The Dynamics of Student Learning within a High School Virtual Reality Design Class

Teresa Morales
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The dynamics of student learning within a high school virtual reality design class

by

Teresa M. Morales

A thesis submitted to the graduate faculty

in partial fulfillment of the requirements for the degree of

MASTER OF SCIENCE

Major: Education

Program of Study Committee
Thomas Andre, Co-Major Professor
Eunjin Bang, Co-Major Professor
Stephen Gilbert

Iowa State University

Ames, Iowa

2010

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ACKNOWLEDGEMENTS

I would like to take this opportunity to thank my husband Bernabe who has encouraged me through this research and writing process. With heartfelt love I value your cheerleading, willingness to discuss and listening to my complaining. Thanks to my mother and stepdad Bob who took me on weekend trips to refresh my mind.

Thanks to my family; Aunt Alice, (Philippines 4:13) Matt, Alex, Julie and Sam for encouraging me. A special thank you goes to my son Tyler whose expertise was priceless and helped me understand the technical aspects of this research. Thanks for letting me pester you with questions.

It is with gratitude and appreciation I thank my major professors Tom Andre and EJ Bang as well as my committee member Stephen Gilbert. Thanks so much for your guidance, advice and time you committed to my graduate school experience.
ABSTRACT

This mixed method study investigated knowledge and skill development of high school students in a project-based virtual reality design class, in which 3-D projects were developed within a student-centered, student-directed environment. This investigation focused on the social dynamics of the class and the role of peer mentoring was examined to determine how student behavior and learning were influenced. Additionally, investigation focused on the depth of student content learning, cognitive development, including problem solving. The participants of this study included freshmen through seniors, parents, teachers and administrators. Student interviews and observations were used to collect data as well as surveys concerning student development and growth from the teachers and parents. The results of this study suggested that a virtual reality learning environment promotes the development of meaningful cognitive experiences, creativity, leadership, global socialization, problem solving, and a deeper understanding of academic content.
CHAPTER 1. GENERAL INTRODUCTION

Introduction

Overview

In the emerging 21st century world of education, the holographic teacher looks like an avatar, with fiery blue hair, a Barbie doll figure, and a computer generated voice that demands attention. The students in this futuristic 3D virtual reality (VR) design software classroom have generated the programs to create the learning environment they desire. They open electronic computer notebooks that contain an entire electronic library of knowledge and begin to participate virtually in a 3-D philharmonic concert, chemistry lab, or surgical suite conducting an ongoing heart dissection.
Students become characters from *The Lord of the Rings* as they develop a virtual 3-D scene from the book; they read technical manuals, engage in brainstorming conversations with one another, and incorporate peers ideas into their own projects. The students in this class construct foundations of knowledge to build new knowledge onto based on their existing understanding. They collaboratively build on the knowledge of others, use technical tools and software, in addition to their textbooks. They concoct new inventions and banter like typical teenagers, playing, goofing off, or constructing monsters with Legos.

In this free flowing atmosphere, students quote obnoxious movie lines, use toys, tools, and software they have modified or developed themselves to stimulate project development. In this futuristic noisy, cluttered virtual reality environment, learning and teaching occur with every interaction with peers, with technology, or with the global world. This hypothetical futuristic classroom is occurring in schools across Iowa. This paper reports of an investigation concerning the impact of such learning experiences on the participating adolescents.
General Issue Investigated

This thesis reviews existing research incorporating project-based learning environments (Study 1), with a particular focus on learning environments incorporating virtual reality. In addition, the thesis reports an investigation of the social and learning dynamics and the nature of student learning occurring in an ongoing virtual reality class (Study 2). The high school students participating in this study were involved in project-based learning in which they design and develop virtual reality projects that have an educational aspect.

This topic of study was chosen for multiple reasons. First, as a result of the advances in new technologies, many researchers’ claim (e.g. Dede, 2007; Sawyer, 2006; Seely, Brown & Duguid, 2000) that educational practices must change to meet the current and emerging needs of students as we continue into the 21st century. These researchers point out the world economy is no longer driven by industrialization, but by innovation and knowledge. As a result students need to be prepared to function effectively in world economy that is knowledge-based and
rewards resourceful innovations. A second reason concerned the availability of an initial high school virtual reality program in Iowa. Preliminary results with students in this program seemed positive, and a more formal investigation of the nature of the class and its outcomes seemed warranted.

Through the generosity of commercial firms such as Rockwell Collins, Mechdyne and The Mayo Clinic, combined with the creative intervention of an innovating principal, a student-directed, pioneering class, in which students developed virtual reality projects, was born. With a vested interest in using virtual reality to develop prototypes of new products, researching medical breakthroughs or manufacturing virtual design systems, industry leaders are supportive of virtual reality design classes at the high school and university levels. As business leaders recognize future implications of virtual reality for economic development, they are interested in providing educational opportunities for people to develop virtual reality technical literacy skills. They perceive such skills are vital to manufacturing, military development and research sectors.
Educational practitioners involved in this virtual reality design class have claimed that it fosters accelerated student achievement, the development of multifaceted content knowledge and understanding, and skills necessary for success in a knowledge-based society. Because of the apparent success of this pilot program (Eller, 2009; Morales, 2009; Richard, 2006), other school districts across Iowa have begun to embark on virtual reality programs. The Iowa Department of Education has taken notice of this VR program and is examining how effective it is in promoting student learning and cognitive development. However, the impact of the virtual reality experience on student learning and success has yet to be studied in depth. Relatively little research on student use of virtual reality hardware and software to develop educational products exists. Thus there is a great need for further research in the area of virtual reality learning environments particularly in relationship to their influence on student learning, cognition and skill preparation for the future. This initial research was undertaken to provide formal data and to examine the apparent success or shortfalls of the program. While the present study
provides an initial examination, additional research will be necessary, as the present study was limited by a relatively short time frame, the depth of content knowledge and cognitive skills it could study, and the novelty of the VR technology used.

**Related Previous Research**

The objective of this thesis was to examine the nature and apparent success of student learning in a virtual reality project-based program. To accomplish this goal, two studies were conducted. The first study was a review of literature on technology enhanced learning environments in which students design projects. The second study examined student learning and the nature of the learning in the virtual reality program. Specifically, Study 2 examined the dynamics of the VR classroom in relation to the peer mentoring that occurred and the knowledge students gained in science. Peer mentoring was studied through classroom observations and videotaping; Knowledge gain was assessed by examining how content was represented in student projects and how students communicated their understanding of content in conversations and interviews.
Study 1, the review study, examined constructivist theories which underlie project based learning. It examined the features of project based learning and research on project based learning that involved technology enhanced learning environments in which students developed applications of the technology or used technology to conduct projects. Extensive research has been done on project based learning (Krajcik & Blumenfeld, 1998; Thomas, 2000), and related educational approaches such as problem-based learning (Hmelo-Silver, 2004), case-based reasoning (Kolodner, 2006), and inquiry learning (Cobb & McCain, 2006). All such approaches have in common the organization of the learning experience around some issue: students brainstorm and develop approaches to study or research the issue, carry out the planned and additional research as needed and develop some written physical product that represents their resolution of the issue. In general, this project based learning has been built on the constructivist learning tradition.
Constructivist Theories of Learning and of Teaching.

Phillips (1995) summarized the basic tenets and differences among multiple sub-camps of the family of theories of learning or knowledge development called constructivism. The fundamental idea of constructivism is that human knowledge, whether public knowledge or individual knowledge, does not spring directly from the recording of experience nor is it preformed in the mind. Rather some degree of reflection and reasoning about experiences determine individual and social public knowledge. As human reasoning contributes to knowledge development, misconceptions, emotional laden values, beliefs, and social/political pressures may influence the knowledge that is constructed. Phillips further argues that there is a varying gamut of constructivist theories. These theories vary on their positions along three dimensions: epistemological, sociopolitical, and educational. While the sociopolitical dimension is not emphasized in this thesis, within the epistemological dimension, there are two issues that are relevant. The first issue is to the degree to
which theorists believe that nature or experience imposes knowledge on learners or those learners, whether they are conceptualized as societies or individuals, construct knowledge. The second issue within the epistemological dimension is the degree to which theorists emphasize the society/culture or the individual as the constructor of knowledge. Regardless of the position of theoretical approaches taken, the constructivist family of theories shares key features including:

- Knowledge is constructed from the interaction of experience and prior knowledge, either within the individual or from a social context,
- Knowledge incorporates real world connections,
- Social attitudes, motivation and student engagement influence learning

Knowledge building depends on individual learner activities or on social learning activities. Most importantly, learners, whether individuals or societies, construct their own knowledge by building new ideas onto previous knowledge and
experiences or by creating new ideas adapting, combining, or modifying knowledge structures to create new ways of interpreting.

Project-based learning is a teaching approach that focuses on students developing knowledge by accomplishing long term projects that often cut across disciplinary boundaries, have personal meaning to learners, require learning of new content to accomplish, have considerable student input in their design and implementation, and results in the creation of some product. The product can vary from a written report or multi-media presentation to the creation of an artifact or process to accomplish a task. Project-based learning has its theoretical roots in constructivism. The virtual reality class is organized around projects. A review of theory and research on project base learning is relevant to understanding the class and the empirical research on it that this thesis reports.
Organization of the Thesis.

Study 1 in this thesis is a review of the literature on project based learning. Because project based learning has been informed mostly by constructivist theories, the review provides an overview of constructivist theories on how knowledge develops and constructivist theories for effective teaching. The research review focuses on studies of project based learning and emphasizes recent research that utilizes technology, particularly virtual reality technology. This literature review discusses how project based learning has evolved from past to present, and provides guidelines for project based learning environments. The review was written to be submitted to the Review of Research in Education.

Study 2 in this thesis is a mixed methods investigation of the initial virtual reality class in Iowa. School officials believe this virtual reality class helps students construct complex abstract subject knowledge because they are involved in creating products that represent that knowledge, an effect consistent with prior research (e.g. Lebow, 1995; Salzmann, Dede, Loftin & Ash, 2008). Additionally, the school officials
believe that through the visualization required, students gain inherently deeper understanding, an effect also discussed in previous research (e.g. Barab, Hay, Barnett, & Keating, 2000; Merickel, 1992). In addition to content knowledge, the hands-on experiences constructing virtual reality simulations are believed to facilitate student development of inventiveness and multi-layered meta-cognitive and problem solving skills (Carver, 2009; Collins, 2009; & Greeno, 2009). Additional potential benefits of VR project learning is that projects developed in a VR setting allow students to study in areas which normally would raise ethical questions (e.g. inducing catastrophic failure in a structure) or to study topics in situations that are physically impossible in reality (e.g. be an electron in an electron field). In addition, virtual reality project based learning often involves projects which require disciplinary knowledge learning that involve multiple disciplines (Barab, Hay, Barnett, & Keating; Barnett, Yamagata-Lynch, Keating 1995).

The research context involved a voluntary virtual reality design class in a smaller public high school. Students in the class worked independently to learn the
software and hardware. They were required to develop projects that demonstrated technical skill with the virtual reality programs and also serve an educational purpose. There was little direct teacher supervision; instead, students were accountable for producing and demonstrating a project to their peers, teachers and professional groups. The learning processes of these students involved their own thinking, designing, problem solving and collaborating. The two focus questions of Study 2 included; 1. What were the social dynamics of and the role of peer mentoring in student behavior and learning of the class in practice? 2. What content knowledge and problem solving skills were gained? Study 2 was written to be submitted to ERIC, Educational Resources Information Center. A final chapter provides an overview of the results and lessons learned from this thesis and discuss their importance.
CHAPTER 2. STUDY 1: A REVIEW OF CONSTRUCTIVIST LITERATURE IN PROJECT-BASED TECHNOLOGICAL LEARNING ENVIRONMENTS

This review examines research informed by constructivist philosophies and theories with a particular emphasis on student learning and cognition in virtual reality project-based environments. This review provides:

1) A brief summary of constructivist educational theories and their relationship to project-based learning. Covered are: (A) the nature of constructivist theories of knowledge and the distinction between constructivist theories of knowledge and constructivist theories of education, (B) the features of constructivist theories of education, (C) the benefits claimed for the use of constructivist theories in teaching.
2) An overview of research on project-based learning environments, particularly those in which 3-D virtual reality products are created.

3) A description of effective ways to use to develop student thinking, problem solving and abstract thinking while creating projects in a technology based learning environment.

Concurrent with the development of digital technology-enhanced learning environments; an emphasis on constructivist learning environments using digital technologies has emerged. Such environments typically involve students in problem-based, project-based and inquiry-based learning experiences. Project-based, problem-based, and inquiry-based learning environment involve students as active participants in creating products useful for some task (project-based learning), solutions to contextualized authentic problems related to a socially important issue (problem-based learning), or explanations for scientific, social, or literary phenomena (inquiry-based learning).
Constructivist Learning Theories

With the emergence of new technologies, higher standards for student achievement, and a resurgence of the “learner” as the central focus for curriculum development and educational goals, a discussion of constructivist learning theories is vital (Sawyer, 2006). The new electronic technologies, ranging from toys (e.g. WII) to virtual reality (VR) software, offer possibilities to design highly engaging student-centered learning environments. For example, WII controllers are used as input devices in project-based learning in an Iowa State University (ISU) engineering class (Pusey, 2010) in which the professor uses Wii-motes to teach. Such student-centered classes involve students as active participants in their learning rather than passive receptors of knowledge and skills. Lebow (1995) claims that technology supported constructivist learning approaches have potential to expand students’ higher order thinking skills and provide authenticity and purpose to learning.
The Definition of Constructivist Theory

The term constructivism has become a catch-all phrase for a family of theoretical approaches to knowledge construction, learning, and education that range widely to theories of pedagogy or instruction which focus on how to teach so as to facilitate knowledge construction (Dimock & Bothel, 1999; Gredler & Shields, 2008; Sprague and Dede, 1999; Vygotsky, 1960). Ishii (2003) identified a large number of adjectives “contextual, dialectical, empirical, humanistic, information-processing, methodological, moderate, Piagetian, post-epistemological, pragmatic, radical, rational, realist, and socio-historical,” (p. 2) used to clarify the meaning of various flavors of constructivist theories and pedagogies. Despite this wide range, the premise underlying the different constructivist theoretical perspectives is that knowledge and meaning are not transmitted directly through education and not purely objective, but rather are built upon or constructed by learners or social groups within experiential contexts (Dewey, 1902-1950; Dimock & Boethel, 1999). Dimock and Boethel (1999) define constructivist learning as; “an active learning process
where the students adapt their thinking to build functional understanding in which the
learner and the learning environment are intertwined” (p.6).

Description of Constructivist Theories

Phillips (1995) focuses on constructivist theories as theories of knowledge
and discusses the philosophical and theoretical roots of the constructivist family of
theories. He points out those theories of knowledge that fall under the label
constructivist spring from a variety of sources. Phillips argues these sources include
philosophers such as Kant (1959) theorists who have focused on individuals’
construction of knowledge (e.g. Dewey, 1917; Papert, 1993; Piaget, 1952; Von
Glasersfeld, 1991; Vygotsky, 1978), and theorists and feminist epistemologists who
emphasize social –political and cultural processes (Alcoff & Potter, 1993; Barnes,
1974; Collins, 1985; Nelson, 1993). Phillips argues that contemporary constructivist
theories can be organized by their emphases across two major dimensions:

1. “Humans as creators” versus “nature the instructor.” Phillips notes this
dimension actually extends beyond constructivist theories because at the extreme
end of “nature as instructor”, knowledge is not constructed, but imposed by nature.

However, constructivist theories are complex and, while all emphasize human agency in knowledge construction, theorists differ on this dimension in the degree to which nature plays a role in the construction process. For example, Phillips argues John Locke (1947) approaches the nature as instructor end, but even Locke integrates a role for human thinking / construction in the creation of knowledge. Phillips places Karl Popper (1994) midway on the nature instructs/human create knowledge dimensions. However, individual oriented theorists (e.g. Piaget, 1952; Von Glaserfeld, 1991) and socially oriented theorists (Longino, 1993) argue that individuals or social groups create knowledge and are close to the “human as creator” endpoint of the dimension.

2. Individual psychology versus public discipline. Along this second dimension, theorists vary from the degree to which individuals and their individual reasoning about their experiences is the source of knowledge construction or whether knowledge is constructed by social groups. Within this dimension, some
theorists ignore knowledge construction within the individual and argue that knowledge is solely constructed and exists within groups, others emphasized social processes as influencing individual knowledge construction, and some emphasize individual rationality in knowledge construction with little emphasis on social processes (Gergan, 1999; Hibberd, 2005).

These positions on the nature of knowledge creation have implications for educational processes. Theorists closer to the “human as creator” end of the dimension promote more open-ended, student controlled learning environments. Theorists closer to the midpoint of the dimension will see more balance between teacher control and student control while theorists outside the constructivist end of the dimension are likely to emphasize teacher or instructional control.

Education is a practical discipline concerned with the development of students. As a result, the foundational theories of constructivism discussed by Phillips have been supplemented with pedagogical theories and instructional approaches that focus on how to teach to promote knowledge construction. Ernest
(1996) and an ERIC Summary Document (2003) summarize key teaching considerations or strategies within the constructivist tradition. These include:

- learner’s prior knowledge and goals must be considered in instructional planning and teaching instruction should utilize cognitive conflict strategies push students to remedy their alternative conceptions in their thinking,
- teaching should help students become aware of their own thinking and engage in self reflection, instructional use of multiple representations helps students' development conceptual understanding
- social contexts and influences on learners need to be considered

Additional strategies common to theories that focus on constructivist-oriented teaching are described below.

1. Learning is an ongoing process that takes time during which learners build on prior knowledge and experiences through a set of processes known as cognitive elaboration (Ritchie & Karge, 1996). In cognitive elaboration, learners connect or relate new information or content they are learning to their existing prior knowledge
and experiences. Cognitive elaboration provides supports for learners as they assimilate new content into their cognitive structures. Scaffolding, done by instructors, peers, or others, (Palincsar & Brown, 1984), is a process of providing external support to allow learners to carry out cognitive elaboration and to complete tasks they could not do without assistance. Scaffolding can be provided by a leading question, a reminder to remember relate previous experiences to new content, or provision of a framework to guide the learner (Bass, Contant, & Carin, 2009) or a provision of experiences or discourse within which a student’s perceptions, misconceptions or ideas are challenged (Sawyer, 2006). Scaffolding moves students to their most favorable performance level or, as Vygotsky explained, the zone of proximal development (1978).

Constructivist classrooms are learner centered rather than curriculum/teacher centered. According to Bransford, Brown, & Cocking (2000), a learner centered environment:
“refers to an environment that pays careful attention to the knowledge, skills, attitudes and beliefs that learners bring to the educational setting”… including cultural bias and knowledge.” (p. 23)

Student centered classrooms traditionally emphasize that learners need to be cognitively active in trying to understand the to-be-learned content. Such classrooms typically incorporate socialization through group work to promote social construction of knowledge, allow students choices, utilize hands-on activities as supports for cognitive processing and learning, and stress student problem solving, reflection, and use higher order thinking skills. The teacher encourages deeper thinking through questioning and encouraging student thinking, and motivators come more from within the student rather than the teacher. The specific curricular activities are not solely teacher determined, but incorporate student choices in learning the content (Alexander, 2006; NSES, 1996; NSTA, 1995).

Sprague and Dede (1999) provide a description of a general constructionist classroom which effectively uses computer technology. They argue that, in such a
classroom, the teaching leads students to engage with problem-based activities in which students are encouraged to look beyond what is apparent. Further they argue that such constructivist learning environments need to promote communication among students to share ideas, analyze data, and make life or community connections. Such connections make the content meaningful, interesting, and authentic to the students. In solving such problems, students call upon prior experience and knowledge in order to make meaningful connections to the new content. In such classrooms, students are encouraged to inquire, and are challenged to look outside the box in inventing problem solutions. Group participation and discussion in arriving at solutions to common goals promote deeper learning. Such environments and problems contextualize or situate knowledge and allow students to create meaning that can be utilized in related contexts. Sprague and Dede (1999) further claim that, in constructive learning environments, students are more intrinsically motivated, creative, and critical in their own meta-cognitive processes and are more actively involved in conversations with their peers. Through observing
students’ discussions and problem-solving behaviors, teachers, peers, and potentially others scaffold or guide learning by providing facilitative guiding comments that promote students’ consideration of additional aspects of the problem issues and of context.

Sprague and Dede (1999) reported on a classroom using such a technology-supported, student based instructional strategy. In this classroom, the teacher presented open ended problems and asked questions to stimulate discussions and student thinking. The teacher utilized a Palm Pilot to keep notes about teacher-student and student-student interactions. Such notes provided the teacher with record keeping for documentation. That documentation was useful for providing additional guidance, for parent conferences, for student progress reports, or for behavior tracking for professional interventions as necessary.

In the classroom, students were given ample time to explore academic material or topics of interest to construct their own knowledge. Teachers were encouraged to learn about students’ prior experiences and to integrate them into the
students develop deeper meanings in addition to synthesizing new knowledge onto prior knowledge. Student autonomy was promoted by giving students some degree of control over project choice and the tools of technology used for problem solving. Student responses drove lessons, as the teacher utilized Palm Pilot notes, to shift instructional methods or adjust content for greater learning. Sprague and Dede (1999) argued that their classroom observations supported the conclusion that when students take an active role in learning, their motivation is increased, and they experience authentic critical thinking and construct knowledge that is long-lasting, transferable and functional.

Lebow (1995) summarized essential features of constructivist learning theories and approaches to education; Table 2.1, below, presents his summary. In Table 1, the left column describes an essential feature identified by Lebow; the right column provides a definition of the term.
Table 2.1

### Essential Features of Constructivist Theories

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<td>Engagement</td>
<td>Intentional learning where the student employs strategies that allows for purposeful processing of information.</td>
</tr>
<tr>
<td>Authenticity</td>
<td>Context of learning with value to the practices of the target culture and value placed on the learning task.</td>
</tr>
<tr>
<td>Collaboration</td>
<td>Social interactions that are noncompetitive and affect cognitive development.</td>
</tr>
<tr>
<td>Community</td>
<td>The emphasis on constructed public knowledge.</td>
</tr>
<tr>
<td>Complexity</td>
<td>Concept and case complexities that are influenced by multiple forces of learning.</td>
</tr>
<tr>
<td>Generality</td>
<td>Building existing knowledge to make sense of new information.</td>
</tr>
<tr>
<td>Multiple Views</td>
<td>Looking at the material with different views or for different purposes.</td>
</tr>
<tr>
<td>Ownership</td>
<td>Commitment by the learner to achieve learning goals.</td>
</tr>
<tr>
<td>Autonomy</td>
<td>The feeling students have when they are in charge of the learning process.</td>
</tr>
<tr>
<td>Self Relevance</td>
<td>Achieving personal goals in the context of the learning situations that go farther than just getting a good grade.</td>
</tr>
<tr>
<td>Pluralism</td>
<td>More than one view of reality that explains the phenomena of life.</td>
</tr>
<tr>
<td>Reflectivity</td>
<td>The skill of students to plan and monitor their own learning and thinking.</td>
</tr>
<tr>
<td>Self Regulation</td>
<td>The ability to motivate and take responsibility for learning and project development.</td>
</tr>
<tr>
<td>Transformation</td>
<td>A learner’s ability to reorganize meaningful learning and apply skills to other situations.</td>
</tr>
</tbody>
</table>

*Table developed based on information provided by Lebow (1995).*

This paper is focused on the impact of project-based, technology-facilitated learning / teaching approaches. Contemporary research on such project-based
learning has generally been grounded in constructivist theoretical traditions. This summary of the characteristics of constructivist theories of knowledge and of teaching was designed to identify the theoretical roots and pedagogical features of constructive teaching instruction. These characteristics influence the design of project-based technology-facilitated learning environments.

**Purported Benefits of Constructivist Approaches to Teaching**

While there is controversy in the educational literature about the value of constructivist approaches to teaching (e.g. Tobias & Duffy, 2000), constructivist theories have influenced the educational establishment and have motivated a very large number of teaching approaches and curriculum designs. Proponents of constructivist models argue that there are multiple benefits for constructivist teaching approaches. The National Science Educational Standards (NSES) embody a constructivist approaches. Those standards focus on learning as an active process. That active process involves students in inquiry investigations, interactions with peers and the teacher,
activation and connections to prior individual knowledge. Students need to engage in problem solving while applying new science content, plan, make decisions and experience various assessment practices. NSES summarized the active process of learning as; “learning is something students do, not something that is done to them.” This student or learner centered pedagogy incorporates socialization through group work, allows student choice, utilizes hands-on activities, and stresses problem solving, logic and higher order thinking skills. The teacher encourages deeper thinking through questioning rather than lecture and motivators come more from within the student rather than the teacher. The curriculum is not necessarily focused solely on the academic content, but should incorporate student choices in the content (Alexander, 2006; NSES, 1996; NSTA, 1995).

Based on a national study on the role of technology in supporting education reform, Means and Olson (1995) describe teachers’ perceptions of the value of constructivist approaches.
Figure 2.1 Percentage of teachers who agreed that technology-facilitated project-based learning led to a higher level of the characteristic than did traditional instruction. (Based on information provided by Means & Olson, 1995).

Based on interviews with Means and Olson reported, a substantial proportion of teachers perceived that, with the enhancement of technology, students demonstrate higher quality of products produced, used numerous outside sources for data gathering, developed multiple perspectives and developed skills for
multimedia usage. Figure 2.1 indicates the percentage of teachers agreeing that technology facilitated project-based teaching enhances student learning.

Furthermore, Means and Olson reported that teachers claimed students were able to understand the needs of the intended audience, cultivated creativity and improved design skills and personal presentations. Further, teachers believed that students displayed increased motivation. With respect to working in the group environment, students were able to respond to peer critiques, reflect on and self regulate their learning.

Keengwe and Onchwari (2009) claim that, in constructivist classrooms, students become actively engaged in their own learning and thinking. Students develop higher order thinking skills by interacting with complex materials and problems using creativity along with purposeful connections to life outside the classroom. As students develop an awareness of inquiry and questioning, they enhance their proficiency in using acquired skills and gain a sense of empowerment. Similarly, Savery and Duffy (1995) argued that in the constructionist framework,
interaction with their environment and social negotiations with their peers lead students to gain numerous skills and characteristics essential for success. Such skills include a better understanding of concepts, the development of a sense of ownership in authentic tasks, and an appreciation for the value of challenging assignments and complex problems. Furthermore, students learn to set goals, to test ideas, and to reflect on their hypothesis.

**Project-based Learning**

“Project-based Learning is a systematic teaching method that engages students in learning knowledge and skills through an extended inquiry process structured around complex, authentic questions and carefully designed products and tasks” (Buck Institute, 2003, p.4). Project-based learning is one pedagogical approach that has been used to implement constructivist teaching approaches. While having roots in earlier educational ideas, for example, Dewey’s progressive education (1916), contemporary constructivist ideas and the development of digital
educational technologies have led to a re-emphasis on project-based learning (Fleming, 2000; Greeno, 2006; Krajcik & Blumenfeld, 2006).

Project-based learning, as summarized by Krajcik and Blumenfeld (2006), mandates participants apply knowledge and skills through development of a project that is driven by the student’s own thoughts and creativity. Participants actively construct their understanding of new content by completing a project in an authentic real world context. Participants typically complete some artifact in the project; the artifact can vary from a written report, a presentation, or the creation of some product which fulfills the project specification. The project situates learning in meaningful and interesting contexts for learning, and learners typically have some choice over the nature of the project they complete. To carry out and complete projects, students must call on their prior knowledge and meaningfully integrate it with new content (Greeno, 2006). Greeno adds that, in such situated learning, students construct a deeper conceptual understanding of the content which in turn
facilitates the students’ abilities to generalize constructed knowledge to a broader range of conditions (Greeno, 2006).

Fleming (2000) described the essential features of project-based learning;

Table 2.2 adapted from Fleming, summarizes his description.

<table>
<thead>
<tr>
<th>Feature</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Authenticity</td>
<td>The project focuses on a problem or question that has meaning to the student, and could be solved by an adult or work community. Projects created have a personal or social value beyond school.</td>
</tr>
<tr>
<td>Academic Rigor</td>
<td>Students acquire and apply knowledge and may cross academic disciplines, while the project challenges students to inquire, and develop higher thinking skills.</td>
</tr>
<tr>
<td>Applied Learning</td>
<td>In designing a product students solve problems that are grounded in the context of adult work experience and students are required to use skills such as technology literacy, communication, and collaboration within a group. In addition students are required to develop organization and self management skills.</td>
</tr>
</tbody>
</table>
### Table 2.2 Essential Features of Project-based Learning* continued

<table>
<thead>
<tr>
<th>Feature</th>
<th>Details</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Active Exploration</strong></td>
<td>Students are required to engage in genuine life investigations using</td>
</tr>
<tr>
<td></td>
<td>a variety of research methods and spending time accomplishing</td>
</tr>
<tr>
<td></td>
<td>field work. Learning is expressed through presentations.</td>
</tr>
<tr>
<td><strong>Adult Connections</strong></td>
<td>Adult connections help students understand real world work ethics,</td>
</tr>
<tr>
<td></td>
<td>give expertise knowledge and advice, and adult work becomes visible to</td>
</tr>
<tr>
<td></td>
<td>students.</td>
</tr>
<tr>
<td><strong>Assessment Practices</strong></td>
<td>Students have opportunities to self reflect and assess their projects,</td>
</tr>
<tr>
<td></td>
<td>with clear goals throughout the development, and receive feedback from</td>
</tr>
<tr>
<td></td>
<td>their peers, teachers and other adults.</td>
</tr>
</tbody>
</table>

*Table developed based on information provided in Fleming, 2000.

### Definition and Steps for Implementing Project-Based Learning

As a teaching method, project-based learning can be a powerful approach, but successful implementation requires vision, up-front preparation, thoughtful goal-orientated outcomes, realistic timelines and classroom management strategies. The Buck Institute of Education (2003) is a research and development organization founded for the purpose of developing effective school and classroom practices using project-based and problem-based teaching practices. In its book, Project-based Learning Handbook the Buck Institute describes the process of developing
and implementing project-based learning. This section is based on their guidelines (Buck Institute, 2003).

According to the Buck Institute’s guidelines, the first phase in developing a project-based curriculum is to develop a project idea and decide the scope of the project. The type of project will determine the length of time needed for the project. Initial decisions include, the goals of the project, the audience intended, how the project will be structured so that student autonomy will be promoted and achieved, which and how technological skills will be developed, and what types of assessment will be used to determine if goals are achieved and standards attained.

The Buck Institute guidelines further indicate that, in developing projects, instructional designers and teachers need to work backward from the academic content or main theme and identify current issues related to intended content learning that are of potential interest to students. Additionally, community service opportunities or tie-ins to local and national events that relate to the project’s theme or academic content also should be identified. Students should be involved in the
planning stage as student ownership and responsibility for their learning is a central key to implementing project-based learning projects. Community connections and relevance to students are significant for the success of project-based learning.

Mapping the characteristics of the local community such as services provided by the community, the needs of the citizens who live there, cultural activities, employment opportunities and traits of local neighborhoods to the academic content are important in promoting connections and relevance. Such situated learning allows students both to gain expertise in the content and in the effective use in real situations. In other words, students both learn the knowledge and information and learn how to apply that knowledge and information in contexts meaningful to them.

Situating learning in community issues provides for connections and interactions between the students and members of the community and can promote meaningfulness and interest (Buck Institute, 2003). Modifying the look and feel of the classroom, i.e. decorating it like a science lab or colonial America during the
revolutionary war, for the duration of the project can also help promote interest and meaningfulness.

Second, identifying learning standards and assessments that require student accountability and self monitoring throughout project development is important to project-based learning. Furthermore, while projects require important and realistic academic content learning goals, promotion of student information-seeking, reasoning, problem-solving, creative thinking, and student input into decisions, brainstorming and discussions are inherent and important goals of project-based learning. Projects typically require use or gaining of knowledge from multiple academic disciplines. Thus, by using projects, teachers have the opportunity to incorporate academic content from multiple disciplines. These features can help students see interconnections between disciplines. Projects can provide opportunities to develop essential skills such as collaboration, meeting deadlines, technology literacy and self management (Buck Institute, 2003). A balanced assessment plan, that includes a variety of assessment tools tied to the project's
standards and outcome goals, is important to effective projects. Both regular
formative assessments with feedback to students given frequently at various stages
of development and summative assessments at the end of the project should be
included in the assessment plan. The end product produced by the students should
align with the outcomes and standards expected. A set of checkpoints which guide
students in following a line of development such as proposals, outlines, edited drafts,
peer critiques and self evaluations scaffolds students performance in projects and
provides students with opportunities to demonstrate learning and skill development.
The use of a rubric at critical evaluation stages sets a clear scoring guide for student
performance and proficiency.

In carrying out the project, teachers should work with students to share
project goals. Students should be required to use problem solving tools such as
journal entries, progress reports, plans of investigation, chore lists, and postings on
a class page or other means to promote organization and communication among
group members and the teacher. Furthermore, use of check points and milestones
are an important component to keep students focused, motivated, while also requiring accountability and allowing the teacher to chart student advancement and identify problems that need addressing. A variety of strategies such as informal briefings, weekly reflection sessions, check off lists for tasks completed, progress logs or journals and various other methods can be utilized to help students organize and chart the project’s progression. These tools also give teachers resources for evaluating student performance, skill acquisition and understanding of content knowledge.

The final check point in a project should be a debriefing with the students both individually and within their groups to discuss learning goals, end product reflections, critiques or problems. The plan for evaluation that was clearly developed should be implemented and final presentations of the students’ productions arranged. At this stage students should analyze, and reflect on their learning in some form of culminating evaluation like a portfolio, questionnaire, or discussion forum. Focus questions for these forums should include:
• What did we learn?
• Did we collaborate effectively?
• What skills did we learn?
• What skills do we need to practice?
• What was the quality of your work and participation?
• What connections can we make to other subjects, life situations or similar problems or goals in the future?

When students have invested their energy to complete a quality project, it is time for celebration. Teacher and students should plan a final showing of the projects, including an audience of parents, students and teachers from other classrooms, administrators or community adults. Whether the celebration is a ceremony, special event, a reception or some other planned activity, it allows acknowledgment of what the students have achieved. Special planned celebrations allow for opportunities for the community to view and understand what the students have learned or skills they have developed. The importance of celebrations is supported also by Fleming (2000) who similarly argued that celebrations help students, parents, and the community as a whole to develop connections that
otherwise would not have been formed. Those connections increase the
meaningfulness of contexts and relationships.

**Research Literature on Project-Based Learning**

Thomas (2000) reviewed the earlier literature on project-based learning. He
argued that, in a project-based learning environment, students exchange and debate
ideas as well as solutions to problems encountered. Social interactions in the
project-based learning environment create a community of learners, in which
thinking and collaboration build understanding of concepts. Students mature as they
learn to respect the opinion of others, broaden their world view and become
contributors to the global society in addition to reacting to direction from the
facilitator or teacher.

Projects, problem-solving activities, traditional laboratory activities have long
been part of education. Thomas developed a set of five criteria that he argues
distinguish contemporary project-based learning from earlier approaches (Thomas,
2000). These five critical features are essential for authentic project-based learning in Thomas' view. These features are:

1.) Project-based learning projects are central not peripheral to the curriculum (p2). According to Thomas, in authentic project-based learning, projects carry the main work of the curriculum, i.e. “projects are the curriculum” (p. 3). Classes which include projects as applications that follow traditional instruction or projects used to enrich the curriculum are not authentic project-based learning in Thomas' view.

2.) Projects are focused on a problem or a question that drive students to encounter and struggle with the central concepts and principles of a discipline (p. 3). Projects are designed to lead students to connect and come to understand the essential conceptual knowledge needed in the discipline. Students’ “activities, products, and performances” must serve an “important intellectual purpose.” While a project may involve thematic units and cross academic disciplines this is not a distinguishing feature of projects, according to Thomas. Rather, it is the intellectual purpose the activities serve that is the essential feature.
3.) Projects involve students in a constructive investigation (p. 3). A constructive investigation is one in which students participate in direct inquiry, build knowledge and develop a resolution to the projects’ “defining question” or central issue and in the process, create new-to-them knowledge and skills. Projects in which students utilize already developed knowledge and skills are not appropriate “PBL projects”.

4.) Projects are student-driven to some significant degree (p. 4). Projects in project-based learning, unlike traditional class projects, are not developed by the teacher or prepared in advance. Rather, participants develop their own plan for the project-based upon the “driving question” or issue and they developed their own desired outcomes and determine their own path for accomplishing those outcomes. Students make critical decisions concerning what is the focus of the project and how they manage their time for completion of the project.
5.) Projects are realistic, not school-like (p. 4). Projects have an authentic value and are realistic to life situations. When involved in doing a project, students have an intellectual purpose the outcome of which may produce solutions that can realistically be implemented in life situations. Projects have “authenticity” to the students; in completing the project, student engaged in designing practical resolutions to real life situations.

Thomas’s description of projects is congruent with the description provided by Fleming (2000). Fleming (2000) claimed that seven characteristics or criteria distinguished traditional education projects from the projects in project-based learning. These characteristics are described in Table 2.3 below. These distinguishing criteria are similar to those Thomas describes except that Fleming explicitly involves technology in his description.
Table 2.3

Comparisons of Project-Based Practices - Past and Present

<table>
<thead>
<tr>
<th>Practice</th>
<th>Past</th>
<th>Present</th>
</tr>
</thead>
<tbody>
<tr>
<td>Higher order thinking</td>
<td>Projects based on fact finding.</td>
<td>Projects based on interpreting raw data, drawing conclusions and application of knowledge.</td>
</tr>
<tr>
<td>skills</td>
<td>Ex. Locating countries on a globe and memorizing the capitals.</td>
<td>Ex. Students use a GPS to locate specific spots on the map, plot coordinates and pinpoint location.</td>
</tr>
<tr>
<td>Teamwork and Collaboration</td>
<td>Projects were individually done.</td>
<td>Collaboration across grade levels, or subject areas.</td>
</tr>
<tr>
<td></td>
<td>Ex. Map worksheets</td>
<td>Requires interactions with peers, mentors, and adults from the community.</td>
</tr>
<tr>
<td>Scope</td>
<td>Projects focused on past discoveries.</td>
<td>Projects require students to investigate contemporary issues, predict future events and make connections.</td>
</tr>
<tr>
<td></td>
<td>Ex. Mapping the explorers’ journeys around the world</td>
<td>Ex. Students investigate flooding problem in an area of the community, predict future implications of changes, and connect with realities of implementing changes.</td>
</tr>
<tr>
<td>Table 2.3 Comparisons of Project-Based Practices - Past and Present* Continued</td>
<td></td>
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<tr>
<td>---------------------------------------------------------------</td>
<td></td>
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</tr>
<tr>
<td><strong>Assessments</strong></td>
<td>Projects graded by teacher with criteria set by teacher. Ex. Hand drawn or written posters with a teacher's grading rubric to follow.</td>
<td>Many individual may evaluate the project including the student who created it. Rubrics are jointly constructed by group and the teacher. Ex. Students, peers and teacher jointly create a set of outcomes or project goals.</td>
</tr>
<tr>
<td><strong>Information resources</strong></td>
<td>Projects required used of books, newspapers and other paper sources. Ex. Students look up information in encyclopedias.</td>
<td>Projects require students to synthesize information from multiple sources not necessarily paper sources. Ex. Students use internet, interviews with community members, original documents books and other paper sources.</td>
</tr>
<tr>
<td><strong>Complexity</strong></td>
<td>Projects relatively simple or focused. Ex. Students collect newspaper articles and analyze issues.</td>
<td>Projects require students to evaluate numerous sources and interact with various information or people. Ex. Students develop a movie based on an interview with the mayor on community issues.</td>
</tr>
<tr>
<td><strong>Individualized study</strong></td>
<td>All students complete the same projects on an individual basis. Ex. Students create a poster by themselves about their community.</td>
<td>Students work projects that build on the strengths of the student. They are encouraged to be challenged and explore. Ex. Students create virtual reality projects to better understand science concepts.</td>
</tr>
</tbody>
</table>

*aTable developed based on information provided in Thomas*
Thomas (2000) reviewed research studies on problem-based learning. He reported that, based on papers published by their developers, variants of problem-based learning approaches called Expeditionary Learning (EL) (ELOB, 1999a, 1999b) and Co-nect (Becker, Wong, Ravitz, 1999) led to substantial improvements in standardized test scores when the EL schools were compared to their prior performance or when Co-nect schools were compared to control schools. Table 2.3 summarizes Thomas' views of the differences between past and current project-based learning approaches.

In a three year study of a comparable problem-based learning and traditional schools, Thomas reported that Boaler (1997) found greater learning in mathematics after three years even though there were no differences in beginning scores. Students in the problem-based learning schools also demonstrated superior conceptual understanding of mathematical concepts as compared to the traditional school students. However, Thomas pointed out that both EL and Co-nect are school wide reform approaches with multiple features and gains cannot be uniquely
associated with the problem-based learning components. Additionally, studies by proponents may reflect biases or fail to generalize as projects are scaled up.

Despite these caveats, he argued the results are sufficiently positive to warrant application and additional research. Thomas (2000) further argued that when experimental classes were compared to control classes, problem-based learning led to gains in students problem-solving capabilities (e.g. Gallager, et al 1992; Stepien et al 1993, Barron et al 1998; Cognition and Technology Group at Vanderbilt, 1992; Penuel and Means, 2000), while demonstrating equivalent learning of basic content.

Thomas also reviewed research in which student or teacher self-report of learning gains were examined. He reported that results favored problem-based learning, but also cautioned about the methodological and conceptual weaknesses of self-report research.

Thomas (2000) also reviewed what he calls implementation research or more descriptive research that identifies “challenges associated with enacting” problem-based learning (p. 22). Problems or issues he identified included students’ ability to
carry out the more cognitively complex parts of inquiry and problem-solving,
maintaining motivation for project inquiry and effective collaboration in working
groups, conflict in teachers’ pre-existing beliefs about teaching as they try to
implement a new approach, issues in pursuing problem-based learning or state
mandated goals and standards, difficulties in giving students sufficient responsibility
for learning, time occupied by projects, classroom management in problem-based
learning, technology issues, teachers’ difficulties in effectively scaffolding students
during the project, and school related factors such as resources and inflexible
schedules.

For example, Meyer, Turner, and Spencer, (1997) reported evidence that
some students had difficulty in a self-directed environment. These students
struggled with initiating an inquiry-based project and directing research. They had
trouble managing their time productively, using technology proficiently and needed
supports to help them focus their thoughts and form plans of action. In their empirical
research study, Meyer, et al (1997) studied fifth and sixth grade students who either
sought a challenge in educational situations or avoided challenges. Based on personal interviews with the research participants, they reported that challenge-avoiders indicated they felt negative affects after failure. The challenge-avoider students were more performance oriented\(^1\), used more surface strategies; those strategies that require minimal processing of information, in addition to having lower self-efficacy, and view difficult tasks with fear of failure. These students do not take risks and the final grade is more important than the final quality of a product.

Consistent with Thomas’ concern for implementation issues, Blumenfeld, Soloway, Marx, Krajcik, Guzdial and Palincsar, 1991 also provided evidence of implementation problems. They noted inadequate support for teachers and students when doing project-based learning. Also, a lack of understanding of student motivation, or the students’ point of view when developing projects has hindered the success of project-based educational approaches. Blumenfeld, et al argued that

\(^1\) Performance oriented students focus on comparing their performance with others rather than focusing on mastery or learning goals. They are motivated to do better or avoid doing worse than others (Pintrich and Schunk, 2002).
particular attention must be paid to academic content, organization and psychological factors of learners when designing and implementing project-based learning environments. Projects must sustain student motivation, present quality problems or questions that are relevant to learners, in addition to providing strategies and support to improve teachers’ execution for project success and goals met.

Thomas (2000) also reported on proposed “interventions” that project-based learning implementations should consider dealing with problems in implementation. However, the effectiveness of these interventions was not assessed empirically. Thomas concluded that there were significant limitations on the existing research at the time of his paper and significant challenges to successfully implementing problem-based learning. However, he also argued project-based learning can be an effective teaching and learning method as compared to traditional instruction. He further argued that potential benefits from a project-based learning include: more professionalism from the instructors, improvements affect higher student motivation,
improved attitudes toward learning, development of greater self reliance, and improvements in cognitive development and skills.

Project-based Learning and Virtual Reality

According to Mikropoulos (2001) the definition of a virtual reality (VR) learning environment is “a multi-sensory highly interactive computer based environment where the user becomes an active participant in a virtually real world. A VR learning environment should have an educational objective and provide users with experiences they would otherwise not be able to experience in the physical world” (p. 1). Although this definition is accurate in characterizing the human/computer interactions within VR rooms or caves, it needs to be clarified. In this definition an expert, a professional educator, or experienced designer created the program or environment, with explicit curriculum and learning goals in mind, rather than students designing the entire simulation and controlling their own learning.

Student success with higher order thinking skills, used in math, science, and engineering equals their ability to envision and manipulate abstract ideas (Bransford,
et al, 2000; Gordin & Pea, 1995). There is some evidence that when students are engaged in constructing models in VR learning environments, they can develop multidimensional viewpoints with which they are able to see phenomenon from different perspectives (Barnett, Yamagata-Lynch, Keating, Barab and Hay, 2005).

Barnett et al. (2005) studied undergraduate astronomy students during an eight week summer term. Wandersee, Mintzes, & Novack, (1994) had reported students have great difficulty in understanding astronomical phenomena and relationships. The students in the Barnett et al. study were asked to build 3-D models of complex astronomy simulations using software called Virtual Reality Markup Language or VRML. Working in groups of two and three, students constructed models of the earth-moon-sun system and the entire solar system. They wrote reports and presented their model to the class, articulating how their simulation was similar or dissimilar to the actual solar system. Researchers interviewed students at the beginning of the class and at the end of the class with nine semi-structured questions addressing astronomy concepts. Pre-course
interviews indicated students did not understand earth-moon-sun astronomy. The post-interviews indicated that the students significantly improved their understanding. Barnett et al argued that the process of constructing models led students to perceive the solar system from different frames of references and thereby construct deeper conceptual understandings of solar system geometry and astronomical relationships.

Salzman, Dede, Loftin & Ash (2008) similarly argued that when students can visualize abstract information in a virtual reality environment, they gain a greater understanding of the information. Salzman et al, studied forty-eight high school juniors and seniors in an advanced physics class who used MaxwellWorlds (MW), an immersive virtual reality visualization environment developed by ProjectScienceSpace; which was developed to help students master complex abstract science concepts. In the study students first responded to questionnaires concerning the concepts of electric fields. Using MaxwellWorlds (MW) students built 3-D models of electric fields. With their models, the students manipulated electronic
forces to maneuver and influence charged particles. Working with scripted lessons, students were guided through structured inquiries to make and test predictions about the behavior of charged particles within the MaxwellWorlds program. In the final data collection students responded to questionnaires and a paper and pencil test about the learning experiences.

The tests asked students conceptual questions which required them to visualize the force of motion scenario within the electric field. Students were required to answer using both ego-referenced and the exo-referenced frames of reference. In other words students analyzed the concepts of the electric fields by looking from the perspective of an outsider looking in (exocentric) and from the perspective of looking at the phenomena from the inside to the outside (ego-centric). Participants’ responses confirmed that incorporating frames of reference into visualization tools aided in their ability to learn and apply abstract information and to draw upon multidimensional data. Salzman et al concluded that the exocentric viewpoint is
essential for science study, a very difficult concept for teachers to teach, but one that can be a powerful tool for students (Salzman et al, 2008).

One way VR may be facilitative of learning is by activating the human mental imagery system in the learning of scientific abstractions. Schwartz and Heiser (2006) presented an unorthodox review of research on imagery and its impact on learning. They focused on the relationship between imagery and learning/cognition, and although their research did not focus on VR, the primary point of using imagery to enhance understanding is relevant to VR. More specifically, they argued that imagery is based upon the perceptual system and the perceptual system provides imagery with a “structure of perception” that allow imagery to “complete computations that are difficult to perform linguistically” (p. 284). Imagery, representations and spatial representations support learning by through four non-learned features which they label “effortless structure, determinism, action coupling and pre-interpretation. In their paper, they described how these features of the perceptual/imagery system “supplement non-spatial forms of reasoning” (p. 296).
They cited the history of research demonstrating that integrating the linguistic/symbolic and perceptual/imagery systems promote memory and learning (Paivio, 1986). They also argued that these features stimulate innovation in learning and real life problem solving. When students can envision a project either in their mind or can see an external visual representation, they can utilize the perceptual system to perform manipulations that would be difficult linguistically. Such visualizations, integrated with symbolic (linguistically-mathematical) knowledge allow students to infer structures that may be hidden. While supporting the idea that integration of the perceptual/imagery and linguistic systems can promote learning, Schwartz and Heiser, did argue for additional research to explore the context in which imagery can support learning, creativity, and reasoning (p. 296).

Computer-supported collaborative learning (Stahl, Koschmann, & Suthers, 2006) focuses on how people learn in collaboration by using computers and technology. Stahl et al argued, in a theoretical article, that student learning transpires through social interactions as individuals construct knowledge within
themselves and within the group. In a collaborative learning environment, students develop skills such as; negotiation, sharing, connecting content to relevant meaning, problem solving and working together to produce a quality artifact. In collaborating students have opportunities to display knowledge acquisition and behaviors of learning within short periods of time. Every interaction between individuals, technology and the process of development of the project allows students to exhibit understanding or misconceptions.

**Conclusions**

Major findings in this review indicate many potential benefits to student learning and understanding when students are immersed in a carefully planned, goal orientated, student centered project-based learning environment. As argued by the Buck Institute (2003) students gain higher cognitive development, develop a more global habit of mind and PBL produces gains in academic achievement. Students develop a sense of empowerment as learning has connections and meaning to their lives. Students engage in critical thinking as they solve problems, plan the research,
communicate and present their projects with logic and understanding. More tentatively, Thomas (2000) claimed project-based learning had demonstrated impact on achievement and learning and thereby could increase a student’s ability to transfer knowledge and problem solving techniques and the quality of student education. Thus, there is research support that project-based learning can be an effective method for teaching complex concepts, complicated procedures such as communication, problem solving, and decision making.

Dede (2005) summarized skills students acquire when using immersive media software and technology with relation to PBL. Students attain fluency in multi-media use and programs. They learn by collectively seeking and synthesizing information, learning is active, in which real-life situations or problems are addressed and finally, students have an extension of non-linear representations to express understanding, content knowledge and collaboration of the learning experience.
For all the benefits argued by supporters constructivist learning theories and project-based learning is controversial and under debate. More research needs to be done to evaluate skill acquisition in PBL and technology use. One issue or problem, as reported by Meyer, Turner, and Spencer, (1997), is that some students have difficulty in a self-directed environment. These students may need scaffolding to plan, manage time effectively, and keep focused.

Project-based learning is still relatively rare in schools and implementations require significant support for teachers and students when initiating project-based learning curricula (Blumenfeld, Soloway, Marx, Krajcik, Guzdial and Palincsar, 1991) Blumenfeld, et al argued that particular attention must be paid to academic content, organization and psychological factors of learners when designing and implementing project-based learning environments. Projects must sustain student motivation, present quality problems or questions that are relevant to learners, in addition to providing strategies and support to improve teachers’ execution for project success and meeting goals.
Additional research, concerning PBL within a technology learning environment is required as little is known about the implications for learning and teaching with technology use. To quote Janet Murray (2003) concerning skill development and technology use:

“The explosive growth of technology in every aspect of society offers us a unique opportunity to engage our citizens in economic and civic life. Digital technologies have given us new and better ways to teach and learn. They have made us more efficient at work. In return, they demand that we continually acquire and develop new knowledge and skills. Information and communication technologies are raising the bar on the competencies needed to succeed in the 21st century, and they are compelling us to revisit many of our assumptions and beliefs.”(p. 6)

She states in her article that educators who prepare students for their future should have a plan of action that insures students acquire the proficiencies and aptitudes for using technology and information literacy. Without these skills, she argues, students will be at a disadvantage in the workforce. Research should
include what technological literacy students gain that transfer to the workforce and to
life situations. Attention should be focused on the extent of the conceptual students’
understanding gained, the acquisition of additional skills and knowledge, in addition
to students’ ability to create, invent and to shift imagination from their mind to real
life.

Summary of Literature Review

This literature review established a theoretical background based on
constructivist theories and philosophies. Key points discussed were knowledge is
constructed by the individual learner and new information must be built on old
schemas. Learning is an active process in which students are engaged in
meaningful experiences. Cognitive development and knowledge construction of
learners are influenced by the learning environment, interactions with peers, mentors
and various other individuals.

The practical applications of the constructivist theories were discussed in the
section of project-based learning. In project-based learning the focus is on the
individual student, within a team collaboration setting. Students design the project, observe an authentic question or problem that needs to be solved, and implements the investigation design. Throughout the process, students are engaged to the completion of the project and gain a rigorous understanding as well as the skills to articulate the problem and solutions.

When project-based-learning assimilates new technologies and tools, as discussed in the next section, students gain skills associated with multimedia literacy. In using software that implements visualization, critical thinking and collaboration, technology becomes a powerful empowering tool. Students become innovative, creative and are able to transfer knowledge easily across curriculum in addition to life situations.
Overview

This mixed method study investigated knowledge and skill development of high school students in a project-based virtual reality (VR) design class, in which 3-D projects were developed within a student-centered, student-directed environment. Additionally, the social dynamics of the class and the role of peer mentoring were examined to determine how these factors influenced student learning. Additionally, the student content knowledge as represented in the projects developed was examined. Finally, parent and teachers perceptions of the influence of the class on students’ attitudes and learning were examined. The participants included freshmen through senior students, parents, teachers and the high school principal. Student interviews and classroom observations were used to collect data from students;
teachers and parents data were obtained through online surveys. The results of this study suggested that this application of the virtual reality (VR) learning environment promoted the development of meaningful cognitive experiences, creativity, leadership, global socialization, problem solving and a deeper understanding of academic content. The use of 3-D virtual reality technology for enhancing education is promising and warrant additional research and development as an instructional tool for practical use.

Introduction

In the 21st century world of education, the holographic teacher looks like an avatar, with fiery blue hair, a Barbie doll figure, and a computer generated voice that demands attention. Students in this futuristic 3-D virtual reality (VR) design classroom generate the programs to create the learning environment they desire. They open electronic computer notebooks that contain an entire library of knowledge and begin to participate in 3-D virtual philharmonic concerts, chemistry labs, or ongoing heart dissections in a surgical suite. They become characters from
literature as they develop a virtual scene from a book they are reading and collaborate with one another, incorporating colleague’s ideas into their own projects.

The students in this class construct new knowledge using (1) technical tools and software to develop VR projects, (2) collaborations that provide access to the knowledge of others, and (3) external resources including their textbooks, Internet resources, and outside experts. They brainstorm and banter like typical teenagers, playing, goofing off, or constructing monsters with Legos. In this free flowing atmosphere students quote obnoxious movie lines, use toys, tools, and software they have calibrated or developed themselves to stimulate project development. In this futuristic noisy, cluttered, VR environment, learning and teaching occur with every interaction among peers, with technology, or, through the Internet and online forums, with the global world.

This hypothetical futuristic classroom is actually occurring in schools across Iowa. This paper reports of an investigation of the learning experiences of adolescents, participating in a VR learning environment. This topic of study was
chosen for two reasons. First, with the advances of new technologies, many
researchers’ claim (Dede, 2007; Liu & Noppe-Brandon, 2009; Sawyer, 2009; Seely
Brown & Duguid, 2000) educational practices must change to meet the current
needs of students heading into the 21st century. These researchers point out the
world economy is no longer driven by industrialization but by imagination, creativity,
invention and knowledge. Students need to be prepared to function in this
knowledge-based world economy. Second, student-driven VR projects were
afforded through the generosity of commercial firms and the creative intervention of
an innovating principal. Based on a previous pilot study done by the author (2009),
this VR design class appeared to accelerate student achievement, facilitate
knowledge acquisition and develop skills necessary for survival in a knowledge-
based society. As a result, other school districts across Iowa have embarked on
implementing VR classes. Yet still unclear are the impacts this new environment
have on student learning or how the class functions to produce any effects.

Therefore, this research was undertaken to assess, in greater depth, the success of
the program by examining the impact of the VR experience on student learning and on the classroom processes that contribute to learning.

In general, this class has been built on the constructivist learning philosophies and theories in addition to project based learning practices. The basic premise of the constructivist theory is that knowledge is constructed through some interaction of reasoning and experience (Phillips, 1995). The key points from this family of theories, as summarized in Table 2.1 in Study 1 include: knowledge development is a constructive process in which learners, individually or in social groups, reflect on experiences and prior knowledge to create meanings by inventing new ways of understanding the world and integrating new knowledge into their knowledge structures; knowledge must have real world connections and depends on learners’ and social groups’ activities, motivation and engagement; and social attitudes influence learning and knowledge building. Most importantly learners construct their own knowledge, building new ideas and thoughts onto old theories and ideas (Lebow, 1995).
Related educational approaches such as project based learning (Thomas 2000, Krajcik & Blumenfeld, 1998) problem-based learning (Hmelo-Silver, 2004), case-based reasoning (Kolodner, 2006) and inquiry learning (Cobb & McCain, 2006) have their foundation on constructivist learning theories. The common thread among all these approaches is that of the students construct new knowledge by engaging in social, mental, and physical activities in pursuit of creating a “project” that accomplishes desired goals. The learning environment focuses students on issues which can be investigated to generate understanding for inquiry learning, or about which an artifact can be developed such as project based learning, or problems can be solved. Typically students work collaboratively on projects in these environments. They brainstorm approaches to artifacts, and inquiry for problem solutions. The students, both individually or collaboratively, carry out additional research and development as needed and produce some written or physical product that represents their resolution to the issue (Fleming, 2000).
It is believed that this VR learning environment connects student thinking to complex abstract subject knowledge and uses visualization to gain inherently deeper understanding (Merickel, 1992; Barab, Hay, Barnett, & Keating, 2000). Through project-based experiences, it is believed, students develop multi-layered meta-cognitive strategies, problem solving and cultivate inventiveness (Carver, 2009; Collins, 2009; Greeno, 2006; Sawyer, 2006). Another advantage is that projects developed in a VR setting also allow students to engage in learning experiences in areas that normally raise ethical questions. A final advantage is the VR project based learning is not restricted to individual disciplines. Rather VR projects typically span multiple disciplines and help students to perceive connections among them. Despite these perceived advantages of VR project-based teaching, relatively little research on the educational impact of student use of VR hardware and software to create projects exists. Thus there is a great need for further research that examines students’ use of VR tools in project-base learning environments.
**Research Goal**

This investigation focused on student content learning and problem solving in computer-simulated environment. Additionally the social dynamics of the class and the role of peer mentoring were examined to determine how these factors influenced student behavior and learning in computer-simulated environment. Additionally academic content knowledge was examined. Specifically, this study explored the social dynamics of a three-dimensional virtual learning environment and how student behavior and learning are influenced by those dynamics. Further, it examined the role of peer mentoring and socialization on the development of technical skills. Additionally, a goal of this study was to determine the depth of academic science content the students used, understood, and were able to communicate to others for understanding. The specific research questions addressed in this thesis include:

1. What were the social dynamics of this class and how did peer mentoring influence project development, learning, and student behavior?
2. What level of academic content knowledge, understanding, problem solving skills were acquired?

Method

The study was conducted in a voluntary VR class in a small rural Iowa school district. The purpose of the class was to allow students to use VR software to develop projects with educational purposes. In this class students worked independently of any formal teaching; they were given responsibility to learn the software and develop educational products. Projects may include VR simulations of any topic the student chooses. While a requirement for the class was to produce an educational VR project and a free choice project every nine weeks, the students were not restrained by a teacher's goals or educational objectives. However, teachers may use student-generated projects from this VR class to enhance learning in an academic area they teach. Every end of the quarter (9 weeks), the principal would assess the student projects and pose questions to them to stimulate profound thinking and further project development.
Educational Context

According to the electronically released data by Iowa Department of Education (2009), the district of the participating school of this study encompasses a 167 square mile area in central Iowa that includes numerous small towns cutting across four Iowa counties. Based on academic year 2009-2010 data, the district serves approximately 921 students; the high school serves 288 students. The population within this district is typically in the lower to moderate socioeconomic status range, mostly composed of blue-collar factory workers, farmers, immigrants and retirees. Thirty-four percent of the district’s students participate in the free and reduced lunch program (FRL). Overall, students are mostly racially homogeneous, 93% are white, 6% are from other racial/ethnic backgrounds, and 1% are English language learners.

As stated on its webpage, the mission statement of this district indicates;

“… is committed to a progressive well-rounded educational process that meets the needs of all students, parents, staff, and patrons by establishing a positive
environment through dedicated personnel, quality curriculum, advanced technology, interactive community involvement, open communication and the efficient use of all resources to achieve excellence in education."

The VR class investigated in this research is consistent with and part of the district’s programming designed to achieve the mission statement’s emphasis on preparing students to use advanced technology.

**Physical Classroom**

Unlike a traditional classroom, the physical classroom was created out of storage space; at times it is cramped as it is used as a storeroom for broken and unused furniture. An advantage of the space is that students can flexibly arrange it to enable creative thinking, playfulness, and ease in collaboration. Different areas are designated stations for Lego building, book storage, or a catchall for student possessions. Along the outside walls were long tables with a bank of computers with dual monitor screens. However, there are no Internet connections in this classroom, but students were allowed to go to the library to use the Internet. When students
discussed using the Internet they often indicated they used it at home and saved their work on a memory stick for use in the VR room.

There are a few reference books and various college / high school textbooks covering subjects such as: human anatomy, auto mechanics, computers, 3-D game programming, medieval European history and American history. Students have also brought in magazines that focus on gaming, animation and computer skills. The main technical manuals for the software were available and include: Blender 2.3, Introducing Character Animation for Blender, Essential Blender, and Introducing Maya 2009.

The classroom contains a large VR machine; called ImmersaDesk. It was manufactured by Fakespace (now Mechdyne) and was donated by the Mayo Clinic. ImmersaDesk allows students to view pictures and movies they create in three dimensions. According to Mechdyne’s website (http://mechdyne.com), it is a business that develops “immersive, networked and collaborative visualization systems” and immersive software for virtual phototyping, business, education,
military, biotechnology and federal government purposes. ImersaDesk is a 4 ft by 5
ft rear-projection machine in which an angled screen displays computer simulations
and models. During an observation, a student described the function of this machine
(Figure 3.1) as follows.

“Basically what this machine is designed to do is to take these pictures, these
renders, we can make movies also and we put them into 3-D. It is called
stereoscopic viewing. What it does is….when you are viewing things in the real
world you look with both your left and right eye. This helps you determine depth
perception. That is what we are simulating with a stereoscopic screen. The stereo
takes 2 images your left eye and your right eye and lays them over on top of each
other and flickers back and forth between the 2 at about 150 times a second. Now
what happens is ….these glasses will correct that so you are only seeing your left
eye with your left eye and only seeing your right eye with your right eye. It gives you
a sense of 3-D on the screen.”
A main desktop computer along the outer wall of the room is equipped with an

N-Vida 6500 video card which allows two graphic renderings to run simultaneously,

creating the stereoscopic viewing needed for the 3-D effect. This main computer is

wired to the ImmersaDesk with a VGA cord; from this computer, students load their

projects on ImmersaDesk and run projects in 3-D. A second cord, a “sync” cord,

connects the ImmersaDesk with an infra-red emitter, located on the top of the

ImmersaDesk. This emitter allows the students to interact with the program on the

ImmersaDesk using Wii motes, infra-red head tracking devices or full body sensory

suits. Students can create their projects on any computer installed with the Blender

program. To run their projector, they transfer it using flash drives to the main

desktop. The main desktop transfers the program to the ImmersaDesk, which in turn

renders the 3-D perspectives.
Figure 3.1 ImmersaDesk VR Machine by Fakespace (photo T. Morales 2009)

**Typical Class Activities and Structure**

In this VR class, students participated in project-based learning individually and collaboratively without the teacher’s presence. The principal provided the only guidance by explaining expectations for behavior and productivity. According to class expectations, students are required to respect and care for the equipment, peer mentor, and learn to program the VR system themselves by reading the technical manuals or experimenting with the software. They are expected to produce
2 VR products each nine week quarter. Additionally all students are expected to give public presentations and to demonstrate their projects to visitors.

The atmosphere of the class was similar to that of student-centered inquiry in that noisy and free-flowing environments were encouraged in order to stimulate imagination, creativity, innovation, and to promote collaboration in helping each other learn to program and create projects. Students are not given direct instruction, told what to create, or which method to use. Students are allowed to goof off, play, discuss/collaborate, and use Legos or other manipulatives for pre-design inspiration. An important attitude within the classroom is that failure is not fatal; students try an approach; if it doesn’t work, they try another approach; or trash that approach to the project and start over with another approach.

An essential feature of this learning environment was peer interactions. During these interactions, students took multiple roles depending on the level of skills and knowledge they had. For instance, to positively affect the quality of projects’ development, a student may assume the role of a leader or a facilitator who
gathers and critiques ideas generated by individuals or group members.

Alternatively, a highly skilled student in computer graphics may assume the role of running computer simulations or creating 3-D objects based on ideas suggested by a group students acting in the role of brainstorming student subject matter experts.

Therefore, the nature of the students’ learning in this multi-sensory, highly interactive, VR environment was not partakers or users of already created virtual worlds, taking on the identity of an avatar. Rather, they were creators of virtual villages, libraries, or fascinating worlds or objects. One important difference between this learning environment and other project-based programs is that it endorses laissez-faire style learning in which students or learners have greater degree of freedom over their own learning. The students must create VR projects, but they select their own questions or projects to work on. They formed constantly changing collegial peer groups; switched and took on multiple roles depending on learning situations, expertise, or social dynamics. Typically, students conduct research on the topic of their project, seek outside resources or references to improve their
understanding; make models to try out their ideas, and create multiple versions of 3-D simulations as they develop their projects.

These synergistic problem solving experiences embedded in the VR class aspired to unleash student imagination, creativity, and innovation. The class structure facilitated students practicing collaborative learning skills and learning how to make each other’s weakness irrelevant by building on the strengths of others through many different forms of dialogues. As an example, the forms of dialogue consist of self-talks, small-talks, persuasion, agreements, arguments, critical discussions, information-seeking, interview, advice-solicitation, expert consultations, negotiations, and public speaking.

**Institutional Review Board and Informed Consent**

Institutional Review Board approval was obtained in March, 2009; a project extension was approved November, 2009. Informed consent from participants was obtained by hand delivering description letters about the research study to the students and their parents. Additionally, informed consent for teachers and parents
was attached to the beginning of the online questionnaires and respondents could not begin the survey until they gave consent.

Participants

Participants included students in the VR class, their parents, teachers and the principal from Avatar High School. In this paper, pseudonyms are used in order to protect the identity of participants and the school.

Student Participants Students were selected for their enrollment in the VR program/class. Two female and 32 male students were enrolled in the class; three of these students declined to participate in the research study. Because of its collaborative nature, the researcher observed the entire class. However, no observations involving the three students who declined were included in this study. The remaining 31 participants ranged from age 15 to 18 and included freshmen through seniors. Overall, participants had a mean grade point average of 3.11 with a range from 2.365 to 4.0. The students in the VR class had a mean percentile ranking of 68.5 on the science component of the standardized Iowa Tests of Basic
Skills. Extra-curricular activities of these students included art, band, Future Farmers of America, employment and home school support groups; they were not necessarily talented athletes, overachievers, or students who stood out among others.

**Focus Group Participants** Eight students were chosen, as a purposive sample, to examine how peer interactions occurred in the class. Table 3.1 summarizes the background information on these students. Of these eight students, two were freshmen females, the remaining students were male and included 1 sophomore, 2 juniors, and 1 senior. Three of the students, a sophomore, junior, and senior, had previous experiences in this VR class. The senior student had a cumulative grade point average of 3.8 and participated in sports and music groups. A female freshman was homeschooled; there were no grade data available for this student. For socialization and field trips/events, this student participated in home-school activities with a support group of other homeschooled families. Additionally, this student participated in educational activities not available at home such as the
### Table 3.1

**Background Information of Students in the Focus Group**

<table>
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<th>Previous semesters in VR class</th>
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<th>Nina (N)**(F)</th>
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Table 3.1  Background Information of Students in the Focus Groupa Continued

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*a A coding scheme was used for student names. The first letter of each student represents student’s grade level T is 12th grade, E is 11th grade, S is sophomore 10th grader and N 9th grade. *(E) represents having experience in a VR classroom from 4-7 semesters. **(N) represents having little to no experience in the VR classroom (F) equals female.
VR class. As noted through observation and impersonal interviews, the second female freshman was shy, unobtrusive and soft spoken. This student was included as a participant in the focus group to observe the effectiveness of the peer mentoring and instruction. In addition, the newcomers included two freshmen males and a junior male. The final two students were males with low to moderate experience in VR, a sophomore and a junior.

Teacher, Staff, and Parent Participants Eight out of thirty-six teachers and staff (22%) and thirteen parents or guardians (42%) of the thirty-one student participants participated in an online survey. Teacher and parent survey data were intended to provide triangulation for the observation and interview data. The surveys are presented in Appendix A and Appendix C.

Data Sources and Analysis

This study incorporated four data sources: (1) observations, notes, and video recordings of students that included brief informal interviews with students in the class conducted during the observations, (2) formal interviews with three previous
year’s seniors, (3) samples of student projects, and (4) online questionnaires for teachers and parents. I visited the classroom on 18 days spread over the Spring and Fall semesters. For six of these days I was a guest, and was getting familiar with the students, the VR room, the equipment and the building. One these days, I did not participant in the role of the researcher.

As used in this thesis, an observation consists of my watching and interacting with one or more students about a particular situation. During a class visit, multiple observations would occur. For example, I might watch, videotape, and ask a student questions while the student was working on an object on the computer. This situation would be one observation. I might then turn to a student working nearby and watch as the student programmed something on the computer. This second situation would provide a second observation. Next, the students might begin to interact as one student asked the second how to accomplish something. As they interacted, I would observe and might ask a clarifying question. This third situation would be a third observation. Table 3.2 summarizes the data sources and collection.
Table 3.2  
Summary of Data Sources and Collection

<table>
<thead>
<tr>
<th>Data source</th>
<th>Video tapes</th>
<th>Interviews</th>
<th>Student projects</th>
<th>Surveys</th>
</tr>
</thead>
<tbody>
<tr>
<td>Data collected</td>
<td>17 hrs 45 mins.</td>
<td>22 informal</td>
<td>3 formal</td>
<td>teachers- 8 parents- 13</td>
</tr>
<tr>
<td>Data analysis</td>
<td>Viewed, transcribed and coded for science, math concepts, skill development, looked for themes</td>
<td>Analysis with rubric Appendix D</td>
<td>Looked for themes</td>
<td></td>
</tr>
</tbody>
</table>

1) **Video-recordings and observations.** The 31 students in this study were observed as they worked on their projects in the VR classroom; 17 hours and 45 minutes of videotapes were collected over the course of 18 random days during the fall and spring semesters. Observation periods ranged in length from 20-40 minutes during regular academic periods. The students were observed as they discussed with one another their thoughts in solving problems, their reasoning behind elements included in their projects, and their self assessments of their
projects. Observations included exchanges between the students, which provided rich in-depth access to interpersonal and individual behaviors and thinking processes. In addition, the researcher conducted informal interviews with students to explore their thinking processes. Field notes were taken in observing the students initially. The pace and complexity of the classroom made it difficult to obtain complete notes; as a result, video-recordings were taken of classroom activities to obtain a more complete record. This modification also allowed the author to engage more easily in interviews with the students and streamlined the communication between the author and the students.

These videotape observations and interviews were later transcribed (Appendix E). In addition to sessions in which students were working on projects, students also were observed in other situations, such as presentations to professional business people, educators, politicians, school board members and parents. Two presentations to teacher educators and business people and a presentation to parents were observed, videotaped and transcribed. During these 2
presentation sessions, the students demonstrated academic simulations they had created and answered questions from the adults. These observations were especially useful because they helped me gauge the depth of students’ understanding of academic content and their ability to articulate that understanding for the intended audience. In addition, the students’ presentations revealed problem solving skills used and their ability to connect academic content to life situations.

The project emerged from a student presentation of projects for parents and other interested community members in October of 2008. As a result of this presentation, the researcher and the high school principal engaged in numerous conversations about the impact and implications of this type of VR learning environment on the education and student learning. The principal introduced the researcher to the students, provided invitations to planning meetings with business supporters, educational leaders, and the principals of six additional Iowa school districts who wanted to start a VR program in their districts.
**Classroom observations.** The first full day of observations and interactions with the VR students took place in March 2009 during the Spring semester.

Observations and interactions continued to the end of the 2008 school year in May and resumed in the fall semester of 2009 after summer vacation. Eighteen observation days spread over two semesters were done. One hundred and ten observations were videotaped, which included, 11 hours of usable data and 4.25 hours of unusable data for reasons of student privacy and project confidentiality.

Two students were working on an invention and did not want their video tape used.

Most observation days were class days that enabled the researcher to observe, informally interview and video-tape the students in the classroom setting.

April 9, 2009 was a public presentation day at which students gave demonstrations of their projects professional teacher educators from universities and community colleges across central Iowa. I observed and videotaped these student presentations and interactions with adult professionals. After their presentations, the three graduating seniors were formally interviewed as described above. Data collection
stopped at this point for summer break and resumed on August 20, 2009, the second day of a new school year. Observations were begun early in the school year in order to observe how the dynamics of the class were influenced by a change in leadership.

On this second day of the start of the school year, students were observed and videotaped without any interaction between the students and researcher. The behaviors of both new students and experienced upper-class students were observed. The experienced students were expected to mentor and teach the new students. Thus, the upper class mentors were observed and videotaped.

Observation on this day focused on the extent and nature of mentoring that occurred and on how new students began to participate in the class.

Eight class periods of virtual reality were provided by the school. Weekly visits to the third period class and the eighth period class were scheduled. These two periods had a higher number of newcomers to the program and better allowed me to observe how peer mentoring and relationship building developed. Specifically,
I could observe changes in student interactions over the course of the quarter. The third period class included four students. The experienced peer mentor was a senior while the three inexperienced students were two freshmen, and a junior. The eighth period class included four students also. An experienced junior was the peer mentor; the three inexperienced students were a junior and two freshmen. Occasionally this eighth period class had additional VR students coming in to work on projects because they had early out options (could leave at 2:00 because they came to school for class at 7:30 a.m.)

These weekly observations took place from August 20, 2009 to October 21, 2009 which was the end of the quarter (45 days). For these observations, the researcher videotaped and interacted with students in the same manner as in the previous semester, e.g. looking at projects, listening to students talk to one another, and asking questions. I observed peer mentoring and how the leaders, newcomers, and the class as a whole developed classroom community. These focused observations were intended to provide data for Question 1 concerning the role of
peer mentoring. Students were observed when they asked for help from a peer mentor, when a peer mentor was teaching, or when groups of students worked together without a definite peer mentor.

Finally, general academic information was collected during initial observation and informal interview of each individual student. This information was collected to compare academic content demonstrated in the VR projects with the academic content of the science courses the students were currently taking or would take in the future. Also, to assess content knowledge represented in projects, I compared the expressions of content knowledge in their project to the current or future science.

If students followed the high school progression requirements for graduation, for example, freshmen were required to take physical science; sophomores were required to take either biology or introduction to biology, and juniors and seniors had the option of taking chemistry and physics. Student projects were collected as described and analyzed as described below in the Student Projects section.
Table 3.3 summarizes the visit days and observations, including minutes visited, number of observations collected, and the activity of the researcher. As detailed previously, I was a guest on several occasions. Additionally, I was an audience member for a parent presentation night, attended a presentation for the director of the Iowa Department of Education, and was a guest when students presented projects to professionals.

2) Informal Interviews with individual students participating in project development

Two types of interviews were used to collect data. The first type of interviews consisted of informal interviews with the other participants. Interviews were conducted during the observation periods described above in the classroom as the students worked with the VR system and their peers. These interviews began with general questions concerning grade level, prior science courses taken and brief
Table 3.3

Summary of Visit Days and Observations

<table>
<thead>
<tr>
<th>Visit Day</th>
<th>Semester/Month</th>
<th>Minutes visited</th>
<th>Number of observations</th>
<th>Researcher activity</th>
</tr>
</thead>
<tbody>
<tr>
<td>F08-10</td>
<td></td>
<td>63</td>
<td>0</td>
<td>Audience member/parent</td>
</tr>
<tr>
<td>S09-2</td>
<td></td>
<td>15</td>
<td>0</td>
<td>Discussion with principal</td>
</tr>
<tr>
<td>S09-2</td>
<td></td>
<td>378</td>
<td>0</td>
<td>Guest</td>
</tr>
<tr>
<td>S09-2</td>
<td></td>
<td>40</td>
<td>0</td>
<td>Guest</td>
</tr>
<tr>
<td>S09-3</td>
<td></td>
<td>40</td>
<td>0</td>
<td>N</td>
</tr>
<tr>
<td>S09-3</td>
<td></td>
<td>320</td>
<td>9</td>
<td>V</td>
</tr>
<tr>
<td>S09-3</td>
<td></td>
<td>38</td>
<td>10</td>
<td>V</td>
</tr>
<tr>
<td>S09-3</td>
<td></td>
<td>10</td>
<td>1</td>
<td>N</td>
</tr>
<tr>
<td>S09-4</td>
<td></td>
<td>34</td>
<td>9</td>
<td>VI</td>
</tr>
<tr>
<td>F09-8</td>
<td></td>
<td>145</td>
<td>34</td>
<td>VI</td>
</tr>
<tr>
<td>F09-8</td>
<td></td>
<td>30</td>
<td>1</td>
<td>VI</td>
</tr>
<tr>
<td>F09-9</td>
<td></td>
<td>53</td>
<td>9</td>
<td>VI</td>
</tr>
<tr>
<td>F09-9</td>
<td></td>
<td>38</td>
<td>8</td>
<td>VI</td>
</tr>
<tr>
<td>F09-9</td>
<td></td>
<td>10</td>
<td>1</td>
<td>N</td>
</tr>
<tr>
<td>F09-10</td>
<td></td>
<td>10</td>
<td>1</td>
<td>N</td>
</tr>
<tr>
<td>F09-10</td>
<td></td>
<td>20</td>
<td>1</td>
<td>N</td>
</tr>
<tr>
<td>F09-10</td>
<td></td>
<td>26</td>
<td>5</td>
<td>VI</td>
</tr>
</tbody>
</table>

explanations of their projects. These questions included (1) what grade are you in? (2) which science and math courses have you taken or are taking now? and (3) explain what your project is. These interviews and interactions between the peer participants and the researcher were intended to provide data relevant to problem solving strategies used by the students and to their thinking processes as they developed projects. In addition, questions about the project allowed me to
obtain information about the students’ knowledge and understanding of the science content of their projects. For example, to illustrate a question about science content, two students were asked to explain covalent bonds in their water molecule model they developed.

The informal interviews became an integral part of the observation because gaining an understanding of students’ thinking and cognitive processes was a major goal of this study. The interviews were transcribed and coded to identify evidence of skill development, science content understanding and problem solving skills. Thirty-one students participated in these informal interviews and their data were used to answer Research Question 1 concerning the class’ social dynamics and the role of peer mentoring and Research Question 2 concerning the students’ depth of understanding of academic content.

Through these interviews the students were able to articulate problems they encountered. Further, the students used the Blender program to demonstrate the
steps they followed to overcome problems and how they moved from initial ideas to their completed product.

**Formal Interviews with Seniors.** The second type of interview consisted of formal interviews during which I asked three graduating seniors a list of questions (Appendix G). These questions were intended to provide data about the learning environment experienced by these students, the skills they perceived they developed as a result of participating in the VR class and their perception of their acquisition of academic knowledge. Each of the three seniors was interviewed once. The interviews were videotaped and transcribed. These three seniors were key participants in peer mentoring and instruction of the lower classmen. All three of them had been in the VR program six semesters or more.

3) **Samples of student projects in various stages of development.** Projects were collected from the students at the beginning of each quarter, at midterm (4 weeks after start of quarter) and at the end of quarter (9 weeks) or semester (18 weeks). These projects were analyzed for the level of inventiveness, the depth of
conceptual understanding of science content exhibited, the development of 21st century skill development, and the technical skills used. As with the interviews, a coding scheme was developed to record the results of these analyses. Basically I coded for creativity, academic content, technical skills, and 21st century skills. The full coding scheme is presented in Appendix F. Analysis of the project provides data relative to Research Question 2 concerning academic content and strategies exhibited by students to solve problems.

For example a student built a scale model of a family farm. The scale model was coded according to the questions under the four criteria. This project included s (scale), p (proportion), and m (measurement). Furthermore the project was evaluated on the evidence of advanced technology (TL - 3 points) in response to the criteria questions (Appendix F). Each question was assigned one point. Additionally, in assessing students’ projects, early stages of project development were compared to each student’s finished product. A total of twenty projects were collected from different students. Comparisons of early and late development were used to
determine how the students solved problems to achieve the desired effect, motion, or texture from the software.

**Data Analyses**

**Data Transcription.** Videotapes were transcribed by reviewing the tapes and typing the conversations and explanations given by the students. In transcribing, I also noted references to the software program, students’ projects or movements and gestures made by the students. Qualitative analyses of transcripts took place during November and December of 2009.

**Observation Coding** - The observations, as defined above, including the informal interviews, videotapes, and formal interviews, were examined and coded for incidents involving 1) peer mentoring and social interactions, 2) student skill acquisition and 3) academic content displayed in observations. An incident is a situation that involves an example of one of these three categories. An observation could yield multiple incidents. For example, suppose an observation involved a peer mentoring interaction about use of a particular programming skill to represent a
particular academic content. That observation would involve three incidents, one for peer mentoring, one for skills, and one for academic content. Across the observations, two hundred forty-four specific incidents were coded. In addition, within the peer mentoring categories incidents were categorized into incidents involving play, peer teaching, and collaborative interactions.

**Definition and Example of Play.** A play incident was defined or involved students bantering, goofing off with not necessarily with any focus or discussion concerning VR or their projects. As an example of play, in one observation, students were developing a space shuttle scene and through goofing off they created a McDonald’s drive through on the moon.

**S4:** S1 and I were working on this…we couldn’t really figure it out because it was doing all kinds of weird stuff… so we took the joystick and made a landing simulator with this. I made the space shuttle, I made the run way, He made the McDonalds with the McDonald’s sign. He made the ground with the texture and put the controls in it and everything…so now we have the landing
scene on the moon…you can pull in and get McDonalds…. goofing off

releases and relaxes your senses and everything… makes you more calm …

because with the McDonalds we just thought, which way the landing simulator
should work…and then we were just messing around and like HEY you know
what would be funny… a McDonalds on the moon…let’s build a McDonalds
right there.

Once their imaginations were stimulated, the students began to pretend to eat
imaginary fries floating around the room.

**Definition and Example of Peer Mentoring.** Peer mentoring was defined as
student interactions in which the focus and discussion concerned project
development or VR, the students were working together, and one student was in a
teaching or mentor role. The role of mentor would switch from student to student as
necessitated by the individual expertise of each student. Many of these
teacher/mentor incidents occurred within interactions in forums, blogs and use of the
Internet. In the following example of peer mentoring, a student, S12, is creating a
DNA molecule when an advanced student, S1, walks by and provides mentoring on the use of a Blender tool. In this and other examples used throughout this paper, text in red represents a comment I inserted to provide an explanatory context.

S1: How are you going to get it to spiral?

S12: I don’t know I haven’t figured that out yet.

R: Why is that a complicated thing to do?

S1: yes… he’ll probably have to use an editing tool.

R: What is that?

S1: The screw effect. It will make it screw up and around… I don’t know if it will work or not.

R: Is that in Blender?

S1: yeah …basically it does it automatically for him.

S12: that is what I want. How did you find out about that tool?

S1: Just pushing buttons. Here let me show you.
**Definition and Example of Collaboration.** Collaboration was defined as students working together to create a project, solve a problem in which all members of the collaborating team were considered equal in technical skill, or by discussions using in the internet. Provided below is a student’s description of a project involving global warming that was counted as an example of collaboration.

**S21:** I am working on a thing for environmental science. It is a group project …where we are taking a sphere and trying to make the terrain and all the elevations of the continents and stuff….and we are going to show what would happen during global warming… and we want to show the areas that would flood, if the ice caps melted. That is our end of the year project for environmental science.

**Definition and Example of Problem-Solving.** Problem solving was another area in which incidents were coded. A problem-solving incident involved either individual students describing how they overcame obstacles to reach a desire goal, multiple students dealing with an error or unexpected results in the programming, or
brainstorming on how to accomplish an end. In the example below, a student, S12, is quoted as describing a problem solving strategy when trying to learn various elements of the Blender program.

S12: “... I mean at first it is really tough (Blender software) but then after you get used to it, you get used to certain aspects of it. What I do, I kind of go after it as I start with one...one type of aspect of Blender then I go on to the next one...so I started with basic modeling and then I went to animation and now I am at textures ...so basically I just work through and just learn as I go.”

Definition and Example of Academic Content. Academic content was coded into one of four categories: -science concept, mathematics concept, computer language concept, or any other academic concept. A given incident could be coded in more than one category. For example, an incident in which a student programmed a VR demonstration of sand rolling down an inclined plane was coded only in the science concept category. In another example, a student programmed a
horse for a Lord of the Rings scene, this project was coded in the Other Academic Content category because of its connection to literature and also in the science concept category because of its detailed modeling of the articulation and movement of the horse’s skeletal structure. When questioned, the student stated that in building the horse he had to research movement of horses and their anatomy. He said he learned a lot about the feet of horses and bone structure. He described the build of their knees and how knees are connected to the rest of the leg and bone structures.

**Definition and Example of Computer Language.** Computer language, technical skills and references to software use were coded and counted. In the example below high school students are showing the new computer software to a previous graduating senior.

**S4:** we got virtuals…well it’s not here right now but we are going to get them

**S1:** That sucks.

**R:** what are virtuals?

**S1:** Virtuals is a program that writes in….
S4: C, C++

S1: no….it is crazy

R: Was it good….bad…

S1: no is was ugly…. very ugly

R: What is wrong with it?

S1: No one can understand it? You have to write everything out. There is no interface….no interface to write code and then there is interface to structure code….but it’s all code and it does not have a physics engine… and you have to pay another $3000 for a physics engine.

This example was coded as Computer Language because the student demonstrated understanding of the ease of programming in languages that have a graphical interface and access to subroutines or applications that can be incorporated in the programming and languages in which everything must be coded in written symbols.
Appendix H more fully illustrates the coding system. The number and percentage of each type of incident are reported in the results section.

4) Online surveys distributed to parents and teachers

Separate, similar electronic survey questionnaires were developed for the students’ teachers and parents. These questionnaires are presented in Appendix A and Appendix C. These questionnaires examined teacher’ and parents’ assessments of student learning and academic skill development. The surveys also asked about teachers’ or parents’ perception of changes in student attitudes toward school, learning, and skill development in the areas of: creativity, confidence, communication, and motivation. In addition, the questionnaires asked the respondents’ opinion of what the VR class did and for their overall general knowledge about VR. In the survey, the respondents were asked to watch a short video that presented a variety of completed projects by various students. The student projects included examples of moving car engines, a moving el train, a medieval castle with a fire, a robot man doing a back flip and a range of
demonstrations exhibiting advance features of the Blender software. Based on their observations of the video, the survey participants were asked about the realism and creativity of the demonstrations and to express their opinions about the effectiveness of students in communicating academic content. The teacher and parent data collected in response to these items were intended to relate to Research Question 2 which focused on academic content and skill learning. The survey also contained questions that were relevant to Research Question 1 which focused on the social dynamics of the class. On those items, parents and teachers were asked their opinions about the social dynamics of the class without the presence of a teacher.

The surveys were prepared for online administration in October 2009 by the program coordinator in the Office of Distance Education and Educational Technology in the College of Human Sciences at Iowa State University. Email addresses for the teachers were obtained from the high school’s web page, and the email addresses for the parents were provided by the high school principal. Both parents and teachers were sent preliminary emails in October 2009 describing the
research project and indicating that they would receive a subsequent email with a link to the online survey. This initial email asked for their participation. Approximately a week later in November 2009, a second email containing the URL links for the surveys for the teachers and parents was sent. On November 30th, 2009 final reminder emails were sent to teachers and parents encouraging teacher and parent participation if they had not already done so. Informed consent forms were attached to the beginning of the surveys and teachers or parent participants could not begin the survey without consent.

**Data Trustworthiness.** With respect to Research Question 1 results were triangulated by examining consistency across data sources. For example, parent and teachers perceptions of the social dynamics of the class were compared to the observational data with the perceptions of parents and teachers surveys. Similarly, for Research Question 2, the analysis of students’ projects provided triangulation for content knowledge gains demonstrated in the classroom observations. Additionally, results were cross-checked for trustworthiness by member checking with the
students, and checking content accuracy with the high school textbooks for chemistry, biology and geometry.

Results

This research was designed to provide answers to Research Questions 1 and 2. The discussion of the results is organized around the research questions. Qualitative analysis of the classroom observations and student projects revealed four major themes, three related to Research Question 1 and 1 theme for Research Question 2. These themes and the results that support them are described below in separate sections for each research question.

Research Question 1 - What were the social dynamics of the class and how did peer mentoring effect student learning and behavior?

Type of Incidents Observed. A variety of types of social interactions occurred in the class. Table 3.4 summarizes the numbers of observed incidents relevant to peer mentoring and the class’ social dynamics. Out of 244 total incidents coded, 114 related to peer mentoring and the social dynamics of the classroom. Of those
114 incidents, thirty-eight or 33% involved students playing around to enhance creative thought. Incidents of one peer directly teaching one or more other peers in the classroom provided 34 (30%) of social interaction incidents. Collaborative interactions in the class in which participants were in equal roles provided 30 (26%) of the incidents. Four incidents coded (4%) involved online peer teaching and 10 (9%) involved collaboration over the Internet.

**Qualitative Analysis of Social Interaction Incidents.**

As the following description of class interactions among students illustrates, the social dynamics involved a self learning, self motivated and self-directed learning environment. As they worked on their projects, students inevitably needed to develop deeper understanding of the subject matter of their project and the skills needed to program what they wanted into to VR system. They faced problems in getting the VR representations or simulations they were creating to accurately represent the phenomena of interest or to behave in the way they desired. To gain
Table 3.4  
**Number and Percentage of Types of Incidents Coded**

<table>
<thead>
<tr>
<th>Category of Incident</th>
<th>Number of Incidents</th>
<th>Percent of Incidents</th>
<th>Percent of Research Question 1 or 2</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total Incidents Observed</td>
<td>244</td>
<td>100</td>
<td></td>
</tr>
<tr>
<td>Incidents Related to Research Question 1: Social Dynamics</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Play</td>
<td>38</td>
<td>16</td>
<td>33</td>
</tr>
<tr>
<td>Peer Mentoring-Teaching</td>
<td>34</td>
<td>14</td>
<td>30</td>
</tr>
<tr>
<td>Online Peer Teaching</td>
<td>4</td>
<td>2</td>
<td>4</td>
</tr>
<tr>
<td>Collaboration-Non-teaching/Non-global</td>
<td>30</td>
<td>12</td>
<td>26</td>
</tr>
<tr>
<td>Global</td>
<td>10</td>
<td>04</td>
<td>9</td>
</tr>
</tbody>
</table>

Incidents Related to Research Question 2: Academic Learning

<table>
<thead>
<tr>
<th>Category of Incident</th>
<th>Number of Incidents</th>
<th>Percent of Incidents</th>
<th>Percent of Research Question 1 or 2</th>
</tr>
</thead>
<tbody>
<tr>
<td>Computer Language</td>
<td>35</td>
<td>14</td>
<td>27</td>
</tr>
<tr>
<td>Science Concept</td>
<td>52</td>
<td>21</td>
<td>40</td>
</tr>
<tr>
<td>Math Concept</td>
<td>28</td>
<td>11</td>
<td>22</td>
</tr>
<tr>
<td>Other Academic Content Concept</td>
<td>15</td>
<td>6</td>
<td>12</td>
</tr>
<tr>
<td>Problem-solving</td>
<td>24</td>
<td>.09</td>
<td>18</td>
</tr>
</tbody>
</table>

knowledge, learn new skills, and solve problems, students investigated topics, asked each questions, participated in free, open discussions, brainstormed and bounced ideas off one another. Collaboration and peer mentoring occurred naturally as if this type of learning had been taking place during their entire academic careers.
Qualitative analysis of the social interactions generated three major themes related to Research Question 1.

Theme 1. Play/ Freewheeling facilitates generating ideas and creativity

Theme 2. Self/group-Directed learning enriches a knowledge-building community and interactions.

Theme 3. Social media and global collaboration allow students to advance their technology skills and resource-seeking strategies.

Evidence and examples for these themes are presented in the discussion that follows.

1. **Play/ Freewheeling facilitates generating ideas and creativity**

   The analysis of the classroom observations revealed a social setting in which students worked both independently and collaboratively to accomplish their goals. Playful interactions among the students facilitated idea generation and creativity.

   Play/freewheeling is defined as a situation in which student behavior included goofing off, acting silly with their peers, and bantering. Also, situations in which
students played inventive games such as wheel ball, and experimented with the software to explore effects were coded as incidents of play/freewheeling. Rather than simple diversion, freewheeling often served to provide a break to allow insight to occur or let students explore issues in a fun way. As Table 3.4 shows, play/freewheeling occurred frequently in the observations. Incidents coded as play/freewheeling included both direct observation of students engaged in and students discussing play/freewheeling. The following examples demonstrate how play/freewheeling contributed to the students’ project development, problem-solving, and learning. The first two examples are examples in which I observed play/freewheeling; the second two examples are the students discussing it.

In the first example, students are playing a game they developed. “R” represents the researcher while the students in the focus group are coded with pseudonyms and non-focus group students are coded S#. Text in red indicates the researcher’s description of students’ non-verbal behavior or a comment that clarifies a reference to the computer or a switch in student roles.
A clear case of freewheeling was provided by an observation of Eddie.

Eddie, a junior student, with previous VR experience, decided to design a 3-D heart pump. After much research on the function and shape of a human heart, Eddie made several versions of heart models including one with Lego blocks. Yet, he was frustrated when two of square-shape pieces that simulated the heart in 3-D did not operate the way he expected. The liquid, simulated in VR, was leaking despite the parameters he had set to retain it. In frustration he switched activities from designing a heart pump to playing with a ball and paddle. When another student entered, Eddie challenged him to participate in the game by batting the ball at him. They began chit chat as they hit the ball back and forth not talking about VR or projects or of anything in particular.

When I asked about the sudden change in activity, Eddie said he was now working on a physics problem. This puzzling answer can be seen as the following. Having researched the function of artificial hearts, he was confident on the performance of a heart pump. Yet, vital information was unknown to Eddie, such as
adjustments needed for the properties of liquids, in particular blood. Additionally in the conversations below, Eddie, needed to see relationships between the 2 square pieces that pressed the blood out in his VR simulation and an actual shape of a living heart.

**Example 3. 1**

Two students are sitting on rolling chairs and hitting a rubber ball with paddles back and forth across the room.

R: Why are you guys doing that?

Students laughing and smiling

**Eddie (S13, Expert with technology):** We are figuring out a physics problem.

R: *(laughing)* Love that answer.

Students laughing

**Eddie:** We’re working but indirectly.

R: What do you call this game?

**Eddie (S13):** Wheel ball.
**Sam:** We just made it up about a week and a half ago.

Interestingly, the blockage of creative thought was partially resolved through their physical movements in this playful environment. In frustration, Eddie abandoned his heart project and began hitting a rubber ball with a paddle on the wall, then ping-ponged with another student on wheeled chairs. The activity appeared to relax his thoughts as he engaged with his peer in chit-chat and friendly bantering. Further analysis of Eddie indicated this physical activity and care-free learning environment indirectly stimulated his thinking and the problems with his 3-D heart pump. The next observation day Eddie stated that, “this is the first actual brick wall that I have run into. Usually I just play around with it till I figure it out but when I left the heart pump for awhile…when I cleared my mind of my heart project… I got rid of frustration… by inventing wheelball,” a tennis-like game. Through this creative process, he dissociated biological problems with physics problems. Through relaxing and engaging casual conversation, he was able to re-design his two piece heart
pump, which he thought was a physics problem (properties of liquids) into a single self-contained, ball-shape heart that now became a biological problem.

In Example 3.2, the students demonstrated playfully collaborating as they tried to develop a space shuttle landing on the moon when they were at a frustration point in the development process. The project was in advanced development stage, however the students were trying to fix some problems with the particles scattering in places the students had not intended. At a point of frustration, S4 was explaining the project to the researcher (R) while S1 worked on the computer.

**Example 3.2**

S4 was working on the computer while S1 stood behind and looked over his shoulder.

S4: We can’t really figure it out because it’s doing all kinds of weird stuff…

S1: Let me use the joystick…

S4: The particle system is acting up. Every time all the particles came to this spot here where they are supposed to, right there inside the rockets…
for some reason, they were going there *(outside the rocket image)* and

there is another group right back here somewhere *(near the earth cut out)* they just jump from here to there all of a sudden.

**S1**: So what is the problem with the particles? They are going to another part of the screen.

**S4**: yeah … I am trying to figure that out, … we have worked on this the whole period…just give up and delete them … put new ones in ….because it is frustrating,

**S1**: you don’t know why they are doing this?

**S4**: pushes buttons on the computer and deletes images.

**S1**: go in there… reinstate the program and figure it out. You might have accidently put something in there…. Okay after this is done go over here…Wow this looks very interesting. What are these circles here.

**S4**: Dunno, trying to separate the rockets in stages.
S1: That’s not the way to do it. Let me land this on the moon with the joystick…

because it is doing all kinds of weird stuff… look when I use the joystick you got the exhaust coming out the wrong way from the rocket. It doesn’t shoot out like an “M”

S4: yes it does. I looked it up.

(Students bicker slightly back and forth in friendly banter)

S1: It looks like a McDonald’s sign. Exhaust doesn’t come out that way.

S4: I looked it up.

S1: HEY you know what would be funny (laughing and chomping at the air)

…a McDonalds on the moon…let’s build a McDonalds right there.

Leave the exhaust trail in the sky for the sign.

S4: Make it a Drive-thru…

S1: My fries are floating…..(chomping imaginary fries in the air)

Student from within the room: You want fries with that…
R: You know a lot of this stuff is very serious and very intense; do you guys find that if you goof off or this bantering back and forth... it helps you?

S4: yeah it releases frustration and relaxes me and everything... makes me calmer.

S1: with the McDonalds we need to think which way the landing simulator should work & the drive-thru needs to be a vapor lock.

During this bantering period, the students were observed discussing the problems of having a drive through on the moon. They laughed and began chasing imaginary French fries with their teeth, as fries floated off into space. By adding more to the previous student’s statement excitement and motivation drove project creation.

The quoted examples below involves students discussing play/freewheeling.

In Example 3.3, Steve, a sophomore with intermediate technological skills’ gives a description of the learning environment;
Example 3.3

“One aspect we have in this class is the silliness… that lets us be more creative. Here we get to just talk freely… like oh what are you doing? Or I haven’t really figured that out yet. And it is nice to have conversations back and forth, relaxing atmosphere which lets the creativity come through more.”

In this final example a student describes how goofing off enhances his creative juices;

Example 3.4

S13: after a while, like when you start… what is the button for this, what is the button for that, then after awhile it’s like( S13 brushes his hand across keyboard ) wooosh and then you’re done. You mess around on the keyboard for like 5 minutes and you’re done… then you have nothing else to do, and that’s when the kidding around and stuff kicks in and then you start putting in more stuff in your project to make it more fun and more educational.
As these four examples make clear, playfulness and freewheeling, while perhaps at times being just a diversion, also played a functional role in maintaining students’ motivation and contributed to their success in this learning environment.

2. Self/group-Directed learning enriches a knowledge-building community and interactions.

Table 3.4 summarizes the number of incidents related to peer mentoring and collaboration that are relevant to this category. Sixty-four incidents of this type of social dynamic were counted. The following examples illustrate how student directed learning contributed to the development of a knowledge building community and how interactions among students and with other users of Blender on the internet contributed to student learning. Instances classified as examples of this theme included situations in which students indicated verbally that they were trying to solve a problem, situations in which they were testing a game or simulation sequence for another student, or situations in which the student described participating in a forum online. Because the Internet was not available in the VR classroom, the researcher
could not observe directly the students interacting online. Below is an example of three students working collaboratively in which all are on equal terms and respected for their skill and ability.

Interactions among Ted, a senior male, with highly advanced technical skills, Nate, a freshman male, with intermediate technical skills, and Norris, a freshman, male with intermediate technical skills illustrate peer mentoring. In this social interaction, the students worked together to help Nate develop a project, although previously they were working on individual projects. They built knowledge and interacted through self/group-directed learning. For instance, Ted and Nate were working on individual projects when Nate sighed with frustration about a problem with shadows on his lake scene. Ted sitting next to Nate started asking him questions. As their conversation illustrates, Ted exhibited problem solving and mentoring skills to help Nate find solutions to the lake scene problem. Although not as significant as Ted's mentoring, Norris later tried to give his advice to Nate also.
Nate, the creator of the lake scene project, was distressed because of the way the trees were reflecting on the water. Nate wanted the lighting to have the effect of sunlight at 5:00 p.m. in June. The project had a problem with the shadows of the trees in the water.

**Example 3. 5**

**Nate:** I am trying to get my lake scene to look as real as I can.

**Ted:** You took out shadow on purpose? No it is still there.

**Nate:** See there is a little shadow but I want more than just that.

**Ted:** Ya, where you put the light. That is where the light should be. Look at the leaves. The light is where it should be.

**Nate:** That is the good thing about Blender it has a pretty realistic render.

**Nate:** Yeah it is all real time.

**R:** What does that mean?
Ted: Actual minutes...like in a video game...some video games like SIMS...you can have a minute in real time go by but it is really ten hours SIM time.

Nate: And another thing about real time, like this is 5:00 in my backyard, I could go to the exact date set and exact time. I could stand right where that camera is and it would look realistic to the time of day.

(Ted pushing buttons)

Nate: That shadow, is good right there... but that one is too bright.

Ted: Lower it right there. That’s half.

Nate: Let’s check these lights right here.

Ted: Press F, you’re using the older version. On 2.4 there’s a face loop...that may work but... I don’t know. Why do you have the hemi on?

(Hemisphere light source) You can’t keep it pulled out ...because the light only hits what areas it’s touching.

Nate: How do I keep my light?
Ted: Increase the spotlight. And that what was wrong with your hemis.

Nate: See the shadow...now you can see it.

Ted: Yeah, rework that and try it out.

R: Why are you working back and forth between the two monitors?

Nate: We edit it on the computer and render it in Blender. Rework, render

and see if that is what I want.

Ted: Take out the hemis.

Nate: I was told to put them in.

Ted: By who?

Nate: Norris told me that was what I was supposed to do.

Ted: Hemis are for close things. Maybe if you put the hemi right by the water

it will light up the water the way you want.

Nate: That! That right there! Did you see that?...crap

Ted: What are you complaining about?

Nate: It cut off the corner.
Ted: Oh just….

Nate: I have to move this…this and…

R: It almost looks like Google earth. You can see the blades of grass and everything. It is very realistic.

Nate: See now that took it too far out. It’s cutting it off all that back there.

Ted: Looks like the sun is setting or something.

Norris: Yeah, better than it was.

Nate: Now I got to save it.

Ted: I don’t know if I like it double shadowed.

Nate: That is what I had at first then some people yelled at me. Actually it looks pretty cool. But it still cuts the scene off over there.

Ted: Bring the camera out.

Nate: Wait a minute. I wonder if you move the camera… what will that do?

Ted: now your camera is too far in…move it that way.
Nate: I know but I want it to be in. I just want it to cover this spot over here….Now it is too much light.

Ted: The spot is not even hitting the tree.

Nate: (frustrated) My spots aren’t hitting the tree……uuuuh. But you can tell I got a spot or something.

Ted: It looks like a cloudy day.

This observation shows that the participants in the VR class stopped their project at any time to be a mentor or to assist those of other students. In the example, Nate’s problem becomes a collective problem. The students share knowledge of the software, especially Ted, but that knowledge is actualized in practice as they engage in collective inquiry or exploration of specific program changes to create the desired effect in the relationship among light, shadow, water, and tree in the outdoor scene. They started engaging in collective inquiry in order to identify problems and solutions on the relationship among outdoor scenes, lights, and shadows. Through this process, they learned each other's strengths and
naturally positioned themselves in an ad-hoc mentoring roles. Individually each brought rich skills and knowledge that influenced how the social positions, knowledge-buildings, and interactions played out within this specific social dynamics of Ted, Nate, and Norris.

For instance, Ted invoked wide range of knowledge when interacting with Nate directly and Norris indirectly. He was familiar with the scientific concept of light and shadow, technology such as Blender, rendering, video games like SIMS, and communication skills. Ted’s knowledge gave him a leverage of being dominant one over Nate and Norris with respect to programming the system and the use of Blender. Yet, Ted’s actions in this interchange suggest he was acting as the role of facilitator to Nate when interacting with him and the Blender software. Ted’s behavior allowed a flow of role changing and switching that served to make Nate’s lake scene real. Although Nate was the original creator of the lake scene, Ted did not claim the dominant role himself by taking over the project and doing it himself, rather he worked with Nate to figure out the problem.
This example illustrates two interesting dynamics with respect to mentoring.

New comers either let the mentors control their tools such as the computer, or the mouse completely. These interactions become affirmative or dissenting comments by the mentee and no ownership of the project was claimed. Moreover, ideally collaborative mentoring involves making 3-D models in which mentors are given control for certain aspects of the project, but mentees ultimately have final decisions concerning the direction of the model and have the ultimate decision of what help to accept or not. In the situation described above, Nate respected the advice given by Ted, but was reluctant to receive advice from Norris, who had created the problems in the lake scene.

The following student conversations demonstrate how peer teaching enhanced the learning experience and the collective construction of knowledge for a common goal. An experienced student is directly teaching another less experienced peer. S12 is looking through the Blender technical manual and the biology textbook. S1 walks by and begins to take an interest in his project. Because of the free flowing
atmosphere in this learning environment, students have opportunities to brainstorm, teach one another and develop effective communication skills including taking advantage of teachable moments. Helping and discussing a project has become second nature for the students in this class. As the mentor demonstrates the software tool, S12, the project creator, accepts the help without resentment, claiming sole ownership of the project or expressing unwillingness to share an unfinished project.

**Example 3.6**

S12 working on DNA replica

**S1:** How are you going to get it to spiral?

**S12:** I don’t know I haven’t figured that out yet.

**R:** Why is that a complicated thing to do?

**S1:** Yes… he’ll probably have to use an editing tool.

**R:** What is that?
S1: The screw effect. It will make it screw up and around. I don’t know if it will work.

R: Is that in Blender?

S1: Yeah …basically it does it automatically for him.

S12: That is what I want. How did you find out about that tool?

S1: Just pushing buttons. Here let me show you.

S1 takes the mouse and clicks buttons to demonstrate where the editing tool is located.

In the quote in Example 3.7, a student is describing building a project within a group. The students choose their own project and problem to address.

Example 3.7

S21: I am working on a thing for environmental science. It is a group project …where we are taking a sphere and trying to make the terrain and all the elevations of the continents and stuff….and we are going to show what would happen during global warming… and we want to show the...
areas that would flood, if the ice caps melted. That is our end of the
year project for environmental science.”

3. Social media and global collaboration allows students to advance their
technology skills and resource-seeking strategies.

The analysis of the data also highlighted the important role of social
networking to advance technology skills and to develop strategies in order to move
forward in VR projects. The students in the VR class were not only consumers of the
information but producers as well. For instance, the longest staying member of the
VR program, Ted had actively engaged in social networking activities that helped
him become the most wanted mentor in the VR classroom. He achieved advanced
and highly technological specialized skills needed for the VR class through social
networking activities such as internet blogs, forums and YouTube videos. Simply, his
technology skills started with beginning projects such as cubes and adding
armatures for movement. Ted’s skills extended to texturing, animation scripting and
computer programming. In creating games, Ted interconnected all the
characteristics of gaming aspects such as storyline, animation, music and noise to create a global game. In networking, Ted had to synthesize and disseminate the knowledge received and to manipulate the Blender tools to expand mental capabilities. The universal partnership allowed all participants to pool their collective intelligences for the common goal of creating a sophisticated video game.

Ted also seems to have mastered where and how to get information needed when it came to resources. He sought out offline resources such as textbooks, connections with business professionals and peers. He also developed online connections with people from California and Australia whom he had never met but respected as reliable resources. Ted practiced technology skills and developed an identity that is essential in self-directed VR classroom. Within this social dynamic Ted interacted with peers and colleagues from around the world. He entered chat rooms, forums and online tutorials to hone skills and discuss projects with students globally.
In the following example Ted discussed how he became interested in game engine an advanced skill that many of the students in the VR class do not possess.

**Example 3.8**

Ted: So I got in here and I was just reading the book. I was messing with Blender, trying to get used to it… and then I found the game engine. I have been making games, programming and everything. That involves armatures and animation, actual computer typing and modeling.

R: Did you learn from the books and from feeding off of each other in this class?

Ted: The books don’t actually have game engine in it. So I had to go out and actually learn it and found out that not very many people in here know about game engines. They knew about moving around a little bit but I like to take it up a couple of steps farther. I can write the scripts, and we just got video games installed as you can see right there in 3-D. We can play games in 3-D and they pop out at you.
**Ted:** We talk to people in the outside world. There are forums in Blender on their website that you can talk to people. You tell them your problem…and they will tell you problems they have and you bounce ideas off each other. You Tube is a very good place, because you can see tons of videos on everything. If you ever need help you can go there. I found a forum called Forum Diagnostic, and all the people use Blender for different reasons. They have amazing pictures, called renders, animations, architecture and gaming. Which I do. I learned a lot from there and I am actually on a project called Dark Blood, a video game that I am collaborating with guys from around the world. I met this guy from Australia and he knows more about programming than I do. I am modeling and we are working together. We also have a guy in England and another from California.
Teacher and parent surveys.

Although many remarks from students, parents and teachers concerning the freewheeling environment of the VR class were positive, one teacher was concerned about this learning environment;

Example 3.9

“It takes time for the students to become accustomed to generating their own projects and working under their own impetus. Therefore, for a while the students seem to not work very hard, and spend a lot more time goofing around rather than developing projects. Eventually, however, many of them settle down and develop projects that turn out quite well. I do feel, however, that there are some students who need a little more external impetus, that never decide to settle down and work on projects and develop themselves.”

In summary, the peer mentoring, collaboration and teaching taking place in the VR class promoted knowledge building, community building in the class and
altered traditional classroom unwritten social norms such as a teacher as a sole knower. Playing, goofing off and bantering back and forth were expected in this classroom. Paradoxically, these sorts of physical activities disengaged and engaged student thinking on the problem and provided a freedom of mind wandering. Through this mind wandering and play solutions become apparent and multiple viewpoints could be explored. Furthermore, the open, free-for-all learning environment enriched knowledge building as the classroom community shared ideas, discussed positions, and built a social knowledge base. The roles of the mentor and the mentee fluctuated back and forth between the two, like two people working as one. Often “the role of the expert” with advanced skills or knowledge would suddenly switch, as the collaborators complimented one another’s strengths and weaknesses. Finally, social networking augmented the communal knowledge base and supplemented the social skill sets. Students talked with members around the world and collaboratively taught, shared, learned and discussed. As a result,
problems and solutions became universal and skills were honed as advice was taken and given.

**Research Question 2 - What level of academic content knowledge understanding and problem solving were acquired?**

The requirement that students complete a project that represented academic content and that might be used by a teacher appeared to facilitate their learning of content. To gain sufficient understanding of the academic content so as to create a meaningful and potentially useful project, students utilized texts, additional books, and Internet resources to deepen their understanding. Thus they learned more about the particular academic content related to their projects. Observed incidents involving students engaged with academic content numbered 130 out of 244 (53%). The following in-depth examples provide evidence of how this form of project based learning empowered students to engage with and construct deeper understanding of academic content.
Theme 4 - Understanding academic content through models

In the figure below, Titus and Tim, both seniors with advanced technology skills were collaborating by developing and demonstrating a simple chemistry project. In this presentation the students explained a deeper understanding of covalent bonding, and electron fields surrounding molecules.

![Fig. 3.2 water molecule](image)

**Example 3.10**

**Titus:** I made this in Blender. Tim did the rendering. He put a molecular field behind.
Tim: This is one of my creations. It is for my chemistry teacher. A basic water molecule…you have the red spheres of hydrogen; the blue one is the oxygen and the green there in the middle that is the covalent bonding.

R: What is covalent bonding?

Tim: this…shows the green is the sharing of pairs of electrons between the hydrogen and the oxygen.

Titus: This wire mesh around the molecules represents the electron field. We don’t really know where the electron field is but we can show it like this.

R: What is an electron field?

Titus: We know the electrons pass back and forth between the hydrogen and the oxygen.

Tim: We can’t see them but we can represent them like this.

In this scenario, the students built on their prior knowledge of water molecule characteristics. They knew water was created by combining 2 hydrogen atoms with 1 oxygen atom and had knowledge of the atoms bonding together. The problem they
faced in creating this simulation for an audience of beginning chemistry students was how to show covalent bonding. This is an abstract science concept which is not easily understood. In their project, they used the blue color and red color for the separate atoms.

While manipulating their model, they demonstrated greater understanding of the covalent bonding process when they created a wire mesh to represent the electron field. They knew this field was invisible but that it allowed electrons to be shared. The abstract pathway of the electrons and the electron field created is represented with a concrete wire-like animated simulation. Titus and Tim could envision an abstract idea and animate their model to show this invisible force and how the electrons interacted with both the hydrogen atoms and the oxygen atoms.

VR projects afford Titus and Tim to practice three important learning experiences related to modeling: delineation, demonstration, and interpretation. Traditionally, in chemistry, Titus and Tim would have had to learn/memorize vocabulary and concepts from a textbook. There would be fewer social or dialogue
aspects in such learning. In a typical textbook, the authors must explain three
dimensional components using two dimensional restraints. For example the
constraints of demonstrating a water molecule as this; “Note that atoms connected
to the central atom by dashed lines, H-O-H are behind the plane of the paper, and
atoms connected to the central atom by wedges are in front of the plane of the
paper.” (p. 56)

The need to create a dynamic 3-D representation implied that Titus and Tim
had to make decisions about how to visualize each element, use vocabulary words,
and abstract invisible concepts. The process led them to extend vocabulary and
construct knowledge while attempting to make the abstract concepts real. In creating
a simple water molecule, the students had to decide how to represent the hydrogen
and the oxygen atoms. In this case, they used colors and size. They had to figure
out how to symbolize the electronic fields which are invisible, always in flux, but
interconnected to the hydrogen and oxygen at all times. The black circular grids
represent the pathway of these electrons, in and out of the atoms, circling around each one and representing the motion of the electrons.

To understand the double green rings surrounding the atoms, this project needs to be viewed within the 3-D rendering. The above figure is only a small snapshot (1/10) of the entire simulation. When animation was added the green rings dispersed in and out of the atoms like a ghostly vapor. Titus and Tim needed to understand this concept to create a visualized simulation.

As the data indicated, in demonstrating the project, Titus and Tim used vocabulary correctly in context, could explain the science behind the model and understood the abstract concepts of covalent bonding. The students articulated the complexity of sharing electrons and the vagueness behind the electron fields. When compared to a model that scientists created to represent water, the model of Titus and Tim was accurate and detailed.
The next example is taken from a situation in which a student discussed with visiting adult professionals a project he made related to geometry. The student had been having problems in geometry. Jason, as had Titus and Tim in the covalent bonding case, struggled with understanding the concepts stated in the Geometry textbook. He made no connections to the information provided and did not understand relationships among the formulas in the book and practical applications.

Jason, a junior with intermediate technological skills, could not visualize the geometric math concepts he was learning in class. When challenged by the principal to create a project in VR that would represent the concepts, he changed his perspective to look at the problems and formulas from a different context. Like the science textbook, the geometry textbook had the problem of displaying three dimensional objects using a two dimensional format. Jason could not transfer
information he was learning in geometry class until he connected that same geometric information he had been using in the virtual reality 3-D simulations to the 2-D book format.

![Image of a geometric calculation](image)

*Fig.3.3 Student project with geometry connection*

**Example 3.11**

**JASON:** This has actually helped me in geometry. Because I was failing geometry earlier this year and I had a meeting with the principal. He
asked me what was going on and I told him I just don’t understand Geometry. So he told me to try to use stuff that I was using in Blender. He told me to try to convert it into something that you use in VR class. Well I did a project a…educational project…It was a cube. You have to find surface area, density, volume… perimeter and stuff. That was stuff we were learning in geometry with prisms and 3-D figures. Well now I am at a “C” in that class and doing much better.

R: What did you do with the formulas in this project?

JASON: I put them on the cubes …I put given information… and stuff that you want to find right beside the cube. I’ve got all the formulas that you use to find the stuff. I filled it in and it all equals out. Then I put it in game engine so that you could rotate the cube. You can actually see why you are getting the answers you are getting. Like for surface area, you can actually tell by looking at all sides. So by rotating it you can count the sides.
R: So when you rotate it, you can actually visualize it?

JASON: Yeah, it is like, a hands on thing.

R: when you rotated it you actually saw 6 sides?

JASON: that is what you are figuring not just one or two sides. Instead of visualizing in your head you can now see it.

R: Did you actually work those math problems out?

JASON: yes… but this (3-D cube) came off the top of my head…

R: what kind of math and science have you had?

JASON: I went through Algebra, Algebra II, and right now I am in Geometry. I started out with a little bit of trouble in geometry this semester but…I am working back up.

R: Do you think working in VR helped you visualize what you were learning in geometry?

JASON: (very excited) YES, Yes, Yes a lot better seeing it. I had to reach a point where … I do get it…
R: so you needed to make the connection?

JASON: yes I had been working with it all along… I needed to see it.

The observations also provide evidence of students integrating Science, Technology, Engineering, Math, and Literacy (STEML) in their learning. Daily the students faced many challenging problems and knowledge building activities that required them to think strategically. Jason, in the example above needed to visualize the math concept to gain a deeper understanding of how geometry works. The thinking required to create his project led Jason to connect the geometric shapes and the practical uses in real life applications. The context of the math formulas now had meaning to him. They had a function that was applicable to building a deck and purchasing the correct amount of materials needed. Additionally, he developed a sense of understanding in measuring the volume of chemicals, figuring the surface area of a house to be painted, and how to calculate the density of a boat floating in water.
In Example 3.12, Nina (a focus group member) demonstrated using virtual reality for life application in designing the family farm. The family wanted to redesign the placement of buildings to make the farm more productive and efficient. They were diversifying the crops grown and raising exotic animal that required special needs. The farm simulation would be used to view different scenarios and options without a lot of expense to the family. The farm had to be developed accurately and with precision. To create her project, Nina needed to use scale, ratios, proportion and actual artifacts from the farm such as photographs, aerial view photos, plus plats from the county which depicted the land plots in detail. Nina’s actions in developing and completing her project demonstrated collective intelligence, multitasking, and understanding of math concepts. Nina and the parents discussed the farm’s environmental impacts including chemical runoff, drainage and functionality of redesign. Nina developed different scenarios that would benefit the animals and not seriously impact the environment. Because the owners were using greener farming techniques, she needed to incorporate green approaches in her
project design goals including efficient use of resources in working the farm. When Nina was confronted with a design flaw, she sought advice from Ted, a mentor/expert, was sought and this dialogue followed.

**Example 3.12**

**Nina:** I have a question (talking to Ted). I want to move this square over. **Ted** takes the mouse and begins to click buttons on Nan’s project.

**Ted:** Now size it to what you want.

**Nina:** How did you get it to joint?

**Ted:** Control “J”

**Ted:** and with the vortex, the little sub divide thing, it only works with interfaces. It doesn’t really work well with triangles for some reason.

**R:** Explain to me what you did to help her.

**Ted:** Well I just showed her how to bring in a plane that would be the door because if she uses the sub divide which is control “R” which is loop,

so all the faces have to be even. So we make it even so then we can
use subdivide and not be messy. I brought in a separate object and then just joined them together.
Fig. 3.5 Horse with armature
Lastly, in the final example; 3.13, the student was connecting to literature when building a Lord of the Rings fight scene. In this project, when questioned, the student stated that in building the horse the research focused on movement of horses and its anatomy. The student described information learned concerning the feet of horses, bone structure, and movement of the horse. The student described the build of their knees, and how they are connected to the rest of the leg and bone structures. Through this research the student discovered that when a horse breaks his coffin bone, it basically can’t walk anymore and becomes useless. As the student was describing the horse with a broken leg he was laughing and limping awkwardly because he kept stating this piece of information in particular, was not something he set out to learn. This knowledge portrayed him to his peers as an expert in horse anatomy as well as providing comic relief which boosted his self confidence.

**Parent Teacher Survey Data.** Surveys were conducted of teachers and parents to determine if they perceived changes in their students as a result of participation in the VR class. Consistency between the observations, analysis of
student projects, and teacher and parent perceptions can provide triangulation among the various data sources and results. Appendix B contains the complete list of teacher comments and Appendix D contains parent comments from the online surveys. The teachers and parents were asked whether they perceived a positive, negative, or no change in the child or student with respect to items related to academic learning and social skills.

**Social Skills.** Table 3.5 summarizes the teachers’ and parents’ responses with respect to social skills. Twelve parents and eight teachers responded to these items (occasionally a respondent omitted an item). A substantial majority of parents indicated that they perceived positive change on most of the items; across the items the average percentage of parents who chose the positive change response was 80%. Organization was the only item for which a majority of parents did not perceive positive change; the majority perceived no change on this item. Two other items in which the parents who perceived no change and parents who perceived positive change were more evenly split were citizenship and promptness. Only two items
received a single negative change response. (Occasionally a respondent omitted an item). A substantial majority of parents indicated that they perceived positive change on most of the items; across the items the average percentage of parents who chose the positive change response was 80%. Organization was the only item for which a majority of parents did not perceive positive change; the majority perceived no change on this item. Two other items in which the parents who perceived no change and parents who perceived positive change were more evenly split were citizenship and promptness. Only two items received a single negative change response. Teachers generally also perceived positive change, but the percentages are generally less positive than the parent data. Across the social items an average of 66% of the ratings indicated positive change. Statistical comparisons were not conducted between teachers and parents because of the small numbers of participants. In general, the items that a larger percentage of parents rated as a positive change also tended to be items that a larger percentage of teachers rated
Table 3.5

Parent and Teachers Perceptions of Changes in Students' Socialization as a result of VR class participation

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<th>Parents</th>
<th>Teachers</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Positive Change</td>
<td>No Change</td>
</tr>
<tr>
<td></td>
<td>Mean</td>
<td>SD</td>
</tr>
<tr>
<td>Maturity</td>
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<td>0</td>
</tr>
<tr>
<td>Responsibility</td>
<td>1</td>
<td>0</td>
</tr>
<tr>
<td>Public Speaking</td>
<td>.92</td>
<td>.289</td>
</tr>
<tr>
<td>Self Esteem</td>
<td>.75</td>
<td>.452</td>
</tr>
<tr>
<td>Leadership/mentoring</td>
<td>.92</td>
<td>.289</td>
</tr>
<tr>
<td>Citizenship</td>
<td>.58</td>
<td>.669</td>
</tr>
<tr>
<td>Creativity/Inventiveness</td>
<td>.92</td>
<td>.289</td>
</tr>
<tr>
<td>Organization</td>
<td>.33</td>
<td>.651</td>
</tr>
<tr>
<td>Promptness ³</td>
<td>.58</td>
<td>.515</td>
</tr>
</tbody>
</table>

aTeachers did not rate promptnes
positively, but the relationship was not perfect. The Pearson correlation across the commonly rated items between the number of parents and number of teachers rating the item positive was .59. Organization was the least positively rated item for both teachers and parents. One important result was that the majority of responding teachers and parents perceived positive changes in social skills in their children or students as a result of the VR class participation.

**Academic Growth.** Table 3.6 reports the number and percentages of parents and teachers who perceived change in academic areas. As with the social area, the parents and teachers rated items as displaying positive, negative, or no growth. Overall, across the items the parents and teachers tended to perceive positive growth. Across the items, the average percentages selected positive change was 67% of parents and 63% of teachers. Across the items, there were very few ratings of negative change for either parents (2 choices of negative change) or teachers (4 choices of negative change). As compared to the social area, in the academic area, parents and teachers were less consistent in where they saw positive change.
### Table 3.6

Parent and Teachers Perceptions of Changes in Students’ Academics as a Result of VR Class Participation

<table>
<thead>
<tr>
<th></th>
<th>Parents</th>
<th></th>
<th></th>
<th>Teachers</th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Positive Change</td>
<td>No Change</td>
<td>Negative Change</td>
<td>Positive Change</td>
<td>No Change</td>
<td>Negative Change</td>
</tr>
<tr>
<td></td>
<td>Mean</td>
<td>SD</td>
<td>Freq</td>
<td>%</td>
<td>Freq</td>
<td>%</td>
</tr>
<tr>
<td>Academics</td>
<td>.83</td>
<td>.389</td>
<td>10</td>
<td>83</td>
<td>2</td>
<td>17</td>
</tr>
<tr>
<td>Reading Skills</td>
<td>.33</td>
<td>.492</td>
<td>4</td>
<td>33</td>
<td>8</td>
<td>67</td>
</tr>
<tr>
<td>Critical Thinking</td>
<td>.83</td>
<td>.389</td>
<td>10</td>
<td>83</td>
<td>2</td>
<td>17</td>
</tr>
<tr>
<td>Problem Solving</td>
<td>.75</td>
<td>.452</td>
<td>9</td>
<td>69</td>
<td>3</td>
<td>25</td>
</tr>
<tr>
<td>Math Concepts</td>
<td>.50</td>
<td>.522</td>
<td>6</td>
<td>50</td>
<td>6</td>
<td>50</td>
</tr>
<tr>
<td>Oral Language Ability</td>
<td>.67</td>
<td>.492</td>
<td>8</td>
<td>67</td>
<td>4</td>
<td>33</td>
</tr>
<tr>
<td>Written Language Ability</td>
<td>.42</td>
<td>.515</td>
<td>5</td>
<td>39</td>
<td>7</td>
<td>58</td>
</tr>
<tr>
<td>Transfer Between Subjects</td>
<td>.50</td>
<td>.674</td>
<td>7</td>
<td>54</td>
<td>4</td>
<td>33</td>
</tr>
<tr>
<td>Science Concepts</td>
<td>.83</td>
<td>.389</td>
<td>10</td>
<td>83</td>
<td>2</td>
<td>17</td>
</tr>
<tr>
<td>Ability to Question</td>
<td>.67</td>
<td>.651</td>
<td>9</td>
<td>75</td>
<td>2</td>
<td>17</td>
</tr>
<tr>
<td>Logic</td>
<td>.92</td>
<td>.289</td>
<td>11</td>
<td>92</td>
<td>1</td>
<td>8</td>
</tr>
<tr>
<td>Research skills</td>
<td>3</td>
<td>38</td>
<td>4</td>
<td>57</td>
<td>2.43</td>
<td>.535</td>
</tr>
</tbody>
</table>
The average correlation across the items commonly rated by parents and teachers was -0.30. Parents and teachers especially diverged in the ratings of change in reading skills, written language ability, transfer between subjects, and science concepts. As shown in Table 3.6, parents were unlikely to see change in reading ability or written language ability; while a majority of teachers reported positive change. The pattern reversed for transfer between subjects and science concepts; for these two items, many parents perceived change and many teachers tended not to.

**Perceived importance of aspects of the VR program.** Table 3.7 reports parent and teacher perceptions of the importance of various aspects of the VR program. Of the parents responding, most felt that many of the items were important to the success of the program for their children. The only items that were not rated at least somewhat important by a majority of parents were Parental Motivation and Presentations to Parents. For parental motivation, parental perceptions were more evenly split with 46% of the parents reporting this factor as important and 55% indicating it was not important.
Table 3.7
Parent and Teacher Perceptions of the Importance of Various Aspects of the VR Program.

<table>
<thead>
<tr>
<th></th>
<th>Parents</th>
<th>Teachers</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Very Important</td>
<td>Important</td>
</tr>
<tr>
<td></td>
<td>Mean</td>
<td>SD</td>
</tr>
<tr>
<td>Flexibility in projects</td>
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<tr>
<td>Allow creative thought</td>
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<td></td>
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<tr>
<td>Student interest tech</td>
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<td>.0</td>
</tr>
<tr>
<td>Parental motivation</td>
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<td>.522</td>
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<tr>
<td>Public speaking</td>
<td>.83</td>
<td>.389</td>
</tr>
<tr>
<td>Student curriculum^a</td>
<td>.92</td>
<td>.289</td>
</tr>
<tr>
<td>Inquires on interest</td>
<td>1</td>
<td></td>
</tr>
</tbody>
</table>

^aTeachers did not rate student based curriculum
Table 3.7
Parent and Teacher perceptions of the Importance of Various Aspects of the VR Program Continued

<table>
<thead>
<tr>
<th>Aspects</th>
<th>Parents</th>
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<th>Teachers</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Mean</td>
<td>SD</td>
<td>Mean</td>
<td>SD</td>
</tr>
<tr>
<td>Adult mentor</td>
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<td>.622</td>
<td>1.50</td>
<td>.535</td>
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<tr>
<td>Internet access</td>
<td>1.92</td>
<td>.289</td>
<td>1.63</td>
<td>.518</td>
</tr>
<tr>
<td>Presentations/ parents</td>
<td>1.33</td>
<td>.492</td>
<td>1.50</td>
<td>.535</td>
</tr>
<tr>
<td>Presentations/others</td>
<td>1.67</td>
<td>.492</td>
<td>1.63</td>
<td>.518</td>
</tr>
<tr>
<td>A Standard textbook</td>
<td>.64</td>
<td>.505</td>
<td>.25</td>
<td>.463</td>
</tr>
<tr>
<td>Newest technology</td>
<td>1.92</td>
<td>.289</td>
<td>1.63</td>
<td>5.18</td>
</tr>
<tr>
<td>Evaluation of projects</td>
<td>1.92</td>
<td>.389</td>
<td>1.88</td>
<td>.354</td>
</tr>
<tr>
<td></td>
<td>Parents</td>
<td></td>
<td>Teachers</td>
<td></td>
</tr>
<tr>
<td>----------------------</td>
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<td>----------------------</td>
</tr>
<tr>
<td></td>
<td>Mean</td>
<td>SD</td>
<td>Very Important</td>
<td>Important</td>
</tr>
<tr>
<td>A Set curriculum</td>
<td>.83</td>
<td>.389</td>
<td>10</td>
<td>83</td>
</tr>
<tr>
<td>Opt. for collaboration</td>
<td>1.88</td>
<td>.354</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Opt. to problem solve</td>
<td>1.88</td>
<td>.354</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Opt for presentations</td>
<td>.83</td>
<td>.389</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Student research</td>
<td>1</td>
<td>0</td>
<td>12</td>
<td>100</td>
</tr>
<tr>
<td>Teacher</td>
<td>1</td>
<td>.426</td>
<td>1</td>
<td>8</td>
</tr>
</tbody>
</table>

*N – number choosing this response  *Parents did not rate
Table 3.7 provides teacher and parents perceptions on what are the important aspects of the VR program and indicated aspects they consider not important at all.

As indicated in Table 3.7 a majority of parents perceived most aspects of the program as important. The only items not rated as important by parents were parental motivation, giving presentations to parents, and having a teacher.

A majority of teachers also supported most aspects of the program as important. The only items not received a rating of important or very important by a majority of teachers were flexibility in projects, a standard textbook, having a teacher, having an adult mentor, and presentations to parents. On the last two items, however, teachers were evenly split between seeing these factors as important and seeing them as not important. Teachers thought that having a teacher was somewhat important.

*Teacher and Parent Comments.* The questionnaires allowed parents and teachers to provide written comments. These are described below.
As noted above teachers had rated the VR program positively overall. As the following examples indicate, many of their comments supported their ratings.

Example 3.14. “The biggest thing I have seen is the growth and maturity that the students have demonstrated. This is even more evident in the students who would not be considered the top students in their respective classes.”

Example 3.15 “The benefit I most observed is the sense of belonging and self-confidence this has given some students who would otherwise not feel a sense of value or academic worth. The program validates their abilities and challenges them.”

While teachers rated the VR program positively, they also perceived problems as reported in their written comments. Teacher concerns focused on three major issues: (1) the freewheeling/play learning environment, with the lack of supervision, (2) a lack of specific expectations, and (3) and concerns about coordination between the teachers and regular class and the VR class. For number 3, specific
coordination concerns included the teachers were not informed about guests visiting the VR class and the nature of the projects the students were doing in the VR class. Teachers felt there needed to be more coordination between the VR class and other classes. Specific teacher comments, included below, illustrate these three concerns.

**Example 3.16.** “There should be an actual instructor. There needs to be definite criteria and expectations.”

**Example 3.17.** “I think that the students need to share more of their work with the faculty and staff. I have a working relationship with many of them and know what is going on. Most of the staff does not. I think it would help the perception of the program to share with the school. It also has some teachers frustrated that it is not more fully integrated into the classroom. I have expressed to students how I wouldn't mind for them to use virtual reality in lieu of other means during a project.”

According to the survey question when asked if teacher’s expectations had changed, either in reference to teaching VR students or their perceptions of
technology in their classroom, the data indicated the teachers felt the VR experience was positive when students excelled and had changed their perceptions toward technology in their own classroom, although none changed the classroom climate to include VR or new technology. Table 3.8 summarizes this data.

<table>
<thead>
<tr>
<th>Table 3.8</th>
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<th></th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Number and percentage of perceived changes in teacher expectations</strong></td>
<td><strong>Did you change your;</strong></td>
<td><strong>Yes Changed Expectations</strong></td>
</tr>
<tr>
<td></td>
<td><strong>No didn’t Change Expectations</strong></td>
<td></td>
</tr>
<tr>
<td></td>
<td><strong>Freq.</strong></td>
<td><strong>%</strong></td>
</tr>
<tr>
<td></td>
<td><strong>Freq.</strong></td>
<td><strong>%</strong></td>
</tr>
<tr>
<td>Expectations of virtual reality students</td>
<td>6</td>
<td>75</td>
</tr>
<tr>
<td></td>
<td>2</td>
<td>25</td>
</tr>
<tr>
<td>Perceptions on technology use in the classroom</td>
<td>6</td>
<td>75</td>
</tr>
<tr>
<td></td>
<td>2</td>
<td>25</td>
</tr>
<tr>
<td>The manner you teach virtual reality students</td>
<td>1</td>
<td>13</td>
</tr>
<tr>
<td></td>
<td>7</td>
<td>88</td>
</tr>
<tr>
<td>Your classroom climate</td>
<td>8</td>
<td>100</td>
</tr>
</tbody>
</table>

Comments written by parents indicated that they felt their students were experiencing an enriched learning environment. Comments included statements that the students in the class were positive peer models and that the self-direction aspect
of the VR program allowed their child to learn, mature and develop skills in a nonjudgmental environment. Like the teachers, some parents expressed concerns about the lack of supervision and that the play/freewheeling aspect was distracting to their child. When discussing the academic content their child exhibited, the parents were impressed by the high academic expectations of the VR class, the technical skills their child developed, and the development of marketable knowledge and skills

**Parent Comments.** Indicated by the comments, the parents felt their students were experiencing an enriching learning environment. Comments included statements that their students in the class were in a group with positive peer models, the self-direction dynamic allowed their student to learn, mature and develop skills in a nonjudgmental environment.

**Example 3.18**

“VR is a self directed; self motivating type of class and that creates an atmosphere of where S12 has shown the maturity to get things done without
supervision. Much like the real work world environment VR has also afforded him the opportunity to visit the real work world on some of the field trips to industry they have taken.”

Like the teacher concerns, parents were also apprehensive about the lack of supervision and at times the play/freewheeling was distracting to their student. As indicated by the following two parent comments.

**Example 3.19**

“Some of the students in the VR room do not take the program very seriously. These students are very distracting to others that are trying to work. This is especially true for students who tend to lose attention easily. Although, these easily distractible students are usually the most creative and can think outside the box.” “Possibly more frequent adult monitoring.”

When discussing the academic content their student exhibited, the parents noted they were impressed by the high academic expectations of the VR class, the technical skills their student developed, and the development of marketable
knowledge and skills. Table 3.7 above summarizes the teacher/parent data collected.

Table 3.8 above provides teacher and parent perceptions on what are the important aspects of the VR program and indicated aspects they consider not important at all. As indicated by the data parents favored the student-driven, self-motivating, student-driven research and student interest in curriculum as key factors. Less important or not important to parents were the areas of parental motivation and giving presentations to parents. Although parents did support a teacher or mentor and having the students give presentations as well as evaluations.

Teachers on the other hand supported the aspects of evaluating projects, opportunities for collaboration, presentations, problem solving and allowances for creative thought. What was not sufficiently important to them was having a standard textbook or an adult mentor, although they thought a teacher was somewhat important.
The parent and teacher survey data is limited by the number of parents and teachers who responded. Significant tests of differences between the teacher and parents would not be meaningful because of the small sample size. However, the survey data did indicate that both parents and teachers were relatively positive in their beliefs and attitudes about the VR program.

Discussion

This study was based on a project-based VR class in which students worked independently of direct teacher control, but were responsible for producing projects that met design criteria. This project-based, student initiated course was consistent with a broad range of constructivist theories (Phillips, 1995) and new practices into contemporary methods of learning and teaching (Krajcik, 2006). How does and how well is this VR class meeting or exceeding its expectations of learning and education? Overall, the most significant findings of this research included;
1. Knowledge was communal.

2. Skill development was socialized.

3. Each individual student could draw from the collective pool of knowledge and skills of the group to benefit their knowledge acquisition and skill honing.

These findings emerged from the answers obtained to the study's two research questions, “What were the social dynamics of the VR class and how did peer mentoring influence student learning and behavior?” and “What level of academic content knowledge, understanding, problem solving skills were acquired?”

**Social Dynamics and Peer Mentoring.** As described in the results section, knowledge acquisition was the responsibility of both the individual student as well as the entire learning community, including online forums. As Longino (1993) argued, social groups “create knowledge” as with the case of the VR class at Avatar High School, knowledge was created and built upon by the users, or the students. Students learned how to speak the language essential for the class; they learned
how to assimilate technology to develop educational projects involving abstract and obscure concepts.

Each individual student contributed to the coffer of knowledge, with growth exhibited within the group, as described by Ernest (1996). Students brought into the VR experience their individual prior knowledge and skills. Through the process of working in the VR project-based environment, students encountered cognitive conflicts that pushed them to use resources to gain more knowledge, discuss and problem solve with classmates, and to work collaboratively to create their VR projects. These social interactions led students to alter their conceptions and thinking. Students had to learn how to be self motivated, be reflective, learn to question and investigate, and to grasp abstract academic content without a teacher to verify if their assumptions and conclusions are correct. The context of this VR leaning environment influenced the learner by demonstrating essential skills, promoting open discussions, and allowing for creative thought development.
Knowledge was shared among the participants freely, and research was validated by the critiques of peers. Students learned academic content by delving into abstract concepts, deepening their understanding and engaging in inventive investigation within the sharing community. The ongoing learning process of each individual is constructed upon the learning process of the other members in the group. New information is supported by the entire learning community through cognitive elaboration (Ritchie & Karge, 1996) so both the individual learner and the community of learners supports knowledge acquisition.

The social context of this learning environment permitted skills to be transferred from an advanced student to a lesser advanced student within a relatively short period of time. Students asked specific skill related questions, were given immediate feedback and shown how to develop the skill by demonstration. Students practiced skills in a nonthreatening environment in which failure was not fatal and grades did not reflect a student’s ability for success.
As the NSES states “learning is something students do, not something that is done to them.” The skills developed by the VR students were not restricted solely to constructing new academic content but included 21st century skills such as; peer mentoring, leadership, critical thinking and numerous others. Additionally, students developed self direction, self motivation, empowerment and problem solving logic. When faced with a problematic design, students would work and work at the problem and, even in failure, declared they were going to beat this problem. To students, the problem was now a challenge and students could draw upon the resources of the class to solve the problem. This classroom community supported students as they enhanced their own skills, gained deeper perceptions, and ultimately gained a sense of empowerment.

Although this free flowing social environment promoted creativity, social skill exchanges, and gave students control over their own learning, this type of learning environment was not without problems.
The focus group data indicated that two students in particular struggled within this learning environment. Evan was a 4.0 student and knew how to succeed academically but when he enrolled in the VR class, he was lost with no direction for project development, needed feedback that the projects he was developing was correct and did not take control of his own learning. Nan, who was reserved and soft spoken excelled with the software and was eager to create projects but was drastically hindered by not asking for help when needed. When she requested help it was from the person sitting next her rather than others in the class. She never fully utilized the talents and resources of the other students.

The observations from the first days of the school year, the data indicated, as Meyer, Turner and Spencer (1997) have reported evidence; newcomers had trouble adjusting to this type of learning environment. In every incident 100% of the newcomers came into the classroom, sat down and waited for someone to give them instruction or direction. Expectations were not clear for both the peer mentors and the newcomers, as the mentors automatically came into the room, turned on the
computer and began project development. The newcomers sat the entire 40 minute period and waited for the mentors to direct them. Furthermore, the mentors, when they did demonstrate the software, needed to understand that they could not show the entire Blender software in one sitting. They needed to realize that the new comers could only grasp small amounts of information at a time (Bransford, et al 2000).

The capability of students to create advanced VR projects in addition to probing into deeper abstractions of academic content was evident as they utilized the collective pool of skills and knowledge. The students’ motivation prompted them to learn complex concepts, and gain technology literacy beyond a typical high school computer class in addition to developing skills critical for future success. As in the case of Ted, learning was not restricted to the VR classroom only, as he spent time outside of the classroom discussing in forums, mentoring others, and doing research in the local community. The students became global citizens as they used the
internet as a platform to interact with other people, learn new technology and contribute to the global society.

As with the Means and Olson (1995) study the data from this study indicate that, through the enhancement of technology, students create high quality of projects, used technology to research and verify from outside resources the accuracy of their projects, and develop the ability to envision and manipulate abstract ideas (Bransford, et al 2000; Gordin & Pea, 1995). A student was able to visualize a working car engine and demonstrate it using the VR platform, thereby demonstrating understanding abstract concepts of a working gas powered engine.

As in the study of Barnett et al (2005), students had great difficulty understanding astronomical concepts of deep space. In building models of the phenomena the students were able to build relationships and see connections among the elements of outer space. The example of the student who created the math cube for geometry class also parallels the findings of the Barnett et al. study.
As in Barnett et al., the student needed to visualize the math concept to understand it, (Salzman, Dede, Loftin & Ash 2008, Schwartz & Heiser, 2006).

The project-based learning environment allowed students to develop exchanges and debate ideas, and solutions to problems both encountered in the VR class and in real life situations. Social interactions and collaboration built understanding within individuals and the class as a whole. Projects were not central to the curriculum but were a method used to drive research. The projects were of interest to the students, gave the students a sense of ownership, and were student-driven constructive investigations (Thomas, 2000).

As demonstrated by the following interview, the students discussed development of essential independent thinking, risk taking, inventiveness, and ability to visualize completed projects. In reference to Jenkins’ research the following data indicated these students acquired the skills of performance, disturbed cognition, in addition to collective intelligence. In working with a math theorem, S2 used improvisation to understand deeper concepts of math and create his own theory.
Through this process both students expanded mental capacities, pooled knowledge to expand their knowledge foundation and worked toward a common goal, in this case working on a holographic invention. Additionally the project-based learning environment as described by Thomas (2000) provided the opportunities for further student develop thinking and collaboration.

**R:** What math concepts have you used or understand more fully?

**S2:** I made my own math theorem.

**R2:** You did! So tell us about it.

**S2:** ......nay....

**S1:** yeah tell them.

**S2:** It’s the S2 theorem of parabolic focuses. Not foci, focuses. Basically the way it works is you use the derivative and I probably lost you both right there... you use the derivative to find the focus of a parabola.

**R:** Parabola?

**S2:** yes
R: so what have you discovered with this. Does it work?

S2: yes it works

R: how could you use this in practical life?

S2: you can use it for the focus of mirrors. They sometimes use the focus length for mirrors in car headlights. They put the light directly on the focus so that the light shines.

R: Have you taken this to your math teacher?

S2: yes… he said it works

R: have you tested it in VR?

S2: no…not yet but, probably could.

R: Did this help develop critical thinking?

S2: yes absolutely.

R: what are the top reasons why this virtual reality program is a success?

S2: visual learning ...

R: Or is it not a success?
S2: It is a success…

S1: it’s successful…

S2: I would say it is a success.

S1: YES! I would call it a success…

R: Ok but you have no reasons for your success.

S2: self learning…the fact that it is more visual, people are more visual students, and probably the exposure of the game industry… the thing I think that we should be walking away from here with… is the ability to teach yourself, to go farther and learn more by yourself, problem solving and all that. Not so much what you are directly learning but the skills.

R: What skills would you take into a business by having taken this class?

S2: basically problem solving skills.

S1: independence from a teacher and the ability to work in a group.

S2: …and creativity and inventiveness.
As revealed in the present data, the VR project in this high school represents a successful application of the project-based learning model. The model employed in this particular application is consistent with the constructionist approach to constructivist educational models. Constructivist models argue that students integrate and modify their existing knowledge with physical, real-life and social experiences to create new knowledge. The constructionist flavor of constructivism argues that having students build artifacts that meet particular design criteria can lead students to effectively construct new knowledge. In the present class situation, the VR projects that students complete are the artifacts. These artifacts empower students because students have choice in the selection of the project, but the artifacts must meet design criteria specified by the principal. Students must complete two artifacts each quarter and one of them must have an educational connection. The class has become a community of practice in which individuals move from less expert to more expert roles and in which students collaborate in producing the projects. Their projects also lead to approval from the community of practice and
from external social sources. Students also seem to take on an identity as VR class student. Thus multiple theoretical factors contribute to the success of the program

**Limitations.** As with any research study, the present study has several limitations. The researcher was a parent of a student who had been successful in the class. That experience may color the interpretations the researcher placed on the class. The research is based on a relatively limited number of observations obtained over a relatively short period of time. The class is changing from a somewhat experimental to a somewhat institutionalized part of the school curriculum. Only a limited number of students participated and only a small number of parents and teachers provided a data source for triangulation. All of these factors mean that the success of this particular class may depend on the particular configuration of multiple factors that influence the class.

In conclusion, the VR learning experience basically had a positive impact on students’ learning. Model building allowed scholarship into avenues outside the boundaries of typical high school disciplines. Students learned essential skills for
success in the 21st century and became global citizens. However, there were concerns expressed. Some students had difficulty adjusting to the freewheeling atmosphere of the VR class. Some teachers expressed concerns that the degree of student control promoted ineffective uses of time and too much fooling around. Concerns about the coordination between the regular curriculum and the VR class were also expressed. Ways to avoid these problems while retaining the benefits of the VR class should be explored.
Chapter 4. General Conclusions

This thesis was focused around understanding how project-based learning can operate to facilitate student learning. Additionally, it focused on how a particular project-based VR class operated to influence student activities and understanding. The degree to which students constructed understandings and abilities to use skills in a practical way, important academic content related to science, and deepen their ability to use a variety of so-called 21st Century skills. To achieve these goals, this thesis reported a review study of project-based learning (Chapter 2) and a mixed methods empirical research study of the particular classroom (Chapter 3).

Chapter 2 provided a review study of existing theory, empirical research, and practical opinions about effectively using project-based learning in K-12 schools. The review focused on technology-supported project-based learning. Project based learning is an approach to teaching in which students learn by conducting a project that explores “complex, authentic questions” and in which students generate “carefully designed products” that accomplish tasks meaningful to them (Buck
Project-based learning is one manifestation or approach to education consistent with constructivist theories of learning, development, and education. As described by Phillips (1995), constructivism refers to a family of theories all of which posit roles for individuals’ thought and reflection, prior experience and knowledge, and social influences on individual and/or group knowledge development. Chapter 2 summarized the variations among different particular constructivist theories.

Chapter 2 also discussed various specific approaches and recommendations for project-based learning. Recommendations included: projects should have authenticity (or meaning for students), academic rigor, involve applying new knowledge to life-like situations, and involve active exploration. Students should have significant control in designing and carrying out projects.

Research on project-based learning has shown that it can be effective in helping students acquire deep knowledge of a subject matter and enhance problem-solving, self-management, and collaborative social skills. The review of the research
in Chapter 2 found significant success for project-based learning in particular studies. However, project-based learning is not a panacea. As with any other educational approaches, it can be done effectively or ineffectively and the context of particular educational situations likely interact with teaching methods to determine what is effective.

Study 2, presented in Chapter 3 of this thesis, and reported an empirical study of student interactions and learning in a targeted VR class in a small school district in Iowa. The focus of this chapter answered two research questions: “What were the social dynamics of the VR class and how did peer mentoring influence student learning and behavior?” and “What level of academic content knowledge, understanding, problem solving skills were acquired?”

In reference to Research Question 1, three themes were discussed. 1) Play stimulates inventiveness and creativity. 2) self/group directed learning enriches the knowledge building community, and 3) social media advanced skill development,
know acquisition and sharing, and develops the global community. The results of Study 2 provided support for each of these themes.

For example with respect to play, Study 2 documented situations in which when students reached a point of frustration they vented by engaging in an activity of play or goofing off. They bantered back and forth, engaged in physical activity or distracted themselves from their VR project by playing a peer’s video game or mentoring a project. Through play they stimulated their creative juices although the original problem with the exhaust particles was still there. This play sometimes led to new creative ideas relevant to the original problem, collaborative interchanges with peers that helped problem solution. Play became part of the social rules of the community of practice in the class and it seemed to facilitate the class’ collaborative problem solving.

Study 2 provided many examples of the second theme: self/group directed learning enriches the knowledge and skill building for the whole community. In example 3.5 discussed in Study 2 for example, the boys working on Nate’s lake
scene demonstrated mutual respect for all the participants and joint sharing of tools.

In this example, Ted shared his skills and knowledge to benefit Nate and Norris, but the interchange also provided Ted with a problem-solving application of his existing knowledge. The collaborative interaction in this incident was one of many that occurred regularly in the classroom; such collaboration enriched the whole community of learners.

One issue that Study 2 highlighted was that a collaborative atmosphere and peer mentoring are social dynamics and skills that need to be learned by individuals and socialized into the community’s rules of practice. When leadership changed at the start of the new school year, the mentors had to teach the dynamics of the classroom. Newcomers were unaccustomed to the free/open style of the classroom and needed guidance in self-direction. Some newcomers struggled. Another key issue for the peer mentor was knowing how much information to give and when to stop talking and let the peer absorb or practice the information. In class observations
taken on the first day of the new school year, the researcher noted that the mentor gave out too much information and overwhelmed the mentee.

The community of practice incorporated socialization via the Internet in the form of blogging, forums and chat sessions. The use of these resources advanced the technical skills of those who participated and expanded the community of practice. For example, Ted would pose problems in using Blender and world-wide participants would engage in discussions on how to deal with the issues raised. These interactions honed his skills. In return Ted shared his expertise enlarging everyone’s circle of knowledge and skill contributed to the online VR community.

Study 2 reported that model and simulation building in virtual reality assisted students in exploring concepts that were abstract, obscure, or impossible to experience physically. In turn, these explorations led students to gain a deeper understanding of math and science content. In Example 3.9 from Study 2, the students simulated an invisible presence of electron fields and were able to articulate their understanding of this phenomenon. Study 2 supported the review of
research in Study 1 by providing an example of a technology enriched, project based learning environment. Consistent with the theory and research presented in Study 1, a technology-enhanced, project-based learning environment is likely to be effective, if it has a sense of purpose, has expectations and criteria, and provides for student control at an appropriate level. Also it is effective for student expression through presentations, and incorporates student accountability through an expectation of, and assessment for quality end projects that serve a purpose for real life situations.
Appendix A – Teacher Online Surveys
VR Teacher Survey

Informed Consent Document, Parents and Teachers

Title of the Study: The Dynamics of a Virtual Reality Program at East Marshall High School

This is a research study. Please take your time in deciding if you would like to participate. Please feel free to ask questions at any time.

Introduction

The purpose of this study is to examine the dynamics of high school student’s experience within the virtual reality classroom. This study will focus on their thinking skills, problem solving and learning within the context of the virtual reality classroom. You are being invited to participate in this study because you have either worked with these students in an academic environment or are a parent of a student in the district.

Description of Procedures Your opinions provide valuable insights for understanding what students gain from the program and any problems or issues students face in it. The information you provide will help in understanding and potentially improving the virtual reality program. You were selected for this survey because you interact with students involved in the virtual reality program.

Risks

While participating in this study you will experience no risks or emotional harm. All information will be for research only and will be kept anonymous and confidential. Research results will
be made available after publication of the thesis papers if you would like to view them.

Benefits and Participant Rights
If you decide to participate in this study there will be no direct benefit to you and no compensation given to you. It is hoped that the information gained in this study will benefit the virtual reality program at East Marshall, and other high schools across the nation. By publishing the results of the students’ experiences, it is hoped that funding would be provided for programs such as this one. Only the research team of Teresa Morales, Dr Thomas Andre, Dr. E. J. Bang and Dr. Stephen Gilbert will have access to the raw data and observations.

Questions or problems
You are encouraged to ask questions at any time during the study. For further information about the study contact Teresa Morales at (641) 750-0363 cell, (641) 478-3298 or feel free to email me at tmorales79@gmail.com. You may also contact university research supervisors:

- Dr. Tom Andre, (515) 294-1754, tandre@iastate.edu
- Dr. E.J. Bang, ejbang@iastate.edu
- Dr. Stephen Gilbert, gilbert@iastate.edu

If you have any questions about the rights of research subjects or research-related injury please contact the IRB Administrator, (515) 294-4566, IRB@iastate.edu, or Director (515) 294-3115, Office of Responsible Research, Iowa State University, Ames, Iowa 50011.

If you agree to participate, please click on the "Click to Next Page" button below.
VR Teacher Survey

1. Please list all subjects and grades you teach.

2. How many years of teaching experience do you have?

3. How many students in the VR class do you have as a student in other classes?

4. What examples of virtual reality projects have you seen or used in your classroom?
5. Check the areas of growth you have seen in virtual reality students by being in the program.

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<td>professionalism</td>
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6. Please comment on any positive/ negative effects or advantages of having a virtual reality program at Avatar High School.

7. Has the virtual reality program changed...

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<thead>
<tr>
<th></th>
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<tr>
<td>your expectations of virtual reality students</td>
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<td>your perceptions on technology use in the classroom</td>
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<td>the way you teach virtual reality students</td>
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<td>your classroom climate</td>
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8. Describe any other changes that the virtual reality program has brought about.

9. In your opinion, what are the important aspects of the virtual reality program for student success?

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<tr>
<td>projects based on student interest</td>
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<td>student driven research</td>
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<td>opportunity for collaboration</td>
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<td>opportunity for problem solving and logical thought</td>
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10. Describe any other important aspects of the virtual reality program not listed above.
11. In your opinion, how important are the following aspects to the virtual reality program?

<table>
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<tr>
<th>Aspect</th>
<th>Very important</th>
<th>Somewhat important</th>
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<tr>
<td>A teacher</td>
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<td>An adult monitor</td>
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<td>Internet access</td>
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<td>Presentations for parents</td>
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<td>Presentations for other adults</td>
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<td>A standard textbook</td>
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<td>The newest technologies and software</td>
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<td>Evaluation of projects</td>
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<td>A set curriculum</td>
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12. Do you have any suggestions to address weaknesses in the VR program?

13. Please click the movie link, watch the clip, then answer the questions that follow.

The link will open in a new window. When you have finished watching it, come back to this window to
complete the survey.

>> MOVIE LINK

Questions:

a) What did the students demonstrate?

b) How did the students demonstrate any science concepts learned?

14. List any suggestions to encourage more girls to take this class.
15. When students miss your class for VR appointments, what procedures do you have in place for them to make up the work?

16. What kinds of projects would you like to see done in the subject area you teach?

17. What are your expectations of this virtual reality program in the future?

Thank you for taking our survey.
Your response is very important to us.
For further information about the study contact Teresa Morales at (641) 750-0363 cell, (641) 478-3298 or feel free to email me at tmorales79@gmail.com
Appendix B – Teacher survey comments
Comments from teacher surveys

Teacher Demographics

9-12 Guidance Counselor  dual enrollment Psychology (23 years experience)
(Marshalltown Community College) dual enrollment Sociology (Marshalltown Community College)

English--sophomores and seniors (21 years of experience)
Calculus (12th) College Algebra (11th-12th) Statistics (11th-12th) Advanced Algebra (algebra II) 9-12th grades (38 years of experience)
11-12 grade Foods I and II Design Nutrition DE Human Growth and Development DE Creative Textiles Quilting (33 years of experience)
Art 9-12 TAG 9-12 (12 years experience)

Science (Botany Zoology, Environmental Science), Agriculture (Biotech, Animal Science, Agronomy, General Agriculture, Ag Management, Ag and Society) (5 years experience)
Spanish 9 – 12 (1.5 years experience)
Other changes Suggested by teachers  Date 12/2009

Exposure to educators and law makers and higher levels.
I think it has taken away from our school. It looks good on paper and to an outsider but doesn't seem to do anything.
The kids have little to no supervision and it shows.

It has reminded me that students will rise to the level of expectations.
These students have been given the opportunity to be self-directed and have risen to that expectation.

The biggest thing I have seen is the growth and maturity that the students have demonstrated.
This is even more evident in the students who would not be considered the top students in their respective classes.

More interest in our school district as a whole because we are the leaders in the high school area.

I have really changed the way that I think about the use of the computer in art.
I am currently teaching what I call VaRt. I have an indep. student and one that is taking art foundations in the VR realm.

It also has some teachers frustrated that it is not more fully integrated into the classroom.
I have expressed to students how I wouldn't mind for them to use virtual reality in lieu of other means during a project.
Many of the students have not approached or done this.
Positives and Negatives of the program

It gives us one more option for students to explore. Some schools have green houses. Others have sophisticated shops and labs. We have VR. It's unique but has multiple applications.

Positive - it gets a lot of attention for us Negative - it takes the kids out of class a lot for presentations and has little benefit

The benefit I most observe is the sense of belonging and self-confidence this has given some students who would not otherwise feel a sense of value or academic worth. The program validates their abilities and challenges them.

The students are starting to sign up for more challenging classes to learn the basics in math that they use in the VR room. A disadvantage is that sometimes I believe they spend so much time in the VR their daily work slides a little.

Very positive. I have seen students who were ready to drop out and how were low functioning as well as with low self esteem and they have "blossomed" with the VR program. Their presentations are professional and organized. The students are well dressed and respond to questions from all visitors with professionalism.

I really see the benefit of having it here. A number of the students are very organized, and well spoken.
As with everything you have some that are committed and do things well and others don't.

**Weaknesses of the VR program**

More specific timelines/deadlines and projects that can enhance the learning of other students in our high school. Right now it's more of a secret club.

There should be an actual instructor. There needs to be definite criteria and expectations.

I believe the students need to do the research and work on their own with the guidance of a mentor, not a teacher all of the time. Collaboration is needed in the work world.

I think that the students need to share more of their work with the faculty and staff. I have a working relationship with many of them and know what is going on. Most of the staff does not. I think it would help the perception of the program to share with the school.

Continuing to check up on the students by requiring presentations and project evaluations.
**Important skills needed by students for participation in this class**

We very rarely have Div. I athletes but we do have students with VR skills that will allow them to gain scholarship opportunities that they may not get by other means.

Ability to be a self motivated learner. The students are not hounded to get projects done so they have to be motivated to work by internal forces.

Student ownership and dedication, personal responsibility, willingness to better themselves.

**Comments on Video of student work**

a) Creativity  b) Not really

That they can create different shapes. Not sure that I really see any science concepts other than center of gravity.

Understanding of space, unity, variety, harmony texture, value, form, space, movement to name a few of the art concepts that are evident. As far as science concepts I would only be making an educated guess. I don't know the curriculum well enough.
a) attention to detail, creativity
b) The body was well studied and fairly well put together movement-wise

**Suggestions to get more girls in the class**

Recruit

I think that it is intimidating for them. We currently have a few in the program. I am hopeful that this will lead to others.

Require more good behavior in the class.

This shouldn't be an issue.

**Policy for makeup work when students miss class.**

I follow school policy. It's no different than going to a band contest or athletic event.

If we have notice, they can make up the work beforehand, just as they would do if they were missing for any other reason. The issue is that many times we have no notice or if we do it is very short.
They are very good about completing projects.

They need to take personal responsibility and make up the work on their own time, just like any other student.

They have me sign a make-up sheet beforehand. They are usually very good about making up their work.

Projects you would like to see done or could use in class

A human brain with the parts labeled to be used in my Psychology class.

I would like to be able to have the actual video on my computer. It does me no good if they make something that can only be used in the VR room.

With several students doing what I call VaRt I have a number of things created this year. Anatomical studies, Agricultural livestock classifications and comparisons, zoological and botanical classifications and comparisons
House blueprints, human body for anatomy in Spanish

**Expectations for future success and use**

I'm not sure. I would like to see it be a little more structured.

I would like to see it used more efficiently. There seems to be a lot of time and energy put into it with very little results. Again, a full time instructor or advisor would help. Our administrator does it now and there's little control.

I would like to see them work on several areas and branch out into history, music, etc..

Students would continue to improve their projects, their focus and their self responsibilities.

I expect the program to be more communicative and integrated with the staff. It needs to be more organized.
Appendix C – Parent online survey
Introduction

The purpose of this study is to examine the dynamics of high school student’s experience within the virtual reality classroom. This study will focus on their thinking skills, problem solving and learning within the context of the virtual reality classroom. You are being invited to participate in this study because you have either worked with these students in an academic environment or are a parent of a student in the district.

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If you agree to participate, please click on the "Click to Next Page" button below.
1. What is the first name of your student in the virtual reality program?

2. Relationship to child:
   - Dad
   - Mom
   - Guardian female
   - Guardian male

3. What year is your student in?
   - Freshman
   - Sophomore
   - Junior
   - Senior
   - Previous graduate

4. How many semesters has your student been participating in the VR program?
   - 1-2
   - 3-4
   - Over 4
5. Check areas of growth you have seen in your student because of their participation in the VR.

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<td>Knowledge applied to other</td>
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<td>Subject Areas</td>
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<td>Decline in Growth</td>
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<td>Use of a variety of science concepts</td>
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<td>Professionalism</td>
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6. Comments or examples of any of the above:

7. Please list and describe any other areas of growth you have noticed in your student.
8. What traditional science and math classes has your student completed since Dec. 2008? (Check all that apply.)

- General math
- General science
- Biology
- Physics
- Chemistry
- Geometry
- Algebra
- Algebra 2
- Calculus
- Computer
- Anatomy
- Other (please list) [ ]
- Advanced Placement math or science [please list] [ ]
9. What science subjects has your student integrated into a VR project? (Check all that apply.)

- Electricity
- Solar System/astronomy
- Human Anatomy
- Animal Anatomy
- Physics
- Chemistry
- Archaeology
- Earth Science
- Weather
- Biology
- Botany
- Robotics/Computer graphics
- Oceanography
- Other (Please list)
10. What other academic subjects has your child integrated into VR projects? (Check all that apply.)

☐ Reading – literature

☐ Reading – technical

☐ History

☐ Geography

☐ Government

☐ Spelling/writing

☐ Art

☐ Vocational agriculture

☐ Non-Computer Tech - such as automotive, shop, woodworking, drafting, welding, etc.

☐ Foreign languages

☐ Music

☐ World cultures – sociology

☐ Other (please specify)
11. In your opinion, which aspects of the virtual reality program at East Marshall are important?
(This is a required question.)

<table>
<thead>
<tr>
<th>Important</th>
<th>Not important</th>
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<tbody>
<tr>
<td>Flexibility for student–centered projects</td>
<td>✔️</td>
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<tr>
<td>Allowances for creative thought</td>
<td>✔️</td>
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<tr>
<td>Student interest in technology</td>
<td>✔️</td>
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<td>Parental motivation</td>
<td>✔️</td>
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<td>Opportunities for presentations and public speaking</td>
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<td>Student centered curriculum and lack of one main textbook</td>
<td>✔️</td>
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<td>Inquiries based on student interests</td>
<td>✔️</td>
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<tr>
<td>Student driven research</td>
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12. Describe any other aspects of the virtual reality program at East Marshall that are important to you.
13. In your opinion, how important are the following aspects to the virtual reality program?

<table>
<thead>
<tr>
<th>Aspect</th>
<th>Very important</th>
<th>Somewhat important</th>
<th>Not important</th>
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<tr>
<td>A teacher</td>
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<td>An adult monitor</td>
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<td>Presentations for other adults</td>
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<td>The newest technologies and software</td>
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<td>Evaluation of projects</td>
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<tr>
<td>A set curriculum</td>
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</table>

14. Do you have any suggestions to address weaknesses in the VR program?
15. Comments on any negative effects from your student’s participation in the VR program.

16. Please click the movie link, watch the clip, then answer the questions that follow.

The link will open in a new window. When you have finished watching it, come back to this window to complete the survey.

>> MOVIE LINK

Questions:

a) What did the students demonstrate?

b) How did the students demonstrate any concepts learned?

17. If you would like to be interviewed please insert your name and phone number or email here.
18. Did 2 parental adults or guardians of your student in the virtual reality program respond to this survey?

☐ Yes

☐ No

Thank you for taking our survey.

Your response is very important to us.

For further information about the study contact Teresa Morales at (641) 750-0363 cell, (641) 478-3298 or feel free to email me at tmorales79@gmail.com.
Appendix D – Parent survey comments
Comments from Parent Surveys

Describe growth you have seen in your student.

- Speaking in front of hundreds of people in Washington D.C. Responsibility of working for Rockwell-Collins for the summer internship.-Getting up at 5:00 A.M. to drive to Cedar Rapids or Ames every day.

- S26 came to live with us in his junior year at the beginning of the 4th quarter. He has had multiple homes between both parents (19) and multiple school placements (9). He had issues with leadership, maturity, and connectedness and tended to bond with peers that did not steer him in the right direction. He was placed in VR by Mr. K’s recommendation. It was a very good experience for him. He was in a program with some positive peers and was able to talk about and experiment with a program that he was interested in. It was also an area that provided an outlet for him. It is OK to be "different" in the VR room. There was not a "standard" to live up to. It is also a room with high expectations academically and it is OK to be smart. In fact, putting yourself down or selling yourself short is not common talk in the VR room. In the area of communication and professionalism S26 had an experience that he was not expecting. He was alone working on a program and Mr. K walked in with some visitors. S26 jumped in and started talking about the program, which is not something he would have ever thought about doing before. Sure, he had to speak by default, but afterwards he told me "you know it wasn't as hard as I thought to talk in front of others". He was also embarrassed by how he was dressed, old jeans and a T shirt. I was proud that he finally recognized how his appearance created an impression and that he stated he would have liked to have been dressed differently had he known he would be presenting.

- I am especially appreciative of the opportunities that S9 has had to expand on his presentation and public speaking skills. Being able to effectively communicate is key to both business and personal endeavors. Every opportunity to speak publicly increases his confidence. He has also learned the importance of finishing tasks and learned elements of project management.
• VR is a self directed; self motivating type of class and that creates an atmosphere of where S12 has shown the maturity to get things done without supervision. Much like the real work world environment. VR has also afforded him the opportunity to visit the real work world on some of the field trips to industry they have taken.

• When S32 took his required course at MCC on computers his instructor made the comment he could probably teach the class because of his experiences in the VR classroom. I amazed at how well he can navigate many different programs and systems.

• Self confidence has grown.

**Other growth seen in your student**

• S26 is a very bright and caring young man. But, because of all the adversity that he has experienced over his life he has built up a wall around himself. He liked to present himself as arrogant and a Mr. know - it - all. Of course, this was all a front because he felt safer not letting his true personality come out. The VR program has assisted S26 in "fitting in" with students that do not require him to be anything but himself. This is especially important because in a small school a lot of the students have gone to school together for many years. Once these friend groups are formed it is sometimes hard for a newcomer to be accepted, especially at the end of his junior year. That was not the case with this group of students.

• S9 has also had an opportunity to learn valuable citizenship skills. There is an added responsibility to act responsibly based on the trust that Mr. K places in the VR students.

• Participating in VR has opened up more options for career opportunities for my student. She now is exploring careers that are in the VR field.

• Confidence in his ability.
Other suggestions or comments you have concerning your student in the virtual reality program.

- Have more emphasis placed on making applicable connections to student projects and real life applications. Not just a glorified video game.
- The ability for young people to experience something that will make them very marketable in the job market. It just might be the one edge that an employer might look at.
- Exposure to how the real world uses VR and what careers opportunities there are.

Weakness you have seen in the virtual reality program.

- Some of the students in the VR room do not take the program very seriously. These students are very distracting to others that are trying to work. This is especially true for students who tend to lose attention easily. Although, these easily distractible students are usually the most creative and can think outside the box.
- Possibly more frequent adult monitoring.
- The school needs to be careful about how high to set the expectations for these students. They are all very bright and motivated students but they are not geniuses either. Excessive pressure can lead to burnout. A careful balance on pressure needs to be kept.
- Include rudimentary programming classes such as C or C++

Negative effects you have seen in this program.

- Having S26 learn how to self pace and not procrastinate. He has not had much experience with this prior to coming to this high school. Because of going to so many other schools he easily gets the "why try" attitude.
• I do get frustrated when my student wasn't productive during her time there because there were not enough computers or equipment (mouse) so we purchased our own so she could be sure she always had one. Also, we have experienced problems with virus sharing between home and the school. We virus scan everything but she continues to bring them home after VR.

Comments on student work in the video

• I saw cylinders of an engine a tram movement inside of castle.
• The students demonstrated how they could visualize and create images in 3-D. The images were of varying subject from motor pistons to touring a castle. There was also a tornado in motion that was very interesting. The students demonstrated a multitude of concepts. They first had to visualize the image in their minds and then use mathematical and science skills to create their vision in the computer. There were also the concepts of vision and movement.
• Their ability to start with a dot, create objects and make them seem to move. I have no idea how any of it works. :)
• The video had a. animation, texturing, modeling, magnetic effect (bullet train movement), wind patterns in a tornado, etc. b. virtual reality demonstration.
• There was 1) a working rotating machine 2) a moving transit system 3) tornado 4) a castle
• Ability to create from a visual image a computer model that is displayed in a realistic view. Demonstrate knowledge of the software, creativity, ability to make a visualization come to life. This had to take a lot of time so that demonstrates dedication and time management skills.
• I was not able to pull the movie link up.
• The many applications of virtual reality.

Nov. 2009
Appendix E – Transcribed video-recordings
Interview S1 and S2 about invention and math theorem

S2: Well, S1 and I were talking to Mr. K about our invention and he mentioned it to the superintendent. So Dr. M. asked if we could make the mirror smaller to focus the light beam to make a death ray.

S1: Yeah, like Archimedes’ death ray…Mythbusters proved that to be wrong though.

S2: ya I saw that episode. So S1 and I were talking about it and we came to the conclusion that Dr. M’s question was improbable with mirrors. So I kept thinking about it and decided I needed to know about the properties of mirrors and the properties of lenses.

S1: We thought the two mirrors would not work because we could change the circumference but not the height. It would make an image taller but not focus the light to a straight line beam. The mirror focus changed. So like on Mythbusters they were using bronze shields to try to blind the enemy.

S2: But the bronze was not shiny enough and neither are the mirrors. We discussed using lenses instead of mirrors or maybe even both.

S1: We guessed that the mirrors would focus the light into one spot and the lenses would take that focused light and compact it into a beam.

R: So you had to use both?

S2: We think so. And lenses allow UVA and UB rays to come through to make the ray more powerful. So I kept thinking about it and asking questions. I even used quadratic math equations and math equations for parabolas to try to figure out the answer to focus the light to get a beam. Nothing came to me. Then I began to draw diagrams of rays of light and how they angle when they hit the mirror and the angles they reflected off.

S2: I kept asking myself questions and thinking about answers until I came up with my theorem.

6/13/2010
Interview with S1 & S2

R: First of all tell me what grade you’re in.
S1: We are seniors

R: How many semesters of VR have you had?
S1: This is number six for the both of us.

R: Why did you choose this class?
S2: To try something different.
S1: Yeah, it was in the morning announcements that they gonna start a VR program so we were like yeah ok we’ll go. So we went to a couple meetings checked it out. We liked it.

R: Have you seen growth because of your participation in VR in academics?
S1 & S2: yes

R: Maturity
S1: I’d like to think so
S2: Yes

R: Responsibility?
S1: Yes
S2: definitely

R: Reading Skills?
Ty: No
T: But you’re reading technical manuals so…
S2: Technical reading.
S1: yeah, technical reading

R: I’m not saying your enjoyment in reading… but you use it more?
S1: yes

R: How about public speaking?
S1: Yes
S2: Very much so.
R: Give me an example of where you have spoken publically.
S2: Well we had to speak to you.
R: What about any senators?
S1: We had to go to congress. Yeah, we talked to them.
R: Departments of education from where?
S1: From Iowa.
S2: South Carolina
S1: Yeah we met with the director there
R: Foreign countries?
S1: Yeah from India
S2: third in line
S1: third in line to the throne of what do they call him
R: the king or…
S2: he’s third in line to take over the country
S1 he’s in charge of everything
R: what about growth in self esteem?
S2: yeah
S1:yes
R: more confidence?
S1: uhh….. I didn’t really have a self esteem problem
R: What about critical thinking?
S2: yes absolutely
S1: I think critically of most of the people here.
(both laughing)
R: What about critical thinking in your projects?
S2: No my projects are all way too good
R: What about math concepts? What about growth or maturity in math concepts?
S2: defiantly growth
S1: no maturity
R: what kind of growth in math concepts?
R2: can you give an example of what you should apply to...
S2: I made my own math theorem.
R2: You did!
R: so tell us about it.
S2:.......nay....
S1: yeah tell them.
S2: It’s the S2 theorem of parabolic focuses. Not foci. Focuses. Basically the way it works is you use the derivative and I probably lost you both right there… you use the derivative to find the focus of a parabola.
R2: Parabla?
S2: yes
R: so what have you discovered with this. Does It work?
S2: yes it works
R: how could you use this in practical life?
S2: you can use it for the focus of mirrors. They sometimes use the focus length for mirrors in car headlights. They put the light directly on the focus so that the light shines..
R: Have you taken this to your math teacher?
S2: yes… he said it works
R: have you tested it in VR
S2: no…not yet but you probably could
S2: Well, S1 and I were talking to Mr. K about our invention and he mentioned it to the superintendent. So Dr. M. asked if we could make the mirror smaller to focus the light beam to make a death ray.
S1: Yeah, like Archimedes’ death ray…Mythbusters proved that to be wrong though.
S2: ya I saw that episode. So S1 and I were talking about it and we came to the conclusion that Dr. M's question was improbable with mirrors. So I kept thinking about it and decided I needed to know about the properties of mirrors and the properties of lenses.

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S2: But the bronze was not shiny enough and neither are the mirrors. We discussed using lenses instead of mirrors or maybe even both.

S1: We guessed that the mirrors would focus the light into one spot and the lenses would take that focused light and compact it into a beam.

R: So you had to use both?

S2: We think so. And lenses allow UVA and UB rays to come through to make the ray more powerful. So I kept thinking about it and asking questions. I even used quadratic math equations and math equations for parabolas to try to figure out the answer to focus the light to get a beam. Nothing came to me. Then I began to draw diagrams of rays of light and how they angle when they hit the mirror and the angles they reflected off.

S2: I kept asking myself questions and thinking about answers until I came up with my theorem.

R: what about oral language ability?

S2: yes

S1: yes (students goofing off after a long day of presentations and interviews…they were laughing and sort of goofing off.)

S2: yeah, you are in this interview too.

R: What about written language ability?

S1: Written language ability?
R: Can you write proficiently…
S1: yeah we had to write some contracts for Rockwell Collins.
S2: yes, I would say yes on that.
R: what about leadership? You guys are the seniors have you shown any leadership to the under classmen?
S1: on how to mess up their lives maybe.
R: do the underclassmen come to you for advice?
S2: yeah we throw the book at them.
R: the blender book?
S2: yes the blender book
S1: unless they’re more advanced than us likeS8. He’s crazy good.
S2: yeah if S8 asks us something about the game…we would be like dude…you know more than us.
R: what about peer mentoring. Do you take the underclassmen and say here I’ll show you how to do this project?
S2: No
R: Transferring of other subjects? Have you found growth in that?
S2: transferring of other subjects?
S1: What do you mean by that?
S1: like school subjects?
R: no, say you have learned something in another subject, let’s say you learned something in a science class and bring it to virtual reality… or life also…or from English class to VR.
S2: And I can say yes for both of us. We are transferring what we do in virtual reality and trying to make our invention.
R: Great! (Students requested not to be asked about their invention because they want to keep it confidential.)
R: How about citizenship?
S1: I've been a citizen my whole life. (Laughing and acting silly. They were not disrespectful just providing comic relief after a long day)
S2: me too
R: (laughing) What about a use of variety of science concepts?
Have you grown in using science concepts? (The students in the room who were not in the interview were goofing up and trying to get the seniors off track. The whole room burst into laughter and giggling. Students being interviewed lost control and were embarrassed, and laughing out of control)
R: OK here is the next question. You guys are not taking this very seriously.
S1: It is hard to do it with an audience.
R: Next question, in your opinion what are the top three reasons why virtual reality is a success?
S2: visual learning … (More laughing and strange looks to other classmates)
R: Or is it not a success?
S2: It is a success…
S1: it's successful…
S2: I would say it is a success.
S1: YES! I would call it a success… (Laughing and shaking their heads)
R: Ok but you have no reasons for your success.
S2: self learning…the fact that is more visual, people are more visual students, and probably the exposure of the game industry.
R: give me some problems with virtual reality either the classroom or…?
S1: not everybody can think in 3D
R: Explain that.
S1: like the math teacher upstairs has a strictly 2dimensional mind.
S2: another downfall is that there are often distractions (heavy emphasis on distractions) (more audience laughing).
R: if this was your program and you could direct it any way you want what would you do to improve it?
S1: I would only allow certain people in VR. *(laughing)*
R: Ok Mr. k does that so what else?
S2: I would be stricter on that.
S1: yeah stricter.
S2: I would probably try to get more books.
R: Blender books?
S2: Right now I would much rather have the brand new Blender.
R2: You only have 1 book?
S1: we have three.
S2: we have the animation one, the blender essentials, and the…thick one…the Blender manual.
R: what about having more text books… like an anatomy book or reference books?
S2: Well I guess…is that we can get those by going to classrooms. I guess that’s the reason we don’t have anything for that. I noticed Mrs. C. has a giant…bookshelf. She has a bunch of books there for reference.
R: what about the equipment you would want to have in here?
S1: funding would be amazing.
S2: Oh yeas funding.
R: that’s what this research is trying to do is to get money.
S1: I know but we don’t have it right now.
R2: Have you participated in things to get money?
S1: most of it has to be done by Mr. K to get grants but so there isn’t really anything we can do about that.
S2: just about the only thing we can do is to show that it’s a success we’re doing just perfectly and that’ll be the best way for us to help get the money.
R: one student mentioned a body suit…
S2: a Mocap?
R: yeah it has sensors on it...
S2: yeah, It's a Mocap …a motion capture suit. It’s what they use for animated movies sometimes. They’ll have these suits with the little balls on them those balls are for IR (infa-red lights)
S1: they reflect IR.
S2: they reflect IR and they have lights that emit IR …and they have red lights that bounce off the balls… they can use it to tell where that part of the body is. So they lift the arm and the character in the computer program lifts its arm.
R: so if you had a suit like that that would benefit the program?
S2: oh yeah it would defiantly help with a lot of the animations.
R: what about if you had a larger room or one of those flex rooms or a cage?
S2: it probably would help a lot. It would help with the immersion instead of having just one screen.
R: give me your ideas or feelings if you had a teacher in here how the concept of the classroom would change?
S1: your education would be limited by the knowledge of the teacher.
S2: yes, because the best part about this class, I would have to say, is the fact that there is no limit. We can learn as much as we want.
R:I know that a lot of time in this class room people will be goofing off or playing as I call it…
S2: yes there is goofing off…
R: what do you guys think of that?
S2: it depends on how out of hand it gets…because a little bit of sitting back relaxing tossing something up in the air, something inexpensive…very inexpensive …fine. But breaking chairs and all that …that could be bad.
R: from what I’ve seen already people say it’s very important to do that kind of stuff.
S2: yeah work is good, but ...it’s like I was saying, all work and no play, makes Johnny a dull boy.

**Laughing from crowd....**

S1: what?

S2: I know is it makes Jack a dull boy but I was thinking of Here’s......Johnny.....

R: (laughing) that is right.

R: how do you guys evaluate projects?

S1: Mr. K does that.

R: do you ever evaluate your own project?

S2: yeah I get a perfect every time.

R: cool because you are so bright and brilliant right?

S2: Oh yeah.

R: How do you come up with that it is bright and brilliant? (laughing)

S2: I put a lot of bright colors into it.

S1: and brilliant colors.

R: how do you decide it’s a good project?

S1: most of them are artistic and ....like artistic parts of it are... whether you like certain shading or stuff to make you be able to see it well. Sometimes its relevance whether you need something in there or not or whether it just looks dumb and out of place.

R: so as you’re going through your project you say this piece is not relevant so I’m going to take it out.

S2: yeah

R: Do you ever have any one access your projects and give you feedback?

S1: Yeah, people tell ya all the time it sucks.

S2: They always tell you it sucks...they never say OMG...that is so amazing.

S1: No matter how good it really is.
S2: And I think the main reason for that is because they are trying to push us. Ok it sucks let's see what I can do to make it better.
R: Another student said that this type of class will not be realistic to the real world. Do you agree with that or disagree?
S1: I disagree to a point.
S2: I disagree… I mean yes maybe…when you go through work they won't have machines like this…maybe they won't have all this virtual reality technology… but the thing I think that we should be walking away from herewith… is the ability to teach yourself, to go farther and learn more by yourself, problem solving and all that. Not so much what you are directly learning but the skills.
R: Ok, good answer. What about you? (S1) You disagree too?
S1: yeah, because students have their own…they have their own push for things that they want to learn, but if a student … it is a yes/no sort of thing. Because students that don’t want to learn are necessarily going to learn. That is the whole reason why this (virtual reality) survives. Because the kids are interested in it, just the same as if you had a kid interested in art class, they are not going to ruin that art class because it is something they want…ya know to keep going. And so if…if a student does not try very hard, or if they just don’t care… ya know it is going to show and it is going to be the difference between whether the program survives or not.
R: Will it help you in business because this VR in not the way things are done in business.
S1: It is because you don’t have your boss always looking over your shoulder.. You don’t always have the rules in front of you so you know what you can and cannot do.
S2: It is. You don’t always have someone telling you every single step of the way. By the way this person…can we get his name…
R: (laughing) noooooo…
S1: I have a couple friends that will take care of him.
R: I told you identities were in confidence. Just like everything else that goes on in this class.

R: What skills would you take into a business by having taken this class?

S2: basically problem solving skills

S1: independence from a teacher and the ability to work in a group.

R2: Believe it or not those are very important skills that all businesses require…and creativity and inventiveness.

R: Any other things you guys would like to say.

R2: How would girls change the dynamics of the class and why aren’t there any girls?

S1: girls are intimidated and intimidating…

S2: (both laughing) yeah. I am not sure which is more right now but I think it is more intimidated…

S1: yeah cause there are none but when we did have a girl in here, she was kind of…she joined in late…she was behind everybody else… and kind of not exactly wanting to…

S2: push herself so far.

S1: so she didn’t push up to the level of where we were at…at the fear of not doing as well or something.

R: Do you think the girls have an understanding of what virtual reality is? What takes place in this class?

S2: yeah, I think…

S1: some of the girls don’t even know it is here.

S2: I have had that a couple times they walk in here and say what is this room or what is this virtual reality. What? What's that? I think that once they do know it is here and it is a bunch of gaming and all that. It’s not. It is more than that.

R: When you had a girl in here did the other guys work with her and talk with her?
S2: They would not make fun of her, but really she kind of wanted to be independent and she was one of the ones that probably would never ask us anything even if she did not find it in the book.

R2: So she was not getting involved with the guys?

S2: yes, she was the one who was sticking to herself…and she didn’t really push herself. I think that was probably one of the reasons she dropped out. She had a scheduling conflict but…also maybe she didn’t really get as far as us and that intimidated her.

R: Did she feel like she was a part of the group?

S2: maybe not. The guys were not pushing her away, no.

R2: What is this called? (VR machine)

S1: A VR machine…to project things, basically.

R: You guys have any other comments before I turn off the camera?

R2: You two are the wonder boys. I can’t wait to see what the underclassmen will do in the next couple of years.

S2: See that is another thing I like about this class is really when we are out of here …they are going to progress so much farther than we have. It is not like when in other school classes..Ok we’re going to learn this and we are going to teach the exact same things every year. It is going to progress better. It’s like we have real life.

R: exactly and whether you guys know this or not you 2 have set the foundation for this and now the other guys have high standards to reach.

4/12/09
Interview with S22F

R: What is your name?

S22: .....

R: You are a junior.

S22: Yes

R: Are you interested in taking a VR class?

S22: I might be. I don’t know. I don’t really know much about it, that’s probably why.

R: As a girl what is your perspective of Virtual Reality …by knowing it from the outside.

S22: I don’t know it seems like a boy kind of thing to do. Lot of boys, things ….as I see it.

R: Is it more like taking auto shop, would that be a good comparison.

S22: yeah, like welding….or something like that…mechanical.

R: Have you taken a lot of computer classes or do you know how to use a lot of computer programs?

S22: I’ve taken computer apps but I’m not very …. Like I what I do on the computer is pretty much face book and social stuff I guess.

R: Do you ever use PowerPoint and those kinds of things?

S22: I have done PowerPoint before for presentations that is about it?

R: What kind of technology do you use? I mean most teenagers have IPods….

S22: I have an IPod, a cell phone, computer that is pretty much it.

R: What is the biggest thing that keeps you out of this class? Is it because it is full of all boys?

S22: More that I am scared that I would not know what I was doing and I would look stupid….but….other than that.

R: One of the big things that I noticed about this class is that the boys talk to each other and they help each other. Would that be something you would be comfortable with, if you were the only girl in this class?
S22: Yeah I think I would be comfortable with that, because I know all the guys pretty much in this class. We're pretty good friends. I don’t know they might make fun of me more because we are such good friends.

(Laughing)

R: Like boys do at times right. What are our plans after high school?
S22: I'll probably go to MCC (Marshalltown Community College) and take my core classes and decide my major, then transfer to a university.
R: You really don’t have I want be this or this?
S22: No not yet
R: That is ok you are still young. What kind of science classes have you taken?
S22: I am in chemistry right now but I’ve taken biology and physical science my sophomore and freshman years.
R: What kind of math classes have you taken?
S22: I am in advanced algebra right now. I took algebra and pre-algebra.
R: Wow you are a smart girl if you are taking advanced algebra.
S22: Well actually I am a little bit behind; I will take geometry next year
R: If you design a VR project what kind of things would you want to do?
S22: I really like…after looking at S20’s project I really liked his video games and I know S8 does some, I think those are really cool. I would like to design the characters for video games.
R: So you would have fun designing the characters and putting the games together? …That kind of thing?
S22: Yeah, but I just don’t know how to do it. So it is intimidating for me.
R: What about… I also thought about a fun project would be taking a game like guys do when they create their dream team they take their favorite sports teams and players and make a team, and since you have basketball experience would that kind of project interest you?
S22: Yeah that would be fun.
R: take the girls basket ball team and show everyone’s stats or something…
S22: yeah show the things she does or maybe plays or something like that.
R: I think it would be fun to see if your dream can actually do what you want them to
do.
S22: that would be cool.
R: What other sports are you in ... volleyball?
S22: well I was in golf but I am not doing that any more, pretty much just basketball.
R: So you could do VR games of basketball? Maybe golf.
S22: yeah and other sports. I like other sports I just don’t play them.
R: Next year as a senior will you have time to schedule this into schedule?
S22: um….that is a good question, I might be able to. Is it 8th hour? (Turning to
friend in VR class this year) it’s any hour. So yeah I might have time. I’m still kind of
undecided.
R: If you had a program or something that would pay you or compensate you
somehow to take this class would you do it? Would that be a good motivator for
you?
S22: Yes and no because if someone was expecting me to do really good it would
be like more nerve racking…but then it would probably motivate me too.
R: Anything else you would like to say? Any other opinions you would like to add?
S22: No that is pretty much it.
R: Thanks.
Observation and interview #9

S21: I am working on a thing for environmental science, a group project for …where we are taking a sphere and trying to make the terrain and all the elevations of the continents and stuff….and we are going to show what would happen during global warming.

R: that is great. That is a very hot topic….pardon the pun.
S21: and we want to show the areas that would flood if the ice caps were melted.

That is our end of the year project for environmental science.

R: Are the VR students doing another parent presentation day?
S21: I am not sure.

S16 (F) (interview a girl who was hanging out in the VR room, not a participant of the VR program)

R: What do the kids in VR do in here?
S16: What do they do…
R: yeah
S16: they do absolutely nothing.

R: Have you come in and watched any of their projects?
S1: no, well his project …that is about it. He’s making …. What are you making?
S12: DNA
S16: yeah that is it DNA

R: Okay S16 as a smart girl…and an artistic girl….if you had the opportunity would you take VR?
S16: maybe, I don’t know.

R: why didn’t you take VR this year?
S16: because I want to leave early.

R: You want to leave school early or graduate early?
S16: school early, I can’t fit it into my schedule and take all the classes I need.

R: If you had the time would you like to do VR?
S16: No. too much testosterone.

(Laughing an comments from boys in room)

S16: Way too much!
S16: I would need someone else to come in with me.
R: Another girl?
S16: yeah
S16: you get female bashed so bad every day all the time.
R: So the work would not bother you?
S16: No the company I was in.
R: Do you think as a girl you could do a DNA model or learn how to use Blender?
S16: yeah that is no problem.
R: What do you think the other girls think of the VR program?
S16: I think everybody talks about it.....they think the boys get to goof off all day.
They don't really do anything.... Except you hear about S1 and S12 every once in awhile. It's like taking Home Ec. so I can pass this class and go on. If they had another room.....like a female and a male room.....then it would be ok.
R: from a girl's perspective what kind of projects would you do?
S16: From a girls’ perspective....
S12: how about a horse.
S16: a horse for who. I'm not sure....
S12: it doesn't have to do with anything....just a horse.
S12: S16 you mean a horse butt.
S12: no there is a whole horse.
(laughing off camera)
S16: nice...
S16: I don't know. I could do art with it.....something artistic.

(Another girl walks into the classroom)
S16: another female.
R: I am doing an impromptu interview would you like to participate?
S17: of course.
R: I basically want to know why there are no girls taking VR and I want to know a
girls opinion about VR?
S17: I don’t have enough class periods in the day and I am not interested in it the
same… computers the same way the boys are. I am not interested in the work they
do. I am a more of a human interaction type…
R: From your interests what kind of projects would you do if you were in VR?
S17: If I was more interested I would probably would ….i would be really interested
in people… I would want to do a lot with movement..
S1: like make movies and…
S17: yes
S1: plays and TV shows?
S17: yeah
S17: I like theater
R: Shakespeare?
S17: no I would do my own theater.
R: do you feel you are smart enough to do some of the same things the boys are
doing?
S17: yes I just don’t have an interest.
R: Do you know what the other girls think about VR?
S17: I really don’t talk to the other girls about it…. There is basically no opinion.
R: S16 told me that if there was a separate room for girls she might be
interested…Do you follow the same idea?
S17: I really don’t. no. I don’t mind them as much…
S16: you don't mind the bashing you every day because you are female?
S17: No
S16: we want in here and they are like uuuggggk.
S17: That is ok I know I am better than that.
R: good for you.
R: Is there any other comments you have?
S17: I would really be interested in the robotics stuff. Like robot wars …that is really cool.
S16: yeah … like the IT stuff that they do in here I would be more interested in that than virtual reality. Only because when you go to districts and stuff they feed you.. and you get to see a bunch of new people. That’s cool.
R: What are you two going to do when you get out of high school?
S17: I am moving to UNI in Aug and I was thinking about voice education and theater….or I really like politics and I was thinking about doing something like a lobbyist or being in the Peace Corps. Where ever my advisors take me.
S16: I like psychology and stuff so I was thinking social work… but I am not really sure. I really want to do something with like abortion or …human trafficking. I want to fix controversial political issues. You know there are countries out there that sell women and let abortions happen …..it is a demand… like in China they make you no matter what. That is wrong. I realize their population is big …let them have more land I don’t care.
R: knowing where you are going for your futures what kind of VR projects could be associated with your career choice?
S17: As a lobbyist probably in advertising…or presentations I would have to give or to other political leaders would be useful. As an educator I could probably do the same things but with education and in theater it would be really great for staging …you could do amazing things… I saw around Shakespeare Theater where you could walk out onto the stage and it rotated. That is awesome.
S16: as far as the social aspect like the psychology and stuff like that… you could make educational videos, explaining different things from what goes on in your brain
...to other humans interacting and as far as the business aspect goes ...again for advertising, or even like ... I don't know. Never mind.

Date 3/27/09

**Observation 6 and interview S13**

R: Yeah that's like the bible *(blender manual)*, if you haven't opened it up yet you're going to be struggling.

S12: Um no, this is the first actual brick wall that I have run into. Usually I just play around with it till I figure it out.

R: Oh so you're pretty good about what buttons do what.

S13: It's just the more I experience it, the better I can do it.

R: Would you say that you are more of a hand on kind of learner?

S13: Oh yeah, most definitely.

R: So you don't really like the sitting in the class lecture kind of thing? You would rather be playing with it and thinking.

S13: I have to be able to see it or mess with it. Most of the time I mess with it.

R: So that's why VR is so valuable to you, cause you can actually mess with it and do it?

S13: Yeah.

R: So what projects are you working on, what is this?

S13: What I'm trying to do is get more into the heart process, to get it to pump and see how it works. This one I was working with a sphere, just seeing how well it condenses and stuff.

This here *(liquid on computer screen)* in the middle would be the fluid. This right here *(blocks on the computer screen)* is supposed to represent the heart or the muscle. Right now, it needs to be smaller because the water is seeping through the obstacle. It's all jagged. I have to figure out how to fix that to make it *(water)* move more freely.
R: Was your project the one that Mr. K was evaluating the other day? There were two squares.
S13: Oh yeah.
R: So this is an extension of that?
S13: Yeah. This one is more tinkering around with the actual process of it. I also have another one that models the heart…getting that all set up… so when I do figure this (the water motion representing blood pumping through the heart) …I can just make an animation and fill it with water.
R: OK you are basically doing this heart project in steps? You have to figure out this thing and if you get bored you go do something else and then come back to this….Is that how you are doing it?
S13: yes, it is like a puzzle you have to figure out how all the pieces work…that is how I do it any ways.
R: What grade are you in?
S13: I’ m a junior
R: What science classes have you taken so far?
S13: physical science, biology, at the moment I am taking environmental science.
R: What math classes have you taken?
S13: pre algebra, algebra, now I’m in consumer math. I didn’t do so great in algebra so I didn’t want o risk all the stress of Algebra II.
R: yeah sometimes math can be intimidating.
S13: yeah I just wanted to do life stuff that is why I am in that.
R: I was intrigued by the VR because many of the projects I have seen…like your project…. A heart pump…you are not going to get this kind of stuff in an anatomy class and what you are learning would be a pre-med student… so you are actually learning stuff… that is probably 5 or 6 years into college.
S13: I want to get into the medical field of some sort.
R: Do you want to be a doctor …or what?
S13: I don’t quite know yet…at one point I wanted to be a biomechanical engineer or I mean biomedical engineer…that is where you put robotics along with prosthetics…and get more into the robotics part. But then there are times I could be a surgeon in the ER …or something where you see things you don’t get to see every day.

R: I have the feeling that because you have this experience it will take you a long ways in the medical field.

S13: I hope so

R: My suggestion to you is see if you can get college credit for this before you graduate from high school because it will really help you on your path to going somewhere in the medical field.

S13: I hope I can some credit.

R: So what kind of frustrating things have you encountered…. Now you are having problems with?

S13: I worked with armatures when I first began … I don’t that kind of seemed easy once I played around with the settings and stuff…and now I am working with fluid system, I don’t know it is all going good., except for now. Right now I am trying to figure out what is going on with this water system and how to fix it. Armatures, they deal with animation and stuff… that is like the whole skeletal…construction of animation.

Date 3/17/09

Observation # 7 and interview S14 & S20

S14: I am working on a bull riding simulation. Right now I am building a bull riding ring and I am working on the gates right now. That is why I have this curve right here. I want to get the actual gates they use in bull riding.
R: why did you choose that? Is that something you are interested in?
S14: I do bull riding and it is something I really like to do…no one else has done anything with it. I figured if I can put this into 3D imaging and everything it would be pretty cool if a first person riding it.
R: cool. That right there is that part of the bull.
S14: No that is going to be part of the gate.
R: how exciting. What do you want o accomplish form this project?
S14: How it feels to do bull riding. I want to simulate bull riding.
R: Can you simulate broken bones? (laughing)
S14: yeah that would be pretty cool.

Date 3-17-09
R: what about you what are you working on?
S20: I am just working on a little sul de sac. I just started it yesterday …2 days ago.
R: What grade are you in?
S20: I am a junior.
R: What is the main goal for your sul de sac?
S20: I am… I don’t know if S14 is gonnna help me on it but … I am going to have a little Lego guy…walking around with a flashlight…like a policeman or something. My educational projects are over there on that computer.
R: what is it?
S20: I’ll go over there and show you. This is a … here is your given information…and what you are supposed to find, this gives you all these formulas (geometry problems like area of a square and triangulation)…and you are supposed to find all these things on your cube. It gives you the formulas and stuff then you put it in your game engine. Then you rotate the cube to actually see all the different sides, look at the area…surface area…and actually see why it is what it is. Then you
have density…I am still working on that one because I need to like ... be able to see on the inside…

R: wow so this is definitely a math and science cube. Was this and educational project for one of your teachers or just something you wanted to do?
S20: well it was one I used for my the educational for this class and I think what I am going to end up doing for a different class… like chemistry… is maybe doing magnesium atom, I had one started up over there but…swooooosh (vanished)…. Something happened to it.

R: yeah that is the way life is stuff happens. This is really cool though. So you can actually see inside of it, I put it in a wire frame… (switched views now looking at inside of cube)

R: and you are still looking for the same things …like the area of a square…
S20: ya it still show everything that you were given in your first exercise (volume, area, etc)

R: Oh that is cool. Did you actually work those math problems out?
S20: yes… but this (3-D cube) came off the top of my head…

R: what kind of math and science have you had?
S20: I went through Algebra, Algebra II, and right now I am in Geometry. I started out with a little bit of trouble in geometry this semester but…I am working back up.

R: Working in VR help or not with geometry? Could you transfer between the two?
S20: ya for me I don’t know why but it took a little bit longer to actually start seeing everything better…cause I was failing…then Mr. k and I had a little talk and then 3 or 4 days after that….it just started all coming to me…

R; do you think that because you were working in VR it helped you visualize what you were learning in geometry?
S20: YES, Yes, Yes a lot better seeing it. I had to reach a point where … I do get it…

R: so you needed to make the connection?
S20: yes I had been working with it all along…
R: so you made the connection form VR to geometry?
S20: yes.
R: so did you tell what kind of science classes you had?
S20: no, I have had physical science, I’ve had biology and I am currently taking chemistry.
R: next year will you take calculus?
S20: Actually I am going to wait until college to take calculus. I honestly don’t feel I am ready for that.
What science class will you take next year?
S20: I probably want to take human growth or … maybe…honors chemistry. I’m not sure. Chemistry is pretty hard for me right now.
R: but it sounds like you are able to apply a lot of this stuff to the VR and it is helping you anyway so if you do that… what was it?
S20: magnesium atom.
R: if you are doing that… that is pretty intense.

Date 3-17-09

Observation # 8 and interviews
R: The book you have in front of you is an Anatomy book?
S12: This is our regular biology book. This is it the section we are on right now. …genetics…genes and heredity and all that.
R: This is what you are doing on the screen right? (Creating a DNA molecule)
S12: what I am planning to do is that I will start with… the basic model …how it looks in the book, so you can tell what all the pieces are. You will be able to zoom in and out. It will be more complicated and uncomplicated when you zoom in and out.
R: How do you think this kind of project would benefit society?
S12: It will kind of let you look at a virtual model of what DNA would look like and explore… you know how these bonds match up instead of just a boring …picture.
R: Could you create your own human being?
S12: oh yeah right.
R: Do you find the subject of DNA and genetics complicated?
S12: I think, yeah, it is pretty complex stuff….
R: Is it pretty intense?
S12: definitely
R: What is your project?
S20: a game…basically you start at this end of the platform and try to make it to the gold platform… and you have this wall that is trying to push you off… it goes over here and kind of snaps back. You go to the start point…and just make it through…watch out for these walls because they will hit ya. It a maze you have to go through and avoid all the obstacles and the things trying to push you off.
R: What is that black ball you keep bringing up?
S20: the start point… my camera is set to that.
R: Now when I come in here most of you are working on computers but when do you get to work on the big machine?
S20: I myself don’t know how to use it…that is more like S1, S2 and those guys…usually we use it for presentations or when we are trying to put something in stereo.
R: do you learn to use that later in the semester?
S20: You learn it when you are ready to learn it.
R: you don’t do most of your projects in stereo?
S20: I don’t. But usually S2 made a water molecule and S13 made that heart. I usually don’t put it in stereo. Here is my educational project and I mean just for visual purposes… you can like actually…
R: this is the math cube I saw the other day.
S20: you can rotate the block around and you might be able to see it better on that machine… if it was in 3D…
R: I can see how this one in 3D could help people understand math better…
S20: Yeah actually visualizing it… (density of a cube, volume and surface area of the cube) …that is what I had problems with… actually seeing it.
R: After you did that project… did you find that you were able to understand the deeper concepts of math…?
S20: I could understand math ….not just putting numbers in a formula..Definitely visualizing helped me with it.
S1: cool game
S20: ya you have to make it behind the wall.
S1…..awwwwww
S20: yeah it is tough…that is the 5th time I have done it…the new guy, he got it the 1st time he tried it. He’s a guru or something.
S1: (laughing) you can’t beat your own game.
R: with this game what kind of thinking skills, math skills, and science skills are you using?
S1: strategy
S20: yeah strategy mostly… *!$####
R: run and dive mostly
S20: yeah basically…… this sucks…
R: (laughing) you are the one who created it.
S20: Yeah that is the sad part about it.
R: give me a little back ground for what you used to create this game?
S20: It is made up entirely of rectangles…geometry…and I have a little sphere over here…but other than that… just one square.
S20: The reason I choose rectangles was because you can elongate them and they don’t have to be as tall either. That is pretty ideal for fitting through this little door right here.

R: the white checkerboard is that where you fall off?

S20: no….I don’t know really what it is…it’s where you start off at…the building grid…when you build stuff.

R: the background of what you are building on?

S20: yes, when you start Blender.

S12 working on DNA replica

S1: How are you going to get it to spiral?

S12: I don’t know I haven’t figured that out yet.

R: Why is that a complicated thing to do?

S1: yes…he’ll probably have to use an editing tool.

R: What is that?

S1: the screw affect. It will make it screw up and around…I don’t know if it will work or not.

R: Is that in Blender?

R: Is that a button he pushes?

S1: yeah …basically it does it automatically for him.

S12: that is what I want.

R: how did you find out about that tool S1?

S1: Just pushing buttons

R: Just playing with it?

S1: Just playing with it. Here let me show you.

Observation # 8

R: The book you have in front of you is an Anatomy book?
S12: This is our regular biology book. This is it the section we are on right now. …genetics…genes and heredity and all that.
R: This is what you are doing on the screen right? (Creating a DNA molecule)
S12: what I am planning to do is that I will start with… the basic model …how it looks in the book, so you can tell what all the pieces are. You will be able to zoom in and out. It will be more complicated and uncomplicated when you zoom in and out.
R: How do you think this kind of project would benefit society?
S12: It will kind of let you look at a virtual model of what DNA would look like and explore… you know how these bonds match up instead of just a boring …picture.
R: Could you create your own human being?
S12: oh yeah right.
R: Do you find the subject of DNA and genetics complicated?
S12: I think, yeah, it is pretty complex stuff….
R: Is it pretty intense?
S12: definitely

Observation #5  & interview S12
R: So what are you working on?
S12: Well I am creating a virtual tour of what Athens would look like during Greece’s prime, way back in the BCs and everything.
R: why did you choose this project?
S12: Well I knew I needed something educational because we have to do an educational project and a fun project. So I thought this would be something that would be really interesting and really cool to look at. Something not a lot of people have seen. I mean I am sure there is some because there are models out there but I thought a virtual one would be something that could be more accurate.
R: yeah and you could interact with it and go into it and all that stuff.
R: Is this going to be for history class?
S12: Yes most likely

R: Have you ever had any of your teachers use any of your virtual reality projects?
S12: not really. Not yet I have only been in the class since last semester s they haven’t really had a chance to.

R: What grade are you in?
S12: sophomore

R: let’s see your project and I will be asking you questions about what’s going on…what are you thinking when you are doing this and developing this …cause basically the whole study is to figure out what you learning and is this something that a lot more schools should be doing in their districts.

S12; this is just the basic animation I put into it, kind of a camera tour of it.

R: and this is actually the city of Athens?
S12; yeah

R: Where did you get your research for this? Off the internet?
S12: yeah off the internet.

R: a history book?
S12: a little bit from the history book.

R: ok

S12: this is not an exact copy of it. There are a lot of details I want to put into it. This is what the basic premise of it is.

R: you can make this as elaborate or as simple as you want it. It just depends how much work you want to put in to it.

S12: yea and what I am working on right now is I am trying to…just from this it looks kinda boring and there is not a lot of detail in to it…you can see all the buildings and everything. To make it more realistic you could add things like textures and so it looks like the ground would actually have surface texture to it, actually be bumpy and everything. So that is what I am trying to do. I haven’t worked a lot with textures. But that is what I am trying to do.
R: Have you ever traveled to Athens or Greece?
S12: I have not.
R: wow, would you like to?
S12: I would love to. I am going on a trip to Spain this summer which will be pretty fun.
R: oh really. Wow that would be really nice.
S12: yeah
R: What is the end goal for this project?
S12: I want a realistic tour of Athens itself and then maybe what I will do is put animation in that will show the lapse in time, shows it breaking down to what it is today.
R: oh Ok that is cool.
R: Are you going to have a lot of culture from Greece? Like the gladiators or the market place and those kind of things too?
S12: maybe if I get to that level. Right now it will probably be a little simpler than that but maybe after a few years and comeback t it and do more with it.
R: Exactly
S12: So I have added those textures to the ground and surface to make it look more realistic. What I am going to try to do is get these buildings to look, so they have more life to them.
R: right, some of them kind of look like squares right now but if you put the columns and stuffs it adds to it. It looks really cool.
S1: Wow! That looks good.
R: Now do you work with other students and stuff like that?
S12: yeah sometimes, I have on a few projects.
R: asking advice and giving advice?
S12: oh Yeah I always need a little help.
S1: Is it Greece or Rome?
S12: It is Athens.
S1: to specs.
S12: uh, fairly….well yeah
S1: sweet, it looks pretty good
S12: it’s not perfect at all. I will probably go back through and do a little more with it. This is the basic idea of it.
R: Are you going to have a tour guide say this is this building and as you walk through it would guide you.
S12: yeah that is the plan.
R: good it sounds very good.
R: have you approached your history teacher about this project?
S12: I haven’t approached him yet but I probably will as it nears completion.
S12: So hopefully he will want to use it.
R: Yeah show it in the classroom. So how do you feel about people watching your project without it being done? Does it make you nervous?
S12: ummmm…… not really as long as you understand that it is not yet done.
R: the reason I am asking that I read this article and it talked about Pixar, you know they are the ones who do a lot of those movies….Cars and they did toy story and all that. And they said that they have their creators actually show work that is not done because then the group gets to talk about it and critique but at first people don’t want to share stuff because it is not done, not completed…but in this stage that you are working on you can get ideas from other people, bounce ideas off each other…
S12: I am going to take this building right here and try to add some….I’m just going to try to add some features.

(Others enter room teasing and playing around about a girl who dressed up for St. Patrick’s Day)
S12: to this building I am going to add kind of a cream tan texture, so it will look like a clay texture. That will be the basic color and then I am going to add some textures to it that will make it look rough and seem ridged.

R: Are you using Blender like everyone else in this class does?
S12: yep

R: did you find that was hard software to learn?
S12: It definitely has a learning curve… I mean at first it is really tough but then after you get used to it, you get used to certain aspects of it. What I do, I kind of go after it as I start with one…one type of aspect of blender then I go on to the next one…so I started with basic modeling and then I went to animation and now I am at textures …so basically I just work through and just learn as you go.

R: good, good So you are building on what you know… I learned this small skill and go to a bigger skill, a bigger skill and building on what you already know kind of thing.
S12: yes

R: great, where do you get your ideas? I mean was Athens some place that you thought was interesting?
S12: yeah

R: or you were bored in history class so you had to do something…
S12: I just thought… I always wanted to visit it and thought it would be something really cool to see sometime ya know, and I figured this would be one way to do it.

R: exactly

R: What was the hardest part about doing this so far?
S12: So far…just all the … creating the basic structure. The base of it was very difficult because I had to start with a plane and I had to sub divide it so many times so I could create the different levels of the structure. And now the textures are pretty tricky, because I haven’t worked with them very much.

R: Do you find this has really helped your creativity? Research skills anything?
S12: Ya, I taken art classes before… this is kind of a different aspect of an art class. Not only are you trying to do art but you have to do all the research that goes with it so that the final product is artistic and realistic.

R: I know a lot of people do a lot of research off the internet, how do you guys determine if a site is reliable or not? There is a lot of junk on the internet. You don't want your project to have that kind of stuff in it.

S12: I generally trust the site if it is a dot org or a dot gov site, they are more reliable and sometimes I mean if you look at a site and you think well that does not make sense…and then you go to your history book … its completely different… you know that is definitely a site you're gonna wanna use.

R: So you are double checking your research and making sure it is accurate?

S12: Yes, exactly

R: I know you don’t have internet down here, how do you work around that?

S12: that is frustrating when you want to check a fact but we might get internet down here, we might not, I wish we could. But since it is a pretty open class I can save and go the library and do some research up there and come back down. It’s not that big of a hang up but it is one, and I can always go home and I have Blender at my house and I can just import what I am working on to my flash drive and go home and work on it.

R: Ya since there is no internet down here it can be a real big pain.

S12: It is a bit of a pain. Maybe you can mention something to Mr. K.

(laughing)R: Actually what I am hoping as we discover what the kids are learning and basically what I am doing is comparing your high school class learning, let’s say an anatomy class, and here is what you learn in college or like at MIT and if I can prove that what you guys are leaning is much more than what a basic high school education is… you can get the money and the support for these kinds of programs. Basically this is a program where you are doing it all on your own. You are developing things that are very sophisticated and using language that is very
technical. I am hoping that this research will show that these kids are learning things that they should not be learning in high school.

R: Do you find that because you get to do your own project, you are more motivated to do it and think about it more?

S12: Most of the time I am more motivated and sometimes ya know I am still a teenager and I slack off a little bit… (laughing)…yes I definitely feel like if this is my idea and my vision I really want to get it right and I really want to get it done the way I imagined it to be.

R: right… What kind of emotions does that give you… empowerment?

S12: well you definitely work harder and you always strive to be a little bit better…more realistic or whatever aspect you are going for…

R: striving for perfection? A better end product?

S12: ya most definitely because you take pride in it…. This is something I built

R: Do you know what you are going to do in your future?

S12: I am not really sure yet…still kind of along for the ride right now….but definitely virtual reality is something that is very interesting and I really like…and hopefully this class and other things will help me… ya know open some doors and get some opportunities.

R: Ya and I think it probably will because if you are learning this stuff, it's gonna open doors.

S12: ya a very open field I guess.

R: Does your mom and dad support this VR program for you?

S12: OH yeah.

R: So the Blender program is hard, did you do any tutorial or anything?

S12: no, not really I went to the basic tutorial and then I went to some others like particle systems and basic texturing and things like that… a lot of it is I just want to do this… and you get to that point… well I have no idea how to do this…you go to the internet or you ask someone else in the class and then you learn it. Ya know.
R: do ever push buttons to see what will happen?
S12: occasionally but that is not always the best idea, you don’t want to lose all your work.
R: that is true.
R: what kind of science classes have you taken so far?
S12: I am in Biology right now and last year I had physical science… and I am taking honors chemistry next year.
R: okay, what kind of math classes have you taken?
S12: I was in the Algebra class my eighth grade year, so I did advanced algebra my freshman year and now I am in Geometry.
R: good for you.
S12: then next year I will be able to do college algebra and in my senior year I can take calculus.

(Student working on the computer) right now I am just playing with the coloring and shading so it looks… see that right there (pointing to computer) is kind of a preview of what that will look like. See how it has the ridges and the bulges in it… I want it to look like that but a little bit different. More concrete and stone like.
R: that ball is the model of what you are working on?
S12: yeah it can be a square; it can be a ball …pretty much anything.
S12: Another method for this that I think I am going to apply… apply something that looks like a cobblestone street…like you can do image mapping. I can take another picture if it… of an actual cobblestone street and I can put it right here at the land here. So it looks just like a cobblestone street.
R: Basically you can take a photograph and put in there to make it look like the picture.
S12: ya
R: Do you have a camera that you can do that with…a digital camera?
S12: I have a digital camera myself and I can… like there are websites that have high resolution pictures that you can put right onto Blender… like through Blender.org the website that you download Blender software from, they have links of different websites that you can get stuff like textures…

R: Oh that is cool. You can do just about anything you wanted to do.


R: What has been the most frustrating part about doing a project?

S12: well last semester I was working with a ….do you ever watch star wars?

R: yeah

S12: the ATA floor walkers in the 2nd or 3rd one, I was trying to make one of those and I was putting these things called armatures in it… and they were extremely frustrating. They definitely served a purpose but since it was the first time of ever using them, it was very difficult… but ya know I finally… I now know how to use them… and that is what counts. That was the first project I used them but if I ever want to use them I will know how to use them.

R: what kind of thinking process where you going through when you were doing this? What was working and what was not working?

S12: Well it was a trial and error kind of thing…that’s what I was. I tried this method and said well maybe if I moved them here…size this up or size this down…if that will work and if that doesn’t work you try different methods, different types of armatures that you can put in the structure to make it work… work for different things…so it was just definitely a trial and error thing. Or go on line and if I can’t figure this thing out, you ask someone…

R: yeah I notice there is a lot of collaboration, kids will be doing a project and another will ask “how did you get that to work so I can use it in my project?”

S12: yes…. (Back working on computer) well I think this is what I want with this. I am going to change this roof to make it look like a tiled roof..
R: It would be fun sometime to go on vacation and take a bunch of pictures and come back and try to recreate your vacation.

S12: yeah, another project I started but haven’t done much with it, creating the Mayan tower … yeah because I went to Cancun a couple of summers ago. We went to Chichen Itzo and that is the big capitol and this huge pyramid was really awe inspiring. I started a little on that but have not done much with it. That is another project I want to do.

R: yeah we went to Mexico and the whole Aztec culture is so different and the architecture is so different and cool. It is really interesting ya know… and there are not enough projects that depict it. We need projects where we can visualize it. Sounds like a really project to do.

S12: hopefully I can get some more done on it. There is so much stuff you can do in this class.

R: yeah it’s like whatever you can think or dream you can create. What do your mom and dad do?

S12: My dad works at Lennox. He is a… he started as a tool and die and now he is a supervisor/manager type of guy. My mom works at an eye care clinic

R: When you explain your projects to your mom and dad do they understand what you are talking about?

S12: A little bit but they are pretty…they don’t know how this stuff works. (laughing)They are pretty lost.

R: yeah, sometimes I feel that way when watching you guys explain projects.

S12: they like it and think it is pretty cool and everything. I get huge support from them.

R: that is great. I may survey the parents to get what their feeling about this is and what growth have they seen in their kids.

R: Can you identify areas in yourself where you have noticed growth?
S12: Problem solving skills, I have always thought school was really easy and everything. With this it challenges me and I have to really work hard to find the answers.
R: and you are finding out the answers instead of someone telling you.
S12: Exactly
R: how would the dynamics change if a teacher were in the room?
S12: well if we had someone in here who knew … I mean most people don’t know anything about Blender and everything.
R: most people won’t know how to do this. Most adults won’t know how to do this.
S12: yeah, but if we had someone who did…it would be helpful in a lot of aspects but…it would also would be a crutch to lean on, we just go ask the teacher. “Oh we couldn’t figure this out…could you tell us to do it?” Instead of having to go and figure it out ourselves.
R: yes, do you think having a teacher would hurt the collaboration that takes place here. Like if you have a question you go and ask someone else and not a teacher, you ask the one who knows it whether it is a junior, senior, or freshman. If the guy has the skill you go ask them regardless of their class ranking.
S12: ya that would definitely be a lot different because … I mean why would you ask one person who has a skill when you could ask the teacher. It would be a lot simpler but it wouldn’t make you work harder. It would take away the collaboration.
R: So you may not learn as much because you may not be forced to do it?
S12: yes
R: what about instead of a teacher a coordinator?
S12: What do you mean by coordinator?
R: like when the seniors go and give presentations, or when you need supplies, this would be someone who just coordinates the program? You guys have a lot of freedom down here. Do feel like if there was another adult down here, you couldn’t be silly, you couldn’t collaborate, you would be more serious?
S12: I am sure we would be more serious. It might take away from the creativity. It is hard to say, like someone like that would help the class or hurt the class. It is hard to say.

R: right

S12: yes and another aspect we would lose would be the silliness that lets us be more creative. Here we get to just talk freely… like oh what are you doing? Or I haven’t really figures that out yet. And it is nice ….relaxing atmosphere and everything which lets the creativity and aspect of Blender come through more.

R: I think that is a good observation. (student continues work on the computer) Sorry I am not letting you get your work done.

S12: That is ok. We just ended the last quarter and I think my project is coming along nicely.

R: How do you feel about the evaluations by Mr. K?

S12: I like the way he does it because he doesn’t just say well show me what you have done…then just grade us on how well our project is….he asks what have we learned…how we grew by doing this project and everything…I really like how he does that…

R: do you ever do any self evaluations of your projects? Reflections?

S12: During our evaluation, he’ll ask us a lot of questions…like I think that is what he is trying to do …to get us to self reflect, look back at what we have learned.

R: So you could take away from that evaluation something valuable, something to reflect on.

S12: yes

R: when you are doing your projects do you do that kind of thing internally?

S12: OH YES all the time. If you get stuck somewhere… sometimes you have to throw away what you have been doing and try to find a brand new way to do it. Which is frustrating but it is also a good way to learn it.

R: yes when you reach the frustration level you say I am going to do this.
S12: yeah, you build determination…. After you have been there a couple of times you say "I really WANT TO BEAT THIS!"
R: so you are still working on textures.
S12: yep
R: do you know why there are no girls in this class? Have you talked to your friends about it or anything?
S12: I’m not really sure. I don’t know if the girls at our school just aren’t interested in this sort of thing. I don't know.
R: Will you have music with this.
S12: I don’t know but that is a good idea though. I haven’t thought about that.
R: Can you add music and sounds?
S12: After I render the entire animation I am pretty sure that I can save it and put it in a different video playing device or media device. Then you can put it in sound into that and everything.
R: oh ok.
S12: after I am done saving, rendering, and I could put it in a windows movie maker and add sound to there.
R: Explain to me what rendering is?
S12: Rendering is when the computer, takes what you have created here, this big image here, takes it from the viewpoint of the camera and it shows what it would actually look like…right now it looks weird and kind of bland…but I’ll put in all the textures and all the bumps… it will make it look like it actually is… look how it all looks put together.
R: Ok so rendering is like a final product where it polishes it and everything you put in the program is now put together. Does the computer render or the VR machine?
S12: We have the computer render it then we have the VR machine… we use it to render 4D images of this. So if I put in another camera, we could have a…two view points of your eyes. Then we would render both videos on the computer and then
and puts it on to that (VR machine). It has a certain flicker rate… and it runs with the glasses and there is a lot of technical stuff. But it basically shows your project in all its detail, like right now you can see this, it 3d, but if I move it doesn’t change at all, but on that if you move it changes you can see the definite changes and stuff like that.

R: So your computer is limited because it doesn’t allow you to do that but the VR machine does.

S12: Right

R: So that’s where your 3D… and the effect that you are really present in the 3D form… come from. I can feel like we are in Greece or in Athens… but we are not really in the city… walking around.

S12: Right

R: I get it now.

S: 12 That’s like the last…very final step after you have put in all the work … And done everything. You render the two videos and put everything on there.

R: Now does Mr. K evaluate the things on your flash drive?

S12: Generally he doesn’t. Normally he does it on the computer because it’s simpler.

R: Do you ever get headaches from working too much.

S12: All the time, it can be very frustrating, but it’s also very rewarding. After finishing everything… when it is finished you think, “Yes I’ve finally got this.”

R: The sense of accomplishment overcomes all the pain it took to get there.

S12: Right.

R: So you most definitely want to take this next year?

S12: Oh yeah definitely.

R: Have you gotten any high school or college credit for this?

S12: I know I’m getting high school credit, but I’m not sure that it is worth college credit, to my knowledge.
Date 3-17-2009

Observation 6 and interview S13

R: Yeah that’s like the bible (blender manual), if you haven’t opened it up yet you’re going to be struggling.

S12: Um no, this is the first actual brick wall that I have run into. Usually I just play around with it till I figure it out.

R: Oh so your pretty good about what buttons do what.

S13: It’s just the more I experience it, the better I can do it.

R: Would you say that you are more of a hand on kind of learner?

S13: Oh yeah, most definitely.

R: So you don’t really like the sitting in the class lecture kind of thing? You would rather be playing with it and thinking.

S13: I have to be able to see it or mess with it. Most of the time I mess with it.

R: So that’s why VR is so valuable to you, cause you can actually mess with it and do it?

S13: Yeah.

R: So what projects are you working on, what is this?

S13: What I’m trying to do is get more into the heart process, to get it to pump and see how it works. This one I was working with a sphere, just seeing how well it condenses and stuff.

This here (liquid on computer screen) in the middle would be the fluid. This right here (blocks on the computer screen) is supposed to represent the heart or the muscle. Right now, it needs to be smaller because the water is seeping through the obstacle. It’s all jagged. I have to figure out how to fix that to make it (water) move more freely.

R: Was your project the one that Mr. K was evaluating the other day? There were two squares.
S13: Oh yeah.
R: So this is an extension of that?
S13: Yeah. This one is more tinkering around with the actual process of it. I also have another one that models the heart…getting that all set up… so when I do figure this (the water motion representing blood pumping through the heart) …I can just make an animation and fill it with water.
R: OK you are basically doing this heart project in steps? You have to figure out this thing and if you get bored you go do something else and then come back to this….Is that how you are doing it?
S13: yes, it is like a puzzle you have to figure out how all the pieces work…that is how I do it any ways.
R: What grade are you in?
S13: I’ m a junior
R: What science classes have you taken so far?
S13: physical science, biology, at the moment I am taking environmental science.
R: What math classes have you taken?
S13: pre algebra, algebra, now I’m in consumer math. I didn’t do so great in algebra so I didn’t want o risk all the stress of Algebra II.
R: yeah sometimes math can be intimidating.
S13: yeah I just wanted to do life stuff that is why I am in that.
R: I was intrigued by the VR because many of the projects I have seen…like your project…. A heart pump…you are not going to get this kind of stuff in an anatomy class and what you are learning would be a pre-med student… so you are actually learning stuff… that is probably 5 or 6 years into college.
S13: I want to get into the medical field of some sort.
R: Do you want to be a doctor?
S13: I don’t quite know yet…at one point I wanted to be a biomechanical engineer… or I mean biomedical engineer…that is where you put robotics along with
prosthetics…and get more into the robotics part. But then there are times I could be a surgeon in the ER …or something where you see things you don’t get to see every day.

R: I have the feeling that because you have this experience it will take you a long ways in the medical field.

S13: I hope so

R: My suggestion to you is see if you can get college credit for this before you graduate from high school because it will really help you on your path to going somewhere in the medical field.

S13: I hope I can some credit.

R: So what kind of frustrating things have you encountered…. Now you are having problems with?

S13: I worked with armatures when I first began … I don’t that kind of seemed easy once I played around with the settings and stuff…and now I am working with fluid system, I don’t know it is all going good., except for now. Right now I am trying to figure out what is going on with this water system and how to fix it. Armatures, they deal with animation and stuff… that is like the whole skeletal…construction of animation.

Observation 15
(S14 is testing a video game for S20)

R: Do you guys ever play video games to see how the dynamics of them work?

S14: Well we tested the Wii mote out with Harry Potter and the projection screen, and we also used the mouse to see which one was faster. To see which one we could pass the game with faster and to see which was easier.

R: Which one won?

S14: definitely the Wii remote.

R: Is this a first person view point game?
S20: yeah, S14 is taking the position of the camera.
S14: I don't like the falling part.
R: Are you going to add any more dynamics to it?
S20: yes, actually S8 is going to help with that because at the end of that one right there, there is going to be a golden platform…and when you touch that it is going to have some epic music play…because getting there is going to be impossible. I’m starting on that right now.
R: Are you going to create a full fledged game with it?
S20: Maybe….just one solid wall of blocks.
S14: this is going to be insane.
S20: S8 is a game engine guru...
R: how did he learn this stuff?
S20; by reading the book and tutorials…and Blender forums. What those are, are basically blogs where a whole bunch of people who use Blender get together and discuss ideas and how to do everything. He got help from tons of people on there.
R: Is that a common practice in this class to get online and talk with people?
S20: um I myself don’t blog with people. I don’t know about anyone else though. S8 does it for real very seriously.
R: As you are working with this do you have an end goal in mind?
S20: some, I play with it a little and I have an idea to start out with but it is a work in progress because things change all the time.

Date 4/2/2009

Observation 16

Students are giving a presentation and demonstrating their projects to university officials who are in charge of the teacher education programs at their universities. They want to observe the EM program to train teachers to have better technology skills.
S1: Basically I started this class when I was a sophomore. I helped out at the end of my sophomore year but really didn’t get started until my junior year. Got started in August… we got the machine and we got the first computer over there. We pretty much downloaded the program Blender and we just had a book in front of us. So we had to read through the book and we had to figure out how the program worked. This book is pretty much falling apart because we use it so much. You pretty much have to start with this (the book). This will teach you whatever you want to know about the game engine… about the program minus the gaming engine part of it. Blender is a virtual world inside your computer. What it does is that it can see anything in the real world and what can’t be done in the real world can be done in Blender. Pretty much this book tells you how to run the entire program from start to finish. You start out making like gingerbread men and simple things, and learn how to get your bearings down. The entire program starts from a single cube and so you can design a labyrinth…

So let’s go see what S2 is doing over here.

S2: The entire program starts out with a cube and you can design some of the things in this book…like a mini coop car, different creatures and things, motorcycles and cars. It also has simple geometric shapes. Basically what this machine is designed to do is to take these pictures, these renders, we can make movies also and we put them into 3D. It is called stereoscopic viewing. What it does is….when you are viewing things in the real world you look with both your left and right eye. This helps you determine depth perception. That is what we are simulating with a stereoscopic screen. The stereo takes 2 images your left eye and your right eye and lays them over on top of each other and flickers back and forth between the 2 at about 150 times a second. Now what happens is ….these glasses will correct that so you are only seeing your left eye with your left eye and only seeing your right eye with your right eye. It gives you a sense of 3D on the screen.

(Allows group to experience the 3D with the glasses.)
S2: Okay this kind of one of the simpler projects I made. It is a basic water molecule. You have the 2 hydrogen and the oxygen there. The green… light thing you see there is the covalent bond.

(laughing) S1: Everyone is like wow this is cool.

PX: It's going to get cooler.

S1: yeah it's going to get cooler.

R: S1 you just said this is not in stereo. How could you tell?

S1: When it is in stereo you will see 2 images flash back and forth between the 2…you will also see that this IR admittor will have the red IR light on the inside and you can see it flicker. What this thin box does up here is to tell the glasses how fast to flicker.

S2: First of all this isn't even on.

(Both students go to main computer and discuss the IR admittor. They push some buttons etc.)

PX: awwwww there!

S1: See the difference.

S2: freshmen…sorry….they don't computers.

(laughing)

S1: so see you can see this red light is on. It is telling the glasses how fast to flicker and which eye you are looking with.

PX: Why the vast size of this screen?

S1: It gives you a more immersive feeling… it makes you think that it is actually here…it’s not just attached to the screen. If you are watching a 3Dimage on a small screen, it just looks like an image inside a box. But the larger the screen…the idea is to get it larger than your peripheral vision so you can’t see these borders.

PX: Like real life…

S1: yes…simulate real life.

P1: S2 for which class was this for?
S2: This was for chemistry.
R: You said it was a molecule?
S2: Yes, water.
PX: One of the first ones they did at Iowa State in their cave, they did a virus. How it moved along. They had a wand so you touch and you had to touch and you could watch the virus spread. It was spread of AIDS. The spread of AIDS was what they were showing. It was amazing. It was all around you.
PX2: was it on a screen?
PX: No a cave has walls…walls that project so you are using the sides. You are inside it.
S2: This project is S10’s. He is not here right now. I am not quite sure what this is supposed to be… I think it is carbon. I am not sure how many electrons he has.
P1: Yes, this is his carbon atom.
S2: This is an atom. This is an atom not a molecule. You can see the electrons floating around it. As for the colorful starry background, that was kind of my idea because no one knows what it really looks like.
S1: It's like seeing 1000 other atoms in the distance.
S2: There’s a very crooked grain …that is friends in the background…. (2 pieces stuck together)
PX: Oh my gosh! That is so cool!
S1: It really gets 3D when you shift left and right. You can really tell the difference.
P1: We will be getting a motion sensor…a motion detonator where you stand there and if you are walking… it will copy the motion.
PX: It is like walking through a museum?
P1: Yes and we are also looking at getting a little pad where the infra red is picked up and your arm is added there …
S2: it's pretty cool.
P1: This is S1’s project.
S1: Yes this is a house that my dad built. He let me borrow the blueprints for it and so I designed it in VR. This is useful for …say you are shopping for a new house, don’t find anything you like and you decide you want to build a new one. You want it to be exactly to your specifications and so say someone builds this nice $300,000 house. You decide you don’t like it…well that is too bad you have to live with it. But with VR that architect could design this house… you could walk through it and design everything to the furniture you put in it…anything. So it would save you a lot of time and money when making changes after the house is finished.

R: S1 did you anything like CAD with this?

S1: No this was all done in Blender.

R: What kind of math did you use?

S1: Basically just the areas because I had to do conversions. Blender has a scale unit.. it is called one Blender unit but you don’t know how long it is because it is just a computer screen. So you can make it whatever scale you want it to be. You can make it 1 foot equals 1 Blender unit, which is what I did here. So I had to do the conversions and punch in the coordinates for different sizes of things, so that the first floor is the same size as the second floor, or one is not overly huge compared to the other.

R: Is this to scale?

S1: Yes it is accurate. It is to scale.

PX: Ok I am going to ask you kind of a big question here… We’re people who are preparing teachers, at the college level…If we were going to do that…Do I bring my technology people to you to understand this? Do I bring my science people to you?

S1: You bring them all.

PX: I bring them all. It goes across all disciplines.

S2: Yes

PX2: Mostly we would bring the students to you because they will demand that they want this.
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S1: and they will learn it a lot faster than we did…
PX2: They will also say they need this.
PX: Those students become our teachers at the college too.
PX2: For the juniors, when you came into this process, how were you assimilated into what's going on here?
S1: It means how you joined.
(laughing)
PX2: I'm sorry I figured you would be doing it in VR. Because you came here, I mean like you heard this stuff is going on… but when you got here how did you become a part of the process?
S13: I was always interested in computers… I like technology and once I heard about this, I was like alright …technology …I want to learn about it. I want to see it. My attention is always everywhere and then when it is usually this kind of stuff…this just draws my attention. I like this stuff.
PX2: And so you liked computers, you walked in here what happened?
S20: I just started learning.
PX2: Learning from?
S20: learning from manuals, other people, from everything…
PX2: Give us an idea on your project or what have you worked on specifically?
S20: A lot of medical stuff. I really enjoy the medical field. It is always something different, always something to learn.
S1: You are pretty good at armatures.
S20: yeah armatures also work with animations, so you put like these bone structures inside of a mesh or something, and then you can move those armatures around. It will grab a hold of the mesh and you can position it to however you want, and work it into an animation.
S8: I got into VR…like I had a study hall everyday and honestly I get bored in study hall. My friend was in here by himself and he said I should take this class because
he knows I don’t normally like study hall either. So I got in here and I was just reading the book. I was messing with Blender, trying to get used to it… and then I found the game engine. I have been making games, programming and everything. That involves armatures and animation, actual computer typing and modeling….making sure everything works. That is kind of what I do.

PX: It’s just from the books and from feeding off of each other.

S8: The books don’t actually have game engine in it. So I had to go out and actually learn it and found out that not very many people in here know about game engines. They knew about moving around a little bit but I like to take it up a couple of steps farther. I can write the scripts, and we just got video games installed as you can see right there in 3D. We can play games in 3D and they pop out at you.

R: S8 Did you that on the internet, those tutorials?

S8: Yes, on You tube there is a very good place, because you can see tons of videos on everything. If you ever need help you can go there or I found a forum called Forum Diagnostic, and all the people on there use Blender for all different reasons. They have amazing pictures, called renders, animations, architecture and gaming. Which I do. I learned a lot from there and I am actually on a project called Dark Blood. It is kind of violent so I am not going to show it because of obvious reasons. I met this guy on there and he knows more about programming than I do. I am modeling and we are kind of working together.

S13: Well how I got into this class…it was a little bit like S8. I did have a study hall one day and I was just wandering around and I saw a couple of my friends in here. I watched them for awhile and thought I could probably get into this. So I set up a meeting with Mr. K. I wanted to be in here. So he approved it and I was in here the next semester. So I started in January. Well, ever since I have been in here…from the first day I did not understand a thing. I am not going to lie to you. I didn’t understand a thing. But I did go through the book…that gave me a starting point. From there on its like grab from everyone else, let everyone else help you. Right
now I have… this has actually helped me in geometry. Because I was failing geometry earlier this year and I had a meeting with Mr. K. He asked me what was going on and I told him I just don’t understand Geometry. So he told to try to use stuff that you are using in Blender. Try to convert it into something that you use in class. Well I did a project a…educational project…It was a cube. You have to find surface area, density, volume…a perimeter and stuff. That was stuff we were learning in geometry with prisms and 3D figures. Well now I am at a “C” in that class and doing much better.

R: What did you do with the formulas in this project?
S13: I put them on the cubes …I put given information…I wish I could have gotten it into stereo before you got here. I would have put it up there. But I put up given information… and stuff that you want to find. Right beside the cube, I’ve got all your formulas that you use to find the stuff. I filled it in and it all equals out. Then I put it in game engine so that you could rotate the cube. You can actually see why you are getting the answers you are getting. Like for surface area, you can actually tell by looking at all sides. So by rotating it you can count the sides.
PX: So when you rotate it, you can actually visualize it?
S13: Yeah, it is a hands on thing.
R: when you rotated it you actually saw 6 sides?
S13: that is what you are figuring not just one or two sides. Instead of visualizing in your head you can now see it.
S20: What is great about his class is that you learn so many things that you are interested in. But you don’t even have to take a class in it. I went online for our educational project, and right now I am working on my first educational project that I actually used for a class. All my other projects have been mostly anatomy based, or medical orientated, and I haven’t even been in anatomy yet. I plan on taking it in college.
PX: Even though you guys don’t have a teacher in here, you guys are the teachers.
S13: Absolutely
PX: How does that work? How do you stay focused? How do you not get kids in here who might just want to go another way on the computer and…
S8: That is the good thing about not having a teacher in here…you can go off any way you want.

Date 4/9/09

**Observation 17**

_Students continuing discussion with educational leaders form universities and colleges._

S20: I am doing a fluid system right now. I usually use Blender and it is pretty hard. But once I get it down I'm Ok with it.

PX: You guys were at the state house and my colleagues were having a meeting with state examiners and you all where bringing all the stuff in to give your demonstration there. I was walking out and I thought I know them…from all the visits we have had with you boys. You looked nice with the hats and the black suits.

S20: yeah I thought I don’t have any goo d dress clothes. So I am going to the prop closet and get something.

S8: Well today I have a track meet so I just wore my t-shirt.

PX: Are you ready for it? What do you run?

S8: the 4x8 and the distance med and I can run any race but… I like the long distance.

PX: I coached track for 11 years again it was the mechanical side. I coached shot put, high jump and discus not because I could do them but because I loved the mechanical part. So you can pick out the mistakes. Well so you will be here next year?

S20: I will have my project done by then.
S8: I will have more stuff on my web site.
PX: Oh yeah.
S8: I have a website but it is not too up-to-date on all my projects.
PX: You are too busy with your projects?
S8: ya, and everything else…. And with choir and with everything with school.
Anatomy test s and ....
PX: Thank you. Thank you for sharing.
PX: Do the teachers look at your web site?
S8: no, none of them…no my website is more for my projects. I could make a VR website with all the projects on there.
PX: that is neat and it could be a level of assessment that they could stay in touch with you.
S8: yes
PX: You could take them into another world.
PX2: That is a good way to showcase your skills.

Another student talking with educational professional and principal
PX3: So they would have access to lots of other projects and those kinds of things.
S14: Yes.
PX3: So I am hearing that teachers here have kind of adopted options for students, like not everyone in chemistry has to do this kind of project.
S14: yeah, they split it up into different groups. This group of VR kids…as long as you use this program to make this…everyone else is like… doing something else, but they like to watch the VR projects.
PX4: everyone wants to view your projects….they are fighting over the glasses.
P2: (to student) There is a question they would like to hear from you. Let’s say you want to teach and as you develop programs what would you want to see in the teaching program? To come back and teach? Whatever it is you want to teach. What would want the students to know, what would you want to teach them?
S14: I really like how the kids are teaching themselves. I think it is much easier for them to learn and what we do in here, we...if we need help we can go to S1 and S2. We go to someone higher up who knows more about it than we do. That is how I would want everything to work.

PX3: So you are really learning to use multiple resources?

S14: We have the internet; we use tutorials and books online. We have other classmates to get help from.

PX3: So what I am hearing is lots of partnerships too.

S14: yes and there is S8... when we started our first gaming session... teachers had us program in software and some projects.

PX3: Now some of them have talked about connections with people currently in business, now have you are interested in architecture... have you had an opportunity to make any connections.

S14: I haven't talked to anyone yet but I am looking into it. So since I am doing this I am thinking of going into it.

PX3: Possible practicing architecture? Oh course you probably know some things that even they don't know, so I don't know if they want to talk to you.

P2: A design architect firms that helped us with our new building, he (S14) could go down there and this summer, all he had to say is I want to do this and he'll be gone.

PX3: So it is really opening up a lot of opportunities for you?

S14: yes

P2: As soon as the kids say I want to do this, the companies are saying to me as soon as they are ready ...call us. We will take them. Their world is totally different and they will take these guys over others.

PX3: so what I am hearing is that your view of the world. You are bringing a different view of the world that; I have a problem and it may be this...this... and this... but I got that view that I can see multiple answers in multiple places and it is ok if I don't know the answer. So I guess that is kind of what I am hearing.
S14: yes
PX3: Great opportunities.
P2: the main thing like for these guys, their kids are going to be coming up in the school and things are changing. Their kids are going to do the same things these kids did. Change...they will be saying to them you need to change, it's got to be more engaging... there has to be more problem solving. Don’t solve the problem for them. You know people just wait you out... cause I will wait you out and you will tell them the answer. When he came in here the roughest and hardest thing for him to come to was they gave him a book and said read it. He would ask questions and they would say read it the answer is there. Tell me what you read. One day he was real upset with me and all I said to him was “You know it, you have read it and you understand it. It’s with in what you know what the answers to your question is. And I walked away.
PX3: What were your thoughts at that point?
S14: Well I read the book over again and figured it out myself.
PX3: then what?
S14: well I have been using it ever since.
P2: and the point is that I could have told him and that is what he expected. Then he went to S1 and some of the others and asked them the same questions. Then he came back to me and said they would not answer my questions. They are not telling me anything. How am I supposed to know if nobody is telling me what to do? And their point was “he didn’t read it, he said he read it but he didn’t read it” So he reads it and got it.
R: As a student you go into a classroom and the teacher tells you what to do. What was your reaction to this nontraditional way of doing it?
S14: yeah for so long all the teachers list it up on the board and they tell you step by step what you are supposed to do. Then you come in here and you have to teach yourself step by step exactly how to do it, from the book, or online. It was hard.
PX4: In some way do you have more respect for what your teachers are trying to do for you?
S14: Now I do. Yes. Because I know exactly how hard it is to teach yourself and teach others. And the freshmen and to help them.
PX4: the group that is here today are all women and we are thinking: where are the female pairs?
S14: There are none.
PX4: do you know why? Do you have any theories?
S14: Not but yesterday we had the eighth graders come up and most them were girls…they are getting more into it.
PX3: So you are working to recruit. (laughing) we'll come down here and you can teach us. Then maybe we won't feel so out of it. Out of sync of things.
P2: the important thing is everybody thinks that before he can learn anything I should know how to do every aspect of it. He absolutely no clue what i know what to do and what I don't know what to do. He has no knowledge and it makes no difference of what I know or don't know. The reason we do that is because then the bottom line is, it is his education, it is not what I know. All I have done is give the power to him. He can take what he was learned and I can take him in any business, any industry whatever, he is going to be a far better producer. If he decided to teach he would be a tremendous teacher because I told you the baseline those things that are critical now go with it. And that is what we are realizing with these boys. The reading is just substance. The teacher is going to give them the baseline but we have watered down …watered down…watered down. We don't want anybody to fail. The kids don’t do any thinking. S14 realized it is ok to think. Then all he had to do was retool and he failed in his teaching.
PX3: Well he may not have been successful in that piece but we are still holding him at high expectations for demonstrating his skills or his knowledge pieces. Maybe it is
not that but maybe it is that we need to find the right path for him to acquire the skills. Maybe that wasn’t the right route but we can find a new route to do that.
P2: Where you go on from here. As you look at colleges what you most fear of what is going to happen if you have to take that class.
S14: Well college will be a lot easier because I have been teaching myself in this class. So if I don’t understand what they are saying. I will be able to read over it again and understand it a lot more. If I have a question I always know there is some way to find the answer. It doesn’t scare me a whole lot but it is a little scary taking the next step.
PX3: the changes…where you live, the people you will hang out with…and all those things. That is enough to scare you a little bit. So you feel much more prepared?
S14: Yes, more confident.

Date 4/9/09

Observation and interview 10
S13: this one is a… did I show this to you already…
R: I am trying to think…. The heart.
S13: Yeah this is the heart pumping. I am trying to figure out how to get the blood to pump through it. But right now…. Let me see if it is going to work out right…. Oh wait put that over here. … I have to wait for it all to set up…
R: what is the black circle?
S13: the heart…
R: and the pink/
S13: the blood. I'll show you my little problem I am running into. Once I get 20 or 30 frames going… (the blood leaks out from the sides of the heart) I think my problem with it is, I have too much fluid…
R: how are you going to solve that problem/
S13: I don’t know I’m just going to have to play around with it…lesser amount of fluid…what I am trying to do is get rid of all these jagged edges. (Pink liquid around the outside of the heart model). There are so many jagged edges that are taking the actual form of the obstacle…

R: Is your model here a more realistic view of fluids….wouldn’t they take on the shape of the container?

S13: yeah it is taking the shape of the container but leaking out… see here is the fluid the pink…but as it is progressing, the water or whatever is going all crazy on me. It is getting all jagged like there is fluid flying out of the obstacle.

R: you need to fix that problem before you can go n to anything else.

S13: Here is a solid form where you can’t see through it…as you can see it is coming through the actual mesh.

R: Is almost like there is a leak in it.

S13: Ya but there is no actual holes in it anywhere, so I need to figure out what is going on. I think is because there is too much fluid in it. Here’s the fluid right here.

R: Okay when you programmed this in did you have to program …like how many pounds per square inch, or pressure?

S13: well this is the actual fluid right here… this is the domain… and this is the obstacle…and when I had the fluid in this right here (the obstacle) the domain wrapped itself around the actual fluid… this is where it is trying to mold over (the fluid and the domain) it is trying to take the shape of this (the domain), and acts as fluid and it does what it does….acts like the fluid. So I could actually put gravity on to this too. I want it to … since this is the “z” axis, the negative, it should fall… it should drop… but there is no domain right now…OH, does this need to be in here (the water in the obstacle) Oh no I lost it now.

R: Oh no.

S13: I don’t know where it went. Well I should have a planet one here too. (S13 closed the heart model and opened another project.)
**Observation and interview 10**

S13: this one is a... did I show this to you already...
R: I am trying to think.... The heart.
S13: Yeah this is the heart pumping. I am trying to figure out how to get the blood to pump through it. But right now.... Let me see if it is going to work out right.... Oh wait put that over here. .... I have to wait for it all to set up…
R: what is the black circle?
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R: and the pink/
S13: the blood. I'll show you my little problem I am running into. Once I get 20 or 30 frames going… *(The blood leaks out from the sides of the heart)* I think my problem with it is, I have too much fluid…
R: how are you going to solve that problem/
S13: I don't know I'm just going to have to play around with it...lesser amount of fluid...what I am trying to do is get rid of all these jagged edges. *(Pink liquid around the outside of the heart model)*. There are so many jagged edges that are taking the actual form of the obstacle…
R: Is your model here a more realistic view of fluids....wouldn't they take on the shape of the container?
S13: yeah it is taking the shape of the container but leaking out… see here is the fluid the pink…but as it is progressing, the water or whatever is going all crazy on me. It is getting all jagged like there is fluid flying out of the obstacle.
R: you need to fix that problem before you can go n to anything else.
S13: Here is a solid form where you can’t see through it…as you can see it is coming through the actual mesh.
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S13: Ya but there is no actual holes in it anywhere, so I need to figure out what is going on. I think is because there is too much fluid in it. Here’s the fluid right here.
R: Okay when you programmed this in did you have to program …like how many pounds per square inch, or pressure?
S13: well this is the actual fluid right here… this is the domain… and this is the obstacle…and when I had the fluid in this right here (the obstacle) the domain wrapped itself around the actual fluid… this is where it is trying to mold over (the fluid and the domain) it is trying to take the shape of this (the domain), and acts as fluid and it does what it does….acts like the fluid. So I could actually put gravity on to this too. I want it to … since this is the “z” axis, the negative, it should fall… it should drop… but there is no domain right now…OH, does this need to be in here (the water in the obstacle) Oh no I lost it now.
R: Oh no.
S13: I don’t know where it went. Well I should have a planet one here too. (S13 closed the heart model and opened another project.)
R: When you talk about domain could you define that for me?
S13: Domain is… the outer part. Whatever is inside the domain that is what is going to be affected. So say in this whole room…you only want this (holding a stack of books) to be affected by the fluid system…so you are going to make a domain and only this( circular motion around the books) is going to be affected., whatever is inside the domain.
R: so is domain setting boundaries?
S13: yeah, defining space. So I have fluid and don’t want it to go all over the place so I put it in a domain… That is why I made that one sphere an obstacle, so once it is inside that obstacle it shouldn’t be able to move anywhere or go anywhere, because it is an obstacle it should be blocking its way.
R: so the problem is that it is leaking and shouldn’t be doing that?
S13: right (pulls up second project) and here this is a…it’s not an actual model …it is just something I was playing around with… as far as bringing out the elevation, this supposed to represent water…and I am going to turn it into an animation, so that when it melts or whatever, the water is supposed to come out, like a certain percentage of the planet.
R: oh that is great. Is this a simulation to demonstrate the dangers of global warning?
S13: There are things that I do believe about global warming and there are things that I don’t. Like cause …our world, our planet has been here a very long time, and I think it is going to be able to with stand a lot of stuff that is put on it. But at the same time I don’t really know. I ’m only going on what I think. I don’t have any evidence behind it or anything.
R: Have you researched it much?
S13: I’m taking environmental science and that is what we are learning about. So I am looking at both sides of the story and I can understand both sides.
R: so what is the benefit of putting it in a model like this?
S13: to see how it is and what could happen; I don’t know make guesses of what could happen. Ya know learn how to …. (S13 shaping the model and changing the outer surface) model and all sorts of stuff in this class.
R: It looks like play-dough…using play-dough on the computer.
S13: yeah it is pretty cool, fun to play with it. I like it.
R: so what are you doing?
S13: I’m taking it (the mesh) and actually pushing it down, this is like a sculpting mode….it is like taking a piece of play-dough and shaping it. I’m not actually taking anything away but pushing it in and moving it out.
R: did you just make a mountain right there?
S13: yea, and right now I am just subtracting mass…lowering it down… it’s like sea level….below sea level… what this actual is ….this is not water (blue color on green and blue sphere) it’s more an illusion, it's a trick…it is another sphere inside.

R: oh my problem was when you told me that this was an elevation of the earth I automatically assumed the blue was water and the green is grass. You clarified that it wasn’t. (Student pulls the blue ball from the green ball)

S13: see… I mean that is what it is supposed to present but it actually just another sphere. What I am doing is sizing it up or sizing it down so it is going to cover up or seep through the lower spots. But once you get to a certain spot its gonna do that (blue and green both disappear to show the mesh grid)

R: Is that grid the part you are building upon?

S13: yes, like right now the 2 spheres are colliding with each other so it’s like you can see so much…I can only go out so far unless I want to add so much more land..and what I hope to do is pick up a book and try to map the world and…try to…have you seen the book to where it is red, and it is like this is so many feet high…and its yellow this is so many like mountains or whatever…

R: So you are doing elevations right now?

S13: yeah I want to learn about that, try to match it up, kind of accurately as I can…as much as I can any ways, till then it will somewhat accurate, as far as what it will cover. I also want to look up some theories on how much they think the water will cover the planet too.

R: that is impressive.

R: How are you going to research it?

S13: My favorite source is online. I enjoy using the internet cause it is easy and there is a lot of things that you can do with the internet. What I am planning on doing is taking an actual map, wrapping it around this sphere and then doing this modeling thing that I was showing you, and take where all the ocean is, and seep it down …just bring it in where all the mountains are to pull it out. So I know artistically I am
not that good at doing that kind of stuff…so I want to take an actual map and wrap it around the sphere to use that as a ….guide…. and just follow around that…almost trace around it.

R: you say you go to the internet for research, how do you know that the information you get off the internet is reliable or accurate?

S13: I go to multiple places and compare. There are websites… all websites are made by people…they can all be different, so I look around and see what the average … what the average one is or what people usually put up…usually I go to actual educational web sites, dot gov or something like that.

R: do you learn to recognize what sites are reliable?

S13: yeah, depending on where they come from, and also I am on the computer all the time…And you can tell if they are legit or not, by the way they are designed or set up. You can tell pretty much if the website is pretty cheesy as far as how to interface and how everything is set up, the graphics and everything. You can tell if it is professionally made or done by some guy…. in his basement.

S13: I just go around and try to look for the legit stuff and compare them.

Date: 3/27/09

Observation #11

Students are sitting on rolling chairs and hitting a rubber ball back and forth with paddles.

R: Why are you guys doing that?

Students laughing and smiling.

S13: We are figuring a physics problem.

R: (laughing) Love that answer but that is not the truth right?

Students laughing.

S13: We’re working but indirectly.

R: what do you call this game?
S13: wheel ball.
S14: We just started it up about a week, a week and a half ago.
R: You just have to be careful not to break a computer screen and then you will be in trouble.

Observation and interview 12
2 students are working together on the computer, trying out different textures while the 3rd student is playing a video game. When asked if he was going to make a game like the one he was playing, he said no because it was too much like Mario.
R: Can you explain to me what rendering is?
S10: Rendering is a capturing of an image; it is basically the exact same concept like taking a picture. We use the camera as the camera in the game. So what it does it that it lays out what it sees and it goes back over it, to find out the pixels.
R: Ok
S10: So it is like it takes a picture twice almost.
R: Is it scanning it or taking a picture?
S10: Well it takes it part by part so you could call it scanning it.
R: Does it make it a sharper image?
S10: yes
R: you have to have the project rendered before you can put it on the big machine?
S10: yes, unless you are doing something in a game engine…the game engine you just push “P “for play.
R: Explain to me what a game engine is?
S10: A game engine is like a unique second world. (Student bring up an example on the computer)
Like you can press “p” … here let’s get some controllers here… I’ll rotate it like that …when I press “w”. So when I press “p” here … you see… (Object on screen is
flipping back and forth) It is just setting up the things you build in blender with game features…move, jump, spin, shoot….

R: You build things in Blender?
S10: yeah, then transfer it to game engine and that is how we get some of the special effects we do.

R: Do you use both those programs together?
S10: yes

R: why does rendering take so long?
S10: It can take short or long,
S4: depending on how many faces, how many particles…how many objects…depends on all that. If you have one face it can go like that. (Snaps fingers) You have a million faces or a million particles you are never going to render it. The more complicated the longer the rendering.

Student 14 playing game
S14: That is crazy.
S10: Did you get it to come up yet?
R: What is it doing? It looks pretty wild?
S14: There we go…
S10: do you want to delete the characters?
S14: I don’t want to delete them. (Suddenly all character jump and down against a brick wall)
S14: It looks and acts too much like Mario. Go…go…go… wait there is no way out.
S10: I think you’re stuck.
S14: yeah.

R: What are those black things doing? Are they killing you?
S14: I have a star on so they can’t hurt me. I need to find out where that fireball went.
R: (to S4) that looks interesting, what is that with the light right there?
S4: some lamp I have there that is reflecting off the water but it is not showing the water…
S14: go to your water real quick. (3 students working on same project)
S10: scroll over. There is a flat plain. See how clear that is… go to transparent; bring down that tidal water… ya the top one.
S4: then the fixture…right here (pointing to screen menu)
S10: then go to your map too. Break up your form, just a tad. (Click buttons) Is that what you wanted?
S4: (patted his buddy on the back) That is what we do in here.
R: That water looks really cool. Did you want it that black?
S4: No I want it a little more clear, but that is good for now. Because I finally got it to look like the water.
R: As you guys are collaborating, what kind things are you talking about? What kinds of conversations are going on?
S10: gaining expertise from the other guys. Learn a lot from S6, he shows us a lot of things…
(Another student comes in and looks at S10’s project)
S: (talking to S10) Hey you made that? (S10 nods)
S4: No I made that. stole it off the internet…
S: he lies.
S4: well he got the tree off the internet.
S10: no…no…no…
S: Hey you fixed the dirt problem.
S10: It was from the tree. From the tree…
S: anyway the reflection of the tree…
R: What was your dirt problem?
S10: S was making fun of me because I had my tree right there (in water)
S: So you didn’t fix the dirt problem.
S4: no it was the reflection of the tree.
S10: it was the tree.
S: Was it your water simulation or did you use….
S10: It was the plain.
S: See it looks like dirt.
S10: I had little spots from the tree.
S: It looks like dirt. See it looks like the ground is drying up.
S10: He was freaking out about it.
R: But in real life you would have reflections from a tree on the water.
S10: You can actually see on the grass plain right here … see the grass reflecting the shadow on the water…
S4: It looks like 2 areas. The shadows of the tree. You have 2 shadows.
S10 to S4: Boy you are going to get over that.
S4: no I am not …you have a sun and a ….a sun and an arrow
S: You should make a duck in the water.
S4: I’m making a whitetail deer that is going to stand beside the tree. 
S10 working on the computer
S4: Take that off of there and put a sun there… in the hemisphere…
R: When you guys are working on a project like this, who has the final say?
S10: Me because it is my project.
R: Are you ever required to do projects together?
S4: We can. Turn it around. Try that.
S10: (rendering)
S4: Look how much that slowed it down with the 2 lights.
S10: Aw that looks great. That is bright.
S4: take the energy down some
R: It looks great though.
S4: Yeah, a summer day bright.
S10: I don’t want summer day.
S4: I want summer day.

**Observation and interview 13**

S13: These right here are the armatures..see like the little bones or whatever.
R: What is that blue cylinder thing?
S13: the armature…that’s what moves the arm, I don’t know if the camera is picking it up all that well. Here is a top view. This is how the arm bends… but this right here (the elbow bending backwards in unnatural way) (student points to a white cylinder around the armature.) this right here is the envelop, it is grabbing all the skin textures….see like without all those bones showing up….this is all the mesh., and this stuff is unmovable. So you put these bones in here and these envelopes is what grabs the different skin parts.
R: Can you have the skin move separately without the armature?
S13: The skin won’t move at all, unless you put these in here. The skin is actually a … all these different vertices put together, to make all these different faces. Without these bones, things are motionless. You put these bones in here and the envelopes grab all these vertices and as these bones move they pull the vertices with them. So it makes it look like it is actually moving. It is just rearranging it and everything.
R: so that makes it more realistic?
S13: right.
R: So if you added clothes or something you would still need those vertices on there?
S13: yeah so…it would pull it and everything…and you can make these envelopes larger or bigger, depending on how much area you want it to cover. Like bone heat
… I really haven’t used bone heat… I use envelopes. The person I would ask about bone heat is S8.

**Observation and interview 14**

R: So this is a deer you want to put in there?
S4: yeah
R: What are you 2 guys working on?
S8: I am working on the actual game that I am planning to publish on the internet.
R: Wow good for you.
S8: It’s actually like …Womack…but are full fledged games; instead of my little mini games that are still fun but makes no sense. This has a story, more characters, more actions and everything.
R: What is the theme of this game?
S8: It’s an escape game… well….let’s just say it is very violent, how about that.
R: Running, jumping killing…
S8: running, jumping, killing and all that, escaping,…
S9: Like Sonic with guns and swords.

*(laughing)* R: And Sonic was such a nice little game.
S8: and black dreadlocks….I’m just designing the level right now. The actual characters are different. Let me open it up. This is hail, the main character of my game. I am going to have a bunch of different actions but right now I have him set to break dance.
R: really.
S8: If you don’t play for so long he sits down and begins to break dance….and I have to go in and make very action that he ever makes. He’s on walking right now.
R: how cool
S8: he just walks repeatedly. There is also punching…and how I think of the motions is that I actually do them, and then I put them in the game. I used to be into break dancing.

S9: You can’t do that.

S8: I know how to do it.

S9: No you can’t.

S8: I just don’t have time to practice.

R: I wouldn’t want to do it. It looks hard to me.

S8: I do I just don’t have time.

R: would you guys find that having a full length mirror in here help with building some of the motions you want?

S8: yeah but would be staring at myself for quite awhile.

S9: What would help us the most would be one of those….getting one of those…

S8: oh those suits….

S9: the bubble suits. Where you set up a camera and it tracks your motion from your joints and stuff.

S8: and it puts it in..

S9: You can see that and you can have, like with our dual screen… you can have it playing over here while you are working over here on your stuff. That way you have…you actually get what you are trying to make…the real motion.

R: So my next question I guess would be do you use those wooden people models like in art class?

S9: No the bubble suit is much better.

S8: any other questions…

R: there probably will be if you guys don’t mind me watching over your shoulders.

S8: No that is fine.

R: so go ahead and work on it and talk, and don’t let me interrupt your thinking.
S8: Well it is kind of hard for me because I am one of the only game engine people in here.

R: you are

S8: yeah I am one of the few ones….. The other thing about game engine is that it actually takes everything. It takes mesh modeling, texturing, lighting, and puts it all together. So you pretty much learn everything.

R: What is the purpose for what you are working on right here? What is your goal for it?

S9: I don’t know….I just thought it would be fun. I have always been into some of the more realistic type things. And so that is what I have been working on. Trying to get some of my stuff to look as real as I can.

S8: You took out shadow on purpose? No it is still there.

S9: See there is a little shadow but i want more than just that.

R: that is cool.

S8: ya where he put the light is where the light should be. Look at the leaves it is putting the light where it should be.

S8: that is the good thing about Blender it has a pretty realistic render.

S9: Yeah it is all real time.

R: What does that mean?

S8: actual minutes…like in a video game…some video games like SIMS…you can have a minute in real time go by but it is really ten hours SIM time.

S9: and another thing about real time, like this is 5:00 in my backyard, I could go to the exact date set and exact time. I could stand right where that camera is and it would look realistic to the time of day.

R: Can you photos in here? Transfer photos into your projects?

S8: Oh yeah. That is what S6 did right there. He modeled a vertex around the deer … Hold on S6….it shows up as a background image and then you can just model where everything is. And go on from there. Then you have your basic model.
S9: That shadow, is good right there but that is too bright.
S8: lower it right there. That’s half.
S9: Let’s check these right here.
R: So S6 are you stuck?
S6: yeah I had to check the book. I need to figure out how to fill all those right there. Instead of adding a face, I want to fill that.
S8: (to S6) Press F, oh you’re using the older version. On 2.4 there’s a face loop…that may work but… I don’t know

S8: Why do you have the hemi on? (Hemisphere light source)
R: Do you guys know of a game or simulation like a drunk driving simulation where if you react a certain way the computer will respond a certain way?
S8: yes we can do that. That all goes into scripting. Scripting can do multiple choices. Scripting is a big head ache. It’s pretty hard. With scripting you have to like, put in every single variable that could happen. That’s why if you have ever seen a game script…it is huge and long. It gives every possible variable that could happen.
R: you would have to put all that in and think like the computer?
S8: pretty much.
S6: S9 I got it. Shift F.
R: (to S6) How did you figure it out?
S6: Using the book and playing around with it some. Now I just need to shape it. That is gonna suck.
R: What are those yellow lines?
S6: That is the edges on all the faces.
S8: You can pull them out and sculpt and smooth. It’s still going to be a little blocky.
S6: I want to pull…like these 2 legs I want to pull out some. I’ll just select them.
R: you took that from a photograph right?
S6: yes
R: and now you are making it 3D?
S6: yes, like a standing buck.
(back to S9 project)
S8: You can’t keep it pulled out …because the light only hits what areas it’s touching.
S9: how do I keep my light?
S8: increase the spotlight. And that what was wrong with your hemis.
S9: see the shadow…now you can see it.
R: Do you have to go back?
S9: yeah, rework then try it out then…until I find what I want. Rework, render and see if that is what I want.
S8: take out the hemis.
S9: I was told to put them in.
S8: By who?
S9: S…
S8: hemis are for like for close things I think. Maybe if you put right by the water it will light up the water.
S9: That! That right there! Did you see that...crap
S8: What are you complaining about?
S9: It cut off the corner.
S8: Oh just….
S9: I have to move this…this and…
R: It almost looks like Google earth. You can see the blades of grass and everything. It is very realistic.
S9: See now that took it too far out. It’s cutting it off all that back there.
S8: Looks like the sun is setting or something.
R: (to S6 the deer) How is your coming?
S6: yeah, better than it was.
S9: Now I got to save it.
S8: I don’t know if I like it double shadowed.
S9: That is what I had at first then some people yelled at me. Actually it looks pretty cool. But it still cuts me off over there.
S8: bring the camera out.
S9: wait a minute. I wonder if I do this…
S8: now your camera is too far in…move it that way.
S9: I know but I want it to be in. I just want it to cover this spot over here….Now it is too much light.
S8: The spot is not even hitting the tree.
S9 : ( frustrated) my spots aren’t hitting the tree……uuuuh. But you can tell I got a spot or something..on it…
S8: cloudy day.
S9: that is another cool thing, have you seen this um… (clicking buttons and playing on computer)

Date: 4/2/2009

Observation and interviews 18
Students are presenting projects and answering questions from 2 representatives from Marshalltown Community College. The principal is present also.
PMCC: Who were the ones working with us before?
P2: Him, (S2) and the other one is not here. S1 and S2 have internships this summer with Rockwell Collins.
PMCC: Great
P2: And our other student who is not here is being heavily courted by UNI. They are probably going to pluck him this summer and he will work for them next year. Go ahead S2
S2: This class is basically using virtual reality and school. We have here our basic program Blender. You start out with a cube. See it's just a basic cube. From this we create many things and turn them into stereoscopic. We have some people in here like S8 who works strictly with game engine. Basically what stereo is …..when you see things with your eyes you see things with 2 different viewpoints. That is what gives you depth perception. Because you have one eye looking at something and the other eye looking and depending how far apart they are in your vision… you can tell how far it is. So using that knowledge, some smart man came up and made this (VR machine) Ok we will use 2 images, flicker it back and forth at high rates and then we will have glasses that correct that.
S2: This is one of my creations. It is for my chemistry teacher. A basic water molecule…you have the blue spheres of hydrogen; the red ones are the oxygen and the green there in the middle that is the covalent bonding.
R: What is covalent bonding?
S2: this….shows the green is the sharing of pairs of electrons between the hydrogen and the oxygen.
S2: basically the way this class works is we get 4 self projects and 4 educational projects. This is one of my school ones. My next one I am doing I am going to say I am doing for MR. PT and it will be the one for MCC…the computer.
PMCC: So they give you an educational goal and you have to research it and come up with the background information.
S2: Yes, like this water molecule.
PMCC: Pretty good.
PMCC2: How many presentations have you given?
S2: Today…today we have given 1.
PMCC2: But you have given several all over the state right?
S2: yes
P2: multiple
S1: Probably hundreds.
S2: yeah by now.

(Students switch projects on VR machine)
PMCC: What is this?
S1: A house
S2: I'll let S1 take it from here since this is his project.
PMCC: Let me put my specs back on.
S1: this is actually a house my dad built. He let me borrow the floor plans for it and I modeled it in VR and put it in stereo. If someone wanted a house built they could preview it and approve it even before any ground breaking took place. So you would not but a $300,000 house and find out the owner didn’t want it.
PMCC: Like where the bedroom was…
S1: yeah, yeah … without making drastic changes to it…. So Virtual reality can do a lot with prototyping and things that would cost a lot of money to do them in real life. But when you do it in VR you can find something you don't like and change it at no cost. It frees up a lot of time and money.
PMCC2: As the new students come on you have created manuals and some things to help them get into the program. But they also have to create their own?
S1: yes they go through the book, just like we did but we are there for different questions that aren’t in the book… but if they just come to us right up front ask us how to do something well we say…."Well did you read the book?” They say Yes they say no…if they say no then they should probably go read the book, because I don’t hand out free information. We don't tell them what to do.
S2: This is our book and you can tell we use quite a bit by the wear and tear on it. This actually a very outdated book and for Blender 2.3. The program we are running now is 2.4a.

S8: They are coming out with a 2.49 in about 2 weeks I think.

S1: So we are constantly upgrading because we can't afford to buy the book every time.

R: S1 when you did this house what are the basic math and science concepts you used?

S1: We had to do scaling...In Blender you have a measurement called a Blender unit and nobody knows how far it is. Because it is a virtual world...it could be as far as you want it to be. So you can set a conversion like one Blender unit equals one foot in real life. That way you can set everything in aspect...and is in perfect ratio to the real thing, it is all up to scale. That is some of the math you have to do.

P2: S26 talk about what you have learned the whole time you have been in here.

S26: I have ....well I have made the gingerbread man which is the starting program, which it what you start out on. Then I ....these guys have helped me out with developing the whole VR stand point. I now have learned how to animate, create and all that fun stuff.

R: What kind of science projects have you done?

S26: I did a hydrogen molecule.

R: Have you done anything that would be considered a college or university type of project?

S26: I don’t think so.

PMCC2: You run into a problem that can't be solved or is not in the book, other using resources what else do you do...at one point it was connecting with people in the outside world...to get answers to questions?

S8: we still do.
S2: yeah, we still talk to people in the outside world. There are forums in Blender on their website, that you can talk to them….tell them your problem…and they will tell you problems they have and you bounce ideas off each other.
PMCC: You help them with their projects too?
S2: yes
P2: S6 can you tell us what you have gotten out of this so far….as a freshman because you are the key, up and coming as things change.
S6: science has greatly benefitted from my stand point with this class because you can create things like molecules, atoms, show how things bond together with science and DNA strands…For example showing the key parts of the body. I mean math also benefits from this program…but I really find that I learned a lot more from this class than just reading from a textbook, over and over again, studying.
R: As a freshman are you using trigonometry concepts?
S6: Not yet….but I am still a freshman.
R: As a regular high school student are you using those concepts?
S6: No not at this moment. In the future.
R: Are you using geometry?
S6: All the time. Yes.
R: have you had geometry yet?
S6: No that comes sophomore year.
P2: but you have used trig in your VR applications.
PMCC2: How much time do you commit in a week to developing these projects?
S6: Oh……Geez…Generally on a good night I will put in 2-3 hours. And then on weekends Saturdays and Sundays it will be like 4.
PMCC2: Is that expected as part of the course? Or is that just because you are interested in it?
S6: It’s pretty interesting so I spend a lot of free time doing this stuff.
P2: S8 how much time do you spend?
S8: Awwwww… quite a bit because I have to script, animate and program in game engine. So it does take a little while.
P2: spend a lot of time outside of class?
S8: yes
PMCC: Are you thinking of pursuing that?
S8: yes, this class has actually changed what I wanted to do. I wanted to do personal training that is why I was interested in this because of the anatomy parts…now that I am in the game design and I am pretty good at it. I'm actually considering game design or multimedia.
PMCC: Have you started looking at schools for that?
S8: No I haven’t
PMCC: Who are you looking at?
S8: I don’t know. I am just browsing right now because I still want to run track and cross country…in college. But it is kind of hard to find a college like that with both game design and their sports. So I may have to take online classes.
PMCC: have you ruled out going to a community college?
S8: no
PMCC: You should check out Johnson County community College in Overland Park in Kansas. I know they have a gaming program. Now whether or not they have a cross country team, I don’t know. But they have a very outstanding, bigger than most, college regular 4 year colleges…very impressive. Where do you all see yourselves taking this? You got one guy gaming…and what else are we looking at?
S2: engineering.
PMCC: What area?
S2: Physics.
S1: Computer engineering.
S9: gaming
S13: I am going into computer science.
S6: I plan on going into the medical field. Med school…
PMCC: Maybe medical engineering? Or something?
S6: possibly
PMCC: well good. What do we need to do to get more females interested?
S1: We had one…
PMCC: what did you do scare her off?
S1: It was scheduling. She couldn’t be in here but…I am sure it was intimidating at first.
P2: They had 3 freshmen girls…freshmen to be here yesterday that are interested so hopefully…
MCC2: Sell it to them….You guys have to sell it to them.
P2: As you look at MCC, guys, one thing Dr. PMCC and Dr. PMCC2, look at is… a lot of our kids will be at MCC for a year…then transfer to other places…because of the seamless education component…What would you like MCC to have or what would you like to see over there at MCC that would attract kids there… since you have been in here, you look at this and you would say if MCC had this I would definitely look at being a part of that for at least a year.
S8: I think it is fairly obvious what I would like.
R: Have you checked into any of the computer programs at MCC?
S8: Some of them but…not too in depth. I was mainly looking for… I was looking at graphic design. I found out it was a completely different thing. So I mainly go to Google and type in game design degree and it comes up with schools in Vancouver, Pittsburg, Arizona…
R: What about MCC’s program in computer what would you suggest?
S8: I haven’t really looked too much into anything but… I will pretty soon.
R: anybody else have any ideas?
S13: I can’t really decide what might make other people go there but for me, definitely some good computer stuff because I do plan on going to MCC for 2 years after I get out of high school and then transferring over to Buena Vista.

R: What are you going to study at MCC?
S13: Computer networking, computer science…just computers pretty much. That is my main thing.

R: Do they have any virtual reality?
S13: I don’t know I haven’t looked that far into it yet. Right now I am just looking at basics.

MCC2: Right now we have some Virtual reality connected to our drafting program but we are trying to hear what the interest is ….what the need is with connections into our computer networking, or computer science or drafting, or engineering. We have a pretty strong engineering sequence that leads to Iowa State. We kind of need to hear from you guys and what the interest is.

R: What about you 2 guys (S1 &S2) I know you both are going to Iowa State but what kinds of programs would you require they have?
S1: Maybe like a sister program with EM. That would probably be pretty nice because we can’t do a whole of virtual networking. We can’t share products that we make with other students like college students there. That would be kind of nice to have because we can’t even do that with Iowa State because they are not willing to hook their systems up to the net. They have such a huge system but maybe if they were a newer program…ya know with a smaller system and younger stuff…we would be able to network with us.

PMCC: What I have in mind is using my connections over at Iowa State to see if I can get the linkage there to have some dialogue with P2 and ourselves and the Iowa State people…to see what would work that way. In other words, when we know we have students coming out of this program on a pipeline to go to Iowa State, but they would just as soon take a year to go through a community college first, kind as a
transitional component. What is it that we need to offer students in preparation for
that, so that when you get there; they don’t say “Well that didn’t quite cut it and you
have to take it over. You need to take this instead.” So it is a seamless pathway for
you. I am hoping with this... today marks the beginning of a whole new era of
partnerships that will maybe lead down the road in the near future...where we can
be able to offer that.
R: I know you 2 guys (S1 & S2) got credit through MCC...
S1: yeah, we got virtual reality credit.
R: Would something like receiving college credit benefit also?
S2: You mean like a dual enrollment course?
R: yes that is what I am getting at.
P2: we got those in already to a degree it’s on an individual case by case basis. We
worked with Dr. R and he likes the instructors to match up with what we are doing,
so we are there. There instructors have come over and met with these guys so that
they can see what they are working on in the stereoscopic viewing.
R: So you are talking about having that dual enrollment aspect with MCC and EM.
P2: It is already there. It is already in place.
PMCC: Now we need to find out what is the next level of that so we can provide.
And as far as that connectivity with Iowa State, I think the timing couldn’t be more
perfect. Because of some of the state wide initiatives going on right now in the
STEM field.
P2: See at Iowa State you have to be in the graduate level to get into the VRAC, but
because of what these guys have done, they are going to get in next year when they
walk into the door. That is the key for us, whether it be EM students or whether it be
students from another high school or college campus...is that we give them the
fundamentals so that when they go there they are able to import that rather quickly.
That is going to be the catch all. Because if you take these 2 (S1 & S2) or any of
them and they are not going to be involved in that and if you think about this...they
are going to have to go back to traditional sit and go to class and walk out.…after being here where they can control their education and develop… how long are they going to last in that environment? Without being engaged and that's when we go to that critical mass…with all these schools getting on board….you are going to have a group of kids that are going to be very selective, whether it be a 4 year or the junior college. They are not going to go backwards. They will not go backwards.

PMCC: And we pay attention to critical mass.

P2: and that was our real fight there for awhile with Iowa State and stuff. They wanted to go there but they were just going to sit in class…We started questioning if this was the right place to send them. Because what are they going to get out of it?

S1: I have to sit there for 2 years and then we get to do VR.

S2: actually it would be 4 because it is a graduate level.

PMCC2: They do have a course for the juniors and seniors. If MCC or you had the access to another piece of equipment that you don't have right now from Mechdyne…I know they have those rovers that go around and then they have the bigger, newer equipment. What would you recommend? What would you like to learn on that you don’t have access to?

S1: Depends on the space you have. I would like a cave.

(laughing) a C6

S1: ya…ya…but if we could have some…they can pretty much customize what your request are. I don’t know. I don’t know what would be the best thing.

P2: The big thing about it, if you had a cave or you could take those students who are working on this…because they don’t need the system to do it. They can do it on their own computers and use their flash drives in and out. They just need…but if you can put that into a cave setting, what a phenomenal feeling that would be. A sense of accomplishment of what they have done. If MCC even had the like the 4 sided cave…would make a difference too. You know we got …this (huge screen) is our wall that we will be putting up in here with the projector behind. Right now they want
to sample with models, with the traditional desk models and then the wall. They want to work off both. We will be doing that by this summer getting all that stuff set up. Maybe one step above of what you have at the high school level and one step lower than the C6. An in between system where you can take high schools students and first year college students, whether they want to go into the medical field or be an architect or engineering.

4/9/09

Observation #4 and interview S1

R: S1 tell me what you are working on?

S1: I’m working on an invention that will help people see holographic images. I have one that I am working on already but I came up with another one. Basically to represent it I need people in it, so what I do is import an object… its dispersing right here, and then basically it is a solid object, it’s a shell. It has nothing inside of it. To make it move and everything, I have to give it bones. You can see the bones right here, after you put the object to the bones, it has to listen to whatever it tells it. Then you can move certain parts of it…he can spin his arms around. You can make it jog, do jumping jacks, back flips, and whatever you want him to do.

R: Is it the same kind of bones a human would have?

S1: it is actually simplified. It takes a long time to make very single bone in the human body and you don’t need every single bone for this…most of the bones in our body are there for structure stability not actually for movement. So like his hand I only put one bone for all of his fingers so that I can get him to move his hand like this (waved hand back and forth). I don’t need the full mobility of all the fingers for this. If I needed him to do certain things with his hands, like grip things, or whatever, then I would have to make more bones. Basically what I do is… I’m going to duplicate this, so that I have 2 people. The problem with doing this is that they are going to do the exact same thing.
R: Same movement?
S1: same movement… what you would have to do is duplicate the shells and add the bones separately. Otherwise they are going to duplicate everything. Or you can go through and rename all these (the bones) cause the way that the computer works is that it finds the object that it wants to control and makes it do whatever it wants. So if you have 2 of the same name then it is going to do it to both of them.
R: so you go back and rename bone 1, bone 2 and then you get a different range of motion.
S1: yep but I am not going to because I don't need separate movements. I'm probably not going to put any movements in them. Just the thing…the reason I need to make the bones was because when you import the object, his arms are sticking straight out kind of like the DaVinci pose and so it looks really awkward so I would rather have him look more natural.
R: And what was the reason behind this project? So you can figure out holograms?
S1: yes, basically I want to use it to represent to people so they can tell what I am talking about. Most people don’t understand the actual invention itself. And so when you create these models like this, you can create the actor doing things like they would do in real life. And they get a gist of what you are trying to represent.
R: Oh I see so you are building a model of your prototype, so people will be able to understand.
S1: I don't need a model for my prototype because I understand how it works but to represent to other people I need it.
R: But it is transferring what is in your brain into someone else’s brain, so understanding is achieved.
S1: yeah it is really hard to do that with just words.
R: some of the concepts you are dealing with are pretty intense and abstract aren't they?
S1: yeah, just the basics of 3-D, not a lot of people understand the basics of 3-D. Basically a lot of people’s minds think in 2 dimensions, mathematicians can’t understand 3-D, because algebraically it is all 2 dimensional. They can convert trigonometry to algebra because they are better at working in 2-D. If they had it in 3-D they would have to draw an invisible lines behind it to give a representation of what the sheep actually looked like in real life.

R: So what is that on the screen right there?

S1: I am actually building IR cameras, because the invention I have deals with a tracking system and so you have to have multiple IR cameras in order to find distances and things. You can’t calculate the trigo-metric distances using one camera you have to use 2 or 3. It is kind of the reason why we have 2 eyes instead of one because you can calculate distances.

R: That is one of the basic things of VR is that you need to realize that everything you are looking at in real life is in stereo, with your 2 eyes, 2 views.

S1: yep nobody really understands that.

R: So you have to create everything in VR with 2 views?

S1: ya

R: Do you ever use any more? 3? 4?

S1: it doesn’t supply anything because there is not 4 dimensions. If we had 3 cameras you might discover a 4th dimension but there is no 4th dimension.

S1: What I am representing here is the IR camera, IR being infer-red, you can’t see it with your own eyes is why it works well with tracking systems and things like that.

(Working on the computer) What I just did here I used a property called spin duplication. It is just a tool that helps us model things in a circular pattern. So if we wanted to create….like this….a bunch of separate light bulbs around this lens and I didn’t want to model each one and space them all perfectly around this lens. I just created one at the distance I wanted it, I told it how many degrees around I wanted
to go, how many I wanted in the circle, and how many times I wanted it to go around. So it does it all for me.

R: You might as well have the computer do the work.

S1: ya instead of taking the time to do it.

R: So what you are doing right now with those cameras do you have to do that for each camera?

S1: No, I can duplicate the entire set up.

R: so, do it once and then you are done.

S1: ya

R: as you are doing this what kinds of things are going through your head? (S1 deep in thought and concentration) What kind problems are you solving? Or are you?

S1: Most of it is proportions. So that I get things the same size, cause in Blender there is no reference to real life. You can make this entire room the size of a quarter and you would not know the difference; you can zoom in and zoom out. Basically the size isn’t so important but the proportions to each other are.

R: ok

S1: So you don’t have a camera that is bigger than a person, which is probably going to happen pretty soon.

R: Are you going to have to put a light source in there?

S1: yeah that actually what this is right here. I can put different kinds of light sources in there. Basically if I shift to shade mode… as I move this…it will recalculate all the light reflections. So you can see all the light reflecting off their heads. If I put it really close it is really bright. And if I put it further away, you can tell the different definitions.

R: So you could simulate sunlight if you wanted to?

S1: it has a sun right. If you go to add a lamp (computer button) it has a lamp, a sun, a spot light, you can do something called a hemisphere, where it will just apply light to a certain area, or you can do an area light that is more broader.
R: So now you have 4 people and 1 camera.
S1: and like I said you gotta duplicate the cameras. Because you can’t calculate 3-D with just one camera.
S1: ok so now I have 8 cameras. The more cameras you have the better because people can get in the way of cameras so you can’t see certain objects or things. It is very important that I have a lot of cameras on here because we are dealing with a holographic projection system and I want to do an entire object. It has to know where to put the object and it also has to know how to make object look through the eyes of each person.
R: And that is what those little dots are above there? (The scene on the computer)
S1: yeah that is what these pink and green … they are all cameras. Ok so now what I do is I make frame #1 my entire thing and I shift to frame #2 where it is empty so I can model something fairly large and I can send it back to layer 1 and size it down and put it in place. It is a lot easier to model things when there is not a bunch of stuff in the way.
R: This makes sense because it could make your screen very cluttered.
S1: It can get cluttered pretty quick. Pretty much everything you make starts with a cube. You can do different things. You got a plane, cube, circle, sphere, a block sphere, cylinder, and cone.
R: You can change that shape without actually….
S1:... yeah without actually having to do it by hand.
R: Basically when you learn the program of Blender and everything else seems pretty simple.
S1: It's not too bad.
R: learning the program is kind of complicated.
S1: ya it's actually very complicated. I tried to do this during the summer the first year and without a book or anything… and it was pretty difficult.
R: that’s why they say you have to read the book first and if you have a question you have to go to the book.
S1: Basically what I am making now is a pair of glasses. I am actually going to make them look like…what’s his name the guy from star trek…from reading rainbow…his cool looking thing
R: yeah that visor thing Mr. La Forge wore. The blind guy
S1: yeah, yeah and he takes them off and his eyes look all weird. I want to make that pretty much … there might be a better way to do this but…. (Deletes image and clicks key board) . I also want to try to find the easiest way.
R: so you just deleted that right?
S1: yeah because I am going to try it a different way. I ’m going to do something with a plane. ….. (Working) and then I am going to use that spin duplication so that…push control z… control z is a very useful thing because it takes you back.
R: So you can undo very easily?
S1: ok so I am going to spin dup this…actually I am going to do..Exterior duplication… Ok I am going to do a spin. OOOOOoh what happened there? See you can’t tell things you have done until you change perspective. Because I was looking from the top view and I couldn’t see that the planes were stacking on top of each other.
R: So that is what you did see, you accidently hit a button or something.
S1: yeah I hit a button and it made it be there…So I use spin here and it looks a little too blocky.
R: that is why a lot of the guys change the angle so they can see what they got here, because they can see the finished product but then here it was spinning upside down…
S1: yeah it could be a cube…from this perspective but it could be a 300 ft tower from another perspective. It could be 2 dimensional and you have no idea. ….It looked a little too blocky, so I have it set at 16 so I am going to double it to 32. To get double
the blocks in here. I still don't like it, it is not enough for me so I am going to do 64. Spin it… this is the problem … that actually looks pretty cool. What I did was… it will spin around the camera and the cursor so this little target and so if I'm looking straight up and down, it will spin horizontally, if I am looking at it from an angle it will spin at an angle. So I actually have the camera in the wrong spot and it spun it like this…but it actually looks pretty cool. I think I am going to keep it.

R: So you made a mistake but you actually like it?
S1: yeah,

R: Then you are only going to use half of it for the visor.
S1: ummmm hum it is not going to wrap around the entire head. Ok …You can tell it is kind of darker here… It looks like there is 2 faces on top of each other.

R: how did that happen?
S1: I am not sure probably something in the spin duplication. Still looks…

R: Does the computer automatically do things sometimes that you may not know or why
S1: Yes because you are not specifically enough to what you want. A computer can't get anything wrong but it can give you something that wasn't a desired outcome.

R: it won’t think like you.
S1: You can tell it to make a circle and it will give you a big pink, fuzzy circle and that was not what you want.

R: so the more specific you are in the directions, the better off the end product becomes.
S1: yeah, ok so now I have pretty much the visor I wanted. This is kind of hard to do. I have to rotate it so I can get… get it back the way…get it orientated…correctly

R: get it orientated so that you can understand what you are doing right?
S1: yeah,
R: to me it would be very confusing, I think if you have in the wrong direction, and you are working on it and you go back and look at it then discover “oh this is wrong” That would be easy to do right?
S1: yeah… ok I think it is pretty much orientated…now what I have to do is, I have to add 2 cameras...what these cameras are going to do… is duplicate the video on the inside of the glasses that it sees. So you will have a camera I front of your eye and a screen right in front of your eye and it will project onto the screen what you are actually seeing, but it is allowing the computer to alter the video before you see it.
R: really.
S1: so …. The way this actually works is…you have a 3-D object that you want to represent in front of a group of people. So every single person in that group puts on these glasses and they have screens and cameras on the outside. They see what they would normally see, you can barely even tell that you have glasses on and so they see what they would normally see in real life, except for there is an object in there now… this 3-D object that has been put there by the computer. It is pretty much like a game but in real life.
R: Oh Ok
S1: This could actually be a huge video gaming thing that people would love to do. Because you can do it in real life…and you could run around with your hands like this (holding hands as if holding a gun) and the computer could put a riffle in your hands. You wouldn't be able to feel it, but it is there because you see it. You see it! It just feels like it should be there. The tracking system will tell the computer where the gun’s at, where your hand is at, which image to put on top, and which one to put on the bottom.
R: Do you think that in the Star Trek, this guy was supposed to be blind, and when he put the visor on he could see. Do you think this is a real life application for blind people?
S1: Maybe in the future, but all I am doing right now is projecting video onto my eye. A blind person wouldn’t be able to see that video. But they do have things for people who are partially blind; they have glasses that have a screen that will intensify the image. It will bring up the contrast like 300%. Something that we would never be able to see but blind people can see it just fine.

R: right, but if put something in your eye….like sometimes people have damage to the back of the eye and if you put a screen or something…. Like a little bitty screen at the back of their eye, where they now should be able to see it, now you are helping them to see when they were blind right?

S1: yeah.

R: Do you think that… you know there is a lot of sci fi stuff out there… Okay like beam me up Scottie kind of stuff… Do you think a lot of that stuff is possible especially if duplicated in VR?

S1: I think anything is possible as long as you put it in a movie first. Because…

R: (Laughing) in a movie first?

S1: Yeah because if you put it in a movie first someone will invent it. Inventors are waiting for that moment when they come up with something and they are never going to come up with it unless they see it first, unless they see an application where it could be used. They have something visual that trips their mind to make them think about it.

R: Ok

S1: If you put anything in a movie then basically it will come about. It may take 50 or 100 years but it will come about.

R: So you think the VR enhances peoples’ creativity, imagination and inventiveness?

S1: Yes

R: Has it enhanced yours?

S1: yes

(Student is working on the visor he has added bug eyes)
R: it looks like bug eyes
S1: yeah, kind of creepy…. that is one of the only setbacks…. when you are in a video conference a lot of people won’t want to look like this.
R: This is true.
S1: but it really allows people to simulate and see things you are not going to simulate or see anywhere else. I think they will sacrifice anything to able to see that.
R: exactly, I think it that whole social norms, you don’t wear certain clothes at certain times of the year. I think once people get used to it, I think they will be Ok with it.
S1: Now what I am doing is taking… taking the squares just behind these cameras and I’m turning them into screens so I am changing the colors of the screens. Make the glasses black hit tab and pick a new and make it gray. I like gray.
R: You said you duplicated the cameras for the eyes, so now they are not going to work independently. Right?
S1: I don’t need them to work independently.
R: Oh you don’t?
S1: These ones…. They don’t have motions on them. I took…I’m taking the cameras and parenting them to the glasses part of it, so that means that when I want to grab the whole piece, I grab the glasses part. I do this a lot so that when I move it the cameras don’t stay behind.
R: right
S1: so now when you put these on …this is what you will see… you will this in your left eye and this screen is your right eye. You will be able to distinguish depth…like in stereo. And you don’t have to have the flicker. You don’t have to have IR admitters, giving you frequency; you don’t need a high speed video card, so it eliminates a lot of things… You wouldn’t even need this system. You would just need the glasses.
R: ok that is cool.
S1: another hold back will probably change in the next couple years is the fact that 
these are not wireless.
R: What does that mean?
S1: It means it is going to have to have a cord coming off the back of them to the 
computer which is a huge pain. But those polarized lens glasses also weren't 
cordless but they got them now.
R: so we already have the technology to do this any way 
S1: yeah, yeah as soon as there is a need to do it, someone will do it. So for now I 
am going to act like it already exists. But I am going to put a little antenna.
R: If you wanted to pursue this after high school, would it be expensive to buy the 
software and the things you would need? 
S1: No it is freeware. It is all free. You get it off the internet. 
R: You have to go to class? 
S1: yep

**Observation and interview S1**

R: S1 tell me what you are working on?
S1: I’m working on an invention that will help people see holographic images. I have 
one that I am working on already but I came up with another one. Basically to 
represent it I need people in it, so what I do is import an object… its dispersing right 
here, and then basically it is a solid object, it’s a shell. It has nothing inside of it. To 
make it move and everything, I have to give it bones. You can see the bones right 
here, after you put the object to the bones, it has to listen to whatever it tells it. 
Then you can move certain parts of it…he can spin his arms around. You can make 
it jog, do jumping jacks, back flips, and whatever you want him to do.
R: Is it the same kind of bones a human would have? 
S1: it is actually simplified. It takes a long time to make very single bone in the 
human body and you don’t need every single bone for this…most of the bones in our
body are there for structure stability not actually for movement. So like his hand I only put one bone for all of his fingers so that I can get him to move his hand like this (waved hand back and forth). I don’t need the full mobility of all the fingers for this. If I needed him to do certain things with his hands, like grip things, or whatever, then I would have to make more bones. Basically what I do is... I’m going to duplicate this, so that I have 2 people. The problem with doing this is that they are going to do the exact same thing.

R: Same movement?
S1: same movement… what you would have to do is duplicate the shells and add the bones separately. Otherwise they are going to duplicate everything. Or you can go through and rename all these (the bones) cause the way that the computer works is that it finds the object that it wants to control and makes it do whatever it wants. So if you have 2 of the same name then it is going to do it to both of them.

Observation of class #2
Mr. K is assessing student projects and discussing what the students are doing. S4 is demonstrating and discussing project.
P2: S4 are you ready bud. What do you want to show me first?
S4: this would be... I’m not sure what I’m going to do with this in the future but for now it’s a free will project…and it’s just a model that I made of a NASA shuttle…I made it as solid and liquid state boosters, and I put particles on it to simulate flames, and as I get farther into the animation, both sides eject and the rockets on the shuttle sometimes ignite. They fire off and the shuttle keeps going and you turn the page and here is a space station that I want to make that sometime and then I come into this layer and I have a launching pad and this is a model kind of a rough model of the launching pad and I press render and I put a picture of S10’s earth cutting aid, for a background. And some stars. That would be that.
P2: What has been the biggest learning difficulty for you?
S4: The particle system because at one point… when the people came from UNI, every time before it all particles came right in the spot they were supposed to, right there inside the rockets. But when the people from UNI came for some reason, they were going there (outside the rocket image) and there was another group right back here somewhere (near the earth cut out) it just jumped from here to there all of a sudden. So I had to figure all that out, deal with that, before I could show it and get that out. Mesh modeling was something I had to figure out. I got help from S1 and some other people.

P2: Where did you get your idea of how to put your rocket together? Because it is not a class you took. It is nothing we taught you?

S4: well I just needed something to do and I wanted to do something that was kind of difficult and would be a challenge for me. I was looking around and I looked and there was a picture of the space shuttle. I thought that would be mesh modeling skills, it would give me particle skills that would give me animation skills, and would be a real challenge for me. So I decided to come back here and make this.

(P2 called to the office, Researcher finishes interview)

R: Explain to me what mesh modeling means?

S4: It’s where you take a cube or a cylinder or a monkey head, and you take that and make it into something like this. (Shuttle) This is made mostly out of cylinders.

R: Okay so this is a cylinder and this would be a triangle? Mesh modeling allows you to put the picture on it?

S4: Mesh Modeling gives you the shape you need to put things on it.

R: Okay, so like in art class if you want to do a model, a 3-D model, if you made them out of wires like a skeleton for the project.

S4: yes pretty much.

R: okay

S4: when you make it out of wire that is probably the definition of the mesh.
R: Basically you are putting a skeleton under there and basically you can play with the shape.
S4: and not only that you can color it and put stuff on it… like the flag down here, textures… the stars right here and the stripes
R: So what was the problem with the particles? You said they were going to another part of the screen.
S4: yeah … I was trying to figure that out, finally I just gave up and deleted them and put new ones in ….because it was frustrating, no one else knew what was going on either.
R: you didn’t know why they were doing this?
S4: If it happens again I definitely want to go in there reinstate the program and figure it out.
R: You might have accidently put something in there…. Okay after this is done go over here…Wow this looks very interesting. What are these circles here, is that to give you a point of where you are on the screen?
S4: Those are lights. You need lamps and sunspots, and aerial lights these are to project a light on a certain spot and that is what these are; so I can see both sides, from every angle, and the one on the top so I can see.
R: Otherwise you would be doing something like this.....(student shone lights on space shuttle and then turned off the lights, it was a black cut out of the shuttle) doing something in black space , you could not figure out where you were. Even though they are lights they are marker points for you, to know where you were...
S4: This is just a little…this right here is a little… that’s a sun so if I were to select all of these…and move them back here, all you see is this. It is a black shadow.
R: oh right all you see is the black shadow.
S4: You see absolutely nothing else except the plane and the stars.
R: So it is not a simple matter of here is my space ship and I am going to put it in this….now I have to figure out where the light and all that stuff is coming from, so I can actually see it.

S4: yeah

R: It is more complicated than it looks….I mean when I look at the screen, there is the earth… and all these things (ship, stars)

S4: for the particles you have to go in…it's a regular sphere or whatever you want…then you have to come over here and you have to program it to do all this stuff right here (emit particles in the proper shape) You have to tell it, how long to go, how long you want it to last, how many there are, how they come off the emitter, what kind of particles they are, because you can have particle like I have here… you can have hair… you can have something that reacts with the particles.

R: So to make it realistic you would have to know about all this stuff or you could jazz it up a little bit by making hair come out of the ship instead of the particles. So you are figuring out like … the amount of the particles coming out... you are figuring out I need 1000 particles, I need this distance for the particles to run, or they need to go this direction, this speed, you have to figure all that out and put it into the computer.

S4: yeah, another thing I did is when…. After it separates into stages, the rockets fall off and you have to move them into the position you want them and you lock them into that position and that is what I have over here…. That is the graphing of what the completed model is.

R: Okay you have to lock your rockets in there or your demonstration in there so it wouldn’t do other things.

S4: yes, Then S1 and I were working on this…we couldn’t really figure it out because it was doing all kinds of weird stuff… so we took the joystick and made a landing simulator with this. I made the space shuttle, I made the run way, I made the McDonalds with the McDonald’s sign. He made the ground with the texture and put
the controls in it and everything…so now we have the landing scene on the moon…you can pull in and get McDonalds.

R: I wonder if the moon would have a McDonalds.

S4: no it was just something I made.

R: you know a lot of this stuff is very serious and very intense, Do you guys find that if you goof off or you do this bantering back and forth that it helps your creativity, helps….

S4: yeah it release and relax your senses and everything… makes you more calm

R: so you can come up with McDonalds on the moon, rather than here is my project and I’m so stressed. In a regular classroom you probably don’t have that opportunity to do that bantering, that silliness, that…play.

S4: yeah…because if you do all that stuff the teacher comes over with a ruler and smacks you across the head.

R: right…. What are you doing? But you are finding that the play, the bantering back and forth is very good for your creative juices.

S4: yeah because with the McDonalds I just thought, which way the landing simulator should work…and then we were just messing around and I am like HEY you know what would be funny…a McDonalds on the moon…let’s build a McDonalds right there.

R: that just made your project a little more interesting a little bit more fun, and plus you had to figure out how I am going to put a McDonalds there next to the landing scene and now you have a new aspect to your project …that demands more thinking, more creativity.

R: Wow it looks like a real fun project looks like a real fun class.

Observation of class #3

R: Do you find that you get stressed when Mr. k is doing the assessments?
S13: yeah cause he keeps us all in line. It’s not as fun when he is around.
R: Does he ask hard questions?
S13: sometimes yeah, he asks challenging questions, more challenging than others.
R: does it make you think?
S13: yeah, I don’t like to think.

(Laughing)

R: but you are doing an awful lot of it, if you are creating this kind of stuff.
S13: well yeah
R: Even you don’t like to think…are you having fun when you are thinking on your projects?
S13:yeah after a while, like when you start… what is the button for this, what is the button for that, then after awhile it’s like( s brushes hand across keyboard ) wooosh and then you’re done.
You mess around on the keyboard for like 5 minutes and you’re done… then you have nothing else to do, and that’s when the kidding around and stuff kicks in and then you start putting in more stuff in there to make it more fun and more educational.
S13: like I talked with guy and I made this…an educational project it’s just sand that falls from the force of gravity and bounces off other things and slows down, all the way down the ramp.
R: What are you learning with the sand going down the ramps… you learning about gravity…you learning about particles?
S13: You see how fast it goes…(demonstrates project)… you see how fast is goes right there?... and then when you come down here, it slows down a lot because of friction and dampening (wooden ramp narrows) of everything right here, so it teaches you that stuff(mass) slows down when it hits other stuff like my hand goes fast when I just go like that (swoops hand across table cross in a fast manner) but if I
go like that (rubs hand across table surface roughly) it stops and that is exactly what
is incorporated by itself…
R: OH okay.
S13: I helped show that.
R: this is curved (ramps) and this is straight…does this make a difference too?
S13: yeah
R: because this is curved it goes faster, this is flat it is going slow.
S13: well the only reason it’s going faster up here is because that is where it is
starting so it hasn’t had a chance to thin…see it juts out right there then comes back
in because it is curved… it hits the edges right there, bounces back in and goes
through the hole, then starts spreading back out by the time it is done
R: so you are talking about dispersal right here and here it is not…so much
S13: right because that is where goes back in…is
R: and those are important concepts if you want to design something for a game, so
you need to decide… what shape do I want it? Do I want it curved because I can get
better coverage or do I want it flat because I need these properties.
S13: right…pretty much that’s it.
R: What grade are you in?
S13: I’m a freshman.
R: what kind of science classes have you taken so far?
S13: Physical science.
R: Physical science…and you are basically using other sciences other than physical
science
S13: simple…yeah this is kinda jumping me forward because I ask questions of
some people that are past physical science.
R: and even something like this is past physical science, it's more physics…cool
thanks , thanks for sharing.
Observation of Class #1

Mr. K is assessing student projects and discussing what the students are doing. S12 is building models of the elements on the periodic table and also demonstrating a Pong game he made.

P2: So we are working with periodic tables where did you start?
S12: I started at the beginning; I have the table at my house. I grabbed the wrong Blender file.

P2: I will need to see that.
S12: That's fine.

P2: Just a little glimpse. So what did you use as a resource after that?
S12: I actually looked some of the facts up on the internet and I also used our Physical science book for the periodic table.

P2: What kind of problem solving skills did you develop?
S12: just the little things like how if you screw up on one of these little things it could end up being the end of the whole project and starting over.

R: if you screw up on what, the atomic weight?
S12: No if you like come into the game engine you can do the centers and all that stuff.

P2: How will that help in the classroom?
S12: I think it will be a big help because the teacher goes over trying to reach all this stuff like what the atomic weight is and all that and the teacher can actually show the students the 3-D model of the atom, which is nice because I like seeing the things for myself.

P2: What did you learn from this?
S12: scripting

P2: How do you see that helping down the road?
S12: Game development...It's helping me with the periodic table putting that into the game engine, so the students can use it.
P2: How did you come up with concept you are doing?
S12: I was just sitting at home one day watching the Discovery Channel, they were showing a show on the games that they used to play in the arcades and pong was one of the first games ever made and I thought that would be pretty fun to make.
R: So you are using a basic game Pong to learn scripting, which is very complicated?
S12: Yes, and that comes down to...all the stuff with touching, the sensors...S8 helped with most of this stuff...so it went by pretty quick, with all the properties which I had no clue about until he showed me.
R: So by using a basic game you are leaning “x” and “Y” axis and what's going to happen with angles so that when it hits the paddle the piece will go this direction or go that way.
P2: As a freshman, do you feel you would have picked any of this up, what you know now as compared to before you started working on this?
S12: No, just for the fact that, if this class wasn't here I probably wouldn't even know about Blender, therefore I would be sitting at my house, saying “oh that would be cool, oh well it’s Pong” and go on, and play a video game or something.
P2: Is it making some of this class look different, because you said, you looked at the periodic chart, so you look at things and think I can do this differently.
S12: yeah like I was sitting in science the other day, taking a test and something just popped into my head that would be fun to make. I should add that into a VR project. So I am going to incorporate some of that stuff...you know you sit in class and the teacher says something and it just sparks.
R: What you are doing is...bringing what the teacher is telling you and bringing it to life, or bringing into VR so you could actually see it. Do you find that enhances your learning when you bring it into the VR?
S12: I think it does because being able to see it, helps me out a lot better because I can get a mental picture of what it looks like, rather than just the words the teachers say.

R: and such things like elements which are kind of difficult any way, just learning a chart is …. I know this but what applications does it have.

P2: Alright thanks bud.

3-13-09

**Student Project  S26**

Running Yeti

S26: Here is my Yeti. It was supposed to be a bear but I think it looks more like a yeti.

R: What was the most difficult part of this?

S26: It was getting everything to move with the whole running thing. I wanted him to run fluidly, naturally.. and getting everything with it.

R: did you study runners?

S26: Pretty much I watched runners. I am on the football team and we run all the time. I watched the fluid motion.

R: Did you use an anatomy book?

S26: yes there is one in here… I pretty much looked at toe and finger development… I don’t have as many bones in the wrist as a human has... I have the main selection right there...and I have individual fingers and individual toes that branch off...there is not even bones as there should be but it is enough to get him to run as he should.

R: Do you need all the bones?

S26: no I don't need them because I got the motion I want and the running the way I want.

R: What are your plans for this guy?
S26: I want to make him more realistic…with the whole running stance and everything and get the environment to look better.
R: Did you have trouble with the motion?
S26: When he was running his hands and feet were pointing backward and it looked weird. I had to change the angle of them to make the motion go the right direction.

Date: Aug. 30, 2009 (2 weeks into the semester, S26 had previous VR experience)

S11 Interview

R: I have some interview questions do you want to be interviewed?
S11: Do I have to be?
R: No you don’t have to be, it is totally volunteer
S11: Do you want to be?
R: (Laughing) Yes. Because you are one of the experts in it.
S11: I’m one of the experts Okay.
R: Let me go get my questions. This is an interview with S11
1. What grade are you in? Senior
2. What kind of projects have you done? Basically I have kind of done little graphic things…like suits of armor, weaponry, little bit of landscaping a little bit of architecture, just about anything
3. How many semesters of virtual reality have you had? 4
R: 4 semesters Where you one of the ones who started at the beginning?
Somewhat, I was interested in the program and taking the class but I was not able to since I had other classes that I needed to take…I was kind of rejected at that point but that is alright because I got back into it.
R: Basically did you only miss one semester? From the beginning it was my sophomore year, I lost both semesters that year
4. Check areas of growth you have seen in yourself because of your participation in the VR program.

- **Academics** I believe so yeah, I used to not be very good with grades. Needless to say they have improved.

- **Maturity** being around these people no

- **Responsibility** Yes since I have to take care of these little children

- **Reading skills** Weelll Yeah, well no because I don't read that much… but I am reading more now! awesome

  R: You are reading more technical manuals and that kind of stuff right?

  Somewhat, used to

- **Public speaking** a little bit I guess if I speak a little bit in the public I would say that is was not a part of this class but I have gained it.

  R: Would you say you have gained confidence in public speaking? Probably a little bit yeah since I have had to talk to some of the higher ups fat cats and all that.

  R: Did that make you nervous? Scared or thrilled? No I just threw everything out and kind of went, that is kind of my pathology…..of my mind…it’s a good thing

  R: Yeah you are laid back and that is a good thing

  S11: Just lay back and let it go.

- **Self esteem** A little bit yeah! I have! it is kind of cool,

  R: Can you give me an example of how your self esteem has been boosted? I'm just more confident now that people are like “Hey how do you do this?” even though I don't know, it just kind of cool…they how do you do this?”

- **Critical thinking**

  S11: Give me an example of that?

  R: Okay critical thinking would be you can look at something and say “I don't really believe this or I do believe it to be true and here is my reasoning. Have
you developed any skills such as “Yes this research is good, this project is good…this is bad? Nay I have always been kind of just…whatever, everybody works at their own pace, everybody does their own thing to get the best results.

R: Have you gained any skill in reflective thinking where you look at a project and you think I can think about this… I can think if it is good or bad… Have you used any of those skills where you have reflected on something? Not really because I found that you know usually my type of thinking is going to be a lot different from what some other people are going to try to tell me and you know I’m not going to argue with anybody so this is what this is supposed to be. I’ll just impress on them and hopefully they know what they are doing. They are the one talking the fall for it.

- Problem solving A little bit using textbook or manual or even the internet to find my answers

R: what kinds of problems have you faced doing your projects? Mainly what hot keys did what… that was my big one, or like one of them was we had a fluid simulation and it wasn’t working properly… it poured into a bowl or something like that.

- Math concepts I want to say no…because I have been through the higher up maths and even though MR. K says you are going to use math and all that in this class I really never used it

R: What about geometry or algebra? Have you used them? In an …….off sense I think… just kind of manipulating the shapes and all that type of thing. I mean I don’t use the hypothesis of blahh blahhh blahhhh … a squared plus b squared equals c squared…

- Oral language ability A little I suppose even though I have a speech impediment at times and … a slip of tongue at times….needless to say it sounds like an ugly mess
Written language ability we don’t have to write on any of the fields. Nope I never written any instructions or anything.

Leadership Well seeing I have to keep some of these kids in line I would say Yeah… since I am the old wise one

Mentoring maybe a little maybe

Transferring of other subjects For me it is more like history or maybe even some language, you read books and taking something you have been taught in history like every ones old favorite Thermopoly, and to show this is actually what happened instead of like the movie… more realistic view of history

Citizenship taking it into the community: I think more like we draw more schools together so we work closer together… I mean we have had ISU, UNI, some of the local community schools and some from down in Des Moines they are coming to us and saying “hey can use this? What do you guys know? It gets everybody on the same page so that teaching can be revolutionized

Use of a variety of science concepts I don’t know. …on how I look at stuff at a different way

Ability to question Yeah I mean … when I originally started…all these programs when they you first start them up use a cube and that is what I always started with was the cube and now I can switch up things and start something else differently… even just make like if I was… making like a weapon like when I had to start with a box it took so long to do it, I had to shrink it down… resize and all that now I can just take something else and then put it to exactly what I need, learned to be more proficient.

Logic, creativity, inventiveness Well, since I do more things from the past, I can’t really creative or inventive
R: although you are inventing things from the past that you can’t normally see right? Yeah, especially when I feel like ruin castles and stuff like that, you can build them back up and what it would look like. How fun.

☐ Artistic I used to be in art every year, but this year I don’t want to do art because I’m not going to be using it later in my life.

R: have you used a lot of artistic ability in your projects? Just a little bit, I mean it might just be a natural thing for me. I’ve used just a little artistic ability to create armor sets and making engravings and making different stuff like that.

☐ Phone skills I’ve never had to talk on the phone for this class.

☐ Organization Concerning that I have had to put many files into different folders, I guess so, Other than that, not much.

☐ Promptness No, not being lazy. I’m saying that. I’m a senior. You cannot ask me that question.

☐ Professionalism

☐ Other (please specify)___________________________________________________________

5. Comments or examples of any of the above.


7. How has VR changed your attitude toward your education? I used to be one of those kids that didn’t give a … I didn’t care anything about teaching or anything about the school, but now that I’ve used this technology I can see that there will be great improvements with history and instead of using a textbook, you can flip on a screen and say this is what it would look like and instead of seeing a 2-D picture, a whole 3-D thing. Maybe even “experience” what happened.

8. Do you think that VR helped you get through high school? Probably a little bit cause you know it gets rid of some of that down time, so I’m not sitting around
getting, even though I still am and directing some of that creativity I do have and make whatever I have a part of the program.

9. What are some of your educational projects? I’ve done trench warfare, skeletal structures of certain animals and how they move and things like that.

10. What kind of science classes did you have before that would have helped with the skeletal structures? Biology, that’s it.

11. How do you solve problems within the group or individually? Well some of the times I’ve done it individually and sometimes I’ve done it with a group…it really matter on what type of resources you have and who is in the room at the time and if they know what you want to know trying to get some help and if not you just have to either tinker around with it, figure it out yourself, look it up or just have to wait find out later.

R: As a senior would you ask a freshman for help if that freshman knew about a skill? Oh Yeah, freshman all around the room they know more than I do about this program because they use it all the time…use it a lot more than I do… I just do basic stuff, architecture, skeletal structures all that stuff…these kids…no they do the animations, they do video games…they do amazing little stuff…and it’s like cool.

R: Basically when you walk into this room you are not seniors and freshman and have different levels of education…oh no you can’t say that…I mean well so Hey I am a senior! But it is just the fact that I know that the guys in here know a lot more than I do. I give them that much credit though for being a freshman……. You know you are still a freshman.

12. What is your favorite thing about your VR class? Being able to take something that you have learned, something that is in your mind and not really tangible and actually pulling it up on a computer screen and be like THIS IS IT! And for me at least looking at little 2-D pictures on a page and saying cool awesome (sarcastically)
R: yeah but how does this apply to me right? Yeah and then I am able put it up on here, and spin the camera, look and see where everything is at and how everything is built up It’s like hey cool! Awesome! That is how that works.

13. What improvements would you suggest for the VR program? Watching these kids a little more closely … I mean Dam,

R: you actually have a lot of free time down here? Yeah we do but for the most part everybody gets done what they need to do

14. How would having a teacher change the dynamics of the class? I am pretty sure it would make it so that a lot more people putting out and stuff and not so much screwing around. I am just being truthful and I know people are going to hate me for it but uhhhh…

R: I want you to be truthful because…..it is important

S11: but uuuuuh it might take down some of like… I don’t know the free willness of what we have… I know that some teachers will put certain criteria… that you can’t do that, you can’t do this… you have to do this… I mean that kind of takes away the freedom of doing it… and you know you get to your job and it is a half a thing I mean it is just like the regular world if you had job you don’t like you’re not going to do it to the best of your performance.

R: Do you find the playfulness, the silliness that happens down here helps in creativity and learning or it hinders it? I think it helps a little more…I mean it makes people more comfortable with each other and if they need more help they will come to each other so all in all…

R: So if you had a teacher in here that actually taught you this stuff, do you think you would get the same kind of learning? The same kind of projects out of the kids? I really don’t think so because you know the teacher can only tell them certain things, the student only go with what they have been told. They won’t have the free willingness just to kind of go and like I want to do this and we will fly in that direction and grab whatever came along the way, you know it has been said before by Mr. K
most people that have been taught by teachers they just go with the bare minimum of what they want. Since they (VR students) have no minimum they go wherever they want. I mean if you want to create this massive world, everything moves and doing all this cool stuff… they’ll do it or if they don’t they won’t. Possibilities are endless!!!!

R: Do you like that kind of classroom or would you rather be in a classroom where the teacher told you what to do? It’s kind of a 50-50 thing for me I mean I love the freedom, I love being able to do the things I want to do but sometimes it’s just like “wow I really wish someone would tell me what to do.” … you just fell kind of lost sometimes…..oh I don’t have anything to do.

15. How would having a set curriculum or required textbook change the dynamics of the class? I really don’t think it would do much …I mean we have textbooks that tell us what to do with the program … and I have seen some people go through it…since the books are with outdated programming that we don’t use any more…it’s a little bit difficult to use it, apply it… so we use the internet. Oh glorious internet.

16. What opportunities has the VR program opened up for you that you would not normally have?

17. What traditional science and math classes have you completed since Dec. 2008? Check all that apply.

- General math which would be? Regular anything… well I am done taking that
- General science of course i have already done that
- Biology yes
- Physics yes
- Chemistry yes
- Geometry yes
- Algebra yep
☐ Algebra 2 yes
☐ Calculus nooooo!
☐ Computer skills yes
☐ Anatomy nooooo!
☐ Other (please list)-

☐ Advanced Placement math or science (please list) no

18. In your opinion check the 3 top reasons the VR program has brought you success or growth. I think just the freedom to do whatever you want, you get a great variety of projects and products rather than what you just throw out there, we had a guy who made a game and now all these other people who make games say Hey I want to play...cool awesome....and they are pointing stuff at him for it
☐ Flexibility for student –centered projects Yeah I mean to not be hindered by anything, by any criteria and that is just a great thing ...like wow you can’t tell me to do anything so I can do whatever I feel like it
☐ Allowances for creative thought
☐ Student interest in VR
☐ Parental motivation no... what parent what are those...I maybe see them 5 minutes a day
☐ Opportunities for presentations and public speaking
☐ Student centered curriculum and lack of one main textbook
☐ Inquiries based on student interests
☐ Student driven research
☐ It has not brought success or growth to my child
☐ Other (please specify) ____________________________________________
No Growth or success

19. How are VR projects accessed or evaluated? Mr. K will look and see that you actually did that…everybody assess each others

20. Has any teacher used your VR project in their classroom? Which one? Yeah actually the first year that we had the program we used it for a history class…. the monument for world history…

   R: Really so for world history they used a monument. How did that make you feel? Empowered…because everyone was like..oh I want to make that out of Styrofoam and cardboard…cool…I am going to put it up on the screen…

21. What professional or political people have you talked with?

22. What are your thought processes when self reflecting or creating a VR project?

23. Do you plan on taking computer classes at a college or university? No

25. Do you know where you are going to college? Area of study? Not going to college going to join The Marines

   R: So you are not going to a college or university, in the Marines or are you? I don’t know I might later, after I get out of my Marines… I mean they will pay for it ….in full.

26. Do you think you are going to try to get into something with this in the Marines? Probably not in the Marines, considering I will be taking school for teaching, it will probably be integrated into my teaching…if I decide to keep on going with it. My course work will still be there…it will be there somewhere.

   R: In fact if you go into teaching, it doesn’t even matter what kind of teaching you go into, I can almost guarantee that technology will be a part of it, even if you teach history or math or whatever.
S11: Already I have used VR for history teaching…I built a trench… to show what happened in WWI
R: you may be surprised though a lot of VR I used in defense and so when you get into the Marines if they find out that you have this skill or experience… they may put in something where you either are designing it, using it, writing something like that.
S11: yeah
R: Do you anticipate any of that or have the Marines even said anything about VR?
S11: Oh well I don't think they really use it… I think they rely more on using a person, rather than a computer or machine for it… I mean maybe the Army had done VR but besides that I really haven’t asked.
R: Overall what kind of learning experiences have you done?
S11: for me kind of like graphic designing type of thing like what can go where, how to set up and how it’s going to look, rather than do it in real life and build stuff and waste your money… your time on trying to do something that is not gonna happen.
R: Is there any other things you would like to add for this interview, opinions, thoughts, things you don’t like about the program or things you would change?
S11: Not really
R: Would you recommend this to other students?
S11: of course other students
R: Would you recommend it to girls?
S11: Well if girls would get off and do some work.
R: Do you think having girls in class will change the dynamics the silliness of this class?
S11: Nooooo guys are gonna be guys. We do whatever we want.
Date 4/2/09

**Questions for students**

R: What is calculating alpha?
S13: A slider in Blender
R: What does it do... *(Student confused)* I heard someone say they had to calculate alpha.
S13: It's a ...like when you are making water or something, that's like how clear ...how realistic are you going to get it...like shininess.
R: Is it a ratio?
S13: I just put the slider where I want it.
R: Do you actually calculate alpha?
S13: I just experiment with the slider. So if you slide it all the way over here it is going to do that...like that.
R: Do you use it for other things? Like calculating...
S13: I don’t use any math in this class.... it is all visual stuff.
R: Ok
S13: All I ever do is model things and animate.
R: What is bone heat?
S13: Bone heat is where you are doing armatures...which are bone structure, of what you are going to animate...You put a bone in somebody’s arm....and then when you move that armature, the mesh is going to follow...bone heat is what is going to attach that bone to the actual mesh or like the skin. When you make an animal or humans you put armatures in there for movement....then you put the mesh and texture on it.  The bone heat is what keeps....it measures how much of that skin is going to pull....as far as how that bone is attached.
R: The student who described the bone heat said the bone heat was wrong because the skin was wrinkling up.
S13: yeah, it was either too strong or too low, it wasn’t pulling enough of that skin to make it realistic, and like that fish was swimming in the water.
R: What is torque?
S13: I want to say some power..... but I am not sure...
R: a student something was being measured in torque?
S13: at the same time it is not because P.E.T. is measured as something else. I'm not good with vocabulary.
R: What are particle skills?
S13: particle system
R: yes
S13: particles are what generate the light and stuff...if you want to make a laser.
R: It's not the detailing?
S13: no is calculating the speed, length... of the particles.
R: what are envelops?
S13: Oh that is another armature thing. You can either do it with envelops or with bone heat. When you attach the armature ... I can probably show you... I have it on my flash drive. It will take the bone and an envelope will kind of outline how much of the area you want it to take.
R: Which is better bone heat or envelopes?
S13: Depends on how exact you want to get. Envelope is when you just want to just throw it together, it's faster and easier. Bone heat is where you want to get more detailed as far as how much you are going to pull, more specific.
R: how did you learn that?
S13: Playing with it.
R: That was all the questions I had at this time. Just clarifying vocabulary
Appendix F - Rubric for analyzing student projects
## Rubric for Analyzing Student Projects

<table>
<thead>
<tr>
<th>Criteria</th>
<th>Indicators</th>
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<tbody>
<tr>
<td><strong>creativity</strong></td>
<td>Ingenuity of project design</td>
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<tr>
<td></td>
<td>Appropriate topic for project</td>
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<tr>
<td></td>
<td>Visual appeal and accuracy</td>
</tr>
<tr>
<td><strong>Academic content</strong></td>
<td>Connects to academic subject matter</td>
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<tr>
<td></td>
<td>Information presented is factual and correct</td>
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<td></td>
<td>Evidence of content understanding</td>
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<td></td>
<td>Vocabulary used correctly in context</td>
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<td></td>
<td>Evidence of problem solving</td>
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<tr>
<td><strong>Technology skills</strong></td>
<td>Advanced use of software</td>
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<tr>
<td></td>
<td>Variety of software tools exhibited</td>
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<tr>
<td><strong>demonstrated</strong></td>
<td>Explanation of technology used</td>
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<tr>
<td><strong>21st century skills</strong></td>
<td>Communication skills- speaking, writing, public</td>
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<tr>
<td></td>
<td>presentation</td>
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<tr>
<td><strong>demonstrated</strong></td>
<td>Leadership and mentoring</td>
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<td></td>
<td>Work attitudes – quality, goal setting, vision</td>
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<tr>
<td></td>
<td>Life applications</td>
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<td></td>
<td>Career applications</td>
</tr>
</tbody>
</table>
Appendix G – Formal interview questions with seniors
**Student Interview Questions**

1. **What grade are you in?**
2. **How many semesters of virtual reality have you had?**
3. **Check areas of growth you have seen in yourself because of your participation in the VR program.**

- Academics
- Maturity
- Responsibility
- Reading skills
- Public speaking
- Self esteem
- Critical thinking
- Problem solving
- Math concepts
- Oral language ability
- Written language ability
- Leadership
- Mentoring
- Transferring of other subjects
- Citizenship
- Use of a variety of science concepts
- Ability to question
- Logic
- Creativity/ inventiveness
- Artistic
- Phone skills
- Organization
- Promptness
☐ Professionalism
☐ Other (please specify)____________________________________________________________

4. Comments or examples of any of the above.
5. What are your goals for your future?
6. How has VR changed your attitude toward your education?
7. How has VR changed your perceptions toward thinking outside the box?
8. List the projects you have worked on.
9. Give specific examples of science concepts you have learned about or used in a VR project?
10. Give specific examples of math concepts you have learned about or used in a VR project?
11. Give specific examples of problem solving you have used in your VR projects.
12. How do you solve problems within the group or individually?
13. What is your favorite thing about your VR class?
14. What improvements would you suggest for the VR program?
15. How would having a teacher change the dynamics of the class?
16. How would having a set curriculum or required textbook change the dynamics of the class?
17. What opportunities has the VR program opened up for you that you would not normally have?
18. What traditional science and math classes have you completed since Dec. 2008? Check all that apply.
   ☐ General math
   ☐ General science
   ☐ Biology
   ☐ Physics
   ☐ Chemistry
19. In your opinion check the 3 top reasons the VR program has brought you success or growth.

- Flexibility for student –centered projects
- Allowances for creative thought
- Student interest in VR
- Parental motivation
- Opportunities for presentations and public speaking
- Student centered curriculum and lack of one main textbook
- Inquiries based on student interests
- Student driven research
- It has not brought success or growth to my child
- Other (please specify)_________________________________________

20. How are VR projects accessed or evaluated?

21. Has any teacher used your VR project in their classroom? Which one?

22. What professional or political people have you talked with?
23. What are your thought processes when self reflecting or creating a VR project?
24. Do you plan on taking computer classes at a college or university?
25. Do you know where you are going to college? Area of study?
Appendix H – Coding system for transcriptions
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<td>Science concept – ( branch of science)</td>
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<td>52/244 *</td>
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<td>Science concept – optics, light</td>
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<td>Science concept – Anatomy</td>
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<td>21st century skills – work independently, motivation, self reflection,</td>
<td>37</td>
<td>90/244~</td>
</tr>
<tr>
<td></td>
<td>leadership, public speaking, creativeness</td>
<td></td>
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<tr>
<td>21st – PS</td>
<td>21st century skill – problem solving</td>
<td>27</td>
<td>24/90</td>
</tr>
<tr>
<td>PMT</td>
<td>Peer mentoring – teaching</td>
<td>37</td>
<td>34/90</td>
</tr>
<tr>
<td>P</td>
<td>Play- students goofing off while working on projects</td>
<td>42</td>
<td>38/90</td>
</tr>
<tr>
<td>COL</td>
<td>Collaboration – students working together, nonteaching</td>
<td>44</td>
<td>40/90</td>
</tr>
<tr>
<td>GO</td>
<td>Globalization</td>
<td>25</td>
<td>10/40</td>
</tr>
<tr>
<td>~</td>
<td>21st century skill all inclusive</td>
<td></td>
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</tbody>
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(Morales 2010)
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