PILOTING AN ONLINE NARRATIVE-DRIVEN CASE STUDY FOR PROBLEM-BASED LEARNING

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Abstract

Societal change has propelled the demand for distance education and it's associated benefits of learning anywhere/anytime. In medical education, this growth has been stimulated by factors such as the decentralization of health-care and a decrease in opportunities for face-to-face encounters with patients that traditionally provided students "hands-on" experience. To address this need, educators are searching for effective learning platforms and pedagogical models that enable students to collaborate, study, and work at a distance.

This thesis describes a pilot study that investigates the design, development, and implementation of an online problem-based learning (PBL) tutorial and the techniques used to measure the effectiveness of this model. The goal was to create a distributed PBL environment where learners could work together to resolve life-like problems and situations— a process believed to develop professional skills and critical thinking and other.

Keywords: problem-based learning; web-conferencing; distributed PBL; narrative; critical thinking; medical education

Subject Terms: Problem-based learning; Distance Education; Educational Technology

Dedication

To my parents, Carl Schell and Pat Schell

and

To my husband, Richard Poole, and my sons, Tyson and Jarrett Poole

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1 Thesis Overview

The concept for this thesis was sparked by work carried out by the Simulation and Advanced Gaming Environments (SAGE) for learning project (www.sageforlearning.ca), a national initiative exploring the potential of technology-based simulations and gaming for education. My part in this research focussed on the development of an online problem-based learning tutorial designed as a case-study simulation for teaching and learning for medical education.

Increasingly, students and instructors are searching for effective learning platforms and pedagogical models that enable them to collaborate, study, and work at a distance. In medical education, the Web is increasingly used both as a learning tool to support curriculum and as a means for delivering online programs for learning (McKimm, Jollie, & Cantillon, 2003). This growth has resulted in an interest in examining the Internet's potential to support both teaching and learning in a variety of fields.

My research study involved transferring a well-known medical education pedagogy, problem based learning (PBL) to an online environment. I was interested in more than simply transferring PBL to the web; I wanted to push the boundaries of PBL and transform it into a kind of simulation that would allow medical students to practice their skills together in a risk-free setting. To this end, the pilot study was designed to create and test an online case-based tutorial in which learners could work together in a distributed environment to resolve real-life problems and situations; a process thought to be essential for professional development (Albanese, 1993). This

led me to ask: can an online distributed environment support a collaborative problem-solving approach in health education?

To begin this investigation, I selected problem-based learning as a pedagogical framework because its historical relationship with medical education. I then searched for software that could 1) serve as a repository for multimedia resources for the case and 2) provide a communication tool to support the collaborative nature of problem-based learning. My goal was to move beyond the traditional text-based medical case study by creating a visual story of the patient and his illness. By weaving a story into my case study, it seemed probable students would understand, remember and extrapolate from this experience to other situations (Polkinghorne, 1988; Schank & Cleary, 1995) they might face as healthcare professionals. I also wanted to explore the use of multimedia to support learning (Mayer, 2001) by developing multimedia resources students could access as they worked through the tutorial.

This pilot study included two small groups of health-care students. Despite the small number of participants, I believe I have collected information that could inform the design of future online tutorials for nurse practitioners, nurses, and medical students. I also hope the data will help other researchers to create the types of simulations in which students can see the consequences of their actions. For instance, administer a treatment and see the patient improve or become more ill as a result.

My evaluation of the tutorial includes the participants' own perceptions of the tutorial and an analysis of the level of critical thinking that took place in the tutorial. The student assessment describes their opinion of the various elements of the tutorial, while the analysis of the dialogue discusses the student's level of critical thinking which is considered one of the more important attributes of problem-based learning.

In summary, this thesis describes how the tutorial was developed and implemented online and offers an evaluation of the tutorial I carried out in this pilot study.

Chapter 2 provides a literature review that examines key concepts associated with this thesis. Specifically, I discuss the characteristics of problem-based learning in medical education and changes in the health-care system that have stimulated a need for medical education online. I also talk about the importance of collaboration, narrative, and multimedia to my design and how I might transform online PBL into a simulation. I also discuss the relationship between critical thinking and PBL.

In Chapter 3, I identify the design requirements using a medical education methodology that includes an audience and needs assessment, an overview of overall objectives, pedagogical strategies, and how I might integrate my ideas about narrative, multimedia, and collaboration into my design.

Chapter 4 describes how I recruited participants for this case study, and my data collection tools and methods. I present my results and discuss their significance, again focusing on specific design features such as narrative, multimedia, and Voice over Internet Protocol (VoIP) web conferencing as a method for supporting online collaboration. I also detail the methodology I used to measure critical thinking in the tutorial and the results of this analysis. Finally, I discuss the study results and the limitations of the study.

Chapter 5 describes the contributions of this study and opportunities for future research.

2 Literature Review

This thesis reports on a study carried out to inform the design of a collaborative online multimedia Problem-based Learning (PBL) simulation. My aim was to create a model that combined engagement with one of the strongest features of face-to-face learning; social interaction. My objective was to develop a model that:

- Built on a framework of PBL theory and practice
- Incorporated the benefits of multimedia
- Provided a strong narrative line to create a memorable context for learning and application of skills
- Supported collaborative learning
- Moved towards an online simulation to create an authentic environment for learning in a risk free setting

In this literature review, I examined the characteristics of problem-based learning in medical education, and reviewed the changes in the health-care system that has created a need for online medical education. I also discussed the importance of collaboration, narrative, and multimedia, to learning, especially as they relate to medical education.

As I hope to create a basic type of simulation for this pilot study and later progress to more complicated versions, I also included definitions of simulations and guidelines for simulation design.

2.1 Problem-Based Learning (PBL) in Medical Education

PBL has been used in medical education since the mid 60's when it was developed at McMaster University in Hamilton, Ontario and spread to about 60 medical universities world-wide (Norman & Schmidt, 1992). PBL has had a major impact on thinking and practice in medical education for the past 30 or 40 years (J. A. Colliver, 2000b). PBL is defined as a method of instruction that uses patient problems as a context for developing students' problem-solving skills, and gaining knowledge about basic and clinical sciences (Albanese, 1993). A major goal of the PBL approach in the context of health sciences is to produce health care professionals who can collaborate in real-world problem-solving situations. Case studies provide the structure to problem-based learning and offer an ideal practice environment for social negotiation and reflection - two of the activities that promote high-quality thinking (Orrill, 2002).

PBL is usually carried out in small groups of 6 to 8 students with a faculty tutor who offers appropriate feedback and guidance (Wilkerson & Feletti, 1989). The facilitator reveals the case study to the students in stages and at each stage, students discuss the issues of the case, what they know already, and what they need to find out in order to resolve the case. The students then research the learning issues they identified in the process of case study and present this new information to the group in order to move the case forward. In summary, the steps of PBL include (Barrows, 1985):

- Encountering the problem
- Solving the problem using clinical reasoning skills
- Identifying what information is needed through an interactive collaborative process and self-study

- Applying the new information to the problem, and summarizing what has been learned.

The process may conclude with an evaluation of the session and the resources used.

PBL's student-centred approach is thought to have a number of advantages, for example, developing competencies in adapting to change, dealing with problems, reasoning critically, developing self-directed learning skills (Barrows, 1984), adapting a holistic approach, appreciating other points of view, working collaboratively, and self-assessment (Kamin, Deterding, Wilson, Armacost, & Breedon, 2004). PBL also seems like a more challenging, motivating and enjoyable way to learn and the students appear to agree (Kaufman & Mann, 1997).

However, the educational superiority of PBL in relation to the standard approach has been less clear (Colliver, 2000). One of the reasons for this, may be the difficulty of measuring the exact relationship between PBL and the skills it's alleged to promote within the context of professional practice (Kaufman, 2000). However, because of the many advantages of PBL and its widespread use in medical education, I have selected PBL as the pedagogical framework for this research study.

2.2 Critical Thinking and PBL

Decision-making is at the heart of clinical medical practice. 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 (Gambrill, 2006). Medical education often discusses teaching methods that encourage deep

processing, a characteristic of critical thinking necessary to derive clinical inferences from available data, recognize unstated assumptions by weighing evidence, and distinguishing between weak and strong arguments (Miller, 1992).

In my search for instruments that would help me evaluate my online PBL tutorial, I turned to studies that examined the relationship between critical thinking and problem based learning. First, I reviewed the concept of critical thinking in discourse by looking at studies by influential theorists. One study (Garrison, 1991) integrated earlier work (Dewey, 1910; Brookfield, 1987) to create five stages of critical thinking: problem identification, problem definition, exploration, applicability, and integration. This model was further developed by applying codes to analyze discourse (Newman, 1995). These codes contained in-depth and surface descriptors, or deep or shallow indicators, at each stage of Garrison's model.

These codes were later refined to measure critical thinking in PBL in medical education as a way to compare the differences between text and video modalities (Kamin, O'Sullivan, Deterding, & Younger, 2003). In this study, four groups used a face-to-face with text case, four groups used a face-to-face with video case, and five groups worked virtually with digital video. The virtual group participated in web-based asynchronous discussions but posted their facts about the case and their hypothesis before reading what other students wrote. Researchers discovered significant differences at each stage with the virtual groups showing the highest critical thinking ratio while the critical thinking ratio of the video groups was higher than the text groups except in the problem identification stage. Both the video groups recorded a high level of rapport building with the video groups producing more explanations and commitment than the text group.

As Kamin's study included video case study as the focus for problem based learning, I adapted and applied Kamin's coding system to my analysis of PBL tutorial transcripts. I also hoped I could use these codes to compare different modalities such as video and text case studies in the future tutorials. Further detail on the development and application of these codes and the results of my analysis can be found in Chapter 4.

2.3 Migrating PBL to the Web for Medical Education

Medical educators are reassessing traditional venues and methods of PBL because of widespread changes in the medical health system, combined with improvements in technology and an increasing demand for distance education (Kamin et al., 2004). Two changes in health care systems in particular have increased the need for online training: reduced time with patients and a trend towards decentralization (Kamin et al.).

Patients are spending much less time in the hospital or in the doctor's office, reducing the opportunities for face-to-face encounters that traditionally provided "on the job" experience (Kamin et al.). The decentralization of medical training has also precipitated a trend away from large single training hospitals to many smaller regional training centres, making it more of a challenge to standardize the medical education of students across centres. Students are likely to see different types of clinical problems depending on where they are studying and when. For example, when certain significant diseases appear, such as whooping cough, students may be in a different phase of their clinical rotation or working in a region where there are no cases of whooping cough.

The Web has the potential to offer an environment that can support standardized medical education to students dispersed in time or place, and in the process, lessen the demands on real patients as subjects for student practice and observation. It has been shown that technology can provide a useful platform for students to work together to solve problems (Taradi, Taradi, Kresimir, & Pokrajac, 2005) through the integration of collaborative learning models such as computer-supported problem-based learning and distributed problem-based learning (Naidu, 2003).

As societal change propels the demand for distance education and its benefits of learning anywhere/anytime (Bates, 2000) the teacher's role has evolved from deliverer of subject-matter content to facilitator or moderator of learning, within a student focussed, constructivist setting (Naidu, 2003). Both computer supported problem-based learning (Koschmann, 1996) and distributed problem-based learning (Koschmann, 2002) support this new model. In this study, I have selected distributed PBL for medical education primarily because of its ability to support the collaborative nature of PBL.

While it is important to consider the pedagogical framework and learning outcomes in a distributed learning model (Orrill, 2002), it is also important to consider the communication tools needed to support the thinking and interaction, as most of the learning experience in PBL depends on social negotiation (Savery & Duffy, 1995). However, there have been few communication tools that support a variety of interactions between learners in an inquiry-based situations and most of these have been for non-adult learners (Orrill, 2002). A number of asynchronous and synchronous text chat have been used to support interaction in web-based PBL models, for

example, Asynchronous Conferencing Tool (ACT) (Duffy, Dueber, & Hawley, 1998), CSC-PBL (Naidu & Oliver, 1996) and Project LIVE (Kamin et al., 2004).

However, while conducting this literature review, I found no examples of distributed PBL supported by synchronous audio graphic web conferencing. It appears the use of this tool 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 conversation in real time, and allows students to record and modify key points, learning issues, and hypotheses that can be seen by the entire group. As well, it allows participants to view and share multimedia resources available to them online.

2.4 Collaboration in PBL

In traditional face-to-face PBL, students communicate with one another to resolve the problem presented in the case study. To do this, students 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. As 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 (Lave, 1988) and meaningful learning is focused on negotiation and discourse (Schegloff, 1991), 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—or anyone involved in their teaching or learning. Participants can

also share data such as 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 which could prove useful in PBL tutorials.

Network technology that includes audio web conferencing can help students develop their social, reading, writing, communication, and collaboration skills necessary for participating in online discussions (Jonassen & Jonassen, 2000) and by participating in these discussions, students are exposed to a greater diversity of perspectives —objectives compatible with the PBL experience. Learning can become a process of enculturation into the community of learners or practitioners, in this case, into the community of health care practitioners (Wenger, McDermott, & Snyder, 2002)

Synchronous web-based communication may be suitable for supporting PBL because it has shown the ability to support meaningful learning that engages, and enhances multiple forms of thinking (Jonassen & Jonassen, 2000). Jonassen identifies synchronous communication as a "mind tool" which can foster meaningful learning that is active, constructive, reflective, authentic and cooperative; characteristics, which also appear to be compatible with PBL. Furthermore, since social negotiation is at the center of PBL (Orrill, 2002), synchronous Web conferencing may prove to be a useful tool for supporting communication and collaboration in PBL.

Jonassen's recommendations for using synchronous mindtools effectively for learning and teaching (Jonassen & Jonassen, 2000) could work hand-in-hand with PBL. He suggests incorporating a purpose or focus for the conversation such as resolving a problem. He also suggests activities that involve creating an electronic artifact in a shared workspace such as a presentation, report, or solution to focus the learning process and represent the outcome of intellectual activity. In web conferencing,

students have the opportunity to discuss the problems presented in the case study and create collaborative artifacts when they post, modify, and prioritize their hypotheses on the whiteboard. Supplying a context for learning within a virtual community environment can facilitate more meaningful learning (Farquhar, 1996), a requirement that fits the PBL case presentation I use in this study.

Under the right circumstances, I believe synchronous communication tools can support collaborative learning within the PBL context. Chapter 3 describes in more detail how Voice Over Internet Protocol (VOIP) audio graphic web conferencing was integrated into my model.

2.5 Integrating Narrative in Medical Case Studies

Traditional PBL relies on text cases that feature a short description of a patient and some details about the patient's medical problem. These case studies are designed to encourage students to explore a number of possible options and act as a stimulus for learning. The case is disclosed in stages, and at each stage, students identify information they can apply to the case, as well identify what they need to know in order to move forward towards a resolution (Barrrows & Tamblyn, 1980).

Case studies are designed to allow students to practice skills within the context of realistic medical problems and extrapolate to future similar situations. Short cases can allow students to cover a variety of topics quickly and focus on clinical information, however, short paper cases may adversely affect student's perceptions of real patients and their problems. These short paper cases can include a type of language, structure, voice, and perspective that can shape a student's attitude, create situations that depersonalize the patient and the doctor, decontextualize the patient from their overall situation, and enhance a tendency towards detachment

towards the patient (Kenny & Beagan, 2004). Often case studies are written from the doctor's viewpoint and start from the time of the medical encounter; while from the patient's perspective; the timeline may have started much earlier and involved a cast of characters including family and friends. In her paper on the relationship between narrative and case studies, Kenny, et al. suggests this "just the facts" approach may result in a worldview considered natural and normal by a doctor but somewhat divorced from the patient's experience.

To better understand the narrative structure and content of text-based PBL medical case studies, Kenny and Beagan (2004) analyzed a number of case studies by posing the questions adapted in the following table.

Table 1 Summary of Questions in Kenny and Beagan (2004) Analysis of PBL Cases

Narrative Component	Questions
Language	Is the case in patient's language or is it presented in medical terminology?
Audience	Who is the case written for?
Point of view	Does the narrative of the case unfold from the patient's or doctor's point of view?
Time Frame	What is the time frame of the case and what information is there on the patient's previous health and how much information is there about the patient's experience with the symptoms.
Crisis Point	Is there a resolution to the case? Are you told what happens to the patient after the diagnosis? Is there a sense of villain or hero in the story?
Dialogue	Is there any dialogue in the case study? Is the patient quoted? Is there any commentary on the patient's account of this illness?
Character Development	To what extent, are other characters present other than the doctor and the patient? (Family, loved ones) How much do we get to know the patient or others important to his life? Do you get to know their emotions?

I later developed my text-based case study using these questions as stepping stones to create a narrative-driven script for the videos I use for the case study presentation. The next section describes why narrative can be useful in medical problem-based case studies.

2.5.1 Why Use Narrative in Medical PBL Case Studies?

Stories are thought to be central to the way humans make sense of their world (Polkinghorne, 1988) and help us frame our experience, remember it and extrapolate to cope with new situations (Schank & Cleary, 1995). They aid us in constructing

persuasive arguments as well as help us understand, explain and interpret (Bruner, 1990).

Although a story-based approach was once resisted in professional contexts as being unscientific, stories are almost always used to solve problems (Jonassen & Hernandez-Serrano, 2002). Polkinghorne (1988) found that professionals primarily prefer to work with narrative knowledge when asked to provide explanations. Other research found stories to be critical in initiating new members into a practice, (Lave & Wenger, 1991), a concept that ties into the socializing of medical students through case study narratives described by Kenny (2004).

In the medical profession, case studies are important because these are narratives doctors use to communicate their understanding of patients and their medical problems to one another throughout their training and professional lives (Donnelly, 1997). Narrative offers the opportunity to add and structure important elements of reality not included in a purely scientific mode of thinking such as descriptions of what it is like for the patient to be sick or disabled— information that is at the heart of good medical care (Donnelly, 1988).

The studies discussed here show that in professional and everyday contexts, narrative is the primary medium for problem solving. Because of this, it seems feasible that case studies built around a story or narrative could facilitate the development of problem-solving ability over a range of problems and situations not possible in a short text-based case study. "Thick" (richly detailed) cases portray patients as multi-dimensional persons with hopes, fears and beliefs, with deep connections to family and loved ones (Hunter, 1991). These cases are generally richly detailed, messy and comprehensive. Next, I discuss the advantages of producing narrative-driven thick

cases in video, and how this format can encourage a more holistic approach to patient care.

2.5.2 Developing PBL Case Studies in Video

Cases that use video rather than text provide information to students in a more realistic format, and supply context to students (Kamin et al., 2003). Students can observe cues from the patient, learn from the actions of the doctor, and study the patient-doctor interactions. In a visual society, a video of the initial encounter between the doctor and patient may also be extremely effective (Kenny & Beagan, 2004). A video case offers more lifelike details, such as information about the patient's personality, feelings about their illness and behaviour (VanLeit B, 1995). Video can help students explore the patient's perspective and develop reasoning skills.

For these reasons, I decided to develop the text-based case into a video presentation, a process described in more detail in Chapter 3.

2.6 Multimedia in PBL

This case study looks at how did the multimedia help or hinder learners as they worked through a case study. In my study, I use multimedia to enhance the experience of PBL in several ways. I use digital video to present the case and provide multimedia resources to help students resolve the case. As well, VOIP video conferencing allows participants to discuss the case in audio and text chat as well as use a Whiteboard for activities such as recording notes and presenting graphics.

Multimedia software can be a powerful tool in enhancing learning by helping learners to create a deeper understanding than from words or pictures alone (Mayer, 2001). According to Mayer, for meaningful learning to occur in a multimedia

environment, the learner must engage in five cognitive processes such as selecting relevant words, selecting relevant images, organizing selected words, organizing selected images, and integrating word and image based representations. Learning happens when the learner applies processes intended to make sense of the material. The active cognitive processing is a process of model building as the learner constructs a coherent mental representation. Mayer concludes that this process has important implications for multimedia design; the material should have a coherent design that offers the learner guidance on how to build a mental model of the concept. In this way, multimedia design can assist learners in their model building efforts.

Dual-coding theory also implies that the use of visualization enhances learning and recall, in part because images and words are processed in different parts of the brain (Paivio, 1991). Dual-coding theory leads us to anticipate differences in outcomes between a digital video case and a text case.

People remember images better than words because they are more likely to code them in a way that creates two representations rather than one (Bagui, 1998). This may help reduce cognitive load in working memory by aiding learners with weaker backgrounds in the subject matter through visualization of concepts (1998). Visual images may help orient learners quickly as well as make learning more interesting and possibly more memorable (Jha & Duffy, 2002).

Previous research has suggested both advantages and disadvantages of multimedia in PBL. Face-to-face PBL groups using a computer-based video case performed better on a written examination than PBL groups using a text case (Bowdish, Chauvin, Kreisman, & Britt, 2001). Another study compared critical thinking in groups receiving the same case with the same facilitator in one of three formats: (1) face-to-face with a text/paper case, (2) face-to-face with a digital video case, and (3)

"virtual" with a digital video case (Project L.I.V.E.). Researchers found that the text case group identified information more quickly while the video group struggles to articulate what they saw. Because of this, the video groups were lower in critical thinking in some stages but displayed higher levels in others, such as problem description, applicability, and integration (Kamin et al., 2003).

In a study on teacher education and PBL, an interactive multimedia package was developed to help teachers learn how to integrate technology into their teaching. This model incorporated examples of work and reflections of experienced teachers designed to engage users with authentic problems of professional practice, which the participants found the model useful and relevant to their professional lives. (Albion & Gibson, 2000). Researchers concluded multimedia could provide a diversity of perspectives in the form of a large collection of resources, but this diversity may result in students overlooking important information.

One of the difficulties with problem-based learning is that written and oral descriptions of problem situations may not resemble those students may encounter in actual professional situations and as a result knowledge transfer may not occur. The addition of multimedia can create a more complex authentic case that provides students the opportunity to interpret a variety of visual, auditory, and nonverbal cues preparing them to deal with a variety of real problems (Hoffman & Ritchie, 1997).

These studies have important implications for this model because we are interested in the student perceptions of how well the multimedia helped or hindered them as they worked through the tutorial and the level of critical thinking that took place as a student progress through the video case study.

2.7 Transforming Distributed PBL into a Simulation

I would like to touch briefly on the topic of simulations, as I believe my model meets some of the criteria for a basic role-playing simulation and I intend to use the results of this pilot study to build simulations in which students can take actions and see the consequences of their decisions. For these reasons, the following section discusses the characteristics of simulations and the best way to design and implement them. This research also helped me to identify and understand some of the problems I encountered in the pilot study as well as some solutions for addressing them.

There are strong similarities among experiential learning, role-play, and simulations. Early references to role-play and simulations can be traced to the work of Kurt Lewin, who argued effective learning takes place when there is interaction between the learner and the environment and an opportunity exists for social interaction that facilitate student's reflections on the experiences in that environment (Lewin, 1951). Learning occurs when an action takes place and the participant can see the consequence of that action and can chose either to continue or take a new and different action. Participation and reflection allows us to learn from the simulation.

David Kolb, whose work in experiential learning began with experiments in games, simulations and case studies, described simulations and games as presenting learners with a broad experiential learning environment that offers learners support for active experimentation (Kolb, 1984). Learning is a four-step process: 1) watching, 2) thinking, 2) feeling (emotion) and 4) doing. Each experience allows us to reflect and generalize to form new principles to guide us in future situations. Active participation allows us to test these theories.

Studies in educational technology show that learning is enhanced in an environment that simulates the actual one in which the activity takes place, for

example, work completed on goal based scenarios (GBS) and story based curriculum (Schank & Cleary, 1995; Schank, 2002). This research supports the idea that role-playing in an authentic context, could prove productive for practicing skills in a memorable context where they can be recalled and transferred to the workplace.

Schank suggests learning is only successful when students discover and practice strategies in an environment that approximates the one they face in real life. Learning in this way allows knowledge to reside in our memories in a place where it can be easily retrieved. By creating learning situations that allow us to file our experiences in our memories in a meaningful way, we can draw on this knowledge later or generalize from it to cope with new situations.

Schank's work suggests simulations are more successful when they are oriented to the learner's goals and real world context. Learning arises when scenarios are constructed to incorporate the concept of expectation failure so that new knowledge is constantly being rebuilt in the face of new information.

Schank developed new educational software to incorporate his theories and integrated his concept of goal-based scenarios that offered the user a variety of multimedia resources. Based on the belief that story is the essential building block of how one learns and remembers, a strong narrative line was considered an essential component to the structure of goal-based scenarios (Schank, 2002)

Other researchers echo Shank's words when they talk about the value experience and stories play in the construction of memory and reasoning, and the ways they help us to understand and operate in the world (Ip & Naidu, 2001). Although role-play is commonly used as a strategy in conventional educational settings, it is less widely used in distributed online learning environments. However, online role-playing

simulations can be used to create effective learning design, because of the power of the first person experience and the ability of stories to be used as learning resources. These studies claim that the essential ingredients of the online role-playing simulation are: dynamic goal-based learning, a role-play simulation, and online communication and collaboration.

I also considered the literature describing effective simulation design when building my PBL tutorial platform because I wanted to create an authentic environment where students could practice medical skills and thinking as a health professional would in a similar situation. Although there has been little work done on effective design of online simulation environments (Hawley & Duffy, 1998), design criteria based on a constructivist or situated framework suggests problem-solving skills can be promoted in several ways (Hawley, 1998) such as:

- Building around authentic problems.
- Producing authentic cognitive demands in learning.
- Building scaffolding that supports a focussed effort relevant to the learning goals.
- Promoting learning by coaching rather than directing or correcting performance.
- Supporting abstracting, synthesizing and extending the learning through reflection.
- Creating engaging environments.

Providing guidelines, conducting a debriefing, creating an authentic environment, and implementing a strategy for assessment and role assignment are all

considered important criteria when creating role playing simulations (Freeman & Capper, 1999). Providing students with background material on the topic to be discussed, their role, and the context, helps them to reflect on what happens in the simulation and associate it with the problem being simulated. Asking the students to evaluate the simulation is also considered valuable for reflection, understanding and improving a simulation.

Students are more able to apply their knowledge, form appropriate hypotheses, and take advantage of the resources available to them when they have received information about the topic before participating in the simulation, for example, background information received in lectures. Prior instruction should model and teach the expected research skills such as planning, testing, collecting data, and evaluating (Gredler, 2004). In this way, students can develop the competencies to create conceptual models of an element of a domain, and test them in a systematic way. Simulations may also be more effective if they encourage students to focus on how they reached solutions rather than foster an active search for the answers. for example, that learners must be aware of their own cognitive processes so that they can apply these principles to other similar situations (Vygotsky, 1998).

There seem to be many good reasons to use simulations for learning and teaching that offer opportunities that may be impossible to achieve in other more conventional settings. This thesis describes an attempt to employ some of these techniques to build a simulation that allows students to practice in an authentic environment in an online collaborative PBL setting. The next chapter describes the design requirements and how they were implemented to support such a model.

3 Tutorial Design and Development

This section describes the design process for my collaborative online multimedia narrative-driven tutorial. I created a design document that served as a blueprint for a model and outlined requirements and how they would be addressed. By running a pilot study on this platform, I tested this model before implementing it with other students in an existing medical curriculum.

I referred two methodologies when designing my prototype: an instructional design methodology oriented to developing courses for medical education, and a guide for developing web-based learning. The first methodology includes a six-step approach to curriculum development for medical education (Kern, Thomas, Howard, & Bass, 1998):

1. Problem identification and general needs assessments
2. Profile of targeted learners
3. Goals and objectives
    - overall objective
    - objectives from the learners perspective
    - from the program perspective
4. Educational strategies and learning outcomes
5. Implementation

I also considered the key steps in developing an effective educational web site (Cook & Dupras, 2004):

1. Perform a needs analysis and specify goals and objectives.
2. Determine mechanical resources and needs.
3. Evaluate pre-existing software and use it if it meets your needs.
4. Secure commitments from all participants, identify, and address potential barriers to implementation.
5. Develop content in coordination with the web site design:
    - Appropriately use multimedia hyperlinks and online communication.
    - Prepare a timeline.
6. Encourage active learning—self-assessment, reflection, self-directed learning, problem based learning, learner interaction, and feedback.
7. Facilitate and plan to encourage use by the learners:
    - make the web site accessible and user-friendly
    - provide time for learning
    - motivate and remind learners
8. Evaluate both learners and the course.
9. Pilot the web site for full implementation.
10. Plan to monitor online communication and maintain a site for resolving technical problems, and updating content.

The following sections describe the steps I took in designing the platform and developing the tutorial using the two previous methodologies as guidelines.

3.1 Problem Identification and General Needs Assessment

The first step in this process is to define the need for a new approach to medical education in general and problem based learning specifically. The need for online case studies in medical education is summarized in the literature review:

3.2 Profile of Learners

Although my future goal is to create a online tutorial platform for medical or nursing students, there are no medical or nursing schools at Simon Fraser University. I recruited undergraduate Kinesiology students because they are studying to be health professionals and had some background in anatomy and patient assessment. The student participants:

- Were in their mid-twenties
- Had computer experience and use the Internet for research
- Were not familiar with PBL process
- Had some experience with the medical diagnoses process; interview, exam, history but in a Kinesiology context

More information about the participants I recruited can be found in Chapter 4.1 Participant Recruitment for the Case Study.

3.3 Tutorial Objectives

The overall objective of the case study tutorial was to learn to how to use clinical reasoning to diagnose and to learn how to form a treatment management plan.

This objective can be described from two perspectives: more specifically from the learner's and more widely from the program's perspective. Objectives from the learner's perspective are:

- To improve learner's clinical reasoning skills
- To improve the learner's ability to collect information that provides a more in-depth, holistic profile of the patient
- To practice skills such as history taking, exam, record keeping, interpersonal communications, and other procedures

When the tutorial is part of an existing medical or nursing program, the objectives will also be defined in terms of pre-established curriculum outcomes and knowledge. In this context competencies could be measured before and after the tutorial experience. However, since this tutorial was not designed for the students recruited for the pilot study, this type of approach was not considered.

At this point, we are considering the study to be a proof of concept of tutorial design and implementation so we can move to the next stage, implementing the tutorial within a medical curriculum.

3.4 Tutorial Implementation

This section describes how the tutorial was designed and implemented online to replicate the small group face-to-face PBL process. This tutorial was implemented in a computer-mediated environment using WebCT, a course management tool and eLive Elluminate, a Voice Over Internet Protocol web conferencing program. eLive was used as a tool for collaborative real time audio discussions, tutorial activities, and presenting the case study videos, while WebCT provided a repository for course

materials and communication tool. Students accessed the tutorial and eLive from a WebCT web site.

The PBL tutorial process was carried out as follows. The facilitator introduced the students to the tutorial environment through a practice session by showing a short demonstration of the site's features and giving the students the opportunity to try the features themselves. Two sessions of 2.5 hours followed, with self-directed work for students to complete in between sessions using multi media resources stored in WebCT. The group reconvened in eLive for the final 2 hours to present information from their research and to discuss their differential diagnosis and treatment plan.

As the case study proceeded through the medical diagnosis cycle of diagnosis, treatment and management, students had the opportunity to practice the type of decision making processes health professionals use when interviewing patients and diagnosing medical problems.

As in most PBL tutorials, the facilitator released case information incrementally, but in this tutorial, the case study was revealed in a series of videos rather than text. Before each video, the facilitator asked the students what they had learned about the patient and what they would do next. At certain points, the students were asked what they knew so far, what they needed to know (called learning issues) to provide a tentative hypothesis about Sean's illness. The student scribe wrote the learning issues and potential hypotheses on the whiteboard, which students modified and prioritized throughout the tutorial. After the students had seen and discussed all the videos, the group broke for two hours in order to research their learning issues independently. At that point, they left the web conference session and returned to WebCT to access the multimedia resources available for their research.

Following this break, students and facilitator reconvened in the Web conference to present the information they discovered during their research. Once the presentations were complete, the students analyzed information they have collected and suggested the most probable reason for the patient's illness called the differential diagnosis. They concluded the session by providing a treatment management plan and evaluating the tutorial.

The next section describes how a narrative-driven video case study was developed for this tutorial.

3.5 Developing a Narrative-Driven Video Case Study

As described in the literature review, traditional PBL is oriented to short text-based case studies that include a brief description of a patient and some details of the patient's medical problem. The case is disclosed in stages, and at each stage, students identify information they can apply to the case, as well identify what they need to know in order to move forward towards a resolution (Barrrows & Tamblyn, 1980). Although students can cover a variety of topics quickly and find clinical information more readily in text cases, they may also affect the student's perspective on a problem in a way that is considered natural and normal by other medical professionals but rather divorced from the patient's experience (Donnelly, 1997).

Here is a sample of my original short text-based medical case study. It presents a minimum of pertinent facts with no obvious solution yet offers a number of avenues students can explore during the PBL process.

Sore Throat

18-year-old came into the office with complaint of sore throat, running a fever, and with pain of the neck for the past five days. He has some difficulty swallowing, and looked tired. He has dry coughing, had no chest pain, and mild shortness of breath. His appetite was down for a few days now and had been sleeping quite a lot. He was usually in good health and seldom got sick. No illness like diabetes, asthma etc. His girlfriend had somewhat similar symptoms a few weeks ago, but got better spontaneously without seeking any medical advice.

On examination patient noted generally unwell, malaise, and skin felt warm on touch, with perspiration. There was marked white exudates on the pharynx bilaterally and tender swollen glands on both sides of the neck, involving both anterior and posterior cervical lymph nodes. His BP was normal of 120/80 with a pulse of around 90 per minute. Chest was clear and heart sounds normal. On palpation, tip of the spleen could be felt, non-tender, no liver enlargement. Bowel sounds normal. Neurological testing not done.

A rapid slide test for heterophile antibody was done in the office and was negative. A throat swab was also done in patient with into laboratory for blood work, which included CBC, lytes, BUN, creatine, random blood sugar, EBV, mono screening, urinalysis R&M, C&S. (Chest x-ray?)

Patient was then sent home with no prescription, told to have bed rest, lots of fluids, and to take Tylenol for pain and fever, and to return in a day or two for lab results and follow-up.

What are the differential diagnoses?

Treatment Plan?

Follow-up?

Using Kenny's criteria to analyze this text-based medical case (2004), I determined the case was brief and objective and included a list of relevant medical facts. The language was passive; for example, "the tip of spleen could be felt", and includes medical terminology not easily recognized by the patient, for instance, the term, *exudate on the pharynx bilaterally.* The patient's past medical history described clinically relevant facts and the narrative appeared to be a discreet medical event occurring in the present. The text briefly mentioned that the patient's girlfriend had a similar illness a few weeks earlier. There was no dialogue or commentary on the patient's account of his illness. We simply know he is 18 years old with a variety of medical symptoms and a concise medical history. In short, there is little sense of who the patient is and what his situation might be. In fact, we don't even know the patient's first name.

This original text case was expanded into a narrative integrating the principles outlined by Kenny's study (2004). Action begins before the patient, Sean, meets Dr Pearson, as a way to extend the timeline into the patient's personal life and to show aspects of Sean's character, situation, and his emotional state. The opening scene also functioned as a dramatic device to draw students into the story. Here's an excerpt from Scene 1.

SCENE ONE

FADE IN:

INTERIOR-NIGHT-TWO SHOT

As the scene opens we see a young man, eighteen years old, seated on a couch with his partner, a young woman of about the same age. Their

names are Sean and Kelly. They sit in Sean's parent's family room. Sean is visibly ill. He speaks in a voice barely above a whisper and appears pale. Their conversation is punctuated by Sean's dry cough and his near constant touching of his throat. While Kelly appears calm but concerned, Sean becomes agitated as he speaks his lines.

KELLY

No way man.

SEAN

Yes way.

KELLY

I wouldn't do that.

SEAN

Ya, ya would

KELLY

No I wouldn't

SEAN

No it's too true girly girl.

KELLY

I did not sleep with Isaac.

SEAN

Give me a break...and now I got this throat thing goin' on.

Ya know where this leaves me eh?

KELLY

No. Where?

SEAN

I got something goin' on with you. You got some thing goin' on with Isaac and my throat's killin' me! So like what am I supposed to do.

KELLY

Oh God. I am so out outa here unless you smartin' up. I did not do Isaac and all you have is sore throat....

SEAN

My Dad died o' cancer ya know...

The script follows Sean through his interview with Dr Pearson and the a typical clinical medical cycle; present and past medical history, symptoms, physical examination, recommended tests, differential diagnosis and treatment plan. Through the videos, I hope that the students will learn about Sean's hopes and fears about his illness and his situation in life, for example, Sean is worried he's contracted a sexually transmitted disease from his girlfriend, Kelly. The video also shows that Sean is rather immature and quick to blame others for his predicaments. The script is also designed to include "red herrings" or ideas that are irrelevant to Sean's condition so the students are forced to decide what information is pertinent to the case.

Figure 1 Sean and Kelly

From the story, we also learn that Dr Pearson and Sean's relationship is well established and through their conversation, we hear about Sean's interests and background, and see aspects of his personality. Dr Pearson probes to find out more about Sean's emotional state and how he feels about his illness, and helps Sean consider several plausible explanations for his symptoms. The video also offers the opportunity for Dr Pearson to model professional skills, for example, good communication skills.

The video case study uses language more familiar to both the patient and medical students. The story unfolds from both Dr Pearson's and Sean's point of view and extends to a time before Sean's appointment. Details about Sean's health and experience with his illness are also recounted. The crisis point occurs in the initial scene, setting up the scenes that follow. The resolution of the case occurs off screen after the students have seen the series of videos and there is no sense of villain or hero in the story.

After the final scene showing Sean leaving the office for blood tests, the students continued the PBL process, discussing possible test results, differential diagnosis and treatment management plans. Once they have considered and prioritized possible hypotheses, the facilitator disclosed the tests had revealed Sean has mononucleosis.

Carrying on with my case analysis, I find more is known about Sean's feelings towards his problem and his relationship with his girlfriend Kelly as compared to the original text case. By watching Sean and listening to the conversation between Sean and the doctor, it is possible to learn more about Sean's health as the videos progress. Within the context of my limited prototype, Sean, Kelly, and Dr Pearson have become more multidimensional characters than the textbased counterparts.

3.5.1 Weaving Narrative into the PBL Case Study

In PBL medical case study, information is released in stages. Students identify what they know and what they need to know to resolve the case at each stage. During this discussion, students' track issues that need more research and form hypotheses that might account for the patient's illness. In the same way, videos provided information at each stage and questions help students move forward with the case. The opening page of the tutorial facilitator's guide shows this process.

Table 2 Sample: Facilitator Tutorial Guide, Page 1

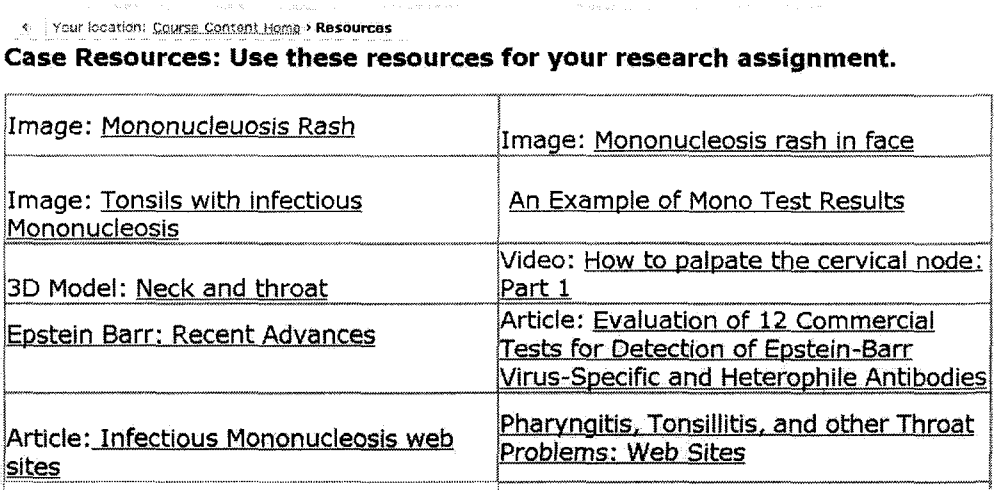
Facilitator	Students	Resource
Set up and show Scene 1 Sean and Kelly	View video.	Scene 1
Ask, what do we know about Sean from this video that might help us with the case later on? Ask Scribe to write down student's points.	Students summarize points.	Video - Scene 1 "Keypoints" Whiteboard
Set up and show part of scene 2a.	View video.	Scene 2a History of Present Illness.
Ask, "What is the key information you learned from this video about Sean's condition?" Ask scribe to write on whiteboard.	Students summarize these key facts.	"Sean's Condition: Key Points" Whiteboard.
Describe "Risk Factors". Give an example. Ask, "What are the relevant of certain risk factors in Sean's case? (age, sex, ethnicity, lifestyle etc.)"	Each student comes up with an idea and asks scribe to write ideas on the whiteboard.	"Risk Factors" Whiteboard

For information on the students' perceptions of the video case presentations, refer to Chapter 4, Tutorial Evaluation.

3.6 Developing Multimedia Resources

Between the two Web conferencing sessions, students conducted research on the learning issues they had identified in the problem based learning process by accessing multimedia resources made available in WebCT, a course management software.

Figure 2 Screenshot of Resource Page


Your location: Course Content Home › **Resources**

Case Resources: Use these resources for your research assignment.

Image: Mononucleuosis Rash	Image: Mononucleosis rash in face
Image: Tonsils with infectious Mononucleosis	An Example of Mono Test Results
3D Model: Neck and throat	Video: How to palpate the cervical node: Part 1
Epstein Barr: Recent Advances	Article: Evaluation of 12 Commercial Tests for Detection of Epstein-Barr Virus-Specific and Heterophile Antibodies
Article: Infectious Mononucleosis web sites	Pharyngitis, Tonsillitis, and other Throat Problems: Web Sites

I worked with a subject matter expert to develop the resources needed for the tutorial including:

- Scanned medical images and illustrations of other possible medical problems described in the case study such as "pharynx with exudates".
- Photo of Sean looking ill.
- 3D model of neck and throat area
- Scan of test results from actual rapid test for strep A
- Video of How to palpate the cervical nodes
- Two articles on mono in PDF
- Several images of Mono and other throat illnesses

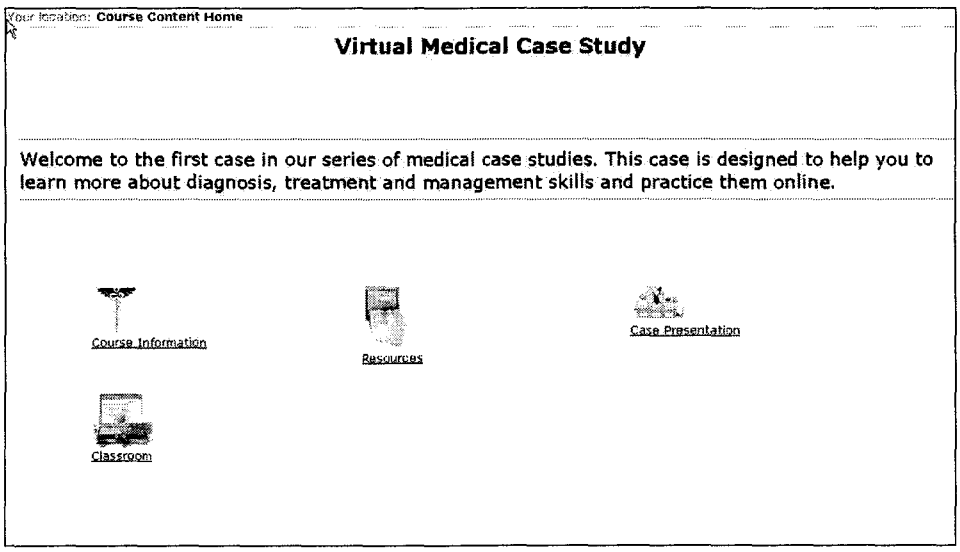
Although a few resources were about diseases not associated with Sean's condition, for example, pharyngitis and tonsillitis, the majority were associated with a

diagnosis of mononucleosis. The next section describes how my design supported collaboration through audio graphic Web conferencing.

3.7 Supporting Collaboration through VOIP Conferencing

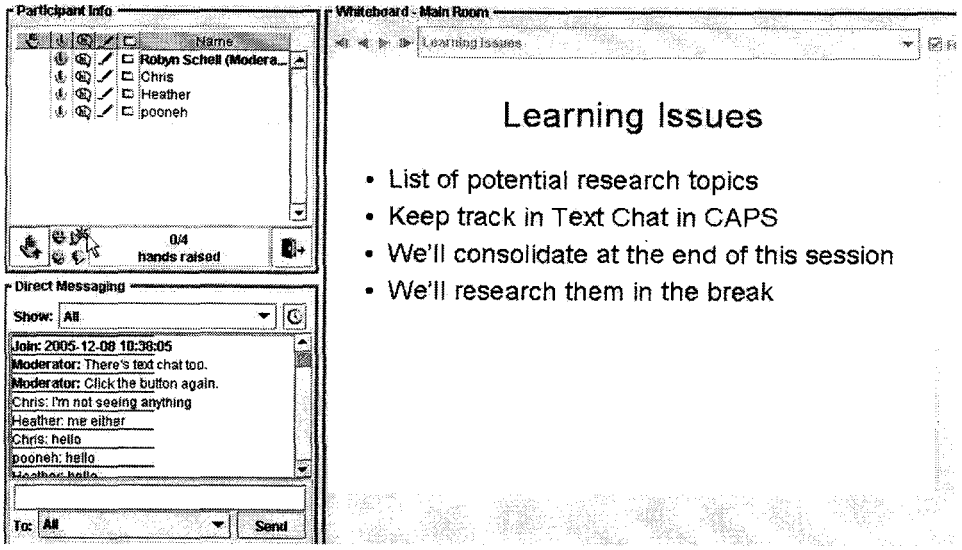
Since collaboration is central to PBL, it is important I support this process online. Voice Over Internet Protocol (VOIP) audio graphic web conferencing was used as a synchronous communication tool for this distributed PBL prototype. Students accessed this tool by clicking the *Classroom* icon on the web site home page.

Figure 3 Home Page with Classroom Icon



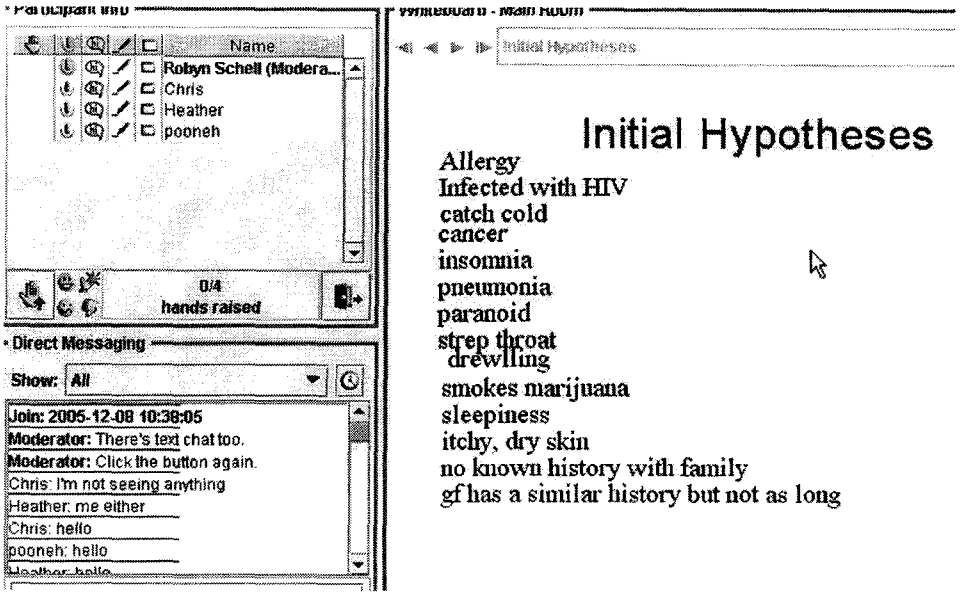
While in the web conference, the facilitator presented a series of videos called The Story of Sean and Kelly. Everyone in the web conference could view the videos. Before and after each video the students discussed in real time audio what they knew so far and what they needed to know in order to move the case forward. They tracked their learning issues on the electronic whiteboard as they would in a traditional face-to-face PBL session.

Figure 4 Screenshot: Learning Issues Procedure



As is typical of PBL sessions, student also compiled a list of possible hypotheses that might explain Sean's illness. The students took turn scribing ideas on second whiteboard, which they modified as they learned about the case. As the session unfolded the group continued to discuss and reflect on the implications of new information.

Figure 5 Screenshot of List of Hypotheses



The facilitator helped the students stay on track, form hypotheses and identify learning issues. When students had seen all the videos, they completed independent research using the resource material stored in WebCT or found their own. Next, the group reconvened in the web conference to present their research findings and complete the last two stages of the case study; differential diagnosis and treatment plan.

The next chapter describes the evaluation of the Online PBL Case Study Tutorial.

4 Tutorial Evaluation

This chapter describes the assessment of my pilot study including a student assessment of the various features of the tutorial and analysis of the transcripts. I describe the tools and methods, the participants and how they were recruited.

4.1 Participant Recruitment for the Case Study

As the intended nursing and medical school audience for my tutorial were unavailable at my university, I recruited 6 Kinesiology students for this research project with some background in anatomy and patient assessment. I personally made an appeal for participants by attending to two Kinesiology lectures. As well, two instructors agreed to forward my e-mail asking students to participate in my study. Students were offered $12 an hour as compensation for participating in the tutorial, which was expected to run for five hours. I provided each participant with an introduction letter and a consent form that described the format of the tutorial and his or her role in the study. I explained I was the facilitator of the tutorial and they were free to ask any questions as we went along.

4.2 Data Collection Tools and Methods

I collected the case study data during two online tutorial sessions using three methods: pre-test survey, post tutorial survey, focus group interview, and an analysis of the tutorial transcripts.

The pre-test survey included questions about the students' academic background as well as their experience with the Internet and computers. After the

tutorial, the students completed a survey rating the tutorial experience as well as participated in a focus group where I gathered information about the student's perceptions of tutorial experience in a more informal setting. This conversation was recorded and transcribed.

The tutorial was also recorded and captured the audio of the conversation as well as the activities, for example, text chat, and Whiteboard activities. Transcription included dialogue, whiteboard, text messaging and notes about activities, for example, "Second video shown".

The analysis of the post tutorial survey and focus group transcripts was oriented to the student's assessment and discussion of some of the tutorial design features including:

- A framework of PBL theory and practice
- Collaborative learning
- A strong narrative line to create a memorable context for learning and application of skills
- Multimedia resources
- An online simulation to create and authentic environment for learning in a risk free environment

In the following sections, I describe the participant profile information gathered from the pre-tutorial survey, and discuss the data collected from the students in the post-tutorial survey and focus group in relationship to principles I used to design and implement the tutorial. Later, I discuss the methodology used to analyze the transcripts and the results of this analysis.

4.3 Participant Profile

The case study was run on two separate occasions, each time with three Kinesiology students who had taken physiology and/or anatomy courses and had some competency using computers and the Internet. I recruited these students because of their health science background and their need to develop and practice patient assessment skills.

Overall, I observed the students to be very proficient with the online tools and using a computer and the Internet. Information collected from the pre-tutorial survey showed all participants had experience using WebCT, but none had used eLive Elluminate or similar web conferencing tools. Half of them had taken online courses and all had used the Internet for research.

Their educational background ranged from second-year to graduate level, with the majority (4 of 6) having completed upper-level courses. All had taken a physiology or anatomy courses although the students rated their knowledge of patient assessment as very limited.

4.4 Student Evaluation of the Tutorial

The following sections describe the student evaluations of the PBL tutorial collected in the post tutorial survey and focus group. I began with the student's ratings of the overall experience then narrowed down to specific design elements. Next, I included more detailed remarks on the same topics gathered during focus group sessions. Although a small sample of six, the students made a number of useful comments.

When asked about the overall experience in the survey, students rated how helpful the audio web conferencing was to their learning experience on a scale of 1

"Not helpful at all" to 5 "Extremely helpful". Their rating averaged at a high level of 4.7 with 4 students rating it a 5, and 2 others a 4. They recorded an identical rating for class activities and exercises. They also rated the discussions as very helpful to their learning, an average of 4.3.

Interestingly, the students were not as happy with the whiteboard and text chat features. For instance, writing sometimes overlapped on the Whiteboard and the students may have found it more efficient to talk in audio rather than text message one another.

When I asked students in the focus group about what they liked and disliked overall about the online tutorial, they were very positive about their ability to interact and communicate with one another. In the following quote, the students comment on the opportunity for practicing their skills collaboratively.

Group 1

Female 2: But this makes it real life as it can get, and then we're all separated too, so it kind of allows us to be on one group, but we're peers collaborating together, so that's good.

Male 1: This is true, that because you got more chance to be interactive than a lecture where you're sitting there listening to a problem the whole time...This is a lot more hands-on.

Female 2: This is where you actually can apply your knowledge, great.

Group 1 also talked about some of the technical problems that might have interfered with their ability to collaborate effectively, for instance, they found writing on the whiteboard awkward as sometimes student's notes could overlap. They also were a little frustrated with the 'push to talk' button, which enabled the participants to talk to one another, but only could be used by one participant at a time. However,

they agreed that one person speaking at a time might be a positive feature and in any case, text chat was an option.

Female 1: I think the good aspect is that this program doesn't really put pressure on you, coming up with answers, and you can try a lot of things and you can all collaborate on the issue. The only thing frustrating is that when you try to talk to somebody, and you try and press the talk button, but someone already pressed it before you.

Female 2: That's probably a good thing, in a situation like this, one person starts talking, the other person starts talking, you have to wait...But that's probably what makes it all worth it at the end.

Male 1: I think it's a good thing that there was only one person speaking at a time, and if you have other things to add to the chat, remember you can type in a comment.

The second group also commented on how engaging they found their ability to collaborate with one another in the tutorial and their options for communication.

Female 1: I definitely liked collaborating with everyone else and I liked how there was different parts; like there was the movie part and the part where you could talk to each other, and then the white board part... and it kind of gets everything going on. It works really well altogether. And you can use more than one of them at once.

Female 2: The interesting thing was that I was not bored ... we could watch the movie, we could talk, we could listen to other people, we could discuss... and I really liked this presentation. I was very impressed because usually during the lectures in classroom I get bored, because only one person is talking, but now, we multi-task things, it was really good.

Male 1: A lot of it is effective, especially being able to talk to other people. I think we utilized the talking part more than we did the text part, but being able to use the whiteboard and talk at the same time, not only do you have your audio use but you also have your visual use too, and then with the text too, you can go back and you know, we are using the text to go back and take a look at what things we need to figure out in order to put things together.

The second group of students also commented on technical problems or features they felt were less than optimal, again mentioning the whiteboard and push to talk button and the moment where we lost connectivity briefly.

Male 1: There were a couple of times when the program actually cut out, or during the audio part when one of us was talking & all of a sudden they'd cut out & you'd be sitting there, and all of a sudden they'd come back... so...

Female 1: I didn't like depending on you to go back and forth between the slides. I like to be able to go back and forth so I could see it while you were talking.

Female 1: I mean, once the discussion got going it went well, but at the beginning it was kind of weird. Maybe just because I'm not used to it or something, it's just hard to figure out how everything works, like pushing the 'talk' button. I didn't know how to push the button & stuff like that...I think that's the main thing I didn't like, is the whiteboard part, everything else seemed to work really well.

4.4.1 Narrative-Driven Case Study

In this survey, students were asked to rate both the videos of case presentation and the story of Sean as a format for the case study. Students rated the video presentation very helpful to their learning while they felt the story of Sean as a format for the case study was slightly less helpful.

In a focus group the students were also asked about the value of the story-based video case presentation, for example, what did they like or dislike about it, what worked well and what didn't, how the case study could be improved. More specifically, I again asked them if they thought the story of Sean added anything to the case study and if Scene 1, set in a time before Sean's meeting with Dr Pearson, added anything to the case study. Although this was a small sample, their comments were revealing.

Here are some examples of what the first group said about Sean's overall story starting with his argument with Kelly and continuing scenes that show Sean's visit with the doctor:

Group 1 Comment on Narrative

Researcher: The story of Sean? Did you feel it added anything to the case study or not?

Male 1: I found it a little bit annoying, but it did the job.

Female 1: I think it was good, seeing that he had attitude and was a bit of a hypochondriac, so it made you think about the situation, or it made me think about it a little more. Is this guy really that sick or... and then you do some research and you find support for some of these ideas.

In the following selection, the Students in Group 2 discuss the narrative in the video based case study. The students describe how they learned more about Sean's personality and wondered if his symptoms were the result of a physical illness or caused by emotional stress. Another student suggested the opening scene had an appeal for younger audiences, that drew them into the story right away.

Group 2 Comments on Narrative

Researcher: Finally, do you think the story of Sean added anything to the case study?

Male 1: I think it did, he starts off being paranoid and I guess he wasn't really paranoid as far as his illness, but he was claiming his girlfriend was cheating on him, and if you follow along you end up getting it might be mono, which as you know is the "kissing disease", His girlfriend could've got that anywhere, but then again, also the way that he acted also makes him seem, like he's a bit crazy.

Male 1: It shows his personality and also, we were coming up with theories such as "is he paranoid?" or is this illness legit? So it could also throw you off a little bit, but in real life you're gonna get people like that.

Female 1: Ya, I thought it was great, I mean, it's one thing to read "We have a 21 yr old white male who has these symptoms," as compared to the when you give us this story about him and his girlfriend,cheating on him. For younger people, they're instantly into it, because it's what happens to us, right. We can identify with it and it makes us totally more interested in it, and then you actually want to learn about it... although, it was a little odd about his girlfriend cheating and his rash seemed to be connected. I mean, the beginning was like "what?!" I don't know... it was good, excellent

Female 2: Ya, it was really good and the thing is people can identify with Sean and who can communicate with him and feel his situation, because most of them have been in this sort of situation before. It makes me more interested to see what happens. I myself was just thinking "what's gonna happen?" and that's why I didn't get bored, I was staring at the monitor.

As the opening scene was designed to develop the narrative from the patient's perspective rather than the physician's, the case begins before the patient meets the doctor. The opening scene shows Sean accusing his girlfriend, Kelly, sleeping with other boys, and passing on some disease to him, something Kelly vehemently denies. When asked if the scene was useful to the case, the first group of students responded with a variety of comments.

Group 1 Comment on Opening Scene

Researcher: Anything in that opening scene that might have helped?

Female 2: It did give us some information, but it should give us some more theories in terms of cancers...

Male 1 Cancers!

Female 2: Everything was attitude!

Female 1: Ya, definitely...

Female 2: And psychology plays an important role...

Female 1: And it was kind of interesting that it was given to us in the first place. You know, was this randomized information or connected with more scenes. STDs? No, that doesn't work? Cancer? Nope, doesn't work either...

Female 2: Actually, that's good coz it might make you think "oh, this can't be an STD"... So it gives you more to think about...

Researcher: Any comments on the scene with Sean and Kelly?

Female 1: Ya, it was funny (M1 agrees)

Female 2: It was hilarious!

Researcher: ... any comment about that video? Is it useful?

Female 2: That was great; it helped the case... gave wider information actually.

The following selection includes the Group 2 students' comments on the opening scene.

Group 2 Comments on Opening Scene

Researcher: What do you think about the opening scene? I added an opening scene with him and the girlfriend. Do you think it added anything?

Male 1: It gave you a sense of what was going on, it helped line up the situation a little bit. A little story line…

Researcher: So you thought it was useful or not?

Male 1: It was useful.

Researcher: Was it?

Male 1: Ya. Just like, if you think about it, if you're not used to portraying people… if you are a doctor in a doctor's office you are not going to see that whole scene, you're just gonna walk; they're just gonna walk in and then you're going to have to putting/posting it altogether

Female 1: Ya, that's definitely a good point. I mean it just got you into it right away. If you are a doctor you really aren't gonna see that. It was just so weird and irrelevant how you put them together. It really gets you interested! This guy who associates his sore throat with his girlfriend cheating on him, I don't know, but it was good.

Researcher: is it?

Female 2: I actually liked the opening scene. It makes me into it, so I really liked it…

The student's comments reflected Kenny's ideas (2004) about story based medical case studies, for example, several felt the portrayal of Sean's experience conveyed information about Sean's state of mind, his personality, and his relationships that were relevant to the case. It also provided details that at first seemed important and then less so as the case progressed, such as Sean's paranoia, his family history of cancer and his marijuana smoking. However, the case study details provided the

background for a variety of explorations and a milieu the students could identify with. The drama also served to draw them into the story and engage them. As one student asked herself; what is going to happen next? One student felt a text-based case would not have drawn her into the case in the same way.

However, it is difficult to isolate the learning experience of the narrative as other factors could also affect how the students assess the success or failure of the story within the context of a medical case study. The use of digital video and the multimedia resources provided for this case could also be relevant. The complexity of creating authentic environments for learning is matched by the complexity of assessing their value.

4.4.2 Multimedia Resources

Although four of the students rated the online resources highly (five out of five), two students found them less useful, rating them 2 and 1 out of 5. Four of the students found the videos of the case presentation extremely helpful and one less so. The students found the series of video helped them to go through it each step of the process although one described the video as providing too much information.

When asked about the resources, one student commented that she liked the accessibility of the resources, which saved time, but another student pointed out that they were too many of the resources focussed on mononucleosis. They suggested more variety of more complex resources, for example, more academic papers.

4.4.3 Online PBL as a Simulation

I was interested the student's perception of this tutorial as a type of simulation where they could practice their skills in an risk-free environment as I hoped to build

on this tutorial to create other more complex, sophisticated simulations. The students commented on how realistic and interactive they found certain aspects of the tutorial. They also indicated they found the tutorial a place where they could have more hands on practice.

Female 2: But this makes it real life as it can get, and then we're all separated too, so it kind of allows us to be on one group, but we're peers collaborating together, so that's good.

Male 1: This is true, that because you got more chance to be interactive than a lecture where you're sitting there listening to a problem the whole time...This is a lot more hands-on.

Female 2: This is where you actually can apply your knowledge, great.

Female 1: I think the good aspect is that this program doesn't really put pressure on you, coming up with answers, and you can try a lot of things and you can all collaborate on the issue.

In the next section, I turn to the analysis of the tutorial transcripts.

4.5 Evaluating the Tutorial Transcripts

This section centres on analysis of the online tutorial transcripts. As other researchers have noted in the past (Colliver, 2000), I found developing a methodology that measures the relationship between PBL and the development of higher-level thinking very challenging.

In my search for instruments that would help me evaluate the online tutorial, I turned to studies that examined the relationship between problem based learning and critical thinking since critical thinking appears to be synonymous with many of the goals of a problem based learning curriculum. As I described in literature review, the concept of critical thinking is closely related to clinical reasoning (Gambrill, 2006) Critical thinking is necessary to develop clinical skills that assess available data by

weighing evidence and distinguishing between strong and weak arguments as described earlier.

To measure the level of critical thinking in the tutorial, I adapted a coding system created by Carol Kamin to measure critical thinking in a PBL medical video case study tutorial, called the "35 indicators of five critical thinking stages and four group process issues". These indicators occur by stage and each stage includes indicators of both shallow (s) and deep (d) thinking (Kamin, O'Sullivan, Younger, & Deterding, 2001). (Appendix 1)

I applied the indicators of deep thinking codes and amalgamated the ideas behind the shallow thinking codes in one code called non-critical thinking (NCT). These noncritical thinking codes could be applied to statements at any stage. I also included a code called technology. In the training for the inter rater reliability trials I further clarified the explanation for four indicators:

Table 3 Clarification of Kamin's Codes

Code	Kamin's Original Code	My Clarification
NI	Asking for information not provided yet (Example: How old is this kid? Nonexample: Have you ever seen a kid with this symptom?)	Responses to the moderators question, "what question would you ask next, or what would you do next" before showing the next video in the case.
A	Discuss ambiguities or facts to clear them up; push limits of knowledge (Example: Which immunization were you thinking about?)	The student is asking for clarification on what was meant
AI	(AId) Identify what the group or individual needs to know (learning issues); includes admitting when the answer is not known and agreeing which phenomena require explanation (Example: I don't know how you rule out ingestion.)	Statements that identify what the group needs to know that are more generic issues, or learning issues, or students admits they don't know
LG	Guiding (Example: You're worried about altered mental status.) or focusing (Example: Have you guys all seen an eight month old?) group by synthesizing where the group is or what they need to do. Asking about reasoning, probing questions.	Guiding related to content. Focusing, synthesizing workgroup needs to do

When I first began to apply the codes for deep and shallow thinking, I found the shallow thinking codes very similar particularly than very difficult to apply to a certain stage in the PBL cycle. For example, I felt the code labelled (NPs) "Repeating information that has already been said (Example: Yeah, he's fussy.)" could be applied at any stage as an example of shallow thinking not just stage 1. Overall, the shallow thinking codes referred to statements that had little or no connection to the case or did little to move the case forward towards a resolution. As a result, I simplified the shallow thinking codes by collapsing them into one category that could be applied at

any stage. Here are my descriptions and examples of Non Critical Thinking codes (NCT) as I defined them in my transcript analysis:

- Information that is not linked to the problem (Example: J: I don't know if this is important but the Doctor asked him if he plays hockey.)
- Making comments without any connection to the problem (Example) N: He claims that he is monogamous.)
- Repeating information that is already been said
- Irrelevant comment or noncommittal (Example: J: Yes I think bacterial infection describes tonsillitis and mono.... I don't know about the marijuana part but - stress, yes, contributes so you decide.)
- Agreeing but not adding any comments (similar to the first NCT indicator)
- Reporting learning issue with no application to problem

I also added another code technology (T). Technology codes applied to statements that included comments and questions about the technology (Example: *Delegates took turns to type on the white board.* Example: you should be able to write - you just click on the white board and click ctrl V it should paste whatever you have copied, on the clip board.)

I also used Kamin's group process statements. Technology and Group Process codes were considered neither critical nor non critical statements.

In Kamin's study critical thinking ratio between minus one plus 1 was calculated for each of the five critical thinking stages. The critical thinking ratio (xd - xs)/(xd+xs), was considered independent of the quantity of participation, reflecting only the quality of the discussion. Dialogue unrelated to critical thinking or discussing

the case reflected group process as the purpose was to investigate the critical thinking of the groups since methodology it was important to represent all the dialogue.

4.5.1 Inter rater Reliability

Two researchers were involved in the inter rater reliability trials for this thesis. The senior supervisor led the training session by having the researchers discuss how how the codes would be interpreted and practice applying them. Based on the training, the definitions of the codes were revised as described in the previous section. Since the transcript contained about 300 lines, we coded 30 statements, or about 10% of the entire number of statements in the transcript.

To determine the starting point, a random number between one and 10 (generated by the web site random.com) was selected. To code at least 10% of the statements available, we coded every 8th statement.

After 3 trials, we achieved an inter-rater agreement ratio of 77.4%, based on the proportion of statements we coded identically to those we did not.

4.5.2 Results

The discussion was broken down into units of information that represented a single element of case information. Units included both phrases and sentences. The length was determined by a single unit of meaning and each unit was assigned to an existing code. Only one code could be applied to each statement and every statement in the transcript was coded.

The following tables show the number of critical thinking statements, group process statements, technology statements, and finally, the total number of coded statements.

Table 4 Number of Critical Thinking Statements per Code (CT)

Stage	Code	Nov 18 tutorial	December 8 tutorial
Identification	NP	22	22
	NI	13	19
CT codes/stage		**35**	**41**
Problem description	A	3	3
	AI	25	13
	OE	2	0
CT codes/stage		**30**	**13**
Problem exploration	L	9	3
	LT	0	0
	LV	0	4
	LG	7	3
Justification	JH	9	6
	JS	31	10
CT codes/stage		**56**	**26**
Applicability	P	5	3
Integration	LI	22	19
Total CT codes		**148**	**102**

Table 5 Total Number of Non Critical Thinking Statements Overall

Total NCT Codes	**NCT**	**44**	**71**

Table 6 Number of Group Process Statements

Rapport	**R**	**29**	**74**
Explaining Process	E	16	15
Dividing	D	5	1
Volunteering	V	3	1
Total Group Process Codes		**53**	**91**

Table 7 Number of Technology Statements

Technology	**T**	**5**	**6**

Table 8 Total Number of Coded Statement

Total Coded Statements	250	273

4.5.3 Analysis and Discussion of Transcript Coding Results

When comparing the ratio of critical thinking statements to noncritical thinking statements, in group 1, 77% critical thinking and 23% were coded non-critical thinking, while in group 2, 58% of the statements were coded critical thinking and 42% coded noncritical thinking.

Table 9 Summary of Results

Code	Group 1	Group 2
CT codes	148	102
NCT codes	44	71
Group Process Codes	53	91
Technology	5	6
Total Coded Statements	250	270

The ratio of critical thinking was higher than noncritical thinking in both groups of participants. The number of types of critical thinking statements per stage was fairly even, except in three instances stages 2 AI (Asking for information not provided yet), and 3 JS (Justifying hypotheses or orders), and Rapport building in Group Process category. When I took a closer look at transcripts to account for the discrepancy between the two groups, I discovered that group 1 asked more questions about what they needed to know, while group 2 went directly to developing a list of their hypotheses. Through exploring what they needed to know, Group 1 showed a tendency for more collaborative discussion, particularly in the earlier stages where their level of critical thinking was higher contributing to their a overall higher ratio of critical thinking.

Group 1 also had more instances of justifying their hypotheses while group 2 suggested hypotheses but was less able to show why these hypotheses were credible. Group 1 statements also contained less instances of simple group rapport statements such as "OK", "Yes" and "I agree". After viewing all the videos in the case presentation, group 1 talked at length about how to prioritize their list of hypotheses. Group 2 chose not to review their hypotheses at this stage but decided they were fine

with them as they were. The higher number of critical thinking statements at the justification (JS) stage does not appear to reflect group 1's interview with a physician who appeared only in the first session, as the statements focused on what they had seen in the case presentation videos.

Although Kamin did not consider the ratio of critical or noncritical thinking to all statements, it is interesting to note, 59% of the items of the total statements were coded critical thinking and 18% noncritical thinking in group 1, with the balance of the other codes relating to group process or technology. In group 2, 38% of the total statements were coded as critical thinking and 26% were coded noncritical thinking, again with the balance of coded statements relating to group process or technology. From this perspective the difference in each group's level of critical thinking is more dramatic.

I also compared my results with Kamin's study. Kamin used (xd - xs)/(xd+xs) as a formula for measuring the level of critical thinking. This formula was considered independent of the quantity of participation, reflecting only the quality of the discussion. In Kamin's study a critical thinking ratio between -1 and +1 was calculated for each of the five critical thinking stages with the following results (Kamin et al., 2003).

Table 10 **Critical-thinking (CT) Ratios for Each Stage of CT by 13 Groups of Third-year Medical Students**

Critical-thinking Stage	Modality	No. of Student Groups	Mean CT Ratio (SD)	p Value*
Problem identification	Text	4	.49 (.19)	.013
	Video	4	.29 (.18)	
	Virtual	5	.92 (.18)	
Problem description	Text	4	.56 (.23)	.017
	Video	4	.69 (.03)	
	Virtual	5	.95 (.05)	
Problem exploration	Text	4	.52 (.17)	.045
	Video	4	.56 (.12)	
	Virtual	5	.80 (.15)	
Applicability	Text	4	.64 (.19)	.067
	Video	4	.81 (.05)	
	Virtual	5	.92 (.11)	
Integration .	Text	4	.67 (.04)	.059
	Video	4	.74 (.15)	
	Virtual	5	.87 (.10)	

in Three PBL Case Modalities, Department of Pediatrics, University of Colorado School ofMedicine, Denver, 2000

I used this formula to calculate the overall mean critical thinking ratio in my own data. Group 1 revealed a ratio of .54 while group 2 showed a ratio of .18. If I compare this to an approximation of Kamin's overall results, my groups show a low level of critical thinking, especially in group 2. Although this is disappointing, this may be explained by the differences in my participant profile. My group included 6 undergraduate Kinesiology students with little or no experience in clinical reasoning, while Kamin's participants included 128 third-year medical students rotating through their pediatrics clerkship over a full academic year. It's likely her participants had

experience with medical case studies and problem based learning while my participants completely lacked experience with problem based learning, and possessed little experience analyzing medical case studies calling for clinical reasoning.

4.6 Discussion of Research Results and Limitations of the Study

I would like to return to the question I posed in the opening page of my thesis: can an online environment support a collaborative problem-solving approach in health education? To answer this question, I discuss the students' perceptions of the tutorial, the analysis of the transcript, and limitations of the study.

The students claimed they found the technology easy to use and the video case of the story engaging and 'lifelike'. They agreed the tutorial provided an environment that allowed them to practice online. They also enjoyed their ability to collaborate in audio and believed this was very helpful when working remotely.

The students questioned the quantity and appropriateness of the multimedia resources. One student referred to an overload of information, another felt the resources were not diversified enough since most of them pointed to a diagnosis of mononucleosis. It is a challenge to create the right balance of multimedia and at the same time not offer too much information. It is also important to consider the students were working in a compressed timeframe and did not have the opportunity to conduct extensive independent research during the break.

When I turn to the results of the transcript analysis to assess the value of the tutorial I concluded it has merit. The system helped me to pinpoint the weaknesses and strengths in student's ability to critically reason and where I could improve as a facilitator. For instance, I noticed group 1's scores were lower than group 2 in certain stages and by studying the transcripts, I discovered that although this group generated

hypotheses, they made fewer statements to substantiate these ideas. With this knowledge, a more experienced facilitator could ask more penetrating, probing questions to help students develop their hypotheses and move beyond simple one-word "group process" types of answers such as, "I agree" or "You go first" etc .

This coding system also shows potential for measuring the effects of different elements of the tutorial with a variety of groups and treatments. For instance, in future research it might be possible to use these codes to measure variables such as the difference in critical thinking between text-based case and video case studies or between tutorials with text forum versus VoIP communication.

This pilot also offers information on how well the technology supports the pedagogy and the learners. Students found the technology used in this pilot study very straightforward to use and they enjoyed using it. We had anticipated the participants would find moving back and forth between WebCT and eLive difficult, but this turned out not be the case for this group. They had no difficulty going back and forth from their entry point in WebCT to Elive Elluminate web conferencing. I also discovered that this technology seemed to support the various components of problem-based learning, including dialogue among the students and between the facilitator and the students. The whiteboard also suitable for scribing hypotheses and learning issues online and closely resembled the procedures in face-to-face session described in other studies and I experienced myself during PBL facilitator training at the University of New Mexico Hospital.

Traditionally, asynchronous text forums have been the basis of collaborative discourse online but it seems that web conferencing may also offer an alternative. Although this is not been explored in this study, real time audio graphic software might offer a feeling of social presence, considered an important element of creating

community online (Gunawardena & Zittle, 1997). As VoIP becomes a more widespread technology, it is likely participants will find it easier to use and a more accessible tool for learning.

While the findings of this part of the study suggest a number of design implications, they must be viewed within the limitations of the study. This pilot study included only a small group of students who were not my intended audience of nursing and medical students. Working with an audience with more extensive background in clinical reasoning and content knowledge, it would be feasible and useful to use both pre-and post tests to measure learning before and after the tutorial. Multiple case studies would provide a wider view of other design options, and so might provide additional or different findings than a single pilot study.

I also believe by situating this tutorial in an actual medical curriculum and responding to the goals of the students enrolled in these courses, the critical thinking level of the students would be higher because the students would have already acquired some knowledge of throat diseases and possess some experience with the clinical reasoning process. It is likely that as students and facilitator became better acquainted with problem-based learning, they would become familiar with its pace, structure, and benefits, better enabling students to take advantage of the student focused pedagogy PBL represents. For example, this facilitator found that by facilitating less, students took more control of their own learning, and became more animated in their discussion of the case. The role and impact of the facilitator is something I have not taken into consideration in this pilot study.

4.7 Future Research

I hope to build on what I have learned in this pilot study to design a more effective model in my next project with the University of the Victoria nurse practitioners and British Columbia Institute of Technology (BCIT) nursing students. I plan to develop a trilogy of stories featuring Sean and Kelly and the second script, Sean's Big Secret, is in production. Our research study is scheduled for November 6, 2006 and includes 15 Nurse Practitioner Masters students with nursing experience. With our BCIT partners, we hope to conduct studies with a larger number of nursing students.

I have several recommendations for future study. It may be useful to investigate the effectiveness of providing a more diversified collection of multimedia, or alternatively, providing only basic generic resources and encouraging the students to add to the collection. By doing their own research, students may be able to develop greater professional skills and contribute to a database of resources that could be more tailored to their requirements. In my next iteration, I plan to store the videos and scripts in the course management tool so students could refer to videos for more detailed study and use text scripts as a quick reference tool.

I also believe that the process for measuring critical thinking in problem based learning could be further refined so that a higher level of inter rater reliability could be reached at an earlier stage in the process. I realized when training another coder, that more detailed explanations of the definitions and a knowledge of problem-based learning are required to achieve a high level of inter rater reliability.

Finally, developing a more interactive PBL simulation with branching capabilities could result in a complex, rich simulation for medical education and move this model to the next level by providing students with the opportunity to take actions

and see the consequences of those actions. Features such as examination tools and a communication tool that allows participants not only to hear one another but also to see one another or patients would be an interesting alternative for distributed PBL.

5 Conclusion

Research must start somewhere and build on pedagogical concepts that have proven successful in the past. The literature review, the design process, and PBL implementation, are connected and add information to how PBL can be developed and delivered in a distributed environment.

I think the study shows exciting, positive results and uses technology for PBL in a way that to my knowledge has not been explored or reported in the literature. As VoIP becomes more common in web conferencing and in online telephone conversations like SKYPE, more people will become comfortable with the technology. With more medical education programs going online, for instance, the nurse practitioner program in B.C., we will see more students accustomed to the use of technology in medical education. As the students mentioned in both the focus groups and in the survey, they found this new medium engaging, and more interesting and interactive than the traditional lecture format. They were positive about their ability to collaborate and get hands-on experience in a "real-life" environment. They enjoyed the videos, talking to one another, and discussing the case.

They also enjoyed the video case presentation. As one student commented, "we can identify with it and it makes us totally more interested in it, and then you actually want to learn about it...." I think the opening dramatic scene and the humour involved in the story drew the students in. (Some of this success may be due to fact the students were approximately the same age as Sean and Kelly, the main characters.) In addition, I would expect the students to have high expectations for

video drama and would be accustomed to seeing sophisticated media presentations on television and cinema, and most likely in videogames. In light of this, their comments about the video case study are encouraging.

I also believe that my analysis of the case study script was quite useful, and contributed to a case design that enriched the student's understanding of the patient's personality and situation. I suggest that thick cases could be used as the basis for creating more realistic simulations for medical education and may produce a more authentic environment than traditional PBL medical text case studies.

Other researchers may find my adaptation of Kamin's codes to analyze the tutorial transcripts useful because it simplifies the system by reducing the number of noncritical thinking codes. Facilitators may find this coding system useful for identifying areas where students are having problems and help them increase their level of critical thinking. I intend to use these codes to measure and compare critical thinking between tutorials using different modalities such as VoIP and text communication. I hope others will find my clarification of the codes useful as well and lead to an increase in inter rater reliability in future studies.

Overall, this tutorial holds promise and sets a new direction for distributed PBL solutions. I hope there will be more studies on how the boundaries of PBL can be expanded to incorporate realistic case studies that recreate the human experience in which medical professionals practice everyday.

6 Appendix

Kamin's Guide to Codes for 35 Indicators of Five Critical-thinking (CT) Stages and Four Group-process Issues*

Stage 1: Problem Identification
New information
(NPd) New problem-related information (Example: He was fine when Mom left for work.)
(NPs) Repeating information that has already been said (Example: Yeah, he's fussy.)
(NId) Asking for information not provided yet (Example: How old is this kid? Nonexample: Have you ever seen a kid with this symptom?)
(NIs) Complaining or repeatedly asking for information that cannot be provided (Example: Why didn't they tell us if there were tears or not?)

Stage 2: Problem Description
Clarifying/agreeing on terms/concepts
(Ad) Discuss ambiguities or facts to clear them up; push limits of knowledge (Example: Which immunization were you thinking about?)
(AIs) Ignoring or exhibiting impatience with ambiguities (Example: Why can't we just ask the patient instead of discussing this?); or asking facilitator to be content expert (Example: Will you tell me what Cushing's triad is?)
(AId) Identify what the group or individual needs to know (learning issues); includes admitting when the answer is not known and agreeing which phenomena require explanation (Example: I don't know how you rule out ingestion.)
(AFs) Facilitator "pearls" - facilitator teaches rather than facilitating. Student responds yes/no to question with no explanation.
Bringing outside knowledge experience to bear on problem
(OEd) Drawing on personal experience (Example: I saw one of these kids last week and we did. . . .)
(OEs) Drawing on irrelevant personal experience, distracting group from case (Example: My brother used to do that with us.)

Stage 3: Problem Exploration
Linking ideas, interpretation
(Ld) Linking facts or ideas (Example: Since his pressure is a little high and we are giving him fluids, it could go up, and if his fontanels are full, we would be worried about increasing the pressure.)

(Ls) Repeating information without making inferences or offering an interpretation or stating that one shares the ideas or opinions stated without taking these further or adding any personal comments (Example: Right, absolutely.)
(LTd) Interpretation of data (what was said in text) (Example: It was hard to understand if that's like hypertonia, or if he's too tired to sit up, or if he was developmentally delayed prior to this event.)
(LVd) Interpretation of data (what was seen in video) (Example: No, because he looked like he had good tone.)
(LTVs) Complaints about technology text/video/computer (Example: I'm sorry, I'm just starting my learning issues since I couldn't access the computer earlier.)
(LGd) Guiding (Example: You're worried about altered mental status.) or focusing (Example: Have you guys all seen an eight month old?) group by synthesizing where the group is or what they need to do. Asking about reasoning, probing questions.
(LQs) Asking closed questions that require rote memory skills, shutting down critical thinking process (Example: What immunization has really changed the face of pediatrics?)

Justification
(JHd) Develop working hypotheses (brainstorming stage when all possible explanations are listed).
(JHs) Unwilling to explore other possible solutions/explanations for problem.
(JSd) Justifying hypotheses or orders/action by providing examples or explaining or reasoning; comparing advantages/disadvantages of hypotheses or orders/treatment; moving hypothesis up/down or out in ranking.
(JPs) Irrelevant or obscuring justification for hypotheses; agreeing but not adding any comments; Noncommittal.

Stage 4: Applicability
Practical utility
(Pd) Discuss practical utility or concerns about approach to patient, lab orders, or treatment (Example: How do you do that test?)
(Ps) Suggest impractical orders/treatment (Example: scattered approach to labs ordering everything possible) or tests unable to relate to hypotheses list; agree but without adding anything new or reasons why there is agreement.
Stage 5: Integration
Teaching each other
(LId) Synthesis of learning issues and application to problem; link findings after self-study to hypotheses; generalize to broader application (Example: How does this child compare with others student may have seen?)
(LIs) Report learning issue with no synthesis or relation to problem.
Critical assessment

(Cd) Student provides self- or peer assessment.

(Cs) Student is superficial or unwilling to assess self or peers.
(CTd) Tutor provides self-assessment, group assessment, or student assessment; prompts students for self- or peer assessment.

Group process issues
(R) Rapport building; active listening; affirmation; introductions, volunteering
(E) Explaining process, questions about process
(D) Dividing up learning issues
(V) Voting on orders or hypotheses by a show of hands

*Kamin CS, O'Sullivan PS, Younger M, Deterding R. Measuring critical thinking in problem-based learning discourse. Teach Learn Med. 2001;13:27-35.

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