Baden (2011) argued that immersive virtual worlds are also important features to be combined with PBL. Consequently, online learning can be expanded, by developing a virtual classroom, space or environment where the sense of engagement but most importantly immersion and presence are higher that before. As stated by Parson and Bignell (2011), “virtual worlds can provide a creative solution to providing physical-world experience within a safe and controlled environment free from the consequences associated with typical physical world experiences”. Authors further argue that there are two existing approaches to run PBL within virtual worlds, the avatar-driven scenarios where participants are requesting information from selected and trained avatars or the information driven approach where students are free to explore the virtual space to gather information.

More specifically, these settings have been defined as multi-user virtual environments (MUVEs). One of the most widely used MUVEs in educational settings is Second Life (SL). This is mainly due to its ability to build rich 3-D environments, offers mature graphical interface and interactions, is highly immersive for players, with a relatively low cost to participate among MUVEs (Salt et al., 2008; Warburton, 2009). Parson and Bignell (2011) presented a case study under the PREVIEW-Psych project, where SL was used in a psychology undergraduate course. They developed a set-family of avatars and students’ task was to communicate with the avatars and study the environment to identify the family’s characteristics. Students reported higher levels of engagement in the module and felt that this new form of digital presence in future contexts and case studies seemed more valuable and successful with acquiring knowledge. In brief, results showed that 3-D MUVEs offered a fun and engaging way towards learning, the involvement of professionals and the context of
future tasks increased their motivation towards learning but also appeared as an environment that would get you off your targeted task.

4 Discussion
With the enormous progress of technology during the past years, we expected to have acquired a wider range of technology forms applied in PBL pedagogies. But why is there such a difficulty in adopting these new “seeds” into the wider system of education, rather than limited studies? What are the barriers contaminating this transformation into an innovating and technologically powerful learning system? While we have seen technology being used to overcome a number of challenges like distance and new forms of presenting information to ease the recall of knowledge, it may also introduce new sets of challenges and difficulties. One of the highly stated difficulties when it comes to technology enhanced learning in classes, as stated by PBL teachers, is the technical part of establishing the right technology and finding the way to work with it and making the technology work when is needed.

Online learning has many apparent advantages, including 24/7 delivery, personalization, interactivity, immediate feedback and online assessment, few of the major problems are poor retention and a high student dropout rate due to the low level of engagement and motivation to learn. The decision to include games and virtual worlds to increase presence in classroom environments has shown that can do the work but can easily attract too much attention on the game rather on the given problem. Additionally, we have seen that PBL sessions involving games and virtual worlds, are not classes taking seriously but instead treated like games (Papamichail et al., 2009). Blended PBL and the fusion of face to face PBL advantages in physical presence and interaction to further support communication and extend the engagement of learners seems to be a highly recommended combination for the delivering the new form of PBL. Interaction between participants in the PBL group is the key element to a successful blended learning experience for all involved. A comparative study between traditional PBL (no-communication at all out of class), blended PBL (communication tools out of class) and traditional methods of lecturing by an instructor has shown that blended PBL students scored higher in terms of academic achievement. Even with simply providing communication ability out of class with tools such as chat, threaded discussions in Blackboard, results were significantly better for blended learning students (Derby & Williams, 2010).

5 Conclusion
The focus of this paper is on technology enhanced and multimedia enriched problem-based learning (PBL) which is on the leading edge of PBL practice as technology is becoming an important tool for communication, collaboration, information retrieval, and knowledge creation, with multimedia, virtual worlds and social networking being the environment for all these. While previous studies have explored the use of technology from a certain perspective, online environments, resources, multimedia, games and virtual worlds we identified a gap in embracing technology in the face-to-face, PBL pedagogy going beyond the use of internet and personal computers. With the advance of technology and the market filled with a variety of technological gadgets, one would expect that, the educational world would embrace the novice technological elements and embed them into the educational environment. The common understanding of the term “technology” for the public is the use of computers, tablets, smart phones etc. Moreover, the PBL setting would be more similar to a study where
information spaces were created to promote discussion in co-located settings (Jones et al., 2009. The current advances of technology in classes have widely used the internet and all features Web 2.0 technologies have to offer. As stated by students (Papamichaile et al., 2009), even with virtual immersive environments for learning, their preferences are still towards face-to-face meetings. Consequently, what are the uses of technology that we can embed in co-located PBL classes to increase students’ engagement, collaboration and fertile discussion?

Acknowledgment
This project is funded by the Cyprus Research Promotion Foundation (DESMI 2009-2010) and the Slovenian Research Agency (ARRS), under the "Bilateral Cooperation" between Slovenia and Cyprus (ΔΙΑΚΡΑΤΙΚΕΣ/ΚΥ-ΣΛΟ/0411).

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