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Exploring Learning in a Technology-Enhanced Environment

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Abstract

The connections between learning and technology were explored and analyzed in this study. Data were collected through a participatory action research case study design in which students enrolled in five different universities in either the United States, England, and Australia participated in creating and

analyzing cases from their teaching practice. Data were analyzed using the Dimensions of Learning Framework created by Marzano and Pickering (1997). Findings indicate that the students' attitudes and perceptions of technology influenced their ability to acquire and integrate knowledge, extend and refine knowledge, and use knowledge meaningfully. Implications for practice and research are drawn.

Keywords

On-line learning, Technology-enhanced environments, Dimensions of learning, Perceptions and attitudes of learning

Introduction

Increasingly technology is becoming an integral part of teaching and learning in educational institutions. Until now much of the research has focused on comparative studies of the differences between face-to-face learning and distance learning in which the students were separated by time and/or distance, with many studies finding there is no significant difference in learning measures among types of instructional delivery (Russell, 1997). With the use of communication technologies in university classrooms, the question is no longer "Is face-to-face or technology-enhanced instruction better?" but more realistically, "How can we use the technology more effectively for learning?" To do this we must first understand how learning occurs in virtual environments and what factors influence it. "At issue is how to create a complex knowledge domain, especially how to build upon and retain the complexity of [learning] in an environment like computer conferencing so that users learn to be critical thinkers by considering issues and ideas from many perspectives" (Harasim, 1990, p. 59).

The purpose of this study was to explore learning processes that adult students used in a technology-enhanced environment. The intent of the study was to more fully understand what factors in a technology-enhanced environment fostered learning, what factors created barriers to learning, what learning processes students used, and finally, how students' thinking and learning patterns developed throughout the course of their technological learning experience.

Literature Review

The major focus of educational research and literature analyzing technology-enhanced environments has often been on teaching and course design (Boshier, 1997; King, 1998; Spector, 2000). The strategies to frame course content, deliver information, use technology, and implement an instructional design process have been described and researched. However, the extent to which courses offered in a technology-enhanced environment promote learning is often a neglected issue (Lian, 2000).

Educational researchers have begun to develop two avenues by which the investigation of learning in technology-enhanced environments is occurring. First, studies are being conducted to investigate the results of learning in technology-enhanced environments. Second, learning models are being created to foster an understanding of learning processes that are occurring in technology-enhanced environments. This literature review addresses research results and the learning process models.

Studies of Learning Results in Technology-Enhanced Environments

How does technology impact student learning? What do students do with information at the completion of their course work? These two questions exemplify the major issues addressed in research investigating the impact of technology on student learning. For example, Chester and Gwynne (1998) found that two-thirds of the students in an on-line course rated their participation in the subject matter as greater than in a face-to-face course. These students indicated that they learned more of the subject matter in an on-line environment. In addition, Hoag and Baldwin (2000) expand on this finding in their study of inter-university student teams collaborating electronically to learn case-based problem solving. Hoag and Baldwin found that "compared to the classroom model, students acquired greater experience in areas other than knowledge of course content: teamwork, communication, time management, and technology use" (p. 337). Additionally, they found that learning outcomes may be more related to a student's positive outlook than to other factors such as grade point average or prior experience.

In looking at what occurs as a result of technology-enhanced learning, Milton, Davis, & Watkins (1999) analyzed interactions occurring within small groups in an asynchronous web-based distance learning environment and found that virtual learning communities developed when there was a fusion of the learning processes and group dynamics. Rheingold (1994) indicated that the potential anonymity of virtual communities contributes to learners feeling that "virtual communities treat them as they always wanted to be treated—as thinkers and transmitters of ideas and feeling beings" (p. 26).

Holt (1998) analyzed student participation in a national issues forum conducted on the Internet for the purpose of studying its effectiveness and analyzing facilitation methods. Holt described how a multi-stage deliberation process developed that was "largely consistent with the theoretical literature about critical and reflective thinking" (p. 46). Finally, Milton and Wilson (1999) indicated that "the analysis of these small groups [in a computer-mediated environment] has taught us that the additional dimensions of time and space supported through collaborative technology increase the complexity of the learning and the interdependence of the processes and people involved" (p. 7).

Learning Process Models

How do learning and thinking processes develop in a technology-enhanced environment? Numerous authors have developed learning process models that depict both learning and thinking processes in technology-enhanced environments. Cicognani (2000) identified four stages through which she felt learners gathered information and developed expertise in an on-line environment. She named these stages generalization, focusing, application, and consolidation (p. 151). In the generalization stage, the learner is introduced to the materials and tools of learning in the on-line environment. In the focusing stage, the learner is focusing on specific understandings of the subject matter. In the application stage, the learner is more creative and focuses on problem solving using the knowledge generated in the first two stages. In the final consolidation stage, the learner consolidates knowledge through the process of summarizing, posing new problems, and finding new solutions.

Jonasseen (2000) chose a different route and elected to use a model of complex thinking as one that explains learning in a technology-enhanced environment. The Integrated Thinking Model (Iowa Department of Education, 1989, as cited in Jonasseen) defines complex thinking as "an interactive system, not a collection of separate skills" (p. 25). In this model complex thinking is composed of content/basic thinking, critical thinking, and creative thinking. Content/basic thinking is further delineated to mean problem solving, designing, and decision-making. Critical thinking, on the other hand, is defined as analyzing, evaluating, and connecting; whereas, creative thinking includes synthesizing, elaborating, and imagining. Jonasseen indicates that complex thinking is a integration of these three types of thinking and that using computers as learning tools will foster multiple types of thinking and thus, learning can be fostered.

For purposes of this study, the work of Marzano and Pickering (1997) offers a framework for learning that can be applied to the analysis of learning in a technology-enhanced environment. Marzano and Pickering have developed what they refer to as the five dimensions of learning. The premise of this model is that five types of thinking are essential to successful learning. Marzano and Pickering have identified the following dimensions of learning in their model:

- Dimension 1: Attitudes and Perceptions;
- Dimension 2: Acquire and Integrate Knowledge;
- Dimension 3: Extend and Refine Knowledge;
- Dimension 4: Use Knowledge Meaningfully; and,
- Dimension 5: Habits of Mind.

Their view (similar to Jonassen, 2000) is that each of these dimensions of learning is intricately related and inextricably connected. In this view of learning, the learners' attitudes and perceptions (Dimension 1) along with their habits of mind (Dimension 5) frame the learning process. If the learners' attitudes and perceptions are positive and they are using productive habits of the mind in their learning, then they can think more effectively along the other three dimensions of learning. These other three dimensions of learning do not exist in isolation nor do they occur in a sequential relationship, rather they are integrated and may actually occur concurrently during the learning process. So ultimately, in the Dimensions of Learning (DOL) Model the processes of acquiring and integrating knowledge, extending and refining knowledge, and using knowledge meaningfully will occur against the backdrop of the students' attitudes and perceptions and habits of mind.

Previously conducted research studies and newly created learning models are beginning to increase our understanding of the connections between the concepts of technology and learning. Previous studies (cited in this literature review) indicated that students do indeed learn in a technology-enhanced environment. Additionally, the development of learning and thinking models enhances our understanding of the processes that underlie learning with technology. However, this previous work indicated a great need for additional information describing the connections between technology and learning processes leading to a meaningful learning experience. The intent of this study was to offer additional research in this developing area.

Research Design

The purpose of this study was to explore the processes through which participants learn in a technology-enhanced environment. The research focused on the ways in which the instructional design, the facilitator, the learner, the technology, and the context impacted the learning process. This study built upon a constructivist design for collective learning. Web-conferencing software (Facilitate.com) was used to support the learning of virtual groups working on case studies.

The following research questions were advanced to guide this inquiry:

- What effect do participants report that technology has on their learning in a technology-enhanced environment?
- How do participants' reflective and higher order cognitive behaviors evolve while learning in a technology-enhanced environment?

This research was conducted as an action research case study using participatory techniques that involved the instructors and students as both subjects and researchers. The goal of this design was to create an environment "in which participants give and get valid information, make free and informed choices (including the choice to participate), and generate internal commitment to the results of their inquiry" (Argyris & Schön, 1989, p. 613).

Data Collection

Members of adult education graduate classes at five universities located in the United States, England, and Australia, and the professors of these classes constituted the research group. Students from all of these classes were assigned to small groups of 5-6 people that reflected both cross-institutional and cross-cultural diversity. During the course students presented a problematic case from their practice as an educator and led the discussion of their case for a one week period. In the other weeks the student participated as a group member in the discussion of other students' cases in their own small group. Then each group used data-based inquiry (Marsick & Watkins, 1999) to probe the underlying dynamics of the case, to challenge the assumptions of the case writer and other group members about learning processes, and to share experience through dialogue for the construction of resolutions to ill-defined problems (Schön, 1983). The total sample consisted of 46 students and five faculty members divided into nine groups where each faculty member served as the facilitator for two groups.

Qualitative data were collected through participant/researcher observations, written components of the course (including such data as the text of the web-based case work, e-mail exchanges between instructors and students, and final reflection papers completed by the students as part of the course), and researcher field notes.

Data Analysis

These data were analyzed using a constant comparative method which is "essentially an inductive strategy for generating and confirming theory that emerges from close involvement and direct contact" (Patton, 1990, p. 153). The data analysis process consisted of three steps. First, researchers reviewed all data collected in the course and generated overarching themes that depicted connections between learning and technology. Second, data from each of the groups were further distilled and categorized using the Dimensions of Learning Framework as a guide. Researchers coded data in each case study, student paper, and web-based discussion using the learning dimensions framework. Data were marked as discussion or paper to indicate case study interaction versus reflective paper comments. Third, researchers analyzed metaphors students created. Upon completion of the course students were asked to create a metaphor that depicted their on-line learning experience. These metaphors were analyzed looking specifically at how the metaphor depicted the students

attitudes and perceptions of learning with technology. The metaphors were then scrutinized to determine the connections to Dimensions 2, Dimension 3, and Dimension 4 of Marzano and Pickering's (1997) DOL Framework. These data analysis strategies were designed to allow the researchers to explore the initial inquiry questions.

Findings

Findings from this study indicate that participant learning is strongly influenced by technology and other dimensions of the learning experience. It was clear from the data that the participant learning was influenced by individual attitudes and perceptions of technology, learning tasks, peers, and facilitators. These factors appeared to be the lens through which participants acquired, integrated, and used meaningfully the knowledge constructed in the learning process. For example, if learners viewed the technology as time-consuming, or felt there was a great time lag between discussion responses then the learning was often viewed as negative or insignificant. However, if learners viewed the time dimensions of the technology as allowing opportunities for reflection then the learning was viewed more positively. It appears that these perceptions and attitudes influenced how learners constructed their knowledge base in a technology-enhanced environment.

Dimension 1: Attitudes and Perceptions

Marzano and Pickering (1997) indicate that attitudes and perceptions toward learning are framed by the student's view of both the climate and the learning task. In this study, students' views of the climate within an on-line learning environment varied greatly. Some students viewed the climate as very positive as indicated by the students who expressed the following.

> In the beginning I could sense the honesty and willingness to share on the part of the various group members. An atmosphere of trust was created. Even when she was asking questions to encourage my reflective practice, [name] was willing to reveal something about her life. Our group came to share in each others' lives. [name] attended her parent's anniversary party, [name] got a new job, [name] went to Boston, [name] went hiking on the Appalachian Trail, [name] had an emergency at the [job] and was left without Internet access, and I felt like I could share my life events too like going to my [job related] convention. [discussion]

> I think one of the biggest benefits of the on-line group is the ability to remove group interaction barriers. Time and space barriers can be overcome by using this technology. The typical group constraint of time is eliminated by this mechanism. [paper]

Additionally, viewing the learning task as positive impacted students' attitudes and perceptions. In this course, the students presented cases from their own practice and the learning task was to analyze the case to uncover assumptions that impacted their teaching practice and then to ultimately reframe and redesign the case. Students who viewed this learning task as positive indicated the following:

> Another sign that the group was growing was during the second case. One of the difficulties, strengths of this forum was that our group consisted of members from a wide range of backgrounds. I think part of the group development came from us crossing boundaries. By this, I mean our group was able to take a situation different from our own and apply our knowledge or questioning skills to aid the group in understanding. [paper]

> The ability for group members to take information from one context to another showed that the group was now not only sharing information but also processing it on a higher level. [paper]

However, some students had different attitudes and perceptions of both the learning task and the learning climate. The two factors of time and participation seemed to interact with feelings about climate and learning tasks in students who had a negative attitude toward the technology. This finding is different than the Marzzano and Pickering (1997) framework, as time and participation are not included in their DOL framework as factors that impact the development of attitude and perception. Students who viewed the technology as negative indicated that participation was an issue for them. Consider the student who indicated:

> I do have some connectedness issues because I know that I am participating in this discussion as part of a class rather than through self-selection. Therefore, the participating to me may seem more like a *have to* than a *want to*. [discussion]

Other students indicated that their student colleagues were not participating in the discussion as much as they thought they should. For example, one student expressed the following to a fellow student after reading an explanation of why that individual's participation had been low.

> Oh, and [name], No more excuses...get focused, get organized, and prioritize....we need your wit and wisdom in this group.. [discussion]

A different student expressed a great deal of frustration when she did not receive comments and participation on her case from her colleagues.

> . . .on my case. How about the rest of you? I know the case probably doesn't have the drama associated with the others, but I see that it still has its connection to "power." [discussion]

The length of time that was required to work and learn in this medium impacted students' attitudes and perceptions, often in a negative way. The issue of time was expressed in both the time it took to learn the content and also the time it took to use the technology. Consider these comments:

> Argg, my comments from yesterday seemed to have disappeared in cyberspace! Or perhaps I just hit a wrong button. But oh well, I will try to reconstruct what I said [discussion]

> I have just spent most of the day writing my contribution towards [name] case and when I came to submit, the whole connection had disappeared. Consequently everything was lost. [discussion]

Finally, students' perceptions of the learning task were often impacted by the use of technology. Many students found the technology cumbersome and also indicated that since part of the learning task was to analyze their own practice it was difficult to do that without face-to-face communication. These two student comments are quite typical of this view.

> I found the facilitate.com method a laborious and somewhat ineffective tool for action learning processes. The human element and rapid interaction facilitated in a face to face group setting proved to be far superior method for testing, discovering and examining my problems, assumptions and eventual discovery of the real problem statement. [paper]

> If I've learnt [sic] one thing this week, it's how much I rely on verbal and body language skills as my main form of communication. I've wanted to get you all in a room to show you what I mean. [discussion]

Metaphors depicting attitudes and perceptions. Each student created a metaphor to describe their individual on-line learning experiences. The variety and range of these metaphors varied, but the analysis clearly showed that the metaphors aptly depicted the students' attitudes and perceptions toward the technology. A sample of the metaphors created by students is depicted in Table 1. These metaphors were classified into three different groups, negative metaphors, hesitant metaphors and positive metaphors.

The negative metaphors were used to describe a learning experience perceived to be foreign, strange or beyond the grasp of the learner. Students used metaphors such as *lost in space*, *a roller coaster* or a *bizarre experience* to indicate that the technology was something unfamiliar and uncomfortable. At the same time these metaphors implied that the students felt disconnected from the rest of the group and/or the facilitators.

The hesitant metaphors painted a different picture by describing a learning experience that was unfamiliar and unique. These students were challenged and willing to try learning with this newer technology. The metaphors of an *old bus on a long journey* or *a kid trying on adult clothes* demonstrate the idea that these students felt out of their element but were intrigued enough with the technology to give learning in this new way a try.

Negative	Hesitant	Positive
Lost in space	Group therapy	Critical analysis
Roller coaster	Old bus on a long journey	Hologram
Bizarre Experience	Kid trying on adult clothes	Mirror to myself
Struggling and Confusion	A party	Vision Quest
	Herd of horses galloping in the wild	Small world after all
		Peeling an orange
		International Brainstormers without boundaries
		A Ropes Course

Table 1.

Metaphors of Student Experiences in a Technology-Enhanced Environment

The positive metaphors were created by students who liked the technology. These students found technology fun, exciting, and a new way to learn. The metaphor of a mirror was used to depict one student's view of how the technology allowed her to hold a mirror up and see her true self in a more reflective sense. Another student used the metaphor of peeling an orange to explain how the more she uncovered about this way of learning the more she enjoyed it. She indicated that finding the sweet inside of the orange was a real treat.

Linking Attitudes and Perceptions with Learning

These metaphors do help to understand students' attitudes and perceptions of the technology, but they become even more important when the connections between the students' attitudes and the learning are analyzed. Figure 1 depicts the relationship between attitudes and perceptions of the technology and the learning achieved by students. According to Marzano and Pickering (1997) students' attitudes and perceptions will impact the learning they achieve. This study supports that assertion and extends that assertion into an on-line environment.

Dimension 2: Acquiring and Integrating Knowledge

In this study, the students who viewed the technology as negative were able to acquire and integrate knowledge as were the students who viewed the technology as middle of the road or positive. For example, consider the student who thought the technology was awkward. When analyzing her case she indicated.

> There were some instances where dichotomous choices/solutions were suggested. I found this to be a negative and rather simplistic approach—a judgment on the part of a participant . . . . Based on the extensive description of the situation and continued explanations provided within the group interaction, I found this to be quite simplistic and dichotomous. [paper]

This student was able to take in some new information related to her own case and that of others but was not able to redesign, reframe, or use the new information in a more meaningful fashion.

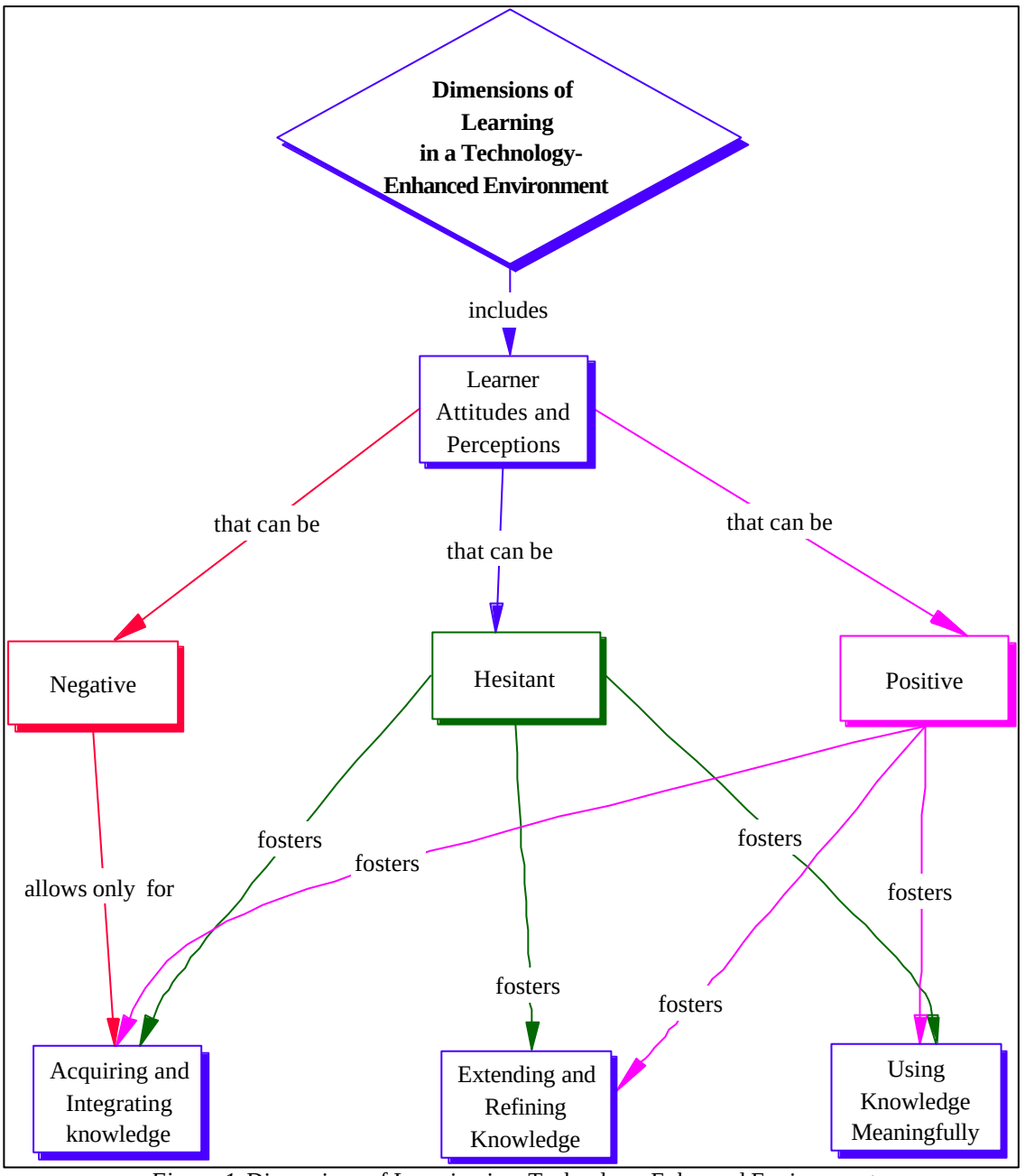

Figure 1. Dimensions of Learning in a Technology-Enhanced Environment

Additionally, students who viewed the technology and online learning as positive were also able to acquire and integrate information. For example, consider how these two students were thinking aloud, recalling prior knowledge, and attempting to construct a model of their practice.

> The most interesting learning from [name] case, was the similarity in learning theories. For example, Blanchard and Hershey state the student in the beginning needs high direction - the Vector model says at the exposure level the CI is responsible for planning and implementing the learning experience. The important thing is that as the student develops competency the role of the teacher decreases and the role of the student increases. Where do you perceive RB to be on the vector model? [paper]
>
> I'm so glad that we're doing this! What have we helped [name] to accomplish? . . . .I had just read Weinstein's article...perhaps that's where I picked it up about space for learning...the problem is that the social constructions for time and space that we put in place for 'work', 'teaching', 'learning', etc., are a challenge to deal with in any setting (work, school, home, etc.). Perhaps we need to

> reframe how we construct environments/contexts for learning? Perhaps we need to slow the process down and understand that each of us learns at a different pace and space in time? Boy, this would drive the guys on Wall Street absolutely bonkers! It presents a great challenge to the status quo. . . [name] . . . Can you be comfortable with an outcome that may not be the one you hoped for in the beginning? [discussion]

Dimension 3: Extending and Refining Knowledge

Study data indicate however, that if students' attitudes and perceptions of the technology were negative, then they did not develop the ability to extend and refine their knowledge. This student summarizes the feelings of a number of individuals in the study.

> At this point, I could have started a discussion about group process and how we are supposed to be helping each other find new perspectives through insightful questions. Because it was my case, I was hesitant to tell the group that they are not asking me the right questions. Or, maybe I was not fully invested in the on-line process to really push this online stuff too far. After all, they were a group of strangers and this is my last formal class of graduate school. Just get me through! [paper]

In contrast, those students who viewed technology hesitantly or positively did develop the ability to extend and refine knowledge. The following student created a hesitant metaphor to describe his attitude about technology and one can see the impact this had on his learning.

> While a first assessment of the experience was negative (didn't feel I got much out of the input of the others), further reflection has led me to see that while my dissatisfaction with others participation led to a negative impression, my learning is still my responsibility and when I took the opportunity to examine my own perceptions and was challenged by the facilitator, I learned much. [paper]

The students who demonstrated a positive attitude about the on-line learning experience developed the ability to extend and refine their knowledge by abstracting, comparing, and analyzing different perspectives. In the following quotes we see the development of this extension of their knowledge base.

> I grew in my understanding of how problems that initially seem defined in my mind based on assumptions I have made are really quite ill-defined when the assumptions are challenged. In addition, when the layers are unpeeled the problem may be markedly more complex than initially realized. I also appreciated the impact of reflecting on the cultural implications on the problems we worked to solve. [paper]

> The airspace that I enjoyed while living away from the on-line group gave me time and space to reflect on the insightful questions and comments that I had received up to that point. I was able to analyze the case more objectively and to attempt to reconstruct the teaching/learning opportunity in such a manner as to incorporate new strategies to facilitate learning. [paper]

> I looked again at my final comment of last night, which you picked up on (...inappropriate approaches to teamwork...). I remember wondering at the time I posted it, whether it conveyed the right message I was looking for. On a second look, I don't think it did, although it has elicited something valuable for me in your comments. On second reading it looks aggressive and defensive—Sorry, I didn't mean it like that. I was wondering what people really think about me and my actions. I think this may come back to my need to be liked. [discussion]

Dimension 4: Using Knowledge Meaningfully

The same finding applied in the area of using knowledge meaningfully. Those students who viewed the experience hesitantly or positively were able to use knowledge in a meaningful way, where as those who viewed the technology-enhanced environment negatively did not seem to use the knowledge meaningfully. For example, consider the lack of learning expressed by this student who viewed the technology from a negative perspective. This student did not feel that he was able to solve problems, make decisions, or use the knowledge he gained in a way that was meaningful to him.

> I think that this was the most neglected aspect of our online discussion. We did not do any systematic practice of new behaviors or in any way play out new ways to solve our problems. I'm sure that this was because of time and technology factors as well. One obstacle was simply that we didn't have enough time each week to fully process a case from understanding through action. The second problem was the artificial nature of our interaction. In a one-on-one situation, it may have felt very natural to explore alternative solutions and even practice behaviors that were unfamiliar to us. In an online discussion, however, the "conversation" flow was disrupted by several people asking questions and offering suggestions. Each discussion could not follow its natural course to a logical conclusion. [paper]

The students who viewed the technology and on-line experience as positive found many creative insightful ways to use the knowledge they created in a meaningful way. They made decisions, solved problems, carried the knowledge back to their practice, identified contradictions and analyzed the systems in which they practice. The following excerpts depict some of the meaningful learning that occurred.

> In response to your thoughts about starting the reflective process earlier I wanted to share with you the proposed schedule of activities I am planning to implement prior to and during the clinical affiliation. [discussion]

> I learned that just as when I am a learner I need to vary my learning style to fit different situations, I also have to vary my teaching style to fit the needs of students. I tend to be comfortable with my teaching style, but I need to find new ways of teaching students who may not be in tuned with my way of teaching. [discussion]

> What I found interesting is during the time my case was up for discussion in the on-line project I was also doing a workshop with similar clientele. Ironically some of the same behavioral issues as my case reflected were happening in my workshop. As I dealt with each of them, I was thinking of the on-line group's suggestion to take more time during workshops to process the activities and to work on the trust issues with the group. To do this I used more probing questions to build trust and redefine what the purpose of the day was as the on-line group suggested. [paper]

Dimension 5: Habits of Mind

Dimension 5 of DOL framework (Marzano and Pickering, 1997), habits of mind along with perceptions and attitudes impact how students learn. However, in this study, types of thinking or habits of mind seemed to develop as students acquired information, integrated that information in their cognitive structures and used that information meaningfully in their practice. This may have been because a major focus of the course was on analyzing assumptions in practice and reframing understanding of practice issues. For example, students discussed how they acquired information differently in this web-based course:

> One main benefit I found with web-based learning, was having to deal with one piece of information at a time. By that I mean when in a face-to-face group, it is necessary to not only listen to what the presenter is stating, but at the same time observe and read both verbal and non-verbal communication . . . being able to fully take in all what is said [sic] in one go can be daunting . . web-based presentation is written and only the presenter's written word requires clarification. [paper]

Students also indicated that integrating information from their learning challenged how they viewed their educational practice. Consider the participants who stated:

> My second discovery about my practice and probably the more important, is the notion of power relationships that exist in my role as administrator and academic. I had not understood or appreciated the very existence of power relationships within my life. [discussion]

> To put my dilemma in to a broader context, I would say that in my role as an adult educator, rather than to teach a skill I attempt to assist the student to gain knowledge of the skill, and encouraging them to become independent thinkers rather than repeaters. [discussion]

Finally participants found ways to use the information meaningfully in their work lives.

> I have made changes to the teaching format with not only this particular student, but with a couple of other students. [discussion]

Interestingly, it appeared that reflective thinking developed from the process of applying and utilizing Dimensions 2, 3, and 4 of the DOL framework, rather than the thinking pattern itself determining how knowledge was constructed. In other words, students seemed to learn how to think more critically through the process of extending and refining knowledge and using knowledge meaningfully.

Discussion, Implications, and Conclusions

In summary, findings of this study indicated that students' attitudes and perceptions towards technology [and the ways in which technology foster the learning climate and structure the learning task] have a major impact on learning outcomes. Students who viewed technology from a negative perspective did acquire and integrate knowledge, but most stopped short of extending and refining that knowledge or using that knowledge in a meaningful way. Students who viewed the technology as positive were able to demonstrate Dimension 2, 3, and 4 of the DOL framework. These findings are consistent with those of Marzano and Pickering (1997).

However, some differences were noted from the Marzano and Pickering (1997) framework in a technology-enhanced environment. First, the level of participation in which groups engaged with the technology was significant in framing the students' attitudes and perceptions. Second, students' awareness of the time required for learning was significant in framing their attitudes and perceptions. Participation and time were two factors not specifically addressed by Marzano and Pickering. Third, in a technology-enhanced environment, it appeared that students developed reflective thinking through the integration and application of Dimensions 2, 3, and 4. As such, the thinking processes appeared to be an outcome of engaging with the technology in the learning process, rather than a way to frame learning.

So what do these findings mean for teaching in a technology-enhanced environment? First, the importance of the students' attitudes and perceptions of the technology is paramount. How students perceive the technology will impact their learning. Thus, on-line instructors need to spend energy, time, and thought in carefully developing the learning climate with the idea that this will impact not only student attitude, but learning outcomes as well. Students in this research study provided good suggestions for instructors when saying:

> Another element, and I felt this was neglected, portion of the web-based groupware design was that our group underutilized the ***chat room*** to get the synchronous experience of communicating with each other or creating role plays as was suggested in the ***redesigning action*** section of our material. We also did not develop the ***expectations***, ***creating common ground***, and ***getting acquainted*** sections enough to really benefit our group in its stages of growth. I really cannot *emphasize how important* I think this could have been in developing richer interactions within the group. Therefore, from a lack of the group development process, the comments made by group members seemed to be taken literally and did not really include any knowledge of the person making them which had the effect of being harsher than they were probably intended. The length of time that we participated in this minicourse also was a restrictive variable in the degree to which the group could develop their various skills and stages of group growth. [paper]

Thus, providing time for group development, discussing the climate of the group, setting expectations, developing ground rules, providing synchronous chats, structuring opportunities to work with peers, and communicating expectations clearly are all teaching strategies that can be developed in a technology-enhanced environment.

Second, instructors in on-line environments need to pay careful attention to the structure of the learning tasks. The level of participation and time commitment required will impact both attitude and learning. Clear explanations of the learning task, discussion of the time required, and the creation of learning tasks based on learner interests are all teaching strategies that can be developed in a technology-enhanced environment.

The researchers conducting this study were initially surprised and perplexed by the amount of variation between student groups learning in a technology-enhanced environment. Some groups excelled—some groups struggled. Some groups demonstrated high levels of learning and thinking—some groups learned through simply taking in

information. Some groups participated continually—some groups were more silent. This variation and unevenness can be addressed through an understanding of the students' attitudes and perceptions of technology. The exciting part of this finding is that facilitating learning climate and developing learning tasks to foster positive attitudes is an activity that instructors can adopt. What surprised the researchers was the strength of the impact that the students' attitudes and perceptions had on their learning in a technology-enhanced environment.

However, this study also generates additional questions for future research. Are the thinking processes that students used in a technology-enhanced environment really an outcome of the learning processes described here? What specific activities can instructors use to foster positive learning outcomes? If students enter a technology-enhanced environment with a negative attitude toward technology, what actions on the part of the instructor will foster a change in attitude? Further exploration of the connections between learning and technology is needed as the use of technology in educational institutions will only continue to grow and expand. Understanding the connections is vital to developing learning and thinking capabilities. As Jonassen (2000) indicates, ". . . when students work with computers, they enhance the capabilities of the computer, and the computer in turn enhances their thinking and learning. The result of this partnership is that the whole of learning becomes greater than the potential of the learner and computer alone" (p. 4).

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