COLLABORATION AND THE USE OF THREE DIMENSIONAL INTERFACE

WITHIN A VIRTUAL LEARNING ENVIRONMENT AND THE IMPACT ON

COMMUNICATION AND LEARNING: A CASE STUDY

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by

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DEDICATION

I dedicate this work to our daughter:

Blythe Noel Burton

January 4, 2007

Though she was with us only a short time, her impact will be felt for the rest of our lives.

And to my grandmother:

Mary Mildred Burton

August 17, 1921 to June 23, 2004

Her faith and belief in the goodness of people inspired me to try to make a difference in the world.

ACKNOWLEDGMENTS

ABSTRACT

The purpose of this study was to determine whether collaboration occurred within 3D virtual learning environments. Furthermore, if collaboration occurred were the elements of Nonaka and Takeuchi's knowledge spiral present as well? By creating a 3D didactic constructivist virtual environment, conversations were observed for collaborative elements. Data for this mixed-design study were gathered through three sources, the 3D virtual environment, a survey created by the researcher, and follow-up interviews.

Findings revealed that the five (5) forms of collaboration: Elementary Clarification, In-Depth Clarification, Inference, Judgment, and Application, amplified the knowledge creation process and indeed occur with virtual learning environments. It was also determined that all four (4) requirements for a knowledge spiral: socialization, externalization, combination, and internalization, did occur during the period of this research within the 3D environment. Thus the creation of new knowledge as knowledge passed from tacit to explicit and explicit to tacit (Nonaka & Takeuchi, 1995) within this 3D virtual learning environment. Qualitative results further suggested that after a period of adaptation by the user, most participants were less likely to get off-topic and focused more on the project given to them.

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CHAPTER ONE

Introduction to the Study

Background

3D Virtual Environments inundate many of today's students' lives. In these environments they fight, love, talk, develop, save societies, and, most importantly, they learn. Can the same be said for 3D Virtual Learning Environments (3D VLE)? Many researchers have begun the inquiries necessary to show that there is no significant difference (Russell, 2001) between this model of education and traditional education. According to Dalgarno (2002),

> Information and communication technologies can be important in the process of adapting to the new demands, as they have the potential to make learning resources more accessible, to allow a greater degree of individualization and to make the learning process a more active one. Two important technological advances in this context have been the widespread adoption of the Internet and increases in desktop computer graphics and processing capability. These three dimensional (3D) environments, which have become almost ubiquitous within the computer games industry, have the potential to harness these technological developments and facilitate new levels of learner-learner and learner-computer interaction. (p. 1)

Dede, Nelson, Ketelhut, Clarke, and Bowman (2004) and Barab, Thomas, Dodge, Carteaux, and Tuzun (2005) have created 3D Virtual Learning Environments (3D VLE) to demonstrate aspects of distance learning and the uses of virtual environments as educational tools. Dillenbourg (2000) found that "the difference between other

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constructivist environments and what virtual environments potentially offer can be described as making students not only active, but also actors" (p. 8).

However, researchers have only begun to explore the use of the 3D VLE as an educational tool. Since collaboration is an important part of the educational process (Bruffee, 1999) of any learning community and, given that communication is necessary within a 3D VLE, collaboration has been chosen as the theoretical lens to view learning and knowledge creation within the 3D VLE. Additionally, Bonk, Kim, and Zeng (2006) when surveying higher education faculty who had taught online have found that:

> When asked to select four pedagogical techniques that would be used most widely online during the next few years from a list of 12 instructional methods, over 65 percent selected group problem solving and collaborative tasks, while 58 percent choose problem-based learning. In contrast, only about 1 in 10 thought they might use lectures, modeling, or Socratic instruction. . . . In addition, most respondents saw the potential of the web in the coming years as a tool for virtual teaming or collaboration, critical thinking, and enhanced student engagement, instead of as an opportunity for student idea generation and expression of creativity (p. 556).

With such an interest on collaboration and constructivism in virtual education, there is a significant need to examine the congruence of these important aspects of learning.

Conceptual Underpinnings of the Study

Why is the occurrence of collaboration within 3D Virtual Learning Environments important? According to Bruffee (1999), conversation must exist for reacculturation to occur. Without reacculturation, the student will not gain the essential vocabulary and

redefinition that is essential to the educational process. Crook (1996) noted three benefits created by peer collaboration: articulation, conflict, and co-construction. By examining conversations within the 3D VLE, it is possible to check for the existence of collaboration.

An additional underpinning of this research, dialectic constructivism utilizes scaffolding to allow the learner to participate in authentic, problem-based learning situations (Dalgarno, 2002). Such an environment provides opportunity for collaboration and immersion within the context of the concept to be mastered. By creating constructivist environments, educators can provide a structured situation for the learner to gain competency over a complex concept (Barab, Thomas, Dodge, Carteaux, & Tuzun, 2005; Dede, 2005; Dede, Nelson, Ketelhut, Clarke, & Bowman, 2004).

Virtual learning environments have allowed the modern student and teacher to interact without regard to location or time (Hobbs, 2004). While distance education has existed since the first correspondence course, only with the aid of modern technology has such educational practices become common place, replacing traditional correspondence courses with virtual learning environments (Hobbs). Dillenbourg (2000, p. 2) noted seven common attributes of a virtual learning environment: 1) the environment has a design, 2) interaction occurs within the environment, 3) the 'place' is explicitly for information and social interaction, 4) learners in the environment are active and contribute to the virtual place, 5) VLE can be used for distance education or classroom enrichment, 6) The VLE integrates multiple technology and pedagogical approaches, 7) most VLEs have a corresponding physical environment.

Creating a constructivist environment that integrates collaboration virtually has been a challenge until the recent past. Popularized by current Massive Multi-player Online Games (MMOG), 3D desktop based virtual learning environments provide a new means of allowing students to safely interact with their environment and one another (Dede, 2005). According to Dalgarno (2002, p. 3), the primary characteristics of a 3D environment includes: 1) use of 3D vector geometry to describe objects shape and coordinates in the environment, 2) the user's view is dynamically rendered according to their location and direction that they face, 3) the user is able to interact with some objects in the environment, 4) the environment may include 3D audio.

Yet, even with the most sophisticated technology currently in existence, without good pedagogy, education will be hampered. Testa (2000, p. 238-243) noted seven practices for good pedagogy in distance education: 1) keep in contact with students, 2) develop collaboration and cooperation within your class, 3) use active learning techniques, 4) give prompt feedback, 5) Time on Task, 6) set and communicate high expectations, 7) respect your students' diverse talents and ways of learning. The concept of providing opportunities for collaboration within a 3D virtual learning environment that utilized a constructivist approach with good pedagogical foundation guided this research.

Statement of the Problem

Over a decade ago, interest in the utilization of computer technology in distance education began to rise with the advent of the internet and online resources. Early attempts were made to create immersive environments (Dede, 1995) that would enable students to participate in a virtual environment via technology. These environments were designed to enable students to gain understanding and skills in complex subject matter.

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Some such environments incorporated constructivist principles and/or the ability to collaborate. Due to improvements in technology and the utilization of 3D environments on a successful commercial basis (Jagex, 2004), there has been renewed interest in the utilization of 3D environments as learning tools.

With the new found success of commercial 3D environments and a desire to utilize the popularity of such environment for the education of the millennial generation (Dede, 2005), the evaluation of such environments for pedagogical purposes is appropriate. While an abundance of research is available on collaboration and constructivist education models, there is only a limited amount of research in theses fields in their use within 3D VLEs (Barab et al. 2005; Dede et al., 2004). Since such research is limited, it was decided by this researcher to contribute additional research to this new method of educating students. This case study was therefore intended to add to the body of research where a dialectic constructivist 3D VLE is used to create a learning environment that encourages collaboration.

Purpose of the Study

A case study descriptive approach was selected for this study, which was to examine the existence of collaboration within a dialectic constructivist 3D VLE. The study was further focused to examine the types (if any) of collaboration that were present within the 3D VLE. Additionally, the data was examined for evidence of a knowledge spiral (Nonaka & Takeuchi, 1995). A case study was selected to focus on discovery rather than hypothesis testing (Merriam, 1998). According to Bogdan and Biklen (1998), qualitative research such as a case study should be selected when the researcher is

investigating human behavior and experience and how people create meaning from those experiences.

The results of this study should contribute significantly to the growing body of research in 3D VLEs and the utilization of collaboration within constructivist environments. It is hoped that this research influences the future development of such environments.

Research Questions

The following research questions guided this inquiry:

1) What types of collaboration are present within a dialectic constructivist 3D Virtual Learning Environment (VLE)?

2) How does the collaboration process contribute to learning within a 3D VLE?

3) Does collaboration within a 3D VLE create the Knowledge Spiral detailed by Nonaka and Takeuchi (1995)?

4) As measured by the student's success at solving programming challenges, what is the rate of success of students participating in the 3D VLE?

5) What are the perceptions of the students regarding the effectiveness of the collaborative process within the 3D VLE?

Limitations and Assumptions

The limitations to this study were as follows:

1) The study was limited geographically to college students in one Midwest state and one Southern state during one academic term.

2) The class was limited in size, with an estimated 40 individuals participating in the study.

3) This study was limited by the reliability and validity of the 3D VLE and any technical problems that occurred during the course of the study.

4) While outside communication concerning the project was discouraged, so as to ensure that the collaboration only occur within the 3D VLE, it is possible that participants may have collaborated outside of the virtual environment.

5) It is assumed that participants were honest in communications and participation.

6) Researcher bias was controlled through triangulation of data.

Design Controls

In the desire to avoid researcher bias, several methods were utilized to guard against that possibility. As Bogdan and Biklen (1998) noted, "The worth of the study is the degree to which it generates theory, description, or understanding" (p. 34). First, all conversations and opportunities for collaboration were recorded through the used of electronic log files. Second, a follow-up survey was completed by participants to gather additional evidence assisting in triangulation of the data. The survey instrument was created using standardized psychometrics establishing reliability and validity (Bogdan & Biklin, 1998). Since surveys carry the potential problems of participants not being truthful and diligent in their responses (Thomas & Brubaker, 2000), controls for this were added by conducting interviews using purposeful sampling as a strategy to gather descriptive data in the subjects' own words so that insights on perceptions may be interpreted (Bodgan & Biklen, 2003). This third sampling utilized semi-structured interviews composed of open-ended questions (Gay, 1996) which were used to triangulate the data. All interviews were recorded and transcribed. Interview transcripts were then provided to the subject interviewed for feedback to ensure that the intent of the answered questions was correctly recorded. Finally, all data was compared with quantitative data gathered from the 3D VLE.

Definitions of Key Terms

The following definition of terms has been provided to assist the reader in better understanding this study:

Asynchronous – Information or lessons that are delivered one way at a time. With this method, students and instructors may be in vastly different locations and working at different times.

Avatar – A three-dimensional representation of a person or object within a virtual universe or Virtual Learning Environment (Steinkuehler, 2004).

Bot – A three-dimensional avatar that is controlled by in-game artificial intelligence.

Collaboration – Where two or more people work together to achieve a goal. Peer collaboration will include articulation, conflict, and co-construction (Crook, 1996).

CMS – Content Management System – provides centralized management for the Virtual Learning Environment.

Constructivist – educational philosophy that the student is the center or focus of the educational process (Fosnot, 1996).

Flaming – the act of posting a hostile message.

Foundational view of Learning – according to this traditional view, knowledge is transferred from teacher to student (Bruffee, 1999).

Immersive Virtual Learning Environment – A virtual learning environment that utilizes a 3D interface of special headgear goggles and often gloves or a special room (Dalgarno, 2002).

Knowledge Spiral – The creation of new knowledge as knowledge passes from tacit to explicit and explicit to tacit (Nonaka & Takeuchi, 1995).

Massively Multiplayer Online Game (MMOG) – An online environment that allows many players to play and interact simultaneously.

Massively Multiplayer Online Role Playing Game (MMORPG) – An online environment that allows players to interact with an online fantasy environment through an avatar.

Multi-User Virtual Environment – "(MUVE) interfaces in which participants' avatars interact with computer-based agents and digital artifacts in virtual contexts." (Dede, 2005, p. 8)

Nonfoundational View of Learning – according to this view, knowledge is socially constructed by the community through social interactions (Bruffee, 1999).

Problem-based learning (PBL) – Educational information that is presented in the context of solving a complex, realistic problem (Bransford, Brown, & Cocking, 1999).

Quest – An "engaging curricular tasks that are connected to academic standards" (Barab et al., 2005, p. 87).

Serious Games – "a game in which education (in its various forms) is the primary goal, rather than entertainment" (Michael & Chen, 2006).

Synchronous – Information or lessons that are delivered from the instructor to the student at the same time. The student receives the instruction at the time that the instructor provides the instruction with no time delay.

Three Dimensional Virtual Learning Environment (3D VLE) – A virtual learning environment that utilizes a three dimensional interface (Dalgarno, 2002). For the purposes of this research it will be limited to desktop computer based interfaces.

Virtual Universe/World – A digital representation of an environment that people can participate in through a desktop based or immersive interface.

Virtual Learning Environment (VLE) – any digital interface to an environment where a learner is presented educational information (Dalgarno, 2002).

Summary

While there is extensive research in the areas of collaboration and constructivist learning, it is limited when applied to 3D VLEs. Through the utilization of a constructivist 3D VLE, it was hoped that collaboration and a knowledge spiral occurs assisting students with the learning of educational material. Successful collaboration will be evidenced by the students not only completing their educational project, but by the presence of articulation, conflict, and/or co-construction (Crook, 1996).

In Chapter Two, a review of literature is provided examining (a) collaboration in learning, (b) constructivist approach in learning, (c) distance education and online learning, and (d) distance education pedagogy. Within Chapter Three, a description of the research design and methodology utilized in this study is presented. The design, a qualitative, multi-case study, has been described. Additionally, the methodology, implementation of the constant comparative method, is addressed. Included in Chapter Four are the presentation of data findings and an analysis of the findings. In Chapter Five, the results of the study are summarized and implications for further research presented.

CHAPTER TWO

Review of Related Literature

Introduction

Distance education is on the brink of several major technological advances (Dede, 2005). These advances make possible many aspects of distance education that heretofore have not been conducive or cost-effective for the average educational institution or educator (Hobbs, 2004). Given renewed interest due to technological advances in research that was largely conducted in the mid to late 1990's, it is appropriate to attempt to demonstrate the phenomenon of "no significant difference" (Russell, 2001) in the area of three dimensional virtual learning environments (3D VLE).

Changes have occurred in technology where it is no longer necessary for students and teachers to interact from the same location or even at the same time (Champion & Freeman, 1998). But just because it is no longer necessary, can it be said to be an equivalent education? One essential component of education is the collaboration that occurs between students and the teachers as well as the collaboration that occurs between students and their peers (Bruffee, 1999). With this in mind, it was decided to examine in this study the use of collaboration in the virtual learning environment for learning and the creation of a knowledge spiral (Nonaka & Takeuchi, 1995).

In order to fully investigate how collaboration and the use of a three dimensional interface within a virtual learning environment had an impact on learning, a literature review was conducted and included four areas of research: collaboration in learning, constructivist approach in learning, distance education, and distance education pedagogy. Collaboration in learning provided recent research and understanding into the field of

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learning. A review of the constructivist approach as it relates to collaboration and distance learning has been provided to show how this approach augments distance learning. A brief history of the development of distance education is included to show the roots of the 3D VLE and the evolution of technologies impact on education. Finally, good pedagogy is essential no matter what educational methods are utilized. A review of pedagogy as it relates to distance education is included.

Collaboration in Learning

In the late nineteen-ninety's the Office of Educational Research and Improvement of the U.S. Department of Education established a committee to review the nation's investment in learning (Bransford, Brown, & Cocking, 1999). A result of that research was five themes that have changed the concepts of how learning occurs.

According to Bransford et al. (1999), over the last thirty years, new understanding and information on how humans learn has resulted in a shift away from drill and practice to be replaced with a "focus on students' understanding and application of knowledge" (Bransford et al., p. 1 of Executive Summary). The five themes to emerge from this research are: the memory and structure of knowledge; analysis of problem solving and reasoning; early foundations; metacognitive processes and self-regulatory capabilities; and cultural experience and community participation. Each of themes will be defined and examined.

Memory is now seen as more than mere associations created by the learner. It is how structure is placed on information. One of the results of research into memory according to Bransford et al. (1999) is a greater understanding of how experts store knowledge. By organizing their knowledge around core concepts, the experts thinking is

guided within the field of expertise. Dede, Salzman, and Loftin (1996) provided an example of such grouping. Through the creation of an immersive virtual world, students were provided opportunity to organize their knowledge and create a more accurate mental model.

Bransford et al. (1999) postulated that "learning theory can now account for how learners acquire skills to search a problem space and then use these general strategies in many problem-solving situations. There is a clear distinction between learned problem-solving skills in novice learners and the specialized expertise of individuals who have proficiency in particular subjects" (Bransford et al., 1999, p. 2 of Executive Summary). Bateson's second level of learning would be classified in this level. In Learning II, the learner develops strategies to maximize their learning (Bateson, 1973).

Through the development of new methods of assessment, researchers have ascertained new knowledge in how infants and young children learn and organize knowledge. Due to this new understanding, educators are now challenged with accounting for and taking advantage of the predispositions, skills, and abilities children arrive at school already possessing (Bransford et al., 1999).

Next Bransford et al. defined metacognition as "the ability to monitor one's current level of understanding and decide when it is not adequate" (Bransford et al., 1999, p. 14). By utilizing metacognitive process and self-regulatory capabilities, a learner is capable of making good use of his or her time, predicting future outcomes, and to plan ahead. Perhaps one of the most interesting items noted by Bransford et al., is the use of "explaining to one's self in order to improve understanding" (p. 11). This reflective thought as internalized conversation (Bruffee, 1999) leads to the final of the five themes.

As Bransford et al. (1999) noted, "It is easy to forget that student achievement in school also depends on what happens outside of school" (pp. 16-17). By recognizing the communities and the acculturation of the learner (Bruffee, 1999), it is possible to create the new community and conversation that is required to create new knowledge. This transfer from tacit to explicit knowledge is an essential part of the creation of a knowledge spiral (Nonaka & Takeuchi, 1995).

Bruffee (1999) expanded this concept of learning as a collaborative process by casting the process of learning as the reacculturation of the learner. Meaning that in order to fully participate in a community of learners, a student or learner must gain new vocabulary, knowledge and language skills as one continues to participate within the culture of learning. This learning process is, by its very nature, a collaborative process (Bruffee).

Furthermore, in this reacculturation process, Bruffee argued that the learner must gain a new vocabulary to participate within the collaborative community. He noted that most have experienced at one time the feeling of not being a member of the community in which they find themselves. Without the proper vocabulary to express themselves effectively, he postulated that they are unable to participate, let alone understand the community with which they find themselves "their worlds were closed by walls of words" (Bruffee, 1999, p. 6). Thus by distributing knowledge and authority amongst themselves, a group becomes a collaborative community (Bruffee).

In defining what collaboration includes, Crook (1996) listed three basic cognitive benefits of peer collaboration: articulation, conflict, and co-construction. Crook noted that peer collaboration causes students to be more explicit in the public declaration of

their ideas. When a student states their concept, they must be clear and concise in their opinions and interpretations. Students will inevitably be faced with conflicting interpretations causing conflict to arise. In the resolution of this conflict caused by their collaboration, they must defend their interpretation, which should cause the student to further reflect on their stance. Borrowing from Vygotsky (1978), Crook's co-construction is the process of students constructing shared knowledge by sharing and building upon each others' ideas. This concept is the same as by Nonaka and Takeuchi's (1995) concept of the knowledge spiral.

Nonaka and Takeuchi (1995) noted that "in a strict sense, knowledge is created only by individuals" (p. 59). As knowledge is shared between individuals within an organization, it moves from being tacit knowledge to explicit knowledge. Nonaka and Takeuchi noted that as knowledge moves from tacit to explicit, it passes through "four modes of knowledge conversion" (p. 72). These modes, socialization, externalization, combination, and internalization, amplify the creation process. This amplification results in knowledge becoming larger in scale as it moves through an organization (Nonaka & Takeuchi).

Dede (2005) articulated that "at present, social groupings depend on co-presence in physical space (roommates, classmates). Collaboration depends on shared physical presence or cumbersome virtual mechanisms. In the future, students will participate in far-flung, loosely bounded virtual communities (independent of cohabitation, common course schedules, or enrollment at a particular campus)" (Dede, p. 10).

While some argue that in and of itself collaboration is neither "efficient or inefficient" (Dillenbourg, Baker, Blaye, & O'Malley, 1996, p. 197), Wulff, Hanor, and

Bulik (2000), noted that the instructor can aid the development of collaboration within a constructivist approach by "redistribut[ing] learning control and power by supporting and/or developing interaction-exchange formats, such as synchronous and asynchronous chat sites and display rooms to cultivate social and individual presence" (Wulff, Hanor, & Bulik, p. 150) . This nonfoundational view of learning allows students to learn in a collaborative fashion, rather than with the traditional foundational view in which knowledge is dispensed from the teacher (Bruffee, 1999). By taking a nonfoundational view of learning, the educational process shifts to a constructivist approach.

Constructivist Approach in Learning

Fosnot (1996, p. 30) noted that constructivism "describes how structures and deeper conceptual understanding come about." According to Dalgarno (2002), the constructivist approach can be summarized in three broad principles: First, "each person forms their own representation of knowledge and consequently that there is no single 'correct' representation of knowledge" (p. 2). Second, the learner in their exploration of their environment discovers that they have a lack of knowledge or an inconsistency in their understanding of their knowledge domain. Third, learning is a social activity, and that knowledge is acquired through interaction (Bruffee, 1999). Moshman (1982) has differentiated the constructivist approach into three categories:

- Endogenous focuses on the individuality of the learner's knowledge.
- Exogenous focuses on the creation of formal instruction and exercises that can help the learner in their acquisition of knowledge.
- Dialectical focuses on the "use of realistic experience through the use of scaffolding and collaboration to develop knowledge" (p. 372).

With the endogenous constructivist focus on the learner discovering knowledge through their exploration, Dalgarno (2002) recognized two ways to utilize a 3D VLE that are consistent with this approach. The first utilizes simulations to create environments for the learner to actively explore that include simulations of the observable world and abstract concepts. An example of one such a project would include AquaMoose 3D Math (Elliott & Bruckman, 2002), which allows the user to explore and create the environment through mathematical formulas. The second way utilizes services as interface in place of traditional web or hypermedia materials. Such an environment might be the exploration of a microscopic environment (Dalgarno, 2002).

The exogenous constructivist approach would utilize a 3D VLE somewhat differently than the endogenous constructivist. Since the exogenous constructivist includes an emphasis on direct instruction to aid the learner, the use of the learning environment will also vary. The exogenous constructivist will utilize traditional resources, allowing the learner to still explore, but with a greater degree of control of that exploration and the sequence (Dalgarno, 2002).

Finally, dialectical constructivists would use the 3D VLE to allow the learner to participate in authentic activities, but with the use of scaffolding provided by teachers and peers. This approach is dependent on collaboration occurring between learners and between learners and experts or teachers. Using a dialectical approach, learners are encouraged to communicate and undertake learning together rather than one their own (Dalgarno, 2002).

Research has shown that the effective use of computer technology enhances student motivation, engagement, and concentration (Priest, Coe, Evershed, & Bush,

2004). This effect is emphasized in virtual learning environments. According to Dede (1995), Virtual environments have been

> "evolving beyond technology-mediated interactions between students and phenomena to technological instantiation of learners themselves and reality itself shifts the focus of constructivism: from peripherally enhancing how a student interprets a typical interaction with the external world to "magically" shaping the fundamental nature of how learners experience their physical and social context" (p. 1).

Effective utilization of collaboration and constructivist approaches can greatly enhance distance education and online learning.

Distance Education and Online Learning

Distance education has been available since the first correspondence course (Hobbs, 2004). Through the years, distance education has matured with new and different methods of delivery. Along with this expansion of delivery models has come the argument of whether or not distance education is equivalent to traditional education. By collecting and analyzing the research in distance education that has occurred over the last seventy-five years, Russell (2001) has shown that there is "no significant difference" between traditional classroom and various modes of distance education.

In fact, online distance education has experienced incredible growth in the short time that it has been available. Allen and Seaman (2004) projected that fall 2004 enrollment in online courses would exceeded 2.6 million student in college level courses, up 24.8% from the previous year's enrollment. Research shows that increasingly, teams of students from around the world are working together to tackle authentic problems

(Kozma, 2003). Online student-centered forums have the potential to nurture community building and develop students' collaboration and communication skills (Luca & Mcloughlin, 2004). The same researchers found that successful online forums were designed to focus on authentic content, stimulate self-reflection, and promoted self-regulation. The delivery of such forums has been enhanced through the development of virtual learning environments (Champion & Freeman, 1998).

Stages of Distance Education

Distance education is broadly defined as the delivery of educational material when the student and faculty are not in the same location (Champion & Freeman, 1998). Distance education has progressed through four distinct stages of development: 1) mail-based correspondence 2) radio and television delivery (one way) 3) television and computer based (two way, synchronous and asynchronous) 4) virtual learning environment. For purposes of this investigation, the review of literature focused on the virtual learning environment as being intertwined with collaboration and constructivist issues for the learner.

Virtual Learning Environment

The VLE provides the glue that allows a student to function within a set environment. Just as a school campus provides all of the needed services for traditionally educated students, the VLE provides services and content management system (CMS) for the distance educated student. The usage of the term virtual learning environment (VLE) has come to refer to any digital environment that presents educational material in an organized manner (Dalgarno, 2002).

Dillenbourg, (2000) created a more restrictive common list of attributes for the qualification of a VLE:

- The environment has a design.

- Interaction occurs within the environment, make it a 'place'.

- While the 'place' might be text or a 3D environment, it is explicitly for information and social interaction.

- Learners in the environment are active and contribute to the virtual place.

- VLE can be used for distance education or classroom enrichment.

- The VLE "integrate heterogeneous technologies and multiple pedagogical approaches" (Dillenbourg, 2000, p. 2)

- Most VLEs have a corresponding physical environment.

Virtual learning environments can be synchronous (students and the instructor communicating at the same time) or asynchronous (where the students and instructor may not be using the VLE at the same time) (O'Sullivan, 2000). Each of the following types of VLE can be used for both synchronous or asynchronous communication and collaboration.

Static web pages

Static web pages are one of the earliest and most basic forms of VLE. While much of the asynchronous content can be compared to textbook reading assignments, it can also be used to present recorded lectures, questionnaires, and quizzes (Navarro, 2000). Instructors, teachers and students can also use static web pages to initiate synchronous communications for collaboration using auxiliary software as IRC, ICQ, or Microsoft Messenger. Though Wulff, Hanor and Bulik (2000) are speaking more

broadly, the statement "independence and separation have been the definitive characteristics of distance education" (p. 144) can be heavily contributed to this form of VLE.

2D interface

A 2D interface is designed to provide various educational resources and basic internet-based services for faculty and students. Examples of 2D interfaces include Blackboard (2004), WEBCT (2004), and open source content management systems (CMS) such as Moodle (n.d.). According to Blackboard (2004), its 2D interface is now used by over 2,200 institutions around the world. Comparatively, Moodle (n.d.) claimed over 7,300 sites using its product. Janicki and Liegle (2001) noted that "these tools provide significant file management and some limited HTML assistance so that an average educator can create web-based course content without the need for a deeper knowledge of the underlying technology" (p. 61).

3D immersive virtual learning environments

3D immersive VLEs utilize additional technology to provide an immersive environment for the learner to participate. This environment allows the participant to 'touch' and manipulate items in a virtual universe. Salzman, Dede, Loftin, and Chen (in press) make a case for the use of immersive virtual reality (VR) for the teaching of complex or abstract concepts:

> For example, learning electrostatics or quantum mechanics involves understanding phenomena that behave in ways remote from direct experience. Additionally, people's real-life experiences are confounded with invisible factors that distort or contradict the principles they need to master. For example, the force of friction unobtrusively distorts objects' behaviors according to Newton's

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Laws of motion. Faced with these mentally challenging tasks, people of all ages and occupations struggle with abstractions. Their lack of real-life referents for intangible phenomena, coupled with an inability to reify ("perceptualize") abstract models, is an important aspect of this problem. (p. 4)

Dede (1995) made a strong argument for the capability of such immersive environments to allow the user to collaborate in a constructivist simulation. An early attempt at such an environment was *Science Space* (Dede, 2005) which allows students to interact with their immersive virtual environment.

Jackson and Fagan (2000), in their research on collaboration within immersive VLEs, found that to help students to be successful in such environments, they "(1) allow them to participate at a level they are initially comfortable with; and (2) provides opportunities to contribute preexisting expertise and to shift roles as expertise increases" (Jackson & Fagan, p. 91) .

The primary drawback of the immersive VLE is the specialized equipment required for successful implementation. A far simpler and currently more popular method of creating 3D VLEs is the use of the traditional desktop computer.

3D desktop based virtual learning environments

The most recent addition to the VLE interfaces is the 3D desktop based VLE. The 3D desktop based interface allows students and faculty to interact either synchronously or asynchronously within a virtual universe. According to Dede (2005), initial uses of this technology incorporated online gaming in immersive environments. Samples of these immersive environments can be seen online in Quest Atlantis (Barab,

Thomas, Dodge, Carteaux, & Tuzun, 2005), Runescape (Jagex, 2004), There (Forterra Systems, 2004), as well as many other online games and environments.

Dalgarno (2002) found that the primary characteristics that are consistent in 3D environments are:

- The environment is modeled using 3D vector geometry, meaning the objects are represented using x, y and z coordinates describing their shape and position in 3D space.

- The user's view of the environment is rendered dynamically according to his or her current position in 3D space, that is, the user has the ability to move freely through the environment and their view is updated as they move.

- At least some of the objects within the environment respond to user action, for example, doors might open when approached and information may be displayed when an object is selected with a mouse.

- Some environments include 3D audio, that is, audio that appears to be emitted from a source at a particular location within the environment. The volume of sound played from each speaker depends on the position and orientation of the user within the environment. (Dalgarno, p. 3)

Many have undertaken various projects to research aspects of virtual learning environments. Some research has focused on the technical aspects of collaboration such as providing voice with lip-sync (DiPaola & Collins, 2003). Others have focused on a specific discipline such as mathematics (Elliott & Bruckman, 2002) or science (Dede, Nelson, Ketelhut, Clarke, & Bowman, 2004). Due to the lower cost, ability to easily

create constructivist simulations, and the ability to create collaborative environments, the primary interface used for this research was the 3D desktop based VLE (3D VLE).

Once technological decisions are made, the instructor is usually concerned with the creation of content utilizing good educational pedagogy. With an understanding of the differences between traditional face to face education and distance learning, faculty can enjoy a much greater degree of success (Mehrotra, Hollister, & McGahey, 2001).

Distance Education Pedagogy

Research revealed that in a survey of school technology coordinators, 57 percent believed that "in ten years, most students will spend at least part of their 'school days' in virtual classes, grouped online with others who share their interests, mastery, and skills" (Fox, Anderson, & Rainie, 2005, p. 24). If this prognostic is accurate, it is critical that educators understand how to successfully create online educational experiences.

Seven basic principles have been developed to facilitate good pedagogy in online learning (Mehrotra, Hollister, & McGahey, 2001; Testa, 2000). These principles are:

- Keep in contact with students

- Develop collaboration and cooperation within your class

- Use active learning techniques

- Give prompt feedback

- Time on Task

- Set and communicate high expectations

- Respect students' diverse talents and ways of learning (p. 237-246).

Traditional, on-site courses may use synchronous and/or asynchronous material. O'Sullivan (2000) identified four pedagogical processes that may be utilized in traditional

or distance education. These include "(1) information presentation, (2) comprehension enhancement, (3) experiential application, and (4) assessments" (O'Sullivan, p. 60). Since students in distance learning are usually separated by time and location, Bender (2000) noted, "short, snappy mini-lectures" are best for online learning and discussion (Bender, 2000, p. 383). Such mini-lectures were found to elicit better student response and participation in the course.

With these principles in mind, pedagogy of distance learning that is specific to the 3D VLE is of primary concern to most educators as they move into the new field. The major constructivist focus of most educators is in the areas of presentation, communication and collaboration.

Presentation within 3D VLE

How to effectively present material within a VLE is generally the first concern of any educator that is making the transition to using a VLE. Within a 3D VLE, the presentation can be accomplished in many ways dynamically. As Prasolova-Forland and Divitini (2003) noted, with a traditional campus, if additional space is needed for a class, it can be a difficult feat to accomplish. Seldom are there additional classroom space, chairs, tables, and the other accessories necessary for a class or to handle a larger class without a great deal of effort. Within a virtual environment, these assets can be literally copied to create additional virtual classrooms and the necessary resources.

Within 3D VLE, the instructor has many more options in the presentation of material to the students. Students may participate in a planned series of events (generally referred to as a quest in most 3D VLEs) (Barab, Thomas, Dodge, Carteaux, & Tuzun, 2005). A student may view a record or live video presented on a wall or virtual television

within the environment. Traditional text information can also be displayed in such an environment allowing the instructor to reuse content previously created for previous VLEs.

Collaboration within 3D VLE

Effective collaboration within a 3D VLE is essential for the learner. Jackson, Taylor, and Winn (1998) found that "peer collaboration played a significant role in student engagement with virtual world engagement" (Jackson et al., p. 123). There are many ways collaboration may occur in such an environment, including but not limited to, text or voice chat (synchronous) and bulletin boards or message areas (asynchronous). By creating opportunities for learners to work collaboratively within the virtual environment, a community is built, which in turn facilitates conversation and learning (Bruffee, 1999) and, potentially, a knowledge spiral (Nonaka & Takeuchi, 1995). Bonk and King (1998) noted 5 levels of interaction via distance collaboration:

Level 1 Interaction: Use of Electronic Mail and Delayed-Messaging Tools.

Level 2 Interaction: Remote Access/Delayed Collaboration.

Level 3 Interaction: Real-Time Brainstorming and Collaboration.

Level 4 Interaction: Real-Time Text Collaboration.

Level 5 Interaction: Real-Time Multimedia and/or Hypermedia Collaboration (pp. 8-10).

Bonk and King further noted that each of these methods of interaction play a part in collaboration. Each level of this taxonomy of distance collaboration contributes its own strengths and weaknesses to the collaborative process.

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Based upon the research of Prasolova-Forland and Divitini, (2003), the 3D VLE also provides an opportunity to create social awareness. Social awareness is "the awareness of the social situation in a group or community in a shared environment, which can be physical, virtual or both: people's roles, activities, positions, status, responsibilities, social connections and group processes" (Prasolova-Forland & Divitini, 2003, p. 58).

Persson (2003) made interesting improvements to digital collaboration through the use of an expressive messaging system. Such a system allowed learners to create and message other learners using an animated avatar system that incorporates text with the animation of the students selected avatar. Persson found that a "rich and well-designed animation library in a simple time-line based structure can provide a useful tool for expressive" (p. 32) messaging.

Popular areas within most VLEs are the community areas. Usually these areas are based upon some thematic scene. These "three-dimensional thematic environment, [were] created with the objective of providing a space where the users can interact" (Kirner et al., 2001). Created as cyber Cafés, meeting rooms, bulletin boards, chat rooms and the likes, these virtual places often become a place where students post suggestions, tips, useful resources and technical advice (Grubb & Hines, 2000). These resources serve as knowledge capital that may contribute to a knowledge spiral within the learning environment (Nonaka & Takeuchi, 1995).

Constructivist approach within 3D VLE

Constructivist 3D VLEs have begun to appear in research partially in thanks to the success of several major Massive Multi-user Online Game (MMOG) environments

(Elliott & Bruckman, 2002). Much of the most recent research in constructivist 3D VLE were created as dialectic environments to utilize a scaffolding to help the learner to be more successful. Dede's (1995) early work in immersive virtual environments, an endogenous constructivist approach was apparent. In more recent work, Dede, Nelson, Ketelhut, Clarke, and Bowman (2004) and Barab, Thomas, Dodge, Carteaux, and Tuzun (2005) all have shifted to use a system that was dialectic in nature.

During Dede's et al. (2004) River City 3D VLE project, students were placed in an environment where they must discover why the people of River City are becoming ill. During the first implementation students made many suggestions for the improvement of the project. These suggestions are important in the design of a successful constructivist/collaborative 3D VLE and are included here:

- Students needed time to experience the world before beginning the formal curriculum. This experience helps them to become immersed in the context.

- The MUVE interface's option of having two communication modes -- a chat and a whisper function – was confusing to students. As a result, most of them relied on the whisper function, which interfered with group collaborative work.

- Students were confused by the connection and relevance of the digitized Smithsonian artifacts in the world.

- Some students became easily lost in the world.

- Students sought to access the books in the virtual library of River City when they were confused.

- Students wondered why, if their avatars were in the world, they too weren't getting sick. (Dede et al., p. 62)

To correct these problems, Dede et al. (2004), created a new version of River City. In the new version:

- Students were given time to explore the world prior to the beginning of the project.

- Redesigned the chat system to allow for scaffolding and a more collaborative environment.

- Redesigned the lab book to help the students understand the digital images and artifacts that they would come across in their exploration of River City.

- Created a permanent link to the system map to help the students see where they were located in the virtual world.

- Augmented the digital library to allow students to be able to click on words and get definitions or other library resources.

- It was not possible with current technology to allow the student's avatar to become ill, so a health meter was implemented that would rise or fall depending on their proximity to the sources of the illness (p. 6).

Such projects as River City (Dede et al., 2004) or Quest Atlantis (Barab et al., 2005) show some of the potential of dialectical constructivist 3D VLE that encourage a collaborative interaction between the students. While this research has only begun to scratch the surface of what is possible, it shows great promise to create exciting educational opportunity for students.

Summary

According to Dede (2005), "collaboration depends on shared physical presence or cumbersome virtual mechanisms. In the future, students will participate in far-flung, loosely bounded virtual communities (independent of cohabitation, common course schedules, or enrollment at a particular campus)" (p. 10).   As educators look to the future, it is essential that students be given a pedagogically sound education. Such an education, according to Bransford, Brown, and Cocking (1999), shall include learning in a collaborative environment.

Constructivism allows for the formation of knowledge for the learner (Fosnot, 1996). In this review of literature, the three primary constructivist approaches were identified (Moshman, 1982). After examining these approaches, a review of distance learning and pedagogy were incorporated.

Since the research within 3D VLEs is limited in scope, and while some promising research has been conducted within 3D VLEs, significant research is still lacking. In this case study, a 3D virtual learning environment utilizing a dialectic constructivist approach was constructed. Next, learners were given a project which provided the organized scaffolding for learning and the opportunity for the learner to collaborate with other learners to further develop their opportunities for learning.

In chapter three, a description of the research design and methodology utilized in this study is presented. The design, a qualitative, multi-case study, is described. Additionally, the methodology, implementation of the constant comparative method, is addressed. Included in chapter four are the presentation of data findings and an analysis

of the findings. In chapter five, the results of the study are summarized and implications

for further research are presented.

CHAPTER THREE

Research Design and Methodology

Introduction

With the success of 3D environments within the entertainment industry, many

educational professionals are now examining this approach to see if it is a viable method

for education. The creation of 3D VLEs has thus far been for specialized purposes for

the teaching of specific or complex concepts that are difficult, expensive, or even

dangerous to teach in a real world setting (Barab et al, 2001; Dede et al., 2004).

The purpose of this study was to examine collaboration within a dialectic

constructivist 3D desktop based Virtual Learning Environment that utilized good

pedagogy. Dalgarno (2002, p. 1) has proposed that such an environment creates many

collaborative opportunities for learner to learner and learner to computer interactions to

aid in learning. Dalgarno also noted that the constructivist approach can be summarized

in three broad principles: 1) everyone forms their own knowledge representation thus

there is no one right representation, 2) by exploration, a learner discovers their lack of

knowledge, 3) learning is essentially a social activity, and that knowledge is acquired

through interaction.   The VLE creates a virtual 'place' where learners may interact with

other learners, the computer, or their instructor (Dillenbourg, 2000). By utilizing good

pedagogy as defined by Testa (2000), a dialectic constructivist 3D VLE was created to

examine collaboration.

Problem and Purpose Overview

3D virtual environments are a major part many of today's student's daily lives.

These virtual environments can create a connected, devout community. Could a 3D VLE

accomplish the same connectedness and devotion while being educational? As the questions asked during this investigation were qualitative rather than quantitative in nature, this researcher utilized a case study design to investigate collaboration within the construct of a dialectic constructivist 3D VLE. By identifying and showing the existence of collaboration in the learner to learner and leaner to computer (Dalgarno, 2002) context, additional research may be conducted to identify if there is the occurrence of a knowledge spiral (Nonaka & Takeuchi, 1995).

According to Bruffee (1999), the reacculturation process as a part of the collaborative educational process is essential to learning. While there is no question of communication within a VLE (Barab, Thomas, Dodge, Carteaux, & Tuzun, 2005; Dede, Nelson, Ketelhut, Clarke, & Bowman, 2004) collaborative research within 3D VLEs is a largely untouched area of research. If, as Fox, Anderson, and Rainie (2005) noted, within the next ten years most students are spending a portion of their school day in virtual classes, these classes should be educationally sound.

Research Questions

The primary research questions which guided this investigation are:

1) What types of collaboration are present within a dialectic constructivist 3D Virtual Learning Environment (VLE)?

2) How does the collaboration process contribute to learning within a 3D VLE?

3) Does collaboration within a 3D VLE create the Knowledge Spiral detailed by Nonaka and Takeuchi (1995)?

4) As measured by the student's success at solving programming challenges, what is the rate of success of students participating in the 3D VLE?

5) What are the perceptions of the students regarding the effectiveness of the collaborative process within the 3D VLE?

Population and Sample

When selecting a population and sample for a case study, the researcher must select participants that will contribute to the study and provide further information to the research (Yin, 1989). Merriam (1998) noted that "purposeful sampling is based on the assumption that the investigator wants to discover, understand, and gain insight and therefore must select a sample from which the most can be learned" (p. 61).

The sample of this case study consisted of college students at a small, public college in the Midwest and a small private college in the South-central areas of the United States enrolled in computer programming courses. These sites were selected due to the broad cross section that these college students represent. Merriam (1998) noted that such sampling is used to reflect the average person or situation.

The sample was drawn from a population of 1600 students attending an open-admissions two year campus and 4800 students attending a private, religiously-oriented campus. Within the population of the public campus comprising 1660 students, 47 percent are full-time, 65 percent are female, 35 percent are male, and 55 percent are traditional college students. The population of the private campus comprised 4800 students, 86 percent are full-time, 55 percent are female, 45 percent are male, and 89 percent are traditional college students. While students at the public college typically considered minority are few in number (4percent), the students attending this university are economically and educationally disadvantaged (89 percent receive financial aid, 74

percent require one or more developmental education course). The private college had a

higher diverse enrollment with 21 percent being classified as minority.

The sample populations for this research were students enrolled in computer

programming courses. After completion of the project within the 3D VLE, students

completed a survey. Based upon the student's progress within the 3D VLE and the

answers received on the survey, the researcher utilized purposeful sampling to select

students to participate in an interview. Purposeful sampling is the process of selecting

subjects because it is believed that they will provide additional insight and direction in

the development of a theory (Bogdan & Biklen, 1998).

Rationale for Case Study

According to Bogdan and Biklen (2003), direction in qualitative research is

determined by open ended questions. During the course of the conducting the research,

the questions will evolve, providing greater insight into the topic of research (Bogdan &

Biklen, 2003; Yin, 1989). Due to the nature of the qualitative study, questions and

assumptions may change during the iterative process of data collection and review.

Merriam (1998) recommended a case study design when the researcher is interested in a

greater insight and discovery of a phenomena rather than testing a hypothesis.

Patton (1997) noted that quantitative research provides an opportunity to measure

"things that can be counted" (p. 273), while qualitative data seeks to capture an

experience and what it meant to the participants. As Patton stated, "Numbers are

parsimonious and precise; words provide detail and nuance" (p. 273). Bogdan and

Biklen (2003) noted that researchers can never obtain a perfect connection between what

they wish to study and what they actually study. Since a perfect connection is not

possible, findings from this study may lack generalizability. Bogdan and Biklen did note that the reliability of the interview questions is not subject to the same scrutiny as in quantitative research. When considering whether to conduct qualitative or quantitative research, this researcher decided to utilize a case study with a mixed-design so as to capture the best of both worlds of data. By using such a design, it is hoped that such research will assist in providing insight into current assumptions and a point from which one can perform future research in the field of 3D VLEs.

Data Collection and Instrumentation

During the course of this research, four instruments of data collection were used. First, as a part of this research it was necessary to create a dialectic constructivist 3D Virtual Learning Environment to see if collaboration and knowledge spiral occur within such an environment. The tool used was developed by the researcher. The 3D VLE utilized the Torque Game Engine produced by Garage Games (2006). The Torque Game Engine was modified to create an environment that enabled learners to interact in a dialectical constructivist environment that facilitates collaboration (Dalgarno, 2002).

The 3D VLE was modified first to incorporate the ability of the avatar to interface with a database and to enable the tracking of the learner through the project. The 3D VLE was further adapted by the researcher to allow the development of the dialectic constructivist system, and the logging of collaboration evidence.

A complete record of all electronic conversations was created while the learners participated in the learning project. Data captured included the individual user, the date and time of the text and the conversation itself. Also collected during this phase of the

research was the second set of data which comprised the success of the student in the identifying and resolving the programming challenge.

The third set of data was a survey created by the researcher. This survey was distributed after the completion of the project by participants. The survey provided Likert type scale and open-ended questions. Two areas of concern with any instrument are its face validity and its content validity. Face validity is questioning the instruments ability to measure what it looks like it measures (Patton, 1997). Haynes, Richard, and Kubany (1995) stated that "*Content validity* is the degree to which elements of an assessment instrument are relevant to and representative of the targeted construct for a particular assessment purpose" (p. 239). Patton asserted that most psychometricians place low importance on face validity, but that face validity can be useful to public relations. Knowing that the instrument has content validity ensures that the instrument is assessing what is intended to be assess. The survey's reliability was examined through a test-retest format with a .91 alpha coefficient. Once the reliability was established and the survey was modified according to suggestions provided by the representative group used for test-retest the survey was administered to the participants. These questions were then used to decide which students would be interviewed to gather additional information from in the fourth phase.

The fourth set of data was open-ended interviews with selected participants. The goal of these interviews was to provide rich, thick, descriptions of the participants experience during the course of the research. Based upon the student's progress within the 3D VLE and the answers received on the survey, the researcher utilized purposeful sampling to select students to participate in an interview. Purposeful sampling is the

process of selecting subjects because it is believed that they will provide additional insight and direction in the development of a theory (Bogdan & Biklen, 1998).

Interview Protocol

The researcher's goal in this study was to gain a greater understanding of collaboration within dialectic constructivist 3D VLEs. By adding to the body of knowledge in respect to virtual learning environments and collaboration, it is hoped that a better understanding of the learning process within such environments will be provided. As tools for gathering data on the process, a dialectic constructivist 3D VLE was created. Participants were provided a project to complete within a specific period of time. All electronic conversations were recorded during the course of the research. Data were also collected on the participants' level of participation and successes.

After the completion of the initial research, participants completed a survey which allowed them to rate their experiences within the 3D VLE. Open-ended questions were included in the survey to gather additional data on the participants' experience. After reviewing the surveys, 10% of the participants were purposefully selected and interviewed by the researcher. Semi-structure questions were used during the interview as recommended by Gay (1996). The questions were designed to further answer the research questions and to gain further insight into the student's experience in the 3D VLE and their responses to the survey. The interviews conducted by the researcher utilized semi-structured, open-ended questions to allow for rich, detailed data. Research in the areas of collaboration (Bruffee, 1999; Crook 1996) and organizational learning, with a specific emphasis on the Knowledge Spiral (Nonaka & Takeuchi, 1995) guided the development of the interview protocol. The survey questions and interview questions

were field tested to ensure content validity. By ensuring content validity, the researcher can be sure that the instrument is relevant to the assessment purpose (Haynes, Richard, & Kubany, 1995). These field interviews were recorded and transcribed. Interview participants were provided with a copy of the draft of their interview so that they could be reviewed and revised to enhance the reliability and credibility of their interviews. Researcher bias was controlled through the triangulation of data from the recorded project transcripts, surveys, and interviews.

Data Analysis

According to Thomas and Brubaker (2000), the first step in organizing data is classifying the data. Bogdan and Biklen (1998) noted that data analysis must involve working with, organizing, and breaking data into manageable units. The process of coding, or identifying categories, classifications, and themes derived from the participants of the study was useful in the organizing of the data. Utilizing the framework proposed by Hara, Bonk, and Angeli (2000), student interaction was categorized into five classifications:

1) Elementary clarification – observation and identification of a problem and its elements. This includes identification of linkages to gain a basic understanding of the problem.

2) In-depth clarification – gaining an understanding of the problem so that it "sheds light on the values, beliefs, and assumptions which underlie the statement of the problem" (p. 125).

3) Inferencing – Use of induction and deduction in the analysis of the problem.

4) Judgment – Making a decision.

5) Application of strategies – "proposing coordinated actions for the application

of a solution" (p. 125).

The second step was axial coding to aid in making comparisons and connections

between and among the identified themes. The final step was summarizing (Thomas &

Brubaker, 2000). The summarizing process is designed to promote synthesis of the data,

identification of patterns, and aid in the discovery of what was important, could be

learned, and what could be shared.

Quantitative data was analyzed using SPSS 13.0 using descriptive statistics.

Mean, frequencies, and standard deviation were provided. The data were used to gain a

better understanding and insight of the success rate of the participants and their

conversations during the study. Given the short time of data gathering, students will be

considered successful in solving the programming challenges if one (1) of the seven (7)

documented or three (3) undocumented problems is solved.

In summation, qualitative data were analyzed in a multi-step process to ensure

triangulation of data. First, the quantitative data were computed to aid in the analysis of

qualitative data. Second, qualitative data from the research were coded and classified.

Third, survey data were analyzed and used for the selection subjects to be interviewed.

Finally, subjects were interviewed which allowed for the gathering of data that might not

have been captured in the previous qualitative data.

Summary

The research design and methodology were presented in chapter three. An

overview of the research problem and purpose were articulated, followed by the research

questions. The sample selection and interview protocols were reviewed. A rationale for

the use of a case study mixed-design study was presented along with the study design.

The process and utilization of quantitative data and qualitative data was identified. This

included the methodology of gathering the data and how it would be analyzed.

Included in chapter four are the presentation of data findings and an analysis of

the findings. In chapter five, the results of the study are summarized and implications for

further research presented.

CHAPTER FOUR

Presentation and Analysis of Data

Introduction

The purpose of this study was to examine collaboration within a dialectic

constructivist 3D desktop based Virtual Learning Environment that utilized good

pedagogy. A mixed design case study was employed to better understand how a VLE

impacts collaboration and learning in such an environment. The following research

questions guided this study:

1) What types of collaboration are present within a dialectic constructivist 3D

   Virtual Learning Environment (VLE)?

2) How does the collaboration process contribute to learning within a 3D VLE?

3) Does collaboration within a 3D VLE create the Knowledge Spiral detailed by

   Nonaka and Takeuchi (1995)?

4) As measured by the student's success at solving programming challenges, what

   is the student's rate of success participating in the 3D VLE?

5) What are the perceptions of the students regarding the effectiveness of the

   collaborative process within the 3D VLE?

Data were analyzed using a multiple step process to ensure triangulation. First

data were gathered from the VLE. Data gathered included 'chat' or conversations held in

the virtual environment. Conversations were classified, axial coded, and summarized

(Thomas & Brubaker, 2000). Second, quantitative and qualitative data from a survey

given at the end of the study were used. The quantitative data were analyzed using SPSS

13.0, providing descriptive statistics of the Likert-type of questions and quantitative data

gathered from the VLE. Qualitative data gathered from the open-ended questions that were included in the survey were further classified, axial coded and summarized in the same fashion as the VLE collaborative data.

Finally, interviews were conducted with 10% or 3 of the participants. Data collected from the interviews were also classified, axial coded and summarized. This data formed the third phase of the triangulation process.

Data Analysis

Data gathered from the VLE and surveys were compiled and analyzed using Statistical Package for the Social Sciences (SPSS) Version 13.0 for the quantitative data. These descriptive statistics provided a comparison of means between the students as well as the participating institutions. Qualitative data from the VLE, surveys and interviews were classified, axial coded, and summarized. Data were classified by utilizing the framework proposed by Hara, Bonk, and Angeli (2000), which creates 5 student interaction categories: 1) Elementary Clarification, 2) In-depth Clarification, 3) Inference, 4) Judgment, and 5) Application of Strategies. For the purpose of this study, the classification categories of 6) Off-topic conversation, 7) Salutations and 8) Flaming (a hostile or demeaning statement directed at another student) were added to provide greater clarity within the data analysis. Data were further categorized by which problems that the communications referred were noted. Utilizing this data, a matrix quantifying the types and topics of conversation could be created, enabling a greater understanding of the participants' collaboration.

Qualitative data were further analyzed using axial coding. This allowed for the emergence of common themes and connections to emerge from the data. Finally, the data

were summarized to help synthesize the data, identify emerging patterns and discovery of what is important or could be learned from the data.

Population and Sample

The population and sample for this study consisted of 28 college students. The sample was drawn from two university campuses in the mid-west and south-central portions of the United States of America. The first university was a public, two year institution. The second campus was a private four-year university. The total number of students participating was 28, 15 from the public institution and 13 from the private university.

<div align="center">Data Collection Instruments</div>

Virtual Learning Environment

As this case study focuses on collaboration within 3D VLEs, a key portion of this research was the creation of a Virtual Learning Environment. This 3D VLE utilized the Torque Game Engine provided by Garage Games and a content pack created by BraveTree Productions, LLC. This commercial engine was modified to allow the gathering of collaborative data.

The process of collaboration within the 3D VLE was a three step process (see Figure 1). Participants created their own account which enabled them to connect to the chat database. After login, the 3D VLE enabled the participant to then connect to a Master Game Server, which provided a link to the hosted game. All chat messages were saved on the Chat Database and forwarded to all active participants through the hosted game.
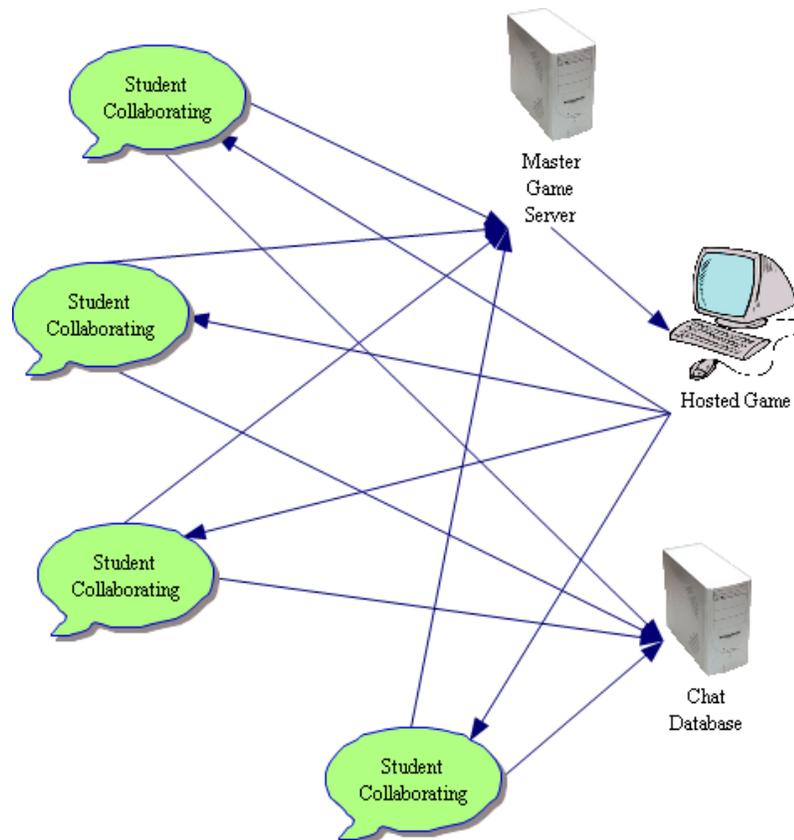
Figure 1 *Participant – Server interaction*

Participants in the study were able to login and collaborate or converse with other participants currently logged in at anytime during a two week period. Participants were given the challenge to 'fix the game'. The environment had seven (7) documented problems and three (3) undocumented problems. Students were challenge to collaboratively solve the problems. When functional the game is designed to allow students to create a bot that simulated artificial intelligence to compete with pre-created bots or other participants' bots. Students were encouraged through the availability of helps, chat, and initial directions to collaborate with fellow participants to find and resolve the problems.

Survey

At the end of the VLE time, participants were asked to complete a survey that contained both Likert type and open-ended questions. The survey contained seven (7) Likert style questions and three (3) open-ended questions. Each of the Likert-type questions consisted of a five-point scale ranging from (1) Never or No to (5) Daily or A Great Deal. The survey was designed to measure the frequency the participants utilized technology to collaborate and communicate and the amount of outside communication concerning the project.

Interview Protocol

To further answer the research questions and to triangulate the data gathered from the VLE and the survey, interviews were conducted as a strategy to gather further descriptive data. According to Bodgan and Biklen (2003), this allowed the researcher to gather additional insights and interpretations from the participant's perspective. Since the purpose of this study was to examine collaboration and learning within VLEs, the questions centered on the participants experience and collaboration within the VLE and the data were sought to answer those research questions. Interviews were conducted by email with participants being given the opportunity to verify and modify the drafts of the interview and the opportunity to revise the draft to improve the reliability of the collected data.

Research Questions

Five research questions guided this inquiry. While responses to each of the questions are provided independently for clarity of presentation, the responses are cumulative and concur with one another. For research questions one, two, and three,

qualitative data from the VLE and interviews were used. For questions four and five,

quantitative and qualitative data were used from the VLE and survey.

Research Question 1: What types of collaboration are present within a dialectic

constructivist 3D Virtual Learning Environment (VLE)?

The researcher examined this question by utilizing qualitative data gathered from

the chat records of the 3D VLE, survey responses, and interviews. First the researcher

read through all of the chat records, survey responses, and interviews to gain a holistic

view of the data. Next, the data were classified and axial coded to allow themes and

clarify students' interests and concerns as well as identify the types of collaboration that

occurred. A list of data codes and programming challenges are provided in Appendix G

and Appendix H respectively.

The chats captured from the 3D VLE provided a rich texture of collaborative data.

Of the 682 conversations that occurred during the two weeks of data gathering, a majority

(62.6 %) were found to be collaborative in nature (see Table 1).

Table 1
Number of Chat Conversations by Classification.

Classification	Conversations
Elementary Clarification	201
In-Depth Clarification	92
Inferencing	35
Judgment	37
Application	62
Off-topic	174
Salutations	67
Flaming	14

Note: N=682 examined conversations

The majority of conversations were initially off-topic or focused on learning the environment. Participants were able to easily move and communicate within the 3D VLE (see Figure 2). After approximately two and a half (2.5) hours of working inside the 3D VLE, there was a dramatic drop in off-topic conversation. At this same point, there was a noticeable change toward conversations that were seeking in-depth clarification and application. From the surveys, several comments were made concerning the initial general collaboration. As one student noted, "Most of it was us helping each other understand the mechanisms of the environment, figuring out what was tied to what." One student found that the collaboration allowed for the "clarification of goals, discussion of problems, fun banter, answered questions that others raised, and some arguments when misunderstandings arose."

Figure 2: *Communication within the 3D VLE*

One participant interviewed stated: "Online, there were many different types of discussions, from productive collaboration to general silliness. Outside of the VLE, more productive communication occurred via text messaging and e-mail chat programs".

While the amount of flaming (a hostile or demeaning statement directed at another student) was relatively low (14 total occurrences, or 2% of the total conversations), it was mentioned by some respondents on the survey. Some considered it "fun banter", while other students mentioned the flaming stating that "I was flamed. And was given advise on the hot keys and how to crash the game" and "well when I was on with other people there was a lot of joking, some flaming…".

Research Question 2: How does the collaboration process contribute to learning within a 3D VLE?

In order to answer research question two the researcher utilized qualitative data gathered from the 3D VLE, surveys, and interviews as well as quantitative data gathered from the survey. The collaboration on a project such as what the participants where tasked with in this case study generally takes the form of the students sharing what they had tried and learned in attempting to solve the problems. One student remarked that when they were able to collaborate with other participants "it helped to hear what others had already tried and to hear suggestions", enabling him to more quickly understand the nature of the tasks.

The survey showed that the majority of participants received help from and provided help to other participants. Thirteen (13) of the fourteen (14) survey respondents stated that they received at least some help from other participants (see Table 2). Twelve (12) of the fourteen (14) participants stated that they provided help to others (see Table 3). When asked what type of help they received, participants stated that:

"Yes, I received help learning to toggle the resolutions in the game so that I was able to see more per command window. "

"I sometimes help from other users in the VLE. Often this was simply communication about where certain pertinent lines of code existed within the scripts of the program."

According to the data presented in Tables 2 and 3, many participants felt like they provided more help than received help. When asked about the help they provided to others, participants stated:

"I was able to answer a LOT of questions regarding the general nature and purpose of the VLE program and clarify upon limitations within the game world.

"Tentative solutions posed by other members of the VLE were presented to me and I was able to comment upon them and offer advi[c]e on how to implement them."

"Well, once [I] noticed that everyone was standing around the terminal and [I] let them know they didn't have to in order to program so then they spread out."

Table 2
Help Received From Participants (N=14)

	No	**Sometimes**	**Regularly**	**Often**	**A Great Deal**
Did you receive help from others?	1	10	1	2	0
Mean = 2.29, Std. Dev. = .83					

Table 3
Help Provided To Other Participants (N=14)

	No	**Sometimes**	**Regularly**	**Often**	**A Great Deal**
Did you provide help to others?	2	5	4	2	1
Mean = 2.64, Std. Dev. = 1.15					

Research Question 3: Does collaboration within a 3D VLE create the Knowledge Spiral detailed by Nonaka and Takeuchi (1995)?

The researcher used qualitative data from the 3D VLE, survey, and interviews to find evidence of Nonaka and Takeuchi's (1995) knowledge spiral. The beginning of a knowledge spiral must show the transference of tacit knowledge to explicit knowledge, passing through the four modes of knowledge conversion: socialization, externalization, combination, and internalization. This process became evident from the chat records recorded in the 3D VLE. One example of the knowledge spiral is presented:

1. RedShirt_Rich: "The Prof says he switched to code on the CLIENT side only for switching between characters"
2. Furry: "Yeah but it is set up differently than the tank code"
3. Furry: "he is calling to two different cs files instead of one"
4. RedShirt_Rich: "Whatever he switched turned off the animations, and I'm not sure the server would EVER see the Ava model..."
5. RedShirt_Rich: "...if the server side code doesn't have the new selection methods"
6. Furry: "let s throw in blue man to see if the code is defaulting to the player.css"
7. Imber: "hey is the problem of not showing the animations and not loading av in the aiplay.cs?"
8. Imber: "OMG i got the animations to work..."
9. Imber: "all problems are in the aiPlayer.cs"
10. Furry: "That s why the[y] have to be in the same file"
11. RedShirt_Rich: "No[w] what?"
12. Imber : "w[ait] ill change to adam"
13. Imber :"ok thats weird"
14. Furry: "See you broke it :)"
15. Imber: "Whatever the server host chooses gets cast to all other players"
16. RedShirt_Rich: "Ava s animations worked for servers AND clients. Adams s animation ONLY works on the Server.
17. Imber: "the call backs need to be uncommented and the male needs to be taken out of the aiplayer.cs file"

In this sample of conversations, the students complete all four (4) of the modes of knowledge conversion: socialization, externalization, combination, and internalization. In the socialization process, tacit knowledge is shared with other students. The students start out by collaboratively sharing what they have learned by experimentation and from others. In Statement 1 and 2 of the conversation, RedShirt_Rich and Furry discuss what they have learned thus far from others and observation inside the 3D VLE. This socialization process ensures that they are both at the same starting point as they prepare to address the avatar and animation problems in the learning environment.

In the externalization conversion of tacit to explicit, a hypothesis is proposed as to where the problem is located. Statements 3 through 7 represent this move from tacit to

explicit. Furry notes to RedShirt_Rich that two data files are being accessed in the computer program instead of just one data, which they had seen in another example. RedShirt_Rich makes a hypothesis that this might be the cause of the animation problems. Furry (in statement 6) proposes a method of checking to see if this might solve the problem. At this point, Imber, in statement 7 notes that the problem being discussed seems to be originating from one data file, beginning the transfer to the combination mode.

As the students move into the combination mode, students create a structure for the problem and attach it to one location with the program files. Statements 8 through 14 show the development of the structure and application of the hypothesis developed in the externalization process. Imber initially believes he has solved the problem by making a change to the data files. As he further applies the hypothesis, it creates other visual problems within the 3D VLE, causing Furry to, in good natured fun, tell him that he just broke the system.

During the final internalization phase of the knowledge spiral, the students take what they have learned thus far and apply it. In statements 15 through 17, the three students discuss what was done to create the differences in the virtual environment and what files were edited. This creates new observations about the problems that they are addressing, which starts a new cycle of the Knowledge Spiral. The 3D VLE shows that it provides an excellent opportunity for the students to practice Nonaka and Takeuchi (1995) knowledge spiral, which they refer to as "learning by doing" (p. 69) (see Figure 3). While the students do not completely resolve the problem in this conversation, it

does form the bases of future conversations of tacit to explicit knowledge creation that eventually leads to a solution being proposed.
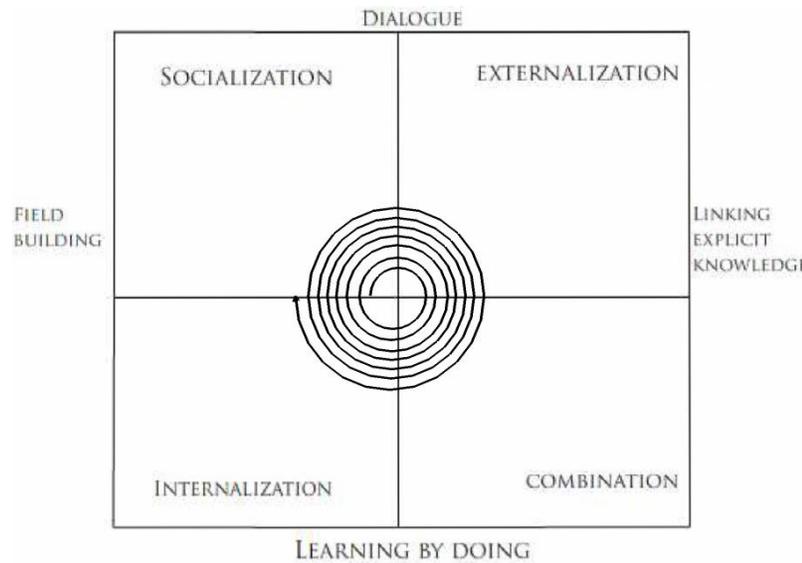
Figure 3: *Nonaka and Takeuchi's Knowledge Spiral*

Research Question 4: As measured by the student's success at solving programming challenges, what is the rate of success of students participating in the 3D VLE?

The researcher utilized both qualitative data derived from the 3D VLE, and quantitative data from the survey to answer this question. Quantitative data were analyzed using SPSS 13.0 to calculate descriptive statistics.

Participants were informed of seven (7) problems in the 3D VLE and given the challenge to find solutions or resolve the problems. These problems were documented, informing the student where the problem was located, possible solutions, and what needed to be done to resolve the problem. There were also three (3) undocumented problems within the environment. The three (3) undocumented problems where designed to be very noticeable and to generate conversation and hopefully collaboration. The

problems were of varying complexity with some of the more complex problems requiring the resolution of simpler problems before they could proceed.

As expected, the participants quickly noticed the three (3) undocumented problems. This generated most of the early elementary clarification collaboration. One of the undocumented problems dealing with the User-Interface was resolved within the first 24 hours. Other problems, such as the correct avatar not loading or animations not working correctly had many potential solutions and applications generated, but were not implemented by the end of the project.

The majority of collaboration occurred helping one another to learn the environment (see Table 4). In this, students who had worked in similar environments previously spent much of their time teaching other students about the environment. When asked what they learned from other participants, one student responded "most of it was us helping each other understand the mechanisms of the environment, figuring out what was tied to what". These students went on to teach others about the environment and additional knowledge that they had gained from using the 3D VLE as shown above in Research Question 3.

Table 4

Classification of Collaboration on Documented and Undocumented Problems

Problem	Doc/ Undoc	Elem.	In-Depth	Inference	Judgment	Application
General		102	17	3	8	5
Write	D	3	4	4	2	1
Save	D	16	32	3	5	3
Compile	D	2	-	-	-	-
Battle	D	7	-	1	-	-
Load	D	2	-	-	-	-
AI	D	10	5	-	-	-
Networking	D	7	2	-	-	-
GUI	U	15	1	2	1	2
Avatar	U	19	16	13	9	23
Animation	U	18	15	9	12	28

Revealed in Table 5 are the number of problems worked on as reported by the participants. Of those participating in the survey, the majority focused on one (1) or two (2) of the problems, where two (2) participants stated they did not work on any problems, and two (2) stated they worked on four (4) or more of the problems

Table 5

Self-Reported Number of Problems Worked On. (N=14)

None	1	2	3	4 or more
2	4	6	0	2
Mean = 1.71, Std. Dev. = 1.2				

During the course of the case study, two (2) of the problems were classified as fixed, and two other problems as solved, but the fix was not implemented. The first problem fixed was dealing with the Graphical User Interface (GUI) which was an obvious undocumented problem. This generated 21 conversations within the first few hours, with a fix being quickly implemented. The second problem fixed was the Write problem. This problem was more complex, with several of the other problems such as Save, Load, Compile, and Battle all dependent on it being resolved. While the fix was slower in being created, it did clear the way for other problems to be worked on and discussed collaboratively.

One interesting note was that many of the participants became fixated on the undocumented problems of the incorrect avatar loading and avatar animations. These problems accounted for 80 and 82 or 11.7% and 12.0 % respectively of the conversations respectively with by far the most proposals for solutions being offered. While a final solution was proposed by the end of the project, it was not successfully implemented by the participants.

Research Question 5: What are the perceptions of the students regarding the effectiveness of the collaborative process within the 3D VLE?

The researcher utilized both quantitative data from the survey and qualitative data from the survey and follow-up interviews to answer this question. Student perceptions of virtual environments are a key to their success. If a student does not enjoy the

environment or does not interact and communicate with others in the environment, the

opportunities for learning through collaboration are obviously greatly reduced.

Sixty-two (62.4) percent of survey respondents found that they at least regularly,

if not more frequently, communicate with others in the 3D VLE (see Table 6). One

student remarked that "it helped to hear what others had already tried and to hear

suggestions", enabling him to more quickly understand the nature of the tasks. Another

student, after an initial time of learning the environment and participating in off-topic

conversation, cajoled his fellow participants to work on the tasks presented with: "Hey

kids... it s time to go to work".

Table 6
Frequency of Communication with Others

	None	Occasionally	Regularly	Often	A Great Deal
Inside 3D VLE	1	3	7	2	1
Outside 3D VLE	3	6	3	2	0

While communication about the project outside of the 3D VLE was discouraged,

78.6% of survey respondents admitted to communicating with others either face to face,

through chat or text messaging. As one participant responded during his interview,

> Outside of the VLE, more productive communication occurred via text messaging
> and e-mail chat programs. Often, this was due to me not being logged in to the
> VLE while others were online and had questions about the general VLE program
> or wanted to get a second opinion on ideas they had had for solving some of the
> problems in the VLE. I received a number of text messages during dinner!

From this acknowledgement, it is clear that the 3D VLE project, though limited in time

and scope, successfully created a community of participants.

Many participants noted that they found collaboration and 3D VLE fun: "The VLE experience was fun, although it was MORE so when other users online were also in the same room physically". A key to the success of any multi-user environment is having enough participants so that collaboration can occur. During low usage periods of the 3D VLE environment, comments such as: "I suppose I'll stop talking to myself" and "Why should I chat? Why should anyone chat?" making it clear that multi-user environments are not as enjoyable when there is no one else is available to communicate or collaborate.

Summary

Provided in Chapter four is a description and analysis of qualitative data derived from the twenty-eight (28) participants in a 3D VLE, a survey and follow-up interviews as well as quantitative data gathered from a survey were used collectively to answer each of the five research questions. An analysis of the data showed the presence of each of the five (5) types of collaboration detailed by Hara, Bonk, and Angeli (2000), how collaboration impacted the learning, the presence of knowledge spirals within 3D environments, the successful completion of programming challenges within the 3D VLE, and students perceptions of collaboration within the 3D environment.

In the final chapter, the researcher presents an overview of the study including the purpose of the study, the design and procedures chosen, the research questions, and a review of the research findings. Additionally the chapter includes a discussion of the findings, the recommendations for future research, and a conclusion.

CHAPTER FIVE

Summary and Recommendations

Introduction

Education has faced a continuous challenge to provide more services and better educational opportunities to those whom it serves. As technology advances, can it help to contribute sound educational experiences? Within this study, the focus has been to examine one aspect of the learning process, collaboration, within a virtual learning environment. Since Bruffee (1999) made a strong case that it is through conversation and collaboration that all learning takes place, whether it is internal or external, it is essential that the 3D Virtual Learning Environments support collaboration effectively.

An introduction to this study was provided in the first chapter. A review of related literature was shared to show the foundations and reasoning behind this study. Next, a review of the methodology of the study was provided. The analysis and presentation of the data preceded this current chapter. Finally, in this chapter the researcher presents an overview of the purpose of the study, the research questions, the design and procedures used, a discussion of the findings, as well as conclusions drawn from those data sets. Additionally the chapter includes a review of the limitations, recommendations for future research, and a conclusion.

Purpose of Study

Interest in using 3-Dimensional immersive technology to teach has continued to increase over the years. One reason is due to the perceived lower risk of failure within a game environment (Gee, 2003). But do such environments enable the conversation that Bruffee (1999) deemed necessary for learning to occur?

During the course of this study participants participated within a VLE specifically designed to encourage collaboration and learning, with the goal to see if collaboration occurs within such learning environments. Also examined was the potential for the development of a knowledge spiral as detailed by Nonaka and Takeuchi (1995). With the expectation that more learning will be occurring within VLEs in the future (Fox, Anderson, & Rainie, 2005), such environments must be designed as educational and pedagogically sound instruments for such delivery. The purpose of this study was to see if collaboration does occur in VLEs, and, if so, what types of collaboration occur. Secondary to this, if collaboration does occur, does a knowledge spiral occur?

Design and Procedures

The population for this mixed design study was comprised of students enrolled in computer programming courses attending either a private, religious college or a public, state college. Twenty-eight college students participated in this investigation.

Quantitative data were gathered using a 3D virtual environment that allowed for the participants to communicate with one another through a built in chat system. Additional quantitative data were gathered through a follow-up survey that contained open-ended questions and a purposeful sample of interviews. The interviews, survey and communication from the 3D VLE provided triangulation of the quantitative data. Research Questions 1 and 3 were evaluated based upon the qualitative data.

Qualitative data were derived from statistics gathered from the 3D VLE and the Likert-type scale survey data. Research questions 2, 4 and 5 were evaluated based upon the qualitative and quantitative data.

Findings of the Study

Cook (1996) noted that successful collaboration is evidenced by students not only completing their educational project, but by the presence of articulation, conflict, and/or construction. The results of this study found that 3D virtual learning environments do support collaborative learning. Each of the findings is addressed in turn below.

In research question #1, the data was examined for the presence of collaboration within a dialectic constructivist 3D virtual learning environment. Based upon the conversations recorded from the 3D VLE, qualitative statements from the survey and follow-up interviews, all five (5) types of Hara, Bonk, and Angeli (2000) student interaction categories were present in varying degrees. It was not surprising to find that there were more collaboration conversations dealing with Elementary Clarification (201 conversations or 29.5% of all conversations) and In-depth Clarification (92 or 13.5% of all conversations). While the presence of derogatory comments by some participants aimed at other participants was low in quantity (14 or 2% of all conversations), Cook (1996) does state that the presence of conflict is evidence of successful collaboration. Furthermore it would be hoped that students could be directed to express their conflict in a less derogatory fashion.

In research question #2, the data examines for how the collaboration process contributed to learning within the 3D VLE. In answering this question, both qualitative and quantitative data were used to examine the collaboration process. An overwhelming majority of the survey respondents noted that they received some help from other participants (13 of 14 or 92.9%) and provided assistance to others (12 of 14 or 85.7%). Many students noted that they were able to give and receive assistance when it was

needed. An interesting caveat to this quantitative observation noted was that those students who provided assistance to others felt that they had given more assistance (Mean = 2.64, Std. Dev. =1.15) than those getting help noted receiving (Mean = 2.29, Std. Dev. =.83).

In research question #3, the qualitative data was examined for the presence of Nonaka and Takeuchi's (1995) knowledge spiral. The data shows the presence of all four (4) stages of the knowledge spiral: socialization, externalization, combination, and internalization. With the presence of all four (4) stages of the knowledge spiral, it is concluded that Nonaka and Takeuchi's (1995) knowledge spiral does occur within 3D virtual learning environments when they are designed to enhance collaboration.

Research question #4 was examined using both qualitative and quantitative data for the students' success at solving programming challenges. During the two (2) weeks of data gathering, the students were able to solve four (4) of the programming challenges, and fully implement two (2) of the fixes. During the time of data collection, it was noted that the students were initially much more concerned about the undocumented problems which impacted the appearance of the environment than the documented problems which affected the actual usability of the environment. For the participants to successfully diagnose four (4) of the ten (10) problems and successfully fix two (2) of the problems, it is concluded that the students were successful in this programming challenge perhaps through the use of collaborative processes and knowledge creation strategies.

The undocumented problems consumed fully 26.8% of the total conversations that occurred in the 3D VLE. They were also mentioned several times in the qualitative answers included with the survey. Given that the undocumented problems were designed

to be obvious to the participants and generated the most discussion, it is concluded that the students were more concerned about the general appearance and function of the avatars than the documented problems that affected functionality.

Research question #5 required the use of both quantitative and qualitative data in the examination of students' perceptions of the effectiveness of collaboration within a 3D VLE. Data gathered for this question showed that a majority (62.4) did use the virtual environment for communication. An even greater percentage (78.6%) communicated with one another using other means of communication. This shows that while 3D VLEs do encourage collaboration, alternative means of communication beyond in-system chat must be provided or allowed for to encourage an even greater degree of collaboration.

Limitations

As with any research, this study was subject to limitations. Every effort has been made to limit the effects of these limitations on the findings.

1) The study was limited geographically to college students in one Midwest state and one Southern state during one academic term.

2) The case study was limited in size, with 28 individuals participating in the study.

3) This study was limited by the reliability and validity of the 3D VLE and any technical problems that occurred during the course of the study.

4) While outside communication concerning the quest was discouraged, so as to ensure that the collaboration only occur within the 3D VLE, outside communication did occur between participants.

5) It is assumed that participants were honest in communications and participation.

6) Validity and reliability of qualitative data was limited by the researchers own bias.

Implications for Practice

With the prediction that within the next ten (10) years, students will be spending at least a portion of their school day in virtual classrooms (Fox, Anderson, & Rainie, 2005), it is crucial that such environments be pedagogically sound environments that foster collaboration and learning. By showing that such environments allow all five (5) forms of collaboration as well as knowledge spirals to occur, the door is opened to conducting broad scale research in collaboration within virtual environments.

Dalgrano (2002) has proposed that 3D environments have potential to encourage learner to learner collaboration. This research has confirmed that potential. Further, the findings of this research directly impact the educational model of today and help to remove reservations of change for alternative learning structures for the future. Distance learning and traditional education have new tools in the 3D virtual learning environment that can be used as supplements, and in some cases replacements, for other resources such as expensive equipment or texts. Special needs for learning disabilities and gifted students as well as those who are physically challenged or even those requiring greater attention due to behavioral problems can learn in a more controlled environment and be offered a level playing field without being offered lesser services than their peers. This type of learning environment can be utilized to lessen the cost and provide equality between all school districts whether they are rural, urban, or suburban.

Recommendations for Future Research

Since beginning this study, other educational tools such as Alice (2007) have become available. While Alice does not incorporate collaborative components that the 3D VLE has, it can have a powerful impact upon on teaching and learning computer programming. According to Burton and Chin (2007), participants spend a great deal more

time on programming projects when they consider the project fun. Does this improve learning? What impact would the addition of collaboration have upon these tools?

With collaboration now being established within 3D virtual environments, many areas remain to be researched regarding impact upon student learning outcomes. What impact does being able to select and design the avatar have upon learning outcomes? If a student is given an avatar and told that the avatar is very good in a subject that the student struggles with, is learning impacted? Is cheating more or less prevalent in a virtual learning environment? An additional field of research deals with the development of virtual real estate. With online environments such as Second Life (Linden Research Inc, 2007) available, how will this impact traditional learning?

Of course more research into the area of collaboration and its utilization within 3D VLE is needed. Since this was a case study, the application of this research is limited through generalization to the general population. However, further large scale research is warranted to ensure the validity and application to a broader range of research.

Moreover, a follow-up to this research would be to explore the importance of the avatar to the participant. Since students were very concerned about their avatar and fixing the problems associated with the avatar far above other problems, this could be a very important area of future research.

Conclusion

The purpose of this study was to determine if collaboration occurs within 3D Virtual Learning Environments. A secondary purpose was to determine that if collaboration occurs, would Nonaka and Takeuchi's (1995) knowledge spiral also occur?

Through the use of qualitative and quantitative research it was determine that all five (5) forms of collaboration do occur, and that knowledge spirals can also occur in a 3D VLE.

Dillenbourg (2002) stated that "the difference between other constructivist environments and what virtual environments offer can be described as making students not active, but also actors" (Dillenbourg, p. 1). By showing that all forms of collaboration as well as knowledge spirals can occur within persistent 3D virtual learning environments, this research provides further evidence that can and should enable students to move beyond merely being active, but to be actors in their educational environments.

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Publications.

APPENDIX A

You are invited to participate in research intended to complete my dissertation entitled "Collaboration and the use of Three Dimensional Interface within a Virtual Learning Environment and the Impact on Communication and Learning: A Case Study

The purpose of the study is to explore the views of a random sample of college students regarding their interaction and responses to using 3D virtual learning environments for educational purposes.

I request your permission to conduct the research in collaboration in virtual learning environments. If you are agreeable to be a part of this study, would you please indicate it by checking the "Agree to Informed Consent and Permission" checkbox below? Before you make a final decision about participation, you must know how your rights will be protected:

You are asked to participate in 3D Virtual Learning Environment where you will have the opportunity to complete several educational exercises and chat with others participating in the project. The entire project will take approximately ten (10) hours to complete over the next two (2) weeks. At the conclusion, you will be asked to complete a short survey and possibly participate in a more in-depth interview. All participation is completely voluntary and you may withdraw at any time during the project without penalty.

Participation in the study is voluntary. Participants may withdraw at any time. If later you do not wish your data to be used, inform me; your wish will be honored before culmination of the study. Declining to participate will have no adverse consequences. For any questions about your participation, please contact me at (325) 674-6989, during the day, or by email at Brian.Burton@acu.edu. You may also contact my dissertation supervisor Dr. Barbara Martin, at (660)643-8823 or by email at bmartin@cmsu.edu.

Survey participants and their answers will remain confidential. Only my dissertation supervisor and I will have access to identifiable data. Participants' identity will not be published. Data will be aggregated for quantitative analysis, and summarized for reporting. All personal identifiers will be removed. All data will be kept for a minimum of three (3) years. Results may be published in Dissertation Abstracts and in professional journals at any time, protecting participants' anonymity and confidentiality.

Participants' control as to which survey items are answered and how much they participate within the 3D Virtual Learning Environment, insures that there will be no identifiable risk greater than that encountered in everyday life. The University of Missouri does not compensate human subjects if injury or discomfort results from the research. Nonetheless, the university holds medical, professional, and general liability insurance coverage, and provides its own medical attention and facilities in the unlikely event that participants suffer as a direct result of negligence or fault from faculty or staff associated with this research. In such eventuality, the Risk Management Officer should be contacted immediately at (573) 882-3735 to obtain a review of the matter and receive

further information. Related ethical guidelines about Protection of Human Subjects set forth in the Code of Federal Regulations "45 CFR 46" will be upheld. This statement is not to be construed as an admission of liability.

Data collection will not be initiated without preauthorization by the Institutional Review Board of the University of Missouri, Abilene Christian University, and Missouri State University. If you have further questions regarding research participants' rights, please contact the Campus Institutional Review Board at (573) 882-9585, or visit http://www.research.missouri.edu/cirb/index.htm or http://ohrp.osophs.dhhs.gov/humansubjects/guidance/45cfr46.htm

I,Brian G. Burton hereby agree to conduct this study in accordance with the procedures set forth in my project description, to uphold the ethical guidelines as set forth in the Code of Federal Regulations 45 CFR 46, 45 CFR 160 and 164, Missouri State University and Abilene Christian University HIPAA Policy, and to report to the IRB any outcomes or reactions to the experiment which were not anticipated in the risks description which might influence the IRBs decision to sustain approval of the project.

If you elect to participate in this study, please check the "Agree to Informed Consent and Permission" checkbox. Your support is very valuable.
Thank you.

Educationally yours,

Brian G. Burton
Doctoral Candidate
University of Missouri

3D Learning Environment Survey

1

How often do you use chat/email/instant or text message?

Never	Occasionally	Regularly	Often	Daily
1	2	3	4	5

2

How often do you play computer games?

Never	Occasionally	Regularly	Often	Daily
1	2	3	4	5

3

How many of the programming problems did you work on?

None	1	2	3	4 or more
1	2	3	4	5

4

How much did you communicate with other people while in the 3D VLE?

None	Occasionally	Regularly	Often	A great deal
1	2	3	4	5

5

Did you communicate with anyone who was participating in the 3D VLE outside of the
3D VLE about the program?

None	Occasionally	Regularly	Often	A great deal
1	2	3	4	5

6

Did you provide help/advice to others while in the 3D VLE?

No	Occasionally	Regularly	Often	A great deal
1	2	3	4	5

7

Did you receive help/advice from others while in the 3D VLE?

No	Occasionally	Regularly	Often	A great deal
1	2	3	4	5

8

Describe the types of communication that you had with other people in
the 3D VLE:

9

What types of help were you able to provide to others?

10

Did you receive help from others while using the VLE? Please describe the help you received.

11

Demographics: Gender

Female	Male
1	2

12

Demographics: Classification

Freshman	Sophomore	Junior	Senior	Other
1	2	3	4	5

13

Demographics: Major

14

If you are willing to be part of a follow-up interview, please provide your name. a number where you could be reached or your email:

APPENDIX C

Interview Questions for 3D VLE

Could you describe your experience of using the 3D VLE?

What types of communication did you have with other students?

What types of help did you receive as you worked on the projects in the 3D VLE?

What types of help or encouragement did you provide in the 3D VLE?

How did the communication within the VLE help or hinder your progress in the 3D VLE?

Educating Students for Christian Service and Leadership Throughout the World

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325-674-2000

ACU

ABILENE
CHRISTIAN
UNIVERSITY

July 18, 2007

Mr. Brian Burton
RR6 Box 6147
Ava, MO 65608

Mr. Burton:

I am writing to inform you that on behalf of the Institutional Review Board I have reviewed and approved your proposal for research titled "Collaboration and the use of Three Dimensional Interface within a Virtual learning Environment and the Impact on Communication and Learning: A Case Study". This project is approved for data collection, analyses, and manuscript preparation. Should any problems develop during the project, please inform the Office of Research promptly.

I hope your work goes well.

Sincerely,

Scott Perkins, Ph.D.
Director of Research

APPENDIX E

Missouri State University
Office of Sponsored Research

DATE: October 9, 2007

TO: Brian Gene Burton
            Computer Information Systems
            Missouri State University

FROM: Tracey Poston, MPA
            Associate Director/Compliance Officer
            Office of Sponsored Research & Programs

HUMAN PARTICIPANTS PROTECTION REVIEW

Your project "Collaboration and the use of Three Dimensional Interface within a Virtual Learning Environment and the Impact on Communication and Learning: A Case Study," was approved by the MSU Protection of Human Participants Institutional Review Board as submitted. Copies of your application and proposal will be on file in the Office of Sponsored Research & Programs. Please note that your project has a starting date of October 1, 2007, and that it was approved until September 30, 2008.

If you find it necessary to extend your project beyond this date, it will be necessary for you to reapply to the Protection of Human Participants Institutional Review Board. The application form for this may be obtained on the Office of Sponsored Research and Programs web page http://www.srp.missouristate.edu.

Please feel free to contact our office if we can be of additional assistance. This project has been assigned the number #06120. Please reference this number when asking any questions regarding this project.

c: Joseph Hulgus, Ph.D.

APPENDIX F

Campus IRB Application Approval Memo

Project Number:	1072577
Project Title:	COLLABORATION AND THE USE OF THREE DIMENSIONAL INTERFACE WITHIN A VIRTUAL LEARNING ENVIRONMENT AND THE IMPACT ON COMMUNICATION AND LEARNING: A CASE STUDY
Approval Date:	12-11-2006
Expiration Date:	11-16-2008
Investigator(s):	Burton, Brian Gene Martin, Barbara Nell
Level Granted:	Expedited

Campus Institutional Review Board

University of Missouri-Columbia

483 McReynolds Hall
Columbia, MO 65211-1150

PHONE: (573) 882-9585
FAX: (573) 884-0663

CAMPUS INSTITUTIONAL REVIEW BOARD APPROVAL FORM
UNIVERSITY OF MISSOURI-COLUMBIA

This is to certify that your research proposal involving human subject participants has been reviewed by the Campus IRB. This approval is based upon the assurance that you will protect the rights and welfare of the research participants, employ approved methods of securing informed consent from these individuals, and not involve undue risk to the human subjects in light of potential benefits that can be derived from participation.

Approval of this research is contingent upon your agreement to:

(1) Adhere to all UMC Policies and Procedures Relating to Human Subjects, as written in accordance with the Code of Federal Regulations (45 CFR 46).

(2) Maintain copies of all pertinent information related to the study, included but not limited to, video and audio tapes, instruments, copies of written informed consent agreements, and any other supportive documents for a period of **three (3) years** from the date of completion of your research.

(3) Report potentially serious events to the Campus IRB (573-882-9585) by the most expeditious means and complete the eIRB "Campus Adverse Event Report". This may be accessed through the following website: http://irb.missouri.edu/eirb/.

(4) IRB approval is contingent upon the investigator implementing the research activities as proposed. Campus IRB policies require an investigator to report any deviations from an approved project directly to the Campus IRB by the most expeditious means. All human subject research deviations must have prior IRB approval, except to protect the welfare and safety of human subject participants. If an investigator must deviate from the previously approved research activities, the principal investigator or team members must:
a. Immediately contact the Campus IRB at 882-9585.
b. Assure that the research project has provisions in place for the adequate protection of the rights and welfare of human subjects, and are in compliance with federal laws, University of Missouri-Columbia's FWA, and Campus IRB policies/procedures.
c. Complete the "Campus IRB Deviation Report". This may be accessed through the following website: http://irb.missouri.edu/eirb/.

(5) Submit an Amendment form to the Campus IRB for any proposed changes from the previously approved project. Changes may not be initiated without prior IRB review and approval except where necessary to eliminate apparent and immediate dangers to the subjects. The investigator must complete the Amendment form for any changes at http://irb.missouri.edu/eirb/.

(6) Federal regulations and Campus IRB policies require continuing review of research projects involving human subjects. Campus IRB

DATE:10/9/07

Name of Investigator: Brian Burton
Department: Educational Leadership & Policy Analysis
Address: RR 6 Box 6147

RE: IRB # 1072577 (Title :COLLABORATION AND THE USE OF THREE
DIMENSIONAL INTERFACE WITHIN A VIRTUAL LEARNING ENVIRONMENT
AND THE IMPACT ON COMMUNICATION AND LEARNING: A CASE STUDY)

Dear Investigator:

Your file was selected for internal audit by the Campus IRB. The application was
originally reviewed at the Expedited level. The audit result determined that your research
activities:

Qualifies for review at the Exempt level.

Your record has been updated in our eIRB database accordingly.   If you have questions,
do not hesitate to contact Janelle Greening, Quality Assurance Associate, at (573) 882-
8984.

Michele M. Reznicek, R.N., M.B.A., J.D.
Campus IRB Compliance Officer
Campus Institutional Review Board

APPENDIX G

List of Data Codes:

1. Elementary Clarification
2. In-Depth Clarification
3. Inferencing
4. Judgment
5. Application
6. Off Topic
7. Salutations
8. Flames

List of Project Problems:

1. Save error   (Documented)
2. Write to file error   (Documented)
3. Compile error   (Documented)
4. Battle error   (Documented)
5. Load Screen error   (Documented)
6. Artificial Intelligence error (Documented)
7. Server connect/Network error(Documented)
8. Avatar Load error   (Undocumented)
9. Animation error   (Undocumented)
10. Programming GUI   (Undocumented)

Vita

Brian G. Burton was born on May 14, 1966 in Anderson, Indiana, the son of Thomas Gene and Sarah Good Burton. He attended public schools in Middletown, Indiana, graduating from Shenandoah High School in 1984. He received a B.S. in Business Administration and Secondary Education with a minor in Computer Science from Abilene Christian University in 1992. He later earned a M.S.Ed. in Secondary Administration (1999) from Missouri State University (then known as Southwest Missouri State University). As part of the University of Missouri statewide cohort program he completed the Ed.D. in Educational Leadership and Policy Analysis (2008). Brian has served as a high school teacher (Lake Country Christian School, Ft. Worth, TX and Anderson Christian School, Anderson, IN), a school administrator (Garden Schools and Republic School District, Republic, MO), a college instructor (Computer Information Systems, Missouri State University, Springfield, MO), and a department chair (Computer Graphics & Programming/Computer Science, Missouri State University – West Plains, MO). He is currently serving as an assistant professor of Information Technology at Abilene Christian University, Abilene, TX, where he is developing a degree in computer game development and serious games.