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A Collaborative, Online, Problem-based Simulation Platform (COMPSoft) for Medical Education

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***Abstract*—In this project, we transferred Problem-Based Learning (PBL), a well-known pedagogy for medical education, to an online environment by transforming it into a simulation where students could practice their skills collaboratively in a risk-free setting. This paper describes the design of a conceptual model and development of a software platform to allow learners to collaborate online in discussing PBL cases. Early testing has been extremely promising, largely due to the extensive work done earlier to build the ENJEUX-S online game platform. Thanks to this work, it has been possible to extend this platform from online games to online simulations. Our first test of the PBL model with undergraduate students was successful in facilitating their critical thinking and was well-received. We are now planning to use COMPSoft in medical schools and to conduct comprehensive evaluation studies of both the model and the platform.**

Keywords-collaboration, online, multimedia, problem-based learning, simulation

I. INTRODUCTION

Dramatic changes in health care delivery have stimulated a large-scale migration of medical education to the web [1]. One of the more significant changes has been the decentralization of the health-care system, resulting in a higher ratio of acutely ill patients and shorter hospital stays. Face-to-face encounters with patients have decreased, and students have fewer opportunities to see a diversity of medical problems. Furthermore, health care decentralization has led to a greater need to standardize learning and teaching experience for medical students, no matter where they live or study. As a result, educators are searching for effective pedagogical models and learning platforms that enable students to study, work, and collaborate at a distance, reassessing traditional venues for medical education [2]. In particular, reduced time with patients and a trend towards decentralization have increased the need for online training. [3].

In our project, we transferred Problem-Based Learning (PBL), a well-known pedagogy for medical education, to an online environment. Our aim was to push the boundaries of PBL by transforming it into a simulation where students could practice their skills collaboratively in a risk-free setting. This paper describes the design and development of a conceptual model and software platform to allow learners to collaborate online in discussing and resolving problem-based learning cases.

II. COMPS: A MODEL FOR COLLABORATIVE, ONLINE, MULTIMEDIA, PROBLEM-BASED SIMULATION

COMPS is an acronym for "Collaborative Online Multimedia Problem-based Simulation." Each of these terms is discussed below.

A. Collaborative Learning

In traditional face-to-face PBL, students communicate with one another to resolve the problem presented in the case study. To do this, they may access a range of information sources such as photographs, web links, or videos, and work in a collaborative environment to discuss the case, their hypotheses, learning issues, and the results of their investigations to resolve the problem. Since collaborative work is integral to PBL, the ability to communicate as a group and refer to shared documents is important in helping students gain an understanding of the problem.

Because social interactions are recognized as being critical to the learning process [4] and meaningful learning is focused on negotiation and discourse [5], synchronous web conferencing may be a useful tool for teaching and learning within the PBL environment. Through synchronous web conferencing, learners and facilitators communicate with each other, or with other students, teachers, mentors, or experts—anyone involved in their teaching or learning.

B. Online

A number of asynchronous and synchronous text chat models have been used to support interaction in web-based PBL models, for example, Asynchronous Conferencing Tool (ACT) [6], CSC-PBL [7], and Project LIVE [8]. However, while conducting this literature review, we found no examples of distributed PBL supported by synchronous audio graphic web conferencing, and it appears that its use is unusual or virtually undocumented. Nevertheless, this technology shows promise because of its ability to support sessions that resemble traditional face-to-face PBL tutorials. For example, this type of technology supports conversations in real time; allows students to record and modify key points, learning issues, and hypotheses that can be seen by the entire

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group; and allows participants to view and share multimedia resources online. Participants can also share data in various forms, including text, audio, video and files. Some web conferencing tools use Voice Over Internet Protocol (VOIP) to enable voice communication and provide other features such as live text chat, shared Whiteboard space, live or pre-recorded video or audio, and application sharing – features that could prove useful in PBL tutorials.

C. *Multimedia Resources*

Educational multimedia uses a variety of different media such as text, graphics, animation, video, and sound, to present information. Multimedia software can be a powerful tool in enhancing learning by helping learners to construct their own knowledge [9].

In COMPS, multimedia resources are used to enhance the experience of PBL in several ways. Cases are presented through digital video, and multimedia resources are provided to help students resolve a case. As well, VOIP video conferencing allows participants to discuss a case in audio and text chat as well as to use a Whiteboard for activities such as recording notes and presenting graphics. Multimedia also addresses student's need for just-in-time information in PBL [10]. In addition, the ability to speed up, slow down or freeze physical occurrences allows learners the ability to see actions not normally available to human experience and provides increased understanding of processes beyond the initial experience [10].

Multimedia may also help to individualize the PBL process to suit learner differences. For example, medical students from different specialties might be able to consult a variety of resources relating to their individual specialties. Problem situations and resources might also vary according to learner's skills and abilities. Finally, multimedia may offer a venue for assessment and increase students' ability to control their own learning [10].

One of the difficulties with problem-based learning is that written and oral descriptions of problem situations may not resemble actual professional situations, so that knowledge transfer may not occur as intended. A more authentic and realistic case can be created using multimedia, which can require students to interpret a variety of visual, auditory, and nonverbal cues that prepare them to deal with real problems [11].

D. *Problem-based Learning*

PBL is defined as a method of instruction that uses patient problems as a context for developing students' problem-solving skills and their knowledge about basic and clinical sciences [12]. PBL has had a major impact on thinking and practice in medical education over the past few decades [13].

PBL is usually done in small groups of six to eight students with a faculty tutor who offers appropriate feedback and guidance [14]. The tutor reveals the case study to the students in stages; at each stage, group members discuss the issues of the case, what they know already, and what they need to find out in order to resolve the case. They then research the learning issues they have identified during the process of case study and present this new information to the group in order to move the case forward. Barrows [15] summarizes the steps of PBL as:

- Encountering the problem;
- Solving the problem using clinical reasoning skills;
- Identifying what information is needed through an interactive collaborative process and self-study; and
- Applying the new information to the problem, and summarizing what has been learned.

PBL's student-centered approach is also thought to develop competencies in critical reasoning, adapting to change, dealing with problems, developing self-directed learning skills [16], adapting a holistic approach, appreciating other points of view, and self-assessment [8]. PBL also seems to be a challenging, motivating and enjoyable way to learn [17]. Finally, PBL appears to lead to equivalent levels of performance on professional licensing exams, which tend to emphasize knowledge acquisition, application, and analysis [18,19].

Producing health care professionals who can collaborate in authentic problem-solving situations is an important goal of PBL. Most importantly, PBL simulates clinical medical practice and decision-making. At every stage of the medical diagnostic cycle, health professionals make decisions: what questions to ask, what information to consider, what treatment would be appropriate. Critical thinking and clinical reasoning are closely related. Both use reasoning to solve problems by relying on standards such as clarity, relevance, and accuracy [20]. Medical education often discusses teaching methods that encourage deep processing, a characteristic of critical thinking necessary to determine relevant clinical inferences from available data, recognize unstated assumptions by weighing evidence, and differentiating between weak and compelling arguments [21].

E. *Simulation*

A simulation has been described as an open-ended situation that evolves with interacting variables [22]. Simulation scenarios must be complex, take any of several directions, and provide players with the experience of functioning in authentic roles in which they can encounter the consequences of their actions. Participants learn when they act, see the consequence of their acts, and can choose either to continue or take new and different actions [23]. Participation and reflection allow them to learn from simulation.

Little work has been done on the effective design of online simulation environments; however, design criteria based on constructivist or situated learning frameworks can promote problem-solving skills in several ways [24]:

- Building around authentic problems;
- Producing authentic cognitive demands;
- Building scaffolding that supports a focused effort relevant to the learning goals;
- Promoting learning by coaching rather than directing or correcting performance;

- Supporting abstracting, synthesizing and extending learning through reflection;
- Creating engaging environments.

A number of factors are considered important in designing online role-play simulations, including providing guidelines, conducting a debriefing, creating an authentic environment, and implementing strategies for assessment and role assignment [25]. Providing learners with background material on the topic to be discussed, their roles, and the context helps them to reflect on what happens in the simulation. Simulations may also be more effective if they encourage students to focus on how they reach solutions rather than emphasizing active searching for answers. Vygotsky, for example, suggested that learners must be aware of their own cognitive processes so that they can apply these principles to other similar situations [26]. Asking learners to evaluate a simulation is also considered valuable for reflection, understanding and improving the simulation.

F. *Key Features of COMPS*

Our design for COMPS included the following key features (current and potential):

- Repository of narrative-based case studies that can be created by the instructors and accessed by the students;
- Asynchronous and synchronous tools where students collaborate with one another;
- Repository of multimedia resources that students can access as they work through a case study;
- Archive of group sessions that can be reviewed at a later date;
- Database that includes information on the client's present illness and medical history, lab test result, physician's orders, and medical management information;
- Virtual physical exam tools that students can use to conduct a physical exam on a specific part of the client's body, with exam results appearing as text, graphics, or sounds;
- Supporting lab results and medical records such as x-rays, MRIs, nuclear imaging, EKGs, PFTs and Echocardiograms, for each case study.

III. COMPSOFT: AN ADVANCED ENVIRONMENT FOR EDUCATIONAL SIMULATIONS

COMPSoft is an online, collaborative, team-based platform for delivering and solving simulated problem-based learning cases. It was developed to implement the model designed for COMPS described above. The COMPSoft environment has three spaces – the *Individual* space, *Team* space, and *Simulations* space. The Individual space, used to create and modify game and simulation sessions, is user-friendly, simple and flexible. The Team space groups players and supports text and audio communications before the start of a simulation. The Simulations space displays the simulation and supports text, audio and video communication during the course of a simulation exercise. It has several video screen display modes and allows up to 12 individual participants. In addition to providing the facilitator with teaching tools (PowerPoint and video viewer, application sharing, white board, and polling), the Simulations space supports student supervision with a control panel that directs participant communication. Finally, collaborative learning is enhanced through private audio and video breakout rooms where participants can work or communicate in parallel for a length of time that may or may not be predetermined by the tutor.

In addition to enabling interactive simulation play, the COMPSoft environment allows teachers and tutors increased use of collaborative work. Since it is low cost and readily accessible on the Internet, the environment can also be used to offer learners a new, dynamic, interactive way of studying or problem-solving in collaborative groups. It can be used by students at various locations to participate in educational simulations. Finally, the possibility of real-time communication helps unite geographically dispersed cultural communities, who can collaborate and learn together on a regional, national and international level.

A. *The Management space*

In COMPSoft, the Management space uses four menus with different functions: (1) The Create menu, for planning a game or simulation meeting, (2) the My Agenda menu, for participation in meetings to which the participant has been invited, (3) the My Profile menu, for management of personal profiles and options, and (4) the Join menu, which enables participation at meetings without invitations.

The Create menu is used to plan a meeting, setting the meeting title; agenda; choice of simulations from a repository; selection of participants) from a default list, personal contact list, or search tool); reservation of a time slot using a calendar, including a series of meetings extending over several weeks; password setup for private meetings; and sending invitations and reminder messages. The meeting coordinator or tutor can add complementary activities including Powerpoint multimedia presentations, office application sharing, drawing software, video viewing, white board annotations, and annotations on multimedia and video presentations.

The My Agenda menu shows to participants outstanding and accepted invitations to meetings, as well as meeting descriptions, including session title, date, duration, number of participants (2-25), session description, and proposed activities.

The My Profile menu manages participants' personal data (last and first name, address, choice of avatar or photo), archives (private and public chat contents and lists of games, simulations, and shared documents) for each meeting at which they have participated, personal contact lists to speed the choice of participants when calling a meeting, and personal simulation lists to help with activity selection during a meeting.

The Join menu allows all members of a given group, for example researchers, students and partners of a research network, to register for in a meeting when they have not received personal invitations. It allows meetings that are scheduled by members a group to be accessible to all.

B. *The Team space*

The Team space (also known as the Waiting Room), creates teams for a simulation, allowing input for the number of teams, team names, player groupings, and team leaders. After teams are created, players gather in the Waiting Room in audioconference mode. This space also allows the coordinator of a simulation to select a communication mode (audioconference or videoconference), to communicate in audio and text with individual participants, and to confirm that participants are present before activating the Simulations space.

C. *The Simulations space*

This space provides all the functions required to animate a simulation. It is divided into a Blue zone and a Green zone. The Blue zone, common to all users participating in a real time simulation, lets them view simulation instructions, answer questions, perform activities, display results (scores, successful or failed activities) and consult online help. The Green zone lets the coordinator (tutor) and each player talk to (voice) and see (video image) the other players of his team (in private communication), talk to the players of the other teams (with public communication) and write messages in a chat space (private or public). It also includes an adaptable control panel depending on the type of user: coordinator, co-coordinator, or participant.

IV. COMPSOFT WEB SERVICES ARCHITECTURE

COMPSoft is an extension of the ENJEUX-S platform for online delivery of multiplayer games [27]. ENJEUX-S and COMPSoft use Web Services development, based on a Service-Oriented Architecture (SOA) model that ensures efficient management and operation of games and Web simulations. Specific pedagogical and technological criteria motivated the choice of architecture and programming languages for the environment. After we discuss these choices, we describe the COMPSoft software model, development software, standards and programming languages, as well as the platform's language options.

A. *Development Criteria*

Our choice of development technologies was based on two sets of criteria. On the pedagogical level, the aim of the architecture was to be the least restrictive possible on the hardware side, while being as flexible as possible in the integration of the Internet Web services without requiring the downloading of components onto the user's workstation. We also needed to allow players general access from a simple URL as transparently as possible. On the simulation level, each supervisor (professor, simulation coordinator, or team leader) needed to be able to control the complexity of the simulation environment by using certain functions to adapt the simulation strategy or learning situation.

On the technical level several considerations dictated our choice: (1) the robustness of the broadcasting environment, (2) a good potential for the evolution of the technologies to be used, and (3) the capability of building components in the form of Web objects that could be easily modified and parameterized by the supervisor and the participants, in order to create environments adapted to their needs.

These considerations led the research team to adopt a 100% Web Services architecture (SOA: Service-Oriented Architecture). This architecture employs Flash technology for the video and audio components and Microsoft .Net technology for the application sharing components and the player management functions. The programming was done using Web 2.0 technology.

B. *The Software Model*

This model is based on SOA architecture with several layers: (1) a client layer (the user interface), including two kinds of components – real-time communication components and functional simulation components; (2) a network layer that transfers data between the user interface and servers; (3) a server layer with two types of servers – a communications server for the management and transmission of data flows in real time (video, audio, data) and a data server (Web Services) that executes database tasks or requests. The database contains information on players and simulations (profiles, player authentication, rules, etc.). Between the layers and servers, the XML/SOAP language permits encapsulation during information exchanges among distant and different systems when a data conversion into a universal language is required. Furthermore, this architectural model offers the possibility of calibrating and increasing the number of servers depending on demand, an essential property to avoid service bottlenecks and slowdowns.

C. *Technical Components*

Three development packages were used to build objects for the environment. .Net Web Services software was chosen to develop the Web services; this software had been previously used for a user interface for online games and was kept in order to maintain consistency among the environment's different interfaces. These Web services carry out all database requests as well as more complex operations, such as sending invitation emails or obtaining communications server connections.

Macromedia Flash was used due to its performance in real-time communications. A zone was set aside in the user interface to display the communication tools and another for the games and simulations designed for the Web. Tools interfacing with the database are available in the Adobe Flash Media Server 2 platform. The Flash Remoting function allows the interface to obtain from the database the required information to be displayed in the user interface and to manage the proper operation of the system.

Web Services and Flash were integrated in the ASP.Net environment to allow the most recent functions to be readily added.

To use COMPSoft, each player must have a computer with a Web camera, a headset and a high-speed Internet connection. Access is available through http://compsoft.savie.ca to registered members of SAVIE (Société pour l'apprentissage à vie). An organization must first register (at no cost) as a member of SAVIE at www.savie.ca, after which individuals in the organization can obtain free accounts. Because COMPSoft is designed to be used across Canada and internationally, it is initially available in English and French; we intend to translate it into other languages as needs arise and funding allows.

V. Conclusion

This paper has discussed the design of a conceptual model for online problem-based learning and the development of a software environment to implement the model. Early testing has been extremely promising, based on the extensive work done earlier to build the ENJEUX-S online game and collaboration platform [27]. Thanks to this work, it has been possible to extend this platform from online games to online simulations. Our first test of the PBL model with undergraduate students was successful in facilitating learners' critical thinking and was well-received by participants [28]. We are now planning to use COMPSoft in medical schools and to conduct comprehensive evaluation studies of both the model and the platform.

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The preferred spelling of the word "acknowledgment" in America is without an "e" after the "g". Avoid the stilted expression, "One of us (R.B.G.) thanks . . ." Instead, try "R.B.G. thanks". Put applicable sponsor acknowledgments here; DO NOT place them on the first page of your paper or as a footnote.

References

[1] J. McKimm, C. Jollie, and P. Cantillon, "ABC of learning and teaching: Web based learningm" Br Med J, vol. 326, pp. 870-873, April 19, 2003.

[2] S. B. Issenberg, W. C. Mcgaghie, E. R. Petrusa, E. R., Gordon, D. L., and R. J. Scalese, "Features and uses of high-fidelity medical simulations that lead to effective learning: A BEME systematic review," Med Teach, vol. 27, pp.10-28, January, 2005.

[3] C. Kamin, P. O'Sullivan, R. Deterding, and M. Younger, "A comparison of critical thinking in groups of third-year medical students in text, video, and virtual PBL case modalities," Acad Med, vol. 78 (2), pp. 212-218, February, 2003.

[4] J. Lave, Cognition in Practice: Mind, Mathematics, and Culture in Everyday Life. Cambridge: Cambridge University Press, 1988.

[5] E. A. Schegloff, "Conversation analysis and socially shared cognition," In Socially Shared Cognition, L. Resnick, I. Levine, and S. D. Bernard (Eds.), Washington, D. C.: American Psychological Association, 1991, pp. 150-172.

[6] T.M. Duffy, B. Dueber, and C. L. Hawley, "Critical thinking in a distributed environment: A pedagogical base for the design of conferencing systems," In Electronic Collaborators: Learner-centred Technologies for Literacy, Apprenticeship, and Discourse, C. J. Bonk and K. S. King (Eds.), Mahwah, NJ: Lawrence Erlbaum Associates, 1998, pp. 51-78.

[7] S. Naidu, and M. Oliver, "Computer-supported collaborative problem-based learning: An instructional design architecture for virtual learning in nursing education," J Dist Ed, 11, 1996, pp. 1-22.

[8] C. S. Kamin, R. D. Deterding, B. Wilson, M. Armacost, and T. Breedon, "The development of a collaborative distance learning program to facilitate pediatric problem-based learning," Med Educ Online [serial online], 1999, vol. 4, pp. 1-12. Available from http://www.Med-Ed-Online.org.

[9] R. E. Mayer, Multimedia Learning, Cambridge: Cambridge University Press, 2001.

[10] R.J. Spiro, and J. C. Jehng, "Cognitive flexibility and hypertext: Theory and technology for the nonlinear and multidimensional traversal of complex subject matter," In Cognition, Education, and Multimedia: Exploring Ideas in High Technology, D. Nix and R. Spiro (Eds.), Hillsdale, NJ: Lawrence Erlbaum Associates, 1990, pp. 163-205.

[11] B. Hoffman, and D. Ritchie, "Using multimedia to overcome the problems with problem-based learning," Inst Sci, vol. 25, March, 1997, pp. 97-115.

[12] M. A. Albanese, "Problem-based learning: A review of literature on its outcomes and implementation issues," Acad Med, vol. 68, January, 1993, pp. 52-81.

[13] J. A. Colliver, "Effectiveness of problem-based learning curricula: Research and theory," Acad Med, vol. 75, March, 2000, pp. 259-266.

[14] L. Wilkerson, and G. Feletti, Problem-based learning: One approach to increasing student participation," New Directions for Teaching and Learning, issue 37, Spring, 1989, pp. 51-60.

[15] H. S. Barrows, How to Design a Problem-based Curriculum for the Preclinical Years, New York: Springer Publishing Company, 1985.

[16] D. M. Kaufman, and K. V. Mann, "Comparing students' attitudes in problem-based and conventional curricula," Acad Med, vol. 71, October, 1996, pp. 1096-1099.

[17] D. M. Kaufman, and K. V. Mann, "Students' perceptions about their courses in problem-based-learning and conventional curricula," Acad Med (suppl), vol. 71, January, 1996, pp. S52-S54.

[18] D. M. Kaufman, and K. V. Mann, "Comparing achievement on the Medical Council of Canada qualifying examination part I of students in a conventional and problem-based learning curricula," Acad Med, vol. 73, November 1998, pp. 85-87.

[19] D. M. Kaufman, and K. V. Mann, "Achievement of students in a conventional and problem-based learning (PBL) curriculum," Adv Hlth Sci Ed, vol. 4, March, 1999, pp. 245-260.

[20] E. D. Gambrill, Critical Thinking in Clinical Practice: Improving the Quality of Judgments and Decisions, second ed., Hoboken, NJ: Wiley, 2006.

[21] M. A. Miller, "Outcomes evaluation: Measuring critical thinking," J Adv Nurs, vol. 17, December, 1992, pp. 1401-1407.

[22] M. Gredler, “Games and simulations and their relationship to learning,” In Handbook of Research on Educational Communications and Technology, second ed., D. H. Jonassen (Ed.), Mahwah, NJ: Lawrence Erlbaum Associates, 2004, pp.571-581.

[23] K. Lewin, Field Theory in Social Science: Selected Theoretical Papers, New York: Harper, 1951.

[24] C. L. Hawley, and T.M. Duffy, “Design model for learner-centred, computer-based simulations,” Proc: Selected Research and Development Presentations at the 1998 Convention of the Association for Educational Communications and Technology, pp. 159-166.

[25] M. A. Freeman, and J. M. Capper, “Exploiting the web for education: An anonymous, asynchronous role simulation,” Aus J Ed Tech, vol. 15, Autumn, 1999, pp. 95-116.

[26] L. S. Vygotsky, “Development of thinking and formation of concepts in adolescence,” In Child Psychology: The Collected Works of L. S. Vygotsky, R. W. Rieber (Ed.), New York: Plenum, 1998, pp. 29-81.

[27] L. Sauvé, L. Villardier, and W. Probst, “Online multiplayer games: A powerful tool for learning communication and teamwork,” in D. Kaufman and L. Sauvé (Eds.), Educational Gameplay and Simulation Environments: Case Studies and Lessons Learned, Hershey, PA: IGI Global, in press.

[28] R. Schell, and D. Kaufman, Collaborative Online Multimedia Problem-based Learning Simulation (COMPS), in D. Kaufman and L. Sauvé (Eds.), Educational Gameplay and Simulation Environments: Case Studies and Lessons Learned, Hershey, PA: IGI Global, in press.

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