THE IMPACT OF AN INTEGRATIVE 3-D VIRTUAL LEARNING ENVIRONMENT IN DIVERSE NINTH GRADE EARTH AND SPACE SCIENCE CLASSES

by

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Abstract

Problem-based learning in the sciences has been demonstrated to be a successful educational approach to engage students and increase content knowledge. However, the power of collaborative learning to engage students, increase content knowledge and develop problem-solving skills in the sciences has not yet been fully researched. Collaborative learning has an enormous potential not only to foster student learning, but also to increase interest in the sciences and promote cutting-edge education strategies worldwide.

Collaborative learning tactics in this study take place within the virtual learning environment entitled "GeoWorlds." GeoWorlds is an online educational gaming program within the Second Life 3-D Teen Grid. The curriculum was developed as a collaborative, investigative and engaging program to promote learning of Earth science content. The program allows students to be submersed-in and explore different geologic time periods; enabling them to observe species and geological structures while interacting with one another to complete tasks. This study investigates the educational impact, emotional response and overall feedback of the GeoWorlds virtual learning environment on Midwest ninth graders.

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CHAPTER 1 – Introduction

Rationale

In comparison to past generations, high school students today have been exposed to a larger amount of media through advances in technology. Arguments have been made that this increase in media exposure, i.e. computers, video games, television, and cellular phones has changed the way students learn today. According to a Kaiser Family Foundation study (Rideout et al., 2005), between the years 2000-2005, the proportion of 8- to 18-years olds with computers in their homes increased 13 percentage points (from 73% to 86%), and the proportion with Internet connections grew from 47% to 74%. In the same study, media exposure among 8- to 18-year olds was recorded reaching nearly eight-hours a day.

With this much time dedicated to media, educational institutions are exploring how to make these technological tools useful in the classroom. In order to start incorporating media tools in the classroom, new curricula must be developed and fine-tuned. GeoWorlds works to start this redirection from lecture and textbook based, passive learning environments towards an integrative, active and engaging one.

Description of GeoWorlds

GeoWorlds is an innovative new program funded by the The Ewing Marion Kauffman Foundation (2008). It integrates collaborative virtual learning environments with problem-based pedagogy. It was designed using the Second Life immersive education platform to engage students in Earth science courses, while enhancing their problem solving skills and content knowledge. Problem-based learning in the sciences has been demonstrated to be a successful educational approach to increase knowledge level and student engagement. Teachers today are being exposed to a wider range of problem-based curricula based on the national and state science standards in Earth science (Kolodner et al., 2003). However, the power of collaborative learning in a virtual environment to engage students, increase their problem solving skills and content knowledge in the Earth science arena has not been fully researched. This project offers

an opportunity to do just that. The integration of these tools has enormous potential to increase interest in the geosciences and to modernize education worldwide.

GeoWorlds is still in the development stages, but will eventually hold different "islands" representing different geologic concepts; i.e. Geologic Time and Hydrology. In this study, the island of TerraWorld covers concepts of Geologic Time by immersing students in several different environments from the past. TerraWorld presents 3-D visualizations of the major characteristics specific to the Precambrian, Cambrian, Devonian, Permian, Triassic, Cretaceous, Eocene and Pleistocene. These scenarios provide, through their virtual visualizations, chronological position in geologic time, environmental information, dominant life forms, location of the continents and critical changes or adaptations in life history. Each of the scenarios has interactive exploration and content built in, as well as large picture relational understanding between scenarios. These relational pieces guide students on how to recognize and order the events of geologic time using the biota and the environmental conditions that are critical in life history events.

Students explore the 3-D scenarios following their own direction, but are provided set goals to attain specific pieces of information that will contribute to their understanding. Participants can work together, share information and develop new groupings of content while also developing complex linkages through randomly encountered information. The information comes in a wide variety of forms – written explanation, visual, short videos and touching and clicking for data (Ewing Marion Kauffman Foundation, 2008).

CHAPTER 2 – Review of the Literature

The Teaching of and Learning by the Millennial Generation

The Millennial Generation encompasses those individuals that were born between 1982- present. Members of this generation thrive on media and technology and a life without Internet is inconceivable. This generation's members know more about digital technology than their parents or teachers and this directly impacts how students relate to school and learning today (Coates, 2007). Millennials can easily manage to listen to music, work on the computer and watch television all at the same time. This means they

may need a lot of stimulation in their learning environments and may be more focused than it appears to their teachers. Learning needs to be entertaining and fun as this generation can quickly become bored in a learning environment that is not highly active and interactive (Coates, 2007). Though a highly stimulating environment is desired, this is not to say that this is not a generation of readers, as they are constantly reading material via the Internet, so written information also works well with this group.

This is a generation that uses technology for "everything." A classroom that does not incorporate technology will rarely meet students' needs for variety, stimulation and access to information. Some classrooms still require students to study and learn in ways that, to them, are completely different from the ways they operate in every other aspect of their lives. In the same vein, it is important to make subject content fun because if it is not fun, it will be cast into the category of "boring" and may become less effective. Therefore, Millennials may learn better when they are entertained and games are incorporated. Using computer games as an instructional technique may be very effective, as it incorporates many of the strategies that this generation has already developed for learning: multi-media sensory stimulation, interactive-play (either with other people or with the computer), individualization of the learning experience and control over processing time (Coates, 2007).

Games, Simulations and Virtual Learning Environments

GeoWorlds and other virtual learning environments are not generally considered computer “games” per se, but are a form of edutainment or a game-like simulation. Edutainment can be generally defined as a combination of an entertaining media with an educating curriculum, also referred to as educational gaming (Egenfeldt-Nielson, 2009). As the line between games and simulations continues to blur, they are not mutually exclusive, but for the purpose of describing the Second Life program and the purpose of GeoWorlds itself, a distinction should be made. Games are generally defined as a non-realistic/fantasy environment that contains scenarios that engage curiosity, present challenges and are dependent on the player’s control. In addition, a game environment must be goal-directed, rule-governed and contain elements of competition, whether it is between an individual and the game or another individual (Dempsey, et al., 1996).

GeoWorlds falls within this game definition through its semi-fantasy environment, as the geologic time periods no longer exist nor can they be visited in reality. However, GeoWorlds engages curiosity, presents challenges and is navigated and explored completely by the player's control. The environment in GeoWorlds is goal-directed with a few rules, but does not contain direct competition among students, unless one considers academic success competitive.

Simulations, on the other hand, are contentious, but are often reality based. They provide an individual with an opportunity to interact with a replication of a social or physical element in reality (Seidner, 1975). Thus, the individual's interaction with a simulation inherits the rules of reality, reducing the level of control an individual has when engaging the environment (Heinrich et al., 1996). In GeoWorlds, there is a sense of reality because the environment can be manipulated and there can be interaction with other individuals creating a realistic social and collaborative atmosphere. GeoWorlds, therefore, is a combination of game, simulation and classroom. Encompassing specific benefits from each genre, GeoWorlds is a progressive teaching and learning tool for academia.

Technology in Effective Teaching and Learning

As the overlap of technology, media and education continues to grow, more studies are published on successful and non-successful edutainment tools and the evolving ways students are absorbing information due to these technological changes. In today's classrooms, edutainment is becoming increasingly popular and effective whether through reality-based game playing or other technology mediums.

Sasha Barab from Indiana University's School of Education and founder of "The Quest Atlantis Project," has published several studies on the benefits of exploring different ways of teaching the sciences to today's students (Barab & Luehmann, 2008; Barab & Plucker, 2002; Barab & Roth, 2006; Barab et al., 2005; Barab et al., 2007). Through his studies, he was able to create his own virtual learning environment entitled, "Quest Atlantis." Barab's (2002) motivation to create an immersive program for students came from his belief that ability does not reside (and talent development does not occur) in the head of the learner, but is best conceptualized as a collection of functional relations

distributed across persons and particular contexts through which the individual appears knowledgeably skillful. This is to say that simply testing a student on paper cannot fully reflect the intelligence and ability level alone and observing their actions and participation in an environment also points to signs of learning and understanding.

Unfortunately, the majority of school districts base their gifted education and talent development programs on the identification of high ability children using instruments focused primarily on individual capabilities and tests in impoverished contexts using paper-and-pencil items (Callahan et al., 1995; Hunsaker & Callahan, 1995). This difference in paper-and-pencil testing and that of observing students' knowledge and talent in a person-in-situation setting, is a prime example of how academia tends to separate students into test-smart and street-smart categories. GeoWorlds works to test both of these "smarts," as knowledge can be demonstrated through testing on paper and the observations being made of the students' understanding and making connections in the virtual world. It has been demonstrated that skills tested on-paper and in-situation to be similar, if not identical, and thus GeoWorlds works to encompass evaluating students in both arenas (Saxe, 1992).

Saxe (1992) studied children selling produce in open markets in Brazil and found that the children's arithmetic was correct 99% of the time in the market, but their performance on the same problem on a math test was successful only 65% of the time. So, who is smarter? The person-in-situation or the paper-and-pencil student? Virtual learning environments allow all learning styles to reflect their skills and talents, plus provide several contexts in making learning not necessarily easier, but more compatible with a wider range of students and their individual learning preferences. Environments like GeoWorlds provide a space where an individual is fully immersed, resulting in concrete experiences that are foundational to learning, no matter the type of learning style the student is comfortable with.

The complexity of contemporary students' lives (e.g., different classes, after-school experiences, weekend classes, summer programs, interactions with family and friends, interactions within the larger community, in addition to and combined with, round-the-clock media exposure) demands attention by teachers in various new educational contexts. The intellectual and affective experiences of students will only be

fully understood after considering the multiple interactions and contexts of their daily lives (Barab & Plucker, 2002). GeoWorlds takes the step towards putting students in an environment which allows them to act as they want, and explore in a manner that makes sense to them while learning, achieving tasks and solving problems.

Overall, virtual learning environments and educational gaming hold the potential to be effective teaching tools for a variety of learning styles, individual backgrounds and intellectual levels. Information comes in a wide variety of forms when combining an immersive environment with traditional classroom teaching. Information taught to students in GeoWorlds comes through written explanation, visualizations, short videos and pictures, touching objects, clicking for facts/data and sharing knowledge with one another. This variety of accessible information can enable every type of student to learn in a way that makes sense and appeals to them.

Arguments For and Against Educational Gaming

Studies for and against educational gaming, or edutainment, are limited yet thorough in their arguments. The most frequently asserted benefit of virtual-based collaborative learning is that this medium provides interaction of meaning and value that compliments the subject matter while also building connections among students and the environment (Barab & Plucker, 2002; Barab & Roth, 2006). This, in effect, promotes a strong engagement in the topic. For example, when students learn about erosion as a fact to be memorized in school, they unknowingly run the risk of "the fact" becoming just that…'a fact to be memorized at school.' Knowing erosion, in the ecological sense of the term, requires bringing about meaningful real-world recognition or the actual environment in which learners recognize as the mediator that controls the act of erosion (Barab & Roth, 2006).

A primary goal, in which GeoWorlds strives, is to teach concepts to students to be used outside the classroom. In Barab's Quest Atlantis Project, children have completed hundreds of "Quests" either in after-school contexts or without being assigned by their teachers (Barab et al., 2005). Preliminary results in Barab's study show the students are willing to complete significantly more work and rate the activity as more interesting when completed in the context of a virtual learning environment (Barab & Luehmann,

2003). Therefore, a strong positive finding for the use of edutainment is that learning becomes more than just 'memorizing facts at school' and students appear to become more dedicated to the material being taught by the additional time spent on the content in the classroom.

While these kinds of curricula may promote deeper thinking on a topic through game play, Egenfeldt-Nielson (2005) of the IT University of Copenhagen states edutainment holds little intrinsic motivation; rather, he asserts, it relies more on extrinsic motivation through rewards. This is to say, that it is up to the teachers to provide and create the extrinsic motivational incentives and it is not the responsibility of the students to be intrinsically motivated to learn. This lack of intrinsic motivation, supported by game-play, could present a problem in the 'real world' in which not all tasks end in reward. In gaming, extrinsic motivation is developed through arbitrary rewards, (i.e. getting points for completing a level) while intrinsic motivation would, in contrast, be the feeling of mastery from completing a level (Egenfeldt-Nielson, 2007). Whether edutainment can foster intrinsic motivation may rely on whether students demonstrate an interest in the material outside the classroom or outside an educational gaming environment.

A second positive finding of virtual learning environments is creating scenarios for teachers who do not necessarily have access to sites that demonstrate basic and complex geological concepts. Even if teachers did have access, the cost of field trips and logistics prove to be too great of a burden in the midst of K-12 academic scheduling. It is also difficult to find locations where the natural dynamics are unfolding in such a way that they are pedagogically useful, especially given the abbreviated timeframes of classroom teaching (Barab et al., 2007). Virtual simulations are important in the field of geology, history and environmental science as it allows for recreating environmental scenarios which enables students to interact with their surroundings and learn from playing an active, explorative role.

While field trips are often logistically difficult and educational sites limited, it can be argued those trips have fewer distractions away from content than a virtual-reality game. A field trip is not seen as a "game," but as an excursion with a specific purpose. In contrast with a computer program that looks, feels and acts like a video game, learning

and gaming aspects of the lesson may become conflicted. Thus, another argument against educational gaming is that is fails to fully integrate the learning aspect with the computer game aspect. The concern is that there may be a change of focus and concentration of the learning experience to that of the gaming experience, (i.e., students may focus more on the gaming aspects than concentrating on the content they should be learning). This may result in weak learning experiences, especially if the time-on-task issue is considered. The player may not spend the majority of his or her time on the educational experience, but rather gain more gaming experience (Brody, 1993; Facer et al., 2003; Vandebenter, 1997).

While students' focus may weave in and out of content learning and gaming, another benefit of educational gaming is that of focus entirely. Positive impacts of educational gaming has been linked to a disorder that is increasingly diagnosed in children: attention deficit disorder, or ADD (APA, 1994). The effects of video game playing have revealed positive results, demonstrating that when patients with ADD or attention deficit hyperactivity disorder (ADHD) play electronic games, there is a decrease in associated symptoms. After continued game play, patients were able to focus, concentrate and persist in a task (Houghton et al., 2004; Pope, 1996). This is because game play can induce a state of intense concentration, control and engagement known as flow (Csikszentmihalyi & Larson, 1980; Fullerton et al., 2004; Salen & Zimmerman, 2004). With this information, classroom behavior and concentration may benefit from the use of edutainment curricula and a more effective and efficient learning environment could form.

There are strong arguments for and against edutainment in the classroom. With edutainment still not being fully accepted as a learning-tool and not utilized in classrooms as much as it could be, the evidence of advantages and disadvantages will continue to grow as teachers incorporate more gaming and technology into their teaching strategies.

Methodological Considerations

Broad, Overlying Challenges in Education Research

An array of potential research flaws and skepticism come with most education and gaming research. Education technology is still in early stages of testing, especially in

the Earth sciences. Overall, there continues to be a lacking research base from which to draw important implications for teaching and learning in this area (Dipietro et al., 2007).

Studies on educational gaming rarely compare the effectiveness of using gaming as an instructional method to that of other more traditional didactic teaching methods. Gaming as an instructional method is implemented more as a supplement or an addition to traditional methods. Egenfeldt-Nielson (2007) contends that instead of positive results coming directly from the virtual learning environment, post-test score increases could actually be a result of extended time-on-task. Time-on-task is defined as the period of time in which a student is actively engaged in a learning activity (www.education.com). Often in collaborative, engaging environments, edutainment sparks further discussion and interest in students and thus increases learning beyond just time in the classroom. This is why it is important to note that the improvement of tests scores could be a result of additional time spent on the subject outside classroom requirements.

Another concern is that while students may spend more time on the subject outside the classroom, researchers tend to spend less time observing student behavior and their individual learning and spend more time on preparation. Researchers often do not spend a respectable amount of time developing more thorough insights on the impact of the teaching tool they are testing. Data collected and analyzed in these studies are done in a manner similar to what Stake (1995) describes as, "research that requires a few weeks of fieldwork and an additional few months of planning, management, analysis and writing." This timeline is not leisurely, but its concentration may lead to focused observations and insights which is not desirable when one tries to explore all the reasons of how and why students may be performing better when participating in a particular curriculum. Having observations that are too focused through the eyes of one researcher can lead to bias and inaccurate assumptions of the performance and success of a curriculum.

Random sampling in academic based studies is also challenging to overcome, as schools consist of classes which are not considered acceptable as a random sample. Instead, use of intact classrooms is typical in these studies, which involves a cluster sampling technique. As such, a class may have established dynamics or other hidden variables which influence the results. Researchers should determine if basic differences

between classes exist prior to attempting any type of experimental designs. For example, a pre-test exam to establish academic level will be critical to set baseline performance, especially when it is assumed that there will be differences across classrooms. Sampling problems cannot be easily resolved in this setting, but researchers must be aware of the differences and dynamics between participating classrooms and control for them to the extent possible.

Sampling and data collection in classroom settings is further hampered as it also presents challenges associated with attendance, participation and completion of assignments that are being used as research data. These variables can differ from day to day influencing the outcome of results. If large numbers of students are absent, off-task or not turning in their assignments during days of assessment, this can often skew data. Though the methodologies in education research present several issues, the main idea is that these difficulties be acknowledged and controlled as much as possible.

Lastly, and perhaps most detrimental to cutting edge technology-curricula research, is the potential for teacher-resistance to technology in the classroom. This in itself brings a new, complex problem when attempting to execute education-based research that incorporates technology. While in some cases this resistance to technology may be justifiable, in other cases, such as a teacher's lack of willingness to explore different mediums, will likely restrict the evolution and modernization of education in the long run. The most commonly cited obstacles of integrating technology in the classroom as noted by teachers are: (1) material conditions (insufficient number of computers and/or insufficient technology expertise among teachers); (2) difficulty integrating technology into the regular curriculum and instruction; and (3) lack of supervisory and technical staff (Demetriadis et al., 2002; Pelgrum, 2001). Research performed by Qing Li (2007) on student and teacher views on technology concluded that secondary teachers and their students' views on technology were almost always polarized. Teachers, in Li's study, suggested in their comments that their first goal was to "survive" in the classroom and they *know* teaching without technology has worked for many years for many teachers. Therefore, there is no need for teachers to dedicate extra time and effort into integrating technology.

Internal and External Validity Threats Specific to this Study

There are several types of threats to validity when it comes to the social and education sciences. As mentioned before, these threats, while often unavoidable, must be acknowledged in attempt to minimize them. External validity involves the extent to which the results of a study can be generalized (applied) beyond the sample and internal validity includes the several extraneous variables that can rival the hypotheses that assert that GeoWorlds specifically caused the difference in observed test scores (Siegle, 2010; Campbell & Stanley, 1963).

Population validity, an external threat, is the extent to which the results of a study can be generalized from the specific sample that was studied to a larger group of subjects. In the Geoworlds' study, Class A and B students were compared in their demographics, pre-GCI Scores, the Video Game Survey and the Precambrian and Permian Pre-Time Period Quizzes. Interpreting these results helps determine if the participating ninth grade classrooms varied from one another and if so, in what ways.

The Hawthorne Effect, a result of a reactive arrangement, is when subjects perform differently because they know they are being studied. External validity is jeopardized because the findings might not be generalized to a situation. For example, instances in which researchers or others who were involved in the study are not present, may influence the sample populations results. Both classes were aware that this was a Kansas State University research project, as a result of being required to have consent forms signed. Students curious about this research asked questions and may have been more conscious of how their test scores would effect results and impact the study (Siegle, 2010).

The sample population was selected on a volunteer basis via the willingness of the teacher. Students were required to participate as instructed by the teacher, but the population in this study was solely determined by the participating teachers. In effect, this creates an external validity concern as it makes it difficult, if not impossible, to deflect any bias. Worded differently, if ten schools were asked to participate in the study and only one agreed, it can be assumed that that there is something different about that one school. This also applies to participating classrooms as well, in respect to what types of teachers are more willing to participate as opposed to others.

Testing itselfalso can be a threat to internal validity. Generally on achievement and intelligent tests, students taking a test for a second time usually do better than those taking the test for the first time, even without studying. This is called the retest effect. The retest effect means the act of taking a pre-test effects how that group does on the post-test and this occurs because participants are now aware of what material they are to learn, pay attention to and seek answers for throughout the use of GeoWorlds. In this study, students are taking the exact same test before and after working on this curriculum and therefore may have paid closer attention to those questions they witnessed prior to participating.

Multiple-treatment interference, an internal validity consideration, is if the researcher were to apply several treatments it would then be difficult to determine how well each of the treatments worked individually. It might be that only the combination of the treatments is effective. While this study focused on the impact of just GeoWorlds, outside treatments such as the participating teacher's subject matter in similar topics through lecture and other activities similar to GeoWorlds content, could have affected the results. Also, reinforcement tactics through presentations and note-taking could also influence the results of this study by impacting how effective GeoWorlds is independently of these variables.

Lastly, history, or the time between pre- and post- tests, may have held change-producing events in addition to implementing GeoWorlds. This internal threat may include subject matter taught by the teachers in congruence with material similar to GeoWorlds and what students may have witnessed on television or information gained through other educational outlets. Again, as with all internal validity threats, this jeopardizes the strength in which it can be assumed that GeoWorlds was the main cause in changes in test scores.

Research Questions

While collaborative learning is not a new concept in teaching Earth science content, the GeoWorlds curriculum (which integrates collaborative learning within an virtual learning environment) had not been implemented in any high school classrooms until now. Literature on collaborative-based learning in virtual environments is minimal,

with only one thorough study of its effectiveness present. "The Quest Atlantis Project," developed by Sasha Barab at Indiana University, is one other media-based learning environment for the Earth sciences. Barab first studied the benefits of exploring different ways of teaching the sciences and putting his findings into the "Quest Atlantis Project." Beyond GeoWorlds and Barab's research, there is a lack of information on evaluating and assessing the effectiveness of collaborative learning methods in media-based environments and therefore it is important that this tool be explored. Findings may show that this style of teaching could compliment most learning-styles and promote a stronger engagement in science with high school students today.

The Geoworlds study is based on assessments, surveys and qualitative interviews and observations of students and summarizes the effectiveness of the program as a way of teaching Earth science content. The study does not compare the GeoWorlds teaching style to that of other teaching styles; it is meant to examine whether this teaching tool works as a viable supplement or complimentary aid to successfully teaching Earth science content. Therefore, this pilot study works to answer the following overarching question: What is the effectiveness of GeoWorlds in respect to educational impact, affective response and as a contribution to the curriculum? Specifically, four questions guide the study:

1. Are students' post-Time Period Quiz scores different from their pre-test scores as a result of participating in the GeoWorlds curriculum?
2. Are students' post- Geoscience Concept Inventory Assessment scores different from their pre-test scores as a result of participating in the GeoWorlds curriculum?
3. Are students' post-Time Period Quiz scores different from their pre-test scores as a result of using GeoWorlds to study and present specific Time Period content to the remainder of the classes who did not use GeoWorlds to study the same time periods?
4. What are the participating teachers' and students' overall perceptions of GeoWorlds?

To test and provide evidence for answering the broad research questions, the study focuses on the following null hypotheses:

1. There are no differences between students' pre- and post-Time Period Test scores after participating in the GeoWorlds curriculum.
2. There are no differences between group pre- and post-Geologic Concept Inventory Assessment scores after participating in the GeoWorlds curriculum.
3. There are no differences between post-test scores between the students who presented a particular Time Period and those who did not.

CHAPTER 3 – Research Methods

Research Design

A one-group pre-test, post-test research design with a two phase approach was used. Phase one was a causal-comparative quantitative approach and phase two a qualitative approach. A causal-comparative study attempts to identify a cause-effect relationship between two or more groups. This approach was designed to establish if the treatment variable (GeoWorlds exposure) had a significant effect on the dependent variable (student content knowledge). Students in each section of Earth and Space Science were given, during phase one of the study, a pre/post-Geoscience Concept Inventory (GCI) and pre/post Geologic Time Period Quizzes. In phase two, interviews were conducted, GeoWorlds Quests worksheets reviewed and observations were made by the teachers and facilitators. Observations noted aspects of student participation in the virtual world in regards to working together, navigation in the world and the classroom in respect to technical issues and group dynamics.

PHASE ONE:

- The GCI was not only used to uncover the students' baseline geology background, but to also help determine the effect of GeoWorlds in the students' overall understanding of broad geologic concepts through pre- and post-testing.
- The Geologic Time Period Quizzes were evaluated to reflect if the material covered in GeoWorlds was learned and understood. These classes worked in the Precambrian, Permian, Eocene and Pleistocene Time Periods. Groups within the

classes were formed to cover one of the four particular time periods and each group was required to present the material learned to the rest of the class. Students were quizzed before they worked in GeoWorlds and after working in their assigned time periods and had given their presentations.

PHASE TWO:

- The interviews were evaluated to determine the perceptions of GeoWorlds from a teacher and student points-of-view.
- The GeoWorlds Quest Worksheets were evaluated based on completion and understanding of content. They were also studied for potential flaws in the curriculum itself.
- Overall observations of the GeoWorlds curriculum were noted by teachers and facilitating researchers.

Setting, Population and Sampling Frame

Junction City High School (JCHS) is part of USD 475 in Kansas and includes students from Junction City, Fort Riley, Milford and Grandview. The present high school building was completed and occupied during the 1958-1959 school year and houses grades nine through twelve. JCHS is a 6A high school, the largest classification in Kansas, with an estimated enrollment of 1,500 students every year. The high school successfully completed the requirements for the status of Accredited in the Kansas Quality Performance Accreditation system, as granted by the Kansas State Board of Education, in October 2009 (USD 475, 2010).

The school is divided into four academies: Freshmen Success (grade nine), Science and Engineering (grades ten-twelve), Fine Arts and Human Services (grades ten-twelve) and Information Technology (grades ten-twelve). Using a modified eight-block schedule, the students are placed in seven credit classes alternating every other day. Classes may be year long or completed in one semester. The eighth block is a seminar period. Overall, the academic program offers more than 150 credit courses, plus some dual credit courses available through Cloud County Community College, Kansas State University and the Manhattan Area Technical College (USD 475, 2010).

The majority of students in USD 475 are military connected (59%) with an additional 8% being civilians working on Post. A small percent (1%) are in low rent housing and a large percent of students (68%) are totally federally connected. Over half of the students (51%) qualify for the Free or Reduced Lunch Program. Students in the district are predominantly Caucasian (48.7%), with African Americans (22.7%), Hispanics (8.7%), American Indian/Alaskan Natives (0.6%), Asian or Pacific Islanders (2.8%) and Multi-Ethnic (16.5%) making up the remaining students (51.3%) (USD 475, 2010).

Course Description

Earth and Space Science is a one-year, one credit, required freshman course in the Freshman Success Academy. While this is a freshman class, it is important to note that students are not all 'ninth graders,' as the class encompasses students that have not yet met their physical science requirement for graduation. The course offers exploration of the Earth and its atmosphere, as well as the organization and origin of the universe and an introduction to physics and chemistry. Although this is not a math intensive course, mathematics is used as a tool for learning. The class includes lectures, discussions, demonstrations and lab activities throughout the year (USD 475, 2010).

Sample Selection

Two teachers and students in their classrooms participated in the study, comprising a total of nine, ninth grade Earth and Space Science classes. Teacher A taught four courses (n = 102 students) and Teacher B taught five courses (n = 90). Selection was based on the teacher's interest and willingness to participate in the project and all students in their classrooms were to participate if given consent by their legal guardian. While Teacher A taught strictly freshmen, Teacher B had a mixture of freshmen and upper class students who may have transferred from other schools or those who had not yet met their physical science requirement.

Setting

During the study, Teacher A ceased participation prior to completion of the project and data collection. Therefore, only data for the pre-GCI, the Demographics Survey and Video Game Survey were collected, in addition to the interviews. Teacher B and connected classes remained engaged as full participants through completion of the study.

Due to the fact that Teacher A did not implement GeoWorlds in its entirety and ultimately withdrew (thereby withdrawing the students), Teacher A and the students involvement in the study necessitated a shift in study design. The shift came in the form of Teacher A's student data becoming important evidence for external validity of the study design. The limited data collected from those classes were able to be analyzed for the purpose of generalizing the sample population through the comparison of Teacher A students with Teacher B students.

Teacher A used a classroom of desktop computers with a direct connection to the Internet. The students were placed in groups of two or three at the teacher's discretion and assigned one of ten available computers.

Teacher B directly connected three laptops to the JCHS Internet in the back of the classroom and placed students in groups of four. The groups used the laptops and took turns during the class period to achieve the goals of the program.

Participating teachers were provided 20 laptops each to help facilitate the use of GeoWorlds in their classrooms. Upon completion of the study, the ownership of the laptops was transferred to JCHS to make them available to all JCHS faculty. A stipend, that teachers were not aware of prior to volunteering, was also provided at the conclusion of the study. The stipend was awarded dependent on the teachers' involvement, accommodation and facilitation of the GeoWorlds program. Only Teacher B received the stipend upon completion of the study.

IRB Approval & Consent

In accordance with Kansas State University regulations, an application for approval to conduct research on human subjects was submitted and approved effective February 25, 2009 (IRB# 4971). An extension was requested and granted to continue research through the Spring 2010 Semester.

Upon agreement of the two teachers to participate in the program, the principal's signature of consent was required to approve that the GeoWorlds program was allowed and supported in the participating Junction City High School classrooms (Appendix C). After approval was received on behalf of the principal, parental consent was required for those students under 18 years of age (Appendix C). These consent forms were distributed to all students. Students were informed that they would not be able to participate in GeoWorlds and would have to cover material via the textbook if consent forms were not turned in.

Measures

Demographics Survey

A Demographics Survey (Appendix A) covering students' gender, grade point average, age, anticipated major, race and highest degree of education of each parent was distributed to gain baseline information on the participating classes.

Video Game Survey

The Video Game Survey (Appendix B) was adapted from a study performed by Boot et al. (2008) on the effects of video game play on attention, memory, and motivation. In this study, the survey was used to collect baseline information and serve as a covariate in explaining the potential success or failure of the GeoWorlds program and the comfort level of the students using this kind of curriculum in the classroom. Not all questions on the survey are displayed or used, as they were deemed irrelevant for the intent of this study. Questions/statements that were pulled to determine comfort level and experience with personal computers, video game playing and virtual reality-based game included:

1. Do you consider yourself an active video game player?
2. Do you own a personal computer?
3. How often do you play Final Fantasy or similar role-playing video games?
4. How often do you play the Sims or similar video games?
5. How often do you play in Second Life?
6. I consider myself a/an _____ video game player.

Geoscience Concept Inventory

The GCI was created by Julie Libarkin of Michigan State University and Steven Anderson of the University of Northern Colorado (Libarkin and Anderson, 2007). The GCI is a multiple-choice assessment instrument for use in the Earth sciences classroom. The GCI v. 1.0 consisted of 69 validated questions that could be selected by an instructor to create a customized 15-question GCI subtest for use in their course (Libarkin and Anderson, 2007; Appendix D). Questions were validated using the most rigorous methodologies available, including scale development theory, grounded theory and item response theory (IRT). To ensure inventory validity, creators of the GCI incorporated a mixed methods approach using advanced psychometric techniques (Libarkin and Anderson, 2007). These test items cover topics related to general physical geology concepts, as well as underlying fundamental ideas in physics and chemistry.

Each question has gone through rigorous reliability and validation studies and the authors took both classical test theory and Rasch-based approaches in their establishment. Development of the GCI was built upon existing studies and incorporated additional methodologies for development and validation, blending three theoretical bases (scale development, grounded theory and item response theory), and utilized a diverse population of students and institutions during piloting.

The GCI subtest used in this study consisted of 15 questions covering Earth's creation, erosion, dating, surface structures, composition of Earth, geologic time and plate tectonics. Students were asked to mark the best answer, or as many answers that were applicable. Below are three examples of questions that would be found on the GCI subset:

1. Some scientists claim that they can determine when the Earth first formed as a planet. Which technique(s) do scientists use today to determine when the Earth first formed? **Choose all that apply.**
   (A) Comparison of fossils found in rocks
   (B) Comparison of different layers of rock
   (C) Analysis of uranium and lead in rock
   (D) Analysis of carbon in rock
   (E) Scientists cannot calculate the age of the Earth

2. Which of the following can greatly affect erosion rates? **Choose all that apply.**
(A) Rock type
(B) Earthquakes
(C) Time
(D) Climate

3. Which technique for determining when the Earth first formed as a planet is most accurate?
(A) Comparison of fossils found in rocks
(B) Comparison of different layers of rock
(C) Analysis of uranium and lead in rock
(D) Analysis of carbon in rock
(E) Scientists cannot calculate the age of the Earth

The purpose of the GCI in this study was to evaluate learning in the classes and provide data on learning in the geosciences; thus this was operationalized as the dependent variable. Multiple choice tests are generally weak due to the possibility of students knowing very little about a concept, yet are able to pick the correct answer on the exam because the other choices (wrong answers) are not attractive. The GCI, however, compensates for this potential error through supplying answers that are attractive alternatives to students who do not fully understand the concept based on the pilot testing of the assessment.

Geologic Time Period Quizzes

The Time Period Quizzes reflect the content that is specifically covered in the GeoWorlds curriculum via the virtual world, the Quest Worksheets and introductory material. This study included four of the possible eight time periods: Precambrian, Permian, Eocene and Pleistocene. Each quiz has 20 multiple choice questions directly reflecting the material to be learned (Appendix F). The quiz questions were developed by the principal investigator of this study by going through each scenario in GeoWorlds and selecting the most pertinent information. These quizzes were then reviewed by the collaborators on the project for accuracy, content, the complimentary aspects of the GeoWorlds virtual learning environment and the Quest Worksheets. Below are three examples from the Precambrian Time Period Quiz:

1) The "Oxygen Catastrophe" was a time in the Earth's history when…
   A) there was no oxygen present in the atmosphere.
   B) there was too much oxygen in the atmosphere.
   C) there was very little free oxygen in the atmosphere.
   D) there was more hydrogen than oxygen in the atmosphere.
   E) there was more oxygen than hydrogen in the atmosphere.

2) What caused the levels of oxygen to change over time?
   A) respiration
   B) photosynthesis
   C) development of multi-celled organisms
   D) plant life
   E) animal life

3) What element, when combined with oxygen, is evidence for the "Oxygen Catastrophe"?
   A) sulfur
   B) copper
   C) magnesium
   D) potassium
   E) iron

Interviews

The interviews were designed to describe the predicted and actual experience that teachers and students had working with GeoWorlds. Interviews conducted prior to the use of GeoWorlds with the teachers covered the concerns, time-spent on becoming familiar with GeoWorlds, expectations and how they felt about the content being covered. After GeoWorlds, the teachers were asked about the challenges, suggestions for improvement, what things went well and what things did not. The students' interviews before GeoWorlds included how they felt about playing a video game to learn, had they ever used a video game to learn before and concerns about trying something new. Upon completion of the curriculum, students were asked what was most challenging, what things would make GeoWorlds easier and what things they liked (Appendix E). Casual conversations also worked to uncover logistical and classroom issues, student interest, motivation and attitudinal thoughts. The questions were developed by the principal investigator of this study.

GeoWorlds Quest Worksheets

The Quests (Appendix G) were developed by the principal investigator of this study and begin with a written introduction to the time period being studied. Instructions on where to go within the virtual environment and instructions to assist the students in navigating within each scenario precede the introductory material. Questions range from definitions, mapping and observations to broad based written answers that reflect underlying themes. Below is a sample of the Permian Quest:

PERMIAN QUESTS
(290-249 million years ago)

Be on the landmass with the volcano. Your goal is to go to the farthest NW Corner of your Mini-Map, where you will see a slide-show screen of a map of super-continent Pangaea which took place during the Permian. This is where you will begin exploring this time period.

The Permian was a time of continental collisions, evolutionary innovation and catastrophic extinctions. By the end of the Permian, most of the major continents had drifted together to form a giant super-continent called Pangaea. As this vast landmass formed, the amount of coastline shrank along with the tropical swamps it supported. Great mountain ranges were formed as continents collided. In this new world, tetrapods (four-limbed vertebrates) evolved new forms and synapsids - the group that would one day include mammals.

A new type of reproduction also occurred – the amniotic egg. This adaptation allowed newcomers to exploit habitats on dry land. Plant fossils from this period indicate that Pangaea was a patchwork of different environments, from arid deserts to lush tropics to cool temperate forests.

The Permian period also ended with the world's most devastating extinction event of all time. Over 90% of the Earth's species, including insects, plants, marine animals, amphibians and reptiles were destroyed worldwide. The Permian is therefore remembered as the time when life came the closest to being wiped off the face of the planet. Estimates vary, but it's believed that 96% of all marine life and 70-80% of all land dwelling animals perished.

1. Find the blue diamond, which is an "atmospheric indicator," telling you the oxygen and carbon dioxide levels. Record what you find and do you think these stats compare to our atmosphere today?

2. Go to the shoreline and find the large egg with slides inside. Review the slides relating to the benefits of evolving the amniotic egg and write down your findings.

3. Inland from the farthest northwest corner of your Mini-Map where we first began, you can see another map demonstrating the make-up of Pangaea. In the space provided below, sketch Pangaea.

What do you think the interior climate of Pangaea was? Think of what usually dictates climate – mountains, oceans, seasonal fluctuations, etc. There is a large continent today thats interior is similar to that of what Pangaea was – what is this continent? Knowing this might help you decide what the climate may have been like.

4. Are there any organisms that are still alive today that were in the Permian (there are at least 2)? Which are still alive and why do you suppose they were able to survive several mass extinctions?

5. Find and describe the following five organisms and click on the link to the Wikipedia site. List four important facts from the sections of the Wikipedia article suggested below.

- Eryops: Introductory Paragraph and Locomotion
- Dimetrodon: Introductory Paragraph and Description
- Archegosaurus: Entire Article
- Dicynodon: Entire Article

6. From reading the articles above you will have probably seen the terms reptile, amphibian and synapsid. Write a definition for each IN YOUR OWN WORDS and be able to compare and contrast the three. Use the Internet if needed.

- Reptiles:
- Synapsids
- Amphibians:

Observations

Observations of student participation and overall functioning of GeoWorlds were noted on notebook paper by the facilitator. Passive and interactive observations alongside discussions with students and the teachers were also noted.

Procedures

All students were able to participate in the study unless their consent form was not signed, behavioral issues arose or they were absent from the class. Students who were missing a pre- or post-Time Period test score were removed from the study from a statistical analysis perspective, but were still observed from a participation aspect.

Demographics Survey

The Demographics Survey (Appendix A) was distributed priot to any other survey or assessment. The demographic results were inputted into Microsoft Excel by the facilitator for analysis of descriptive statistics.

Student Video Game Usage

Students were given the Video Game Survey (Boot et al., 2008; Appendix B) prior to participating in the program regarding their video game usage and their experience with virtual games similar to that of Second Life. Surveys were distributed and collected by the teachers and then results were inputted into Microsoft Excel by the facilitator.

Geoscience Concept Inventory

Teacher A only distributed the GCI (Appendix D) as a pre-test and therefore post-test assessment scores are unavailable for Teacher A's classes. The pre-test results were inputted into Microsoft Excel and were used to determine generalizability within the ninth grade sample population between Class A and Class B.

Teacher B's students were asked to take the GCI before working in GeoWorlds and answers were collected, graded and inputted into a Microsoft Excel spreadsheet. After the students participated in GeoWorlds, they were asked to take the same GCI and those results were also graded and inputted into Microsoft Excel. Results were analyzed as group mean scores and for the improvement of scores on individual questions, that may or may not have corresponded with the four time periods the teacher selected to cover.

Geologic Time Period Quizzes

Geologic Time Period Quizzes (Appendix F) were distributed by the teachers before students began participating in the GeoWorlds curriculum and then after to reflect content knowledge gains - another dependent variable of the study.

Quizzes were graded by hand or through the Qwizdom Electronic Grading System. Qwizdom is a type of Student Response System; sometimes referred to as Classroom Voting Systems or Clickers, in which students can select their multiple-choice answers on their remotes and their scores are automatically/electronically tallied and graded in the Qwizdom software. Teacher A only executed Pre-Quizzes for the Precambrian and Permian, while Teacher B accomplished all four pre- and post-quizzes. Results were entered into a Microsoft Excel spreadsheet.

Interviews

Interviews (Appendix E) were administered before and after working with GeoWorlds. Both teachers were interviewed and five students were selected by the teacher of Class A and nine students were selected by the teacher of Class B to participate. Both teachers selected students based on a personal criterion of offering the most diverse reactions about participation in the GeoWorlds curriculum. Interviews were conducted with the use of a Flip Video Camera or digital camera. Transcripts were manually recorded through slow playback speed on QuickTime software. All interviews were conducted by the same facilitator and transcripts were coded and analyzed by an outside evaluator for emerging themes and the number of times particular themes were mentioned.

GeoWorlds Quest Worksheets

The Quests (Appendix G) worked to assess the degree of attainment of the learning objectives specific to each scenario. Quests Worksheets are completed individually, though students are working in groups and can assist one another. The worksheet were assessed upon completion or when class time concluded. Responses were assessed on thoroughness and the students' perceived understanding of the concepts based on the opinions of the collaborating teacher and facilitators.

Overall Observations

Observations were made on students within and among groups in the classroom to recognize if students were staying on task and were participating on an individual level.

Communication and interaction of the avatars within GeoWorlds was also noted as well as teacher participation and facilitation. Passive observations were made as the facilitator stepped back to observe the group dynamics without any influence. However, more involved observations through discussions with the students while they were navigating through the world and working on their Quests also occurred. The participating teachers also had casual conversations with the facilitator about their observations on how well the curriculum was going.

Method of Instruction

Teacher A organized students in groups of two or three and then assigned each group to one computer with a provided avatar name and password. An introduction to GeoWorlds and the rules of participating in the program were announced to the class. Students were then given a Precambrian Quest worksheet and were asked to read the introduction aloud to one another in their groups. Upon completing the introduction, the groups worked together to complete the tasks on the Quest Worksheet through the use of GeoWorlds and answer the questions. Unable to complete the study in its entirety due to technical issues, Teacher A and students became a control group to provide external validity for this study.

Teacher B separated the classrooms into four groups of five or six students. Each group was assigned a particular time period in GeoWorlds (Precambrian, Permian, Eocene or Pleistocene). Two groups would spend the first half of the class period on laptops in the back of the classroom completing their assigned Quests while the rest of the class took notes and listened to a lecture on weathering and erosion. The groups would switch half way through the class period and repeat the process. The expectation of groups was to become experts on their particular time period and be able to present what they observed in GeoWorlds and what they learned on their Quest worksheets. Teacher B gave each group half a class period (45 minutes) to work in GeoWorlds and an entire class period to work on their presentations. Two class periods were dedicated to giving the presentations of the material to the rest of the class. Students who did not actively participate in the other time periods were able to gain knowledge on those time

periods from the collaboration of their fellow students teaching them the material through presentations and note-sharing.

CHAPTER 4 – Research Findings

Descriptive statistics (mean, median, mode and standard deviation) were calculated using Microsoft Excel. Comparative statistical analyses were completed using SPSS. Independent *t*-tests, Paired-Samples *t*-tests and One-Way ANOVAs were used to find *p*-values to the 95% confidence level. At a 95% confidence level, if the p-value is greater than or equal to 0.05 the value is considered not significant. If the p-value is less than 0.05, the findings can be declared significant.

Student Demographics

Data were collected during the Spring 2010 semester in the two different teachers' Earth and Space Science classes. Class A had a total of 102 students initially involved in the research and Class B had a total of 90. Demographics for the two participating classes covered gender, age, ethnicity, anticipated major and male/female parent education level and were analyzed using descriptive statistics. Note that totals may differ in all data sets throughout this study due to attendance, participation and non-responses.

Teacher A's classes were surveyed to have a 50% male (n = 51), 50% female (n = 51) population. Teacher B's classes were surveyed to have a 51.11% male (n = 46), 48.89% female (n = 44) population. (Appendix A, Table 1)

The majority of students in Class A and Class B were between the ages of 15 and 16, but the age distributions were highly variable between the two classes as demonstrated in Table 4.1.

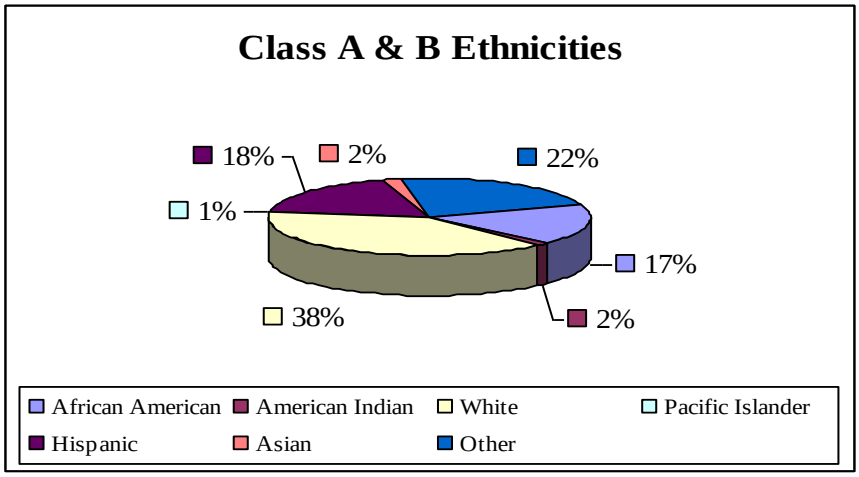
Table 4.1: Age Distribution

Class A	**Number**	**Percent**
14 Years	n = 2	1.96%
15 Years	n = 64	62.74%
16 Years	n = 36	35.29%
Class B		
15 Years	n = 44	49.44%

16 Years	n = 33	37.08%
17 Years	n = 10	11.24%
18 Years	n = 1	1.12%
19 Years	n = 1	1.12%

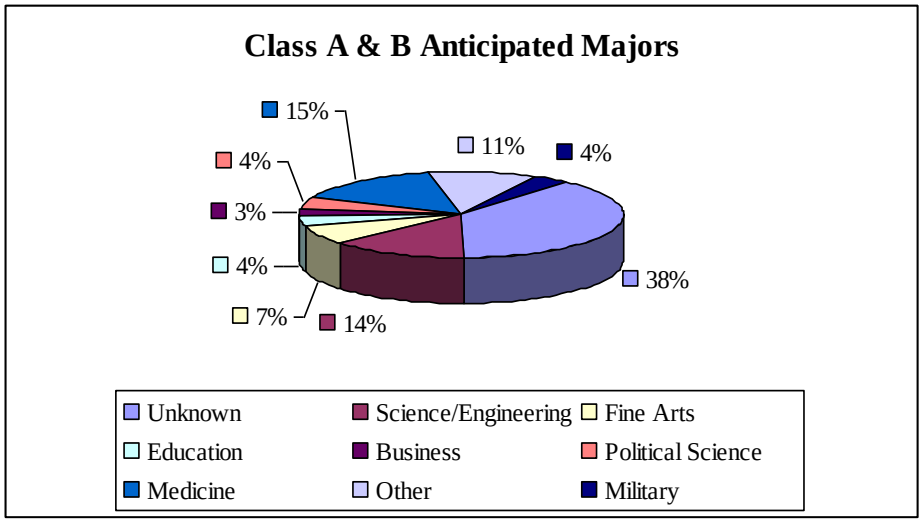
Due to a strong military presence in the community, Junction City High School students hold a diverse population. Figure 4.1 demonstrates the combination of Class A and B ethnicities. (Appendix A, Table 3)

Figure 4.1. Participant Ethnicity.



The students of Classes A and B were interested in a wide variety of potential majors as college students and interests for future careers. Figure 4.2 demonstrates the distribution of interest among both classes. (Appendix A, Table 4)

Figure 4.2. Anticipated Major.



The majority of this population's parent education level lies in the high school graduate and some college levels, with 17.65% of female parents and 5.26% of the male parents earning a bachelors degree. (Appendix A, Table 5).

Video Game Survey

The Video Game Survey (Boot et al, 2008; Appendix B) was conducted to determine how much experience students had in video games and their computer familiarity. This information was used as baseline information to determine if students may be comfortable and confident in taking on this type of curriculum in the classroom.

Figure 4.3. Active Video Game Players. Combined Class A (Yes: n = 54; No: n = 41) and Class B (Yes: n = 38; No: n = 55) responses. Overall 48.94% of students were active video game players.

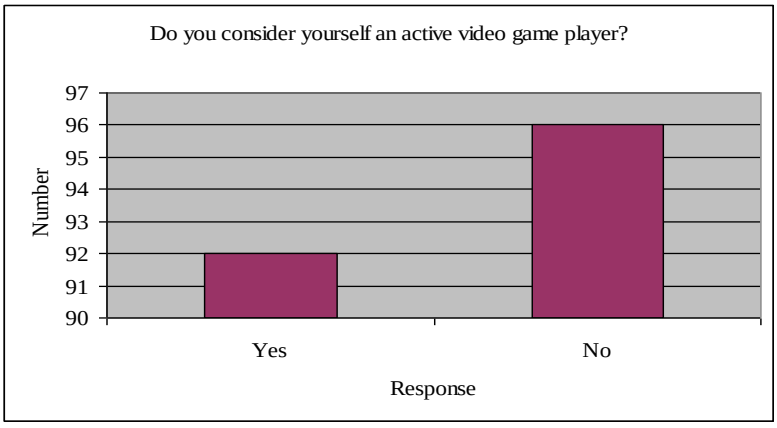


Figure 4.4. Personal Computer Ownership. Combined Class A (Yes: n = 76; No: n = 18) and Class B (Yes: n = 81; No: n = 12) responses. Overall, 83.96% of the population owns a personal computer.

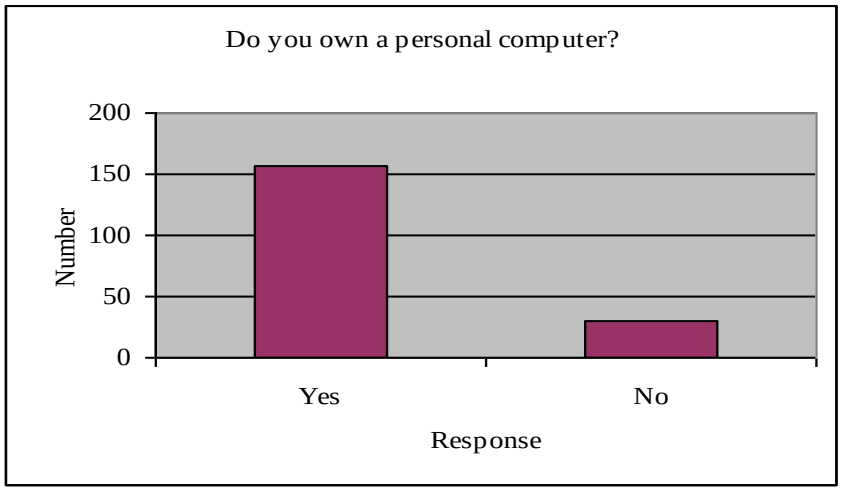


Figure 4.5. Game Play Frequency. Combined Class A and B responses in relation to frequency (Never, Seldom, Sometimes, Frequently or Often) of playing Final Fantasy (n = 89, 31, 21, 20, 26; 47.59%, 16.58%, 11.23%, 10.70%, 13.90%), The Sims (n = 66, 41, 42, 22, 16; 35.29%, 21.93%, 22.46%, 11.76%, 8.56%) and Second Life (n = 154, 20, 8, 4, 1; 82.35%, 10.70%, 4.28%, 2.14% 0.53%).

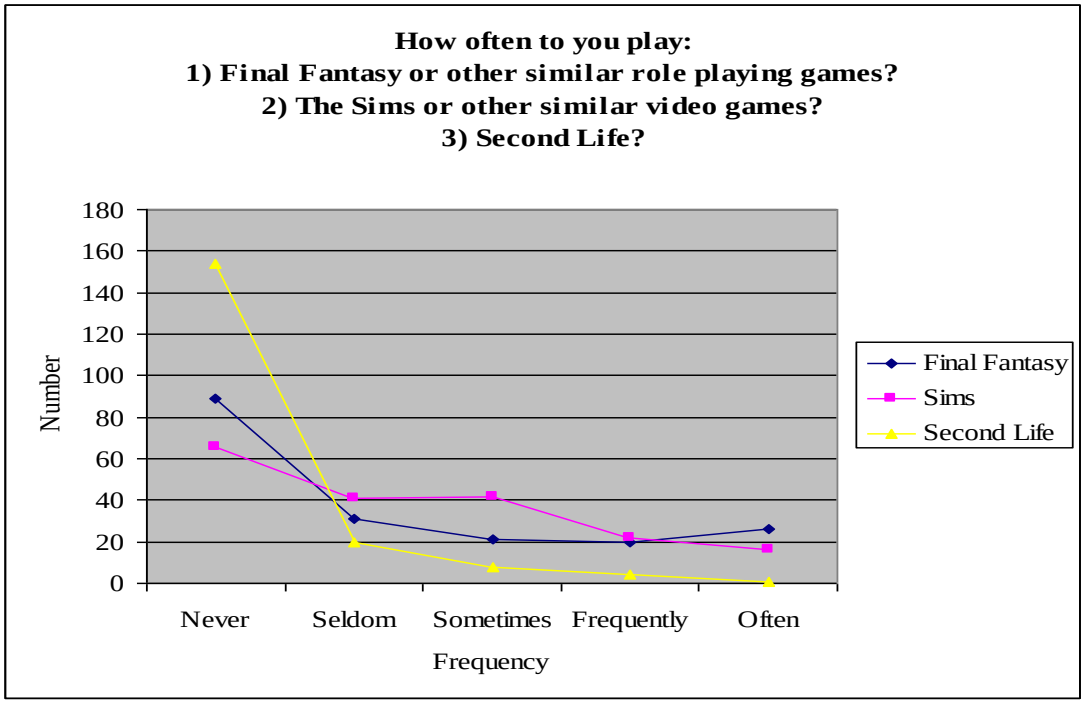
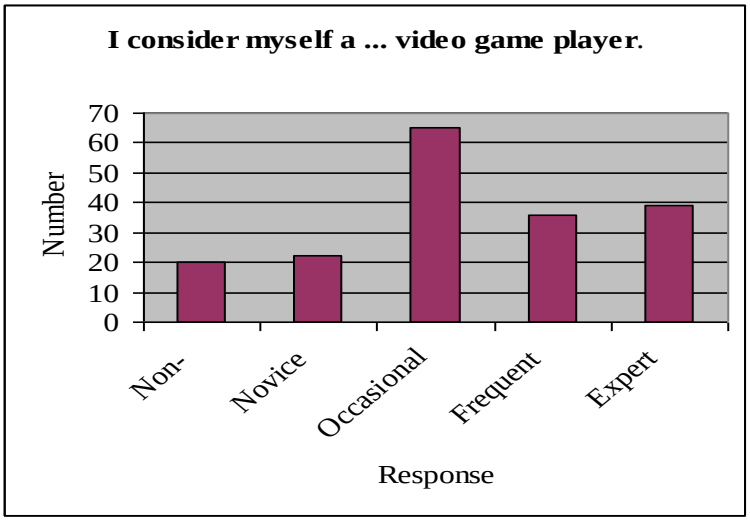


Figure 4.6. Type of Video Game Player. Combined Class A and Class B responses in students' self-perceived experience (Non, Novice, Occasional, Frequent or Expert) in video game play (n = 20, 22, 65, 36, 39; 10.99%, 12.09%, 35.71%, 19.78%, 21.43%).



Questions and Null Hypothesis

To test null hypothesis #1: "There are no statistically significant differences between students' pre- and post- Time Period Quiz scores" and address research question #1: "Upon completion of the GeoWorlds curriculum, were students' post-Time Period Scores different than their pre-scores?" a paired, or dependent-samples *t*-test was conducted. Results indicated Teacher B's students produced significantly higher post-test scores than pre-test scores ($p < 0.05$). Table 4.2 demonstrates a statistical summary of the Time Period pre- and post-Quiz results, where *t*(x) is the sample size and corresponding degrees of freedom, *P* is the significance value based off a 0.05 confidence level, Mpre and Mpost are the mean pre- and post-test scores and *SD* is the standard deviation.

Table 4.2 Summary of Time Period Pre- and Post- Quizzes *T*-Tests

Measure	**Precambrian**	**Permian**	**Eocene**	**Pleistocene**
		***t*-Tests: Pre- and Post-Quizzes**		
t(73), t(74), t(62), t(62)	-15.86	-14.17	-11.05	-14.47
P	0.00	0.00	0.00	0.00
Mpre, *SD*	5.78, 2.47	6.43, 2.23	6.33, 2.48	5.94, 2.94
Mpost, *SD*	14.34, 4.37	12.52, 3.70	12.63, 3.69	13.37, 3.59

To test null hypothesis #2: "There are no differences between group pre- and post- GCI scores after participating in the GeoWorlds curriculum" and address research question #2: "Are students' post-GCI scores difference from their pre-GCI scores as a results of participating in the GeoWorlds curriculum?" an independent-samples *t*-test was conducted. Results indicated that on average, classes did not perform significantly better on their GCI post-tests. Table 4.3 provides a statistical summary of the GCI group score results where t(x) is the sample size and corresponding degrees of freedom, *P* is the significance value based off a 0.05 confidence level, Mpre and Mpost are the mean pre- and post-test scores and *SD* is the standard deviation. (Appendix D; Table A.7)

Table 4.3 Summary of Group GCI Pre- and Post- Score *T*-Tests	
Measure	**GCI**
***t*-Tests: Pre- and Post-Group Scores**	
t(189)	-1.97
P	0.05
Mpre, *SD*	4.47, 2.65
Mpost, *SD*	5.23, 2.71

Further analysis of the GCI in relation to individual questions and the number of correct answer responses demonstrated 11 out of 15 questions (73.33%) on the GCI showed improvement between the pre- and post-tests. Table 4.4 reflects the questions that showed an increase in correct answer responses.

Table 4.4: Changes in Pre- and Post- GCI Answers			
Question #	**Pre Correct (n = 92)**	**Post Correct (n = 100)**	**Difference**
1	2	0	-2
2	7	14	7
3	7	12	5
4	27	43	16
5	45	47	2
6	35	46	11
7	12	25	13
8	37	29	-8
9	28	39	11

10	25	27	2
11	36	46	10
12	40	40	0
13	31	46	15
14	31	57	26
15	47	46	-1

An independent samples *t*-test was conducted to see if these increases GCI correct answer scores were significantly better between the pre and post assessments. Here, t(x) is the sample size and corresponding degrees of freedom, *P* is the significance value based off a 0.05 confidence level, Mpre and Mpost are the mean pre- and post-test scores and *SD* is the standard deviation (Table 4.5). Results show that, on average, students performed better on the post GCI assessment with the 11 questions that were covered in the four time periods the students studied in GeoWorlds ($p < 0.05$).

Table 4.5 Summary of GCI Correct Answer Scores Independent *T*-Test	
Measure	**GCI Correct Answer Score Changes**
***t*-Tests: Pre- and Post-Group Correct Answer Scores**	
t(190)	-3.18
P	0.002
Mpre, *SD*	3.09, 1.95
Mpost, *SD*	4.02, 2.10

To test null hypothesis #3: "There are no differences between students' post-test scores between the students who presented a particular Time Period and those who did not" and address research question #3: "Are students' post-Time Period test scores different from their pre-test scores as a result of using GeoWorlds to study and present specific Time Period content to the remainder of the classes who did not use the GeoWorlds to study those same time periods?" an independent-samples *t*-test was conducted. Results indicated that, on average, participants who studied and presented the Precambrian and Pleistocene Time Periods performed significantly better on their post-Time Period Quizzes ($p < 0.05$), than the students who did not use the GeoWorlds to study those time periods ($p > 0.05$). Table 4.6 demonstrates the different time periods,

mean test scores and significance values between the presenters and non-presenters. Here, t(x) is the sample size and corresponding degrees of freedom, *P* is the significance value based off a 0.05 confidence level demonstrating the differences in changes of pre- and post- test scores of the presenters and non-presenters, Mchanges are the mean difference in pre- and post-test score changes and *SD* is the standard deviation .

Table 4.6 Summary of Time Period Presenters versus Non-Time Period Presenters				
Measure	**Precambrian**	**Permian**	**Eocene**	**Pleistocene**
***t*-Tests: Presenters Pre-Post Score Changes**				
t(18), t(19), t(13), t(17)	-2.15	-0.11	-0.58	-2.90
P	0.04	0.91	0.58	0.01
Mchanges, *SD*	10.39, 4.26	6.21, 4.13	6.92, 4.31	9.41, 2.87
***t*-Tests: Non-Presenters Pre-Post Score Changes**				
t(55), t(55), t(50), t(46)	-2.06	-0.12	-0.55	-2.44
Mchanges, *SD*	7.85, 4.60	6.09, 3.64	6.14, 4.61	6.67, 4.23

Interview Results

An external consultant was used to code and analyze transcripts of the interviews for emerging themes and the number of times a particular theme was mentioned (Appendix E). Categorical themes included, but were not limited to: Hardware/Internet Issues, Geoworlds Mobility and In-Game Logistics (animals, names and figures) and Learning (working in groups, learning and playing). Sample questions and emerging themes are shown below:

Sample Teacher Interview Questions and Responses

1) What were your major concerns when deciding to participate in this study and using the GeoWorlds curriculum?
    a) Time Constraints (33.33%)
    b) Learning (33.33%)
    c) Hardware/Internet Issues (33.33%)

2) What are you most excited about – in relation to GeoWorlds being a part of your classroom?
    a) Hardware/Internet Issues (33.33%)
    b) Learning (66.67%)

3) What did you like about like about using GeoWorlds in your classroom?
    a) GeoWorlds Mobility/Logistics (100%)

4) What would you change about GeoWorlds?
    a) Learning – content (25.00%)
    b) Hardware/Internet Issues (50.00%
    c) GeoWorlds Mobility/Logistics (25.00%)

4) Was the curriculum for GeoWorlds complimentary to what you would be teaching in the classroom? Do you believe students gained more understanding of the material being presented in this way, or your traditional way?
    c) Learning- Overlaps a little with teaching (33.33%)
    d) GeoWorlds Mobility/Logistics - Students learn better; hands-on, fun, like they were there (33.33%)
    e) Learning - Went above and beyond (33.33%)

Student Interview Questions and Responses

1) When you found out that you would be playing a video game to learn Earth Science content, what was your reaction?
    a) Positive (100.00%)
    b) Negative (0.00%)

2) Do you think using a video game as a way of teaching is beneficial and will help you learn the material? Why or why not?
    a) Learning (91.67%)

b) GeoWorlds Mobility/Logistics (9.09%)

3) Is the idea of using a video game as a way to learn, make you more excited about your science class? Why or why not?
    a) Yes (100.00%)
    b) No (0.00%)

4) What did you like about GeoWorlds?
    a) GeoWorlds Mobility/Logistics (58.33%)
    b) Learning (41.67%)

5) What would you change about GeoWorlds?
    a) Hardware/Internet Issues (50.00%)
    b) GeoWorlds Mobility/Logistics (50.00%)

6) What was most challenging about working in GeoWorlds?
    a) Hardware/Internet Issues (73.33%)
    b) GeoWorlds Mobility/Logistics (26.67%)

Quest Answers: A Sample

Students Quest Worksheets were reviewed for responses, areas of confusion and potential needs for question clarification. Below are a few sample questions and (Class B) student responses from each time period.

Precambrian:

1) After determining how organisms evolved to survive in a world without oxygen, how might the atmosphere and the oxygen levels change after billions of years? Some scientists call this "The Oxygen Catastrophe."
    A1) *More organisms = more oxygen and less carbon dioxide.*
    A2) *The process changed the atmosphere by adding more oxygen.*

A3) *The process the organisms used to breath changed the atmosphere by adding more oxygen to the air over the years.*

2) Find and touch the Stromatolites and describe where they are situated within the water hole. Follow the link and in your own words explain how these structures are made and why they are a significant part of geologic studies.

A1) *Formed in shallow water by trapping, binding and cementation of sedimentary grains and cyanobacteria; built up the sediment.*

A2) *They are sedimentary grains and micro-organisms that are trapped and cemented together in shallow water*

Permian:

1) What are the benefits of evolving the amniotic egg?

A1) *Fewer eggs but larger organisms.*

A2) *Allows for fewer eggs and larger newborn, eggs can be laid on land without drying out, animal skips the larval stage.*

A3) *Allowed for fewer eggs and larger being, provides a water impermeable membrane and protects the shell so eggs can be laid on land without drying out. Fertilized eggs are surrounded by liquid protein for growth, so they can skip the larval stage to young adult. Egg made vertebrate life on land possible.*

2) Which two organisms are still alive today (that were alive in the Permian) and why do you suppose they were able to survive several mass extinctions?

A1) *Nautiloids survived because of natural selection, maybe making many babies, one had to survive.*

A2) *Stromatolites provided a protective layering to the cyanobacteria. Nautiloids are very diverse and adapted do different climates.*

A3) *Nautiloid was a marine animal that lived under water and was very diverse. Stromatolites were layers of protection for the cyanobacteria.*

Eocene:

1) Why do you think grasslands and forests dominated during this time?

A1) *They are drought and fire adapted and could be eaten easily.*

A2) *They dominated due to being able to survive different climates.*

A3) *Grasses are easily adaptable. There was a massive root system to cover the land. Grasses were drought and fire adapted.*

2) How did the changes in climate and vegetation affect the herbivores? And as a result, affect the carnivores?

A1) *Herbivores weren't able to eat certain types of plants, so their digestive systems had to evolve to handle it. They starved and died and so did the carnivores.*

A2) *Facing drought, starvation and cold, herbivores were going extinct or evolved. Vegetation was tough to chew, which destroyed teeth.*

Pleistocene:

1) Hypothesize why these animals developed this particular trait during the Pleistocene. Remember during the Eocene, dwarfism reigned until the mass extinction. Fully develop your guess…

A1) *They had more access to food for more eating.*

A2) *Food – they had more food and access to healthy food.*

A3) *Had an abundance of food.*

2) Four major glacial events have been identified. How do you think these glacial events impacted the animals living on land or in the oceans during these events? Name at least two impacts that this ice age had on the animals.

A1) *Food and hunting, also less space of living.*

A2) *Lots of extinction happened. The ice prohibited food, land and such.*

Overall Observations

Teacher A's class was set up in a classroom in which groups of two or three students shared one desktop computer to complete the Quests. Students were observed working well together, sharing time navigating the avatar and discussing/hypothesizing possible answers for the Quests. Due to technical difficulties, specifically slow Internet speed, students were able to adapt to the problem by completing their Quests with the use of Internet searches and discussion. While observed to be frustrated and disappointed, the students stayed on task to finish their assignment one way or another.

Teacher B's class was separated into groups comprising of half the class working on GeoWorlds and the other half doing book-work or listening to the lecture. Noise levels sometimes caused concern with this configuration, but the students working on GeoWorlds respected the rest of the class in terms of staying on task, being conscious of time restraints and keeping their voices low. The groups, though large for the small laptop computer, worked fairly inclusively. Students took turns navigating if they were comfortable doing so, while the others read the questions aloud from the worksheet and advised/suggested areas in which to explore to find the answers. Unfortunately, most likely due to the large group size, there were students who appeared excluded or disinterested. The facilitator made these observations and attempted to get them involved by requesting they become the navigator with the goal to make the group dynamics more equal. Overall, Teacher B's classroom set up, though noisy at times, was successful in respect to time limitations, student involvement and completing the curriculum.

Supplemental Analyses: External Validity

The pre-GCI scores and Video Game Surveys (Appendix D; Appendix B) used in Classes A and B were analyzed to determine if the samples were representative of the population. An independent-samples *t*-test was conducted on the pre-GCI to determine if there was a significant difference in the population between classes. Results indicated that there were no significant differences between Class A and Class B pre-GCI scores.

An independent-samples *t*-test was also conducted on the results of the Video Game Survey to determine if there was a significant difference between the classes; again, to determine if the samples were representative of the population. Results indicated that there were no significant differences between Class A and Class B. Table 4.7 demonstrates the statistical summary for both the GCI and Video Game Survey in relation to generalizing the population where t(x) is the sample size and corresponding degrees of freedom, *P* is the significance value based off a 0.05 confidence level, Mpre and Mpost are the mean pre- and post-test scores and *SD* is the standard deviation.

Table 4.7 Statistical Summary: Generalizing the Sample Population		
Measure	**GCI**	**Video Game Survey**
***t*-Tests: Generalizing the Sample Population**		
t(192); t(188)	0.78	0.46
P	0.43	0.12
M_{classA}, *SD*	4.75, 2.29	3.01
M_{classB}, *SD*	4.47, 2.65	2.83

Demographic statistics, using a chi-square analysis and independent-samples *t*-test, showed no significant differences ($p > 0.05$) in areas such as gender, major, parents' education, race, gender, age and GPA between the two participating classes. Age did show a significant difference ($p < 0.05$), likely do to the fact the Class A encompasses strictly freshmen, and Class B encompasses freshmen and those students who have not yet filled their physical science requirement (see Table 4.1 for Age Distribution). Table 4.8 demonstrates the statistical summary in generalizing student demographics within Class A and Class B where t(x) is the sample size and corresponding degrees of freedom, *P* is the significance value based off a 0.05 confidence level, Mpre and Mpost are the mean pre- and post- test scores and *SD* is the standard deviation.

Table 4.8 Statistical Summary: Generalizing Demographics					
Measure	**Gender**	**Major**	**Parent Edu.**	**GPA**	**Age**
Chi-Square: Gender, Major & Parent Edu.					
x^2 (1); x^2(6); x^2(8)	0.02	18.7	12.43	-	-
P	0.88	0.02	0.061	-	-
***t*-Tests: GPA & Age**					
t(92); t(189)	-	-	-	1.49	3.52
P	-	-	-	0.14	.001
M_{classA}, *SD*	-	-	-	3.34, 0.68	15.33, 0.51
M_{classB}, *SD*	-	-	-	3.1, 0.73	15.67, 0.81

CHAPTER 5 – Summary and Discussion

The purpose of this study was to collect a range of information to determine whether GeoWorlds was an effective education tool for improving students' knowledge

on geologic time and their knowledge on general geological concepts. The information collected was based on finding the educational impact and affective response to determine the overall success of the curriculum. This research was able to provide answers to questions in some of these areas and to develop suggestions for improvement in others.

Baseline Information: Video Game Usage

The Video Game Survey (Appendix B) presented diverse findings in the skills of the participating classrooms. Students, when asked if they would consider themselves an active video game player, a little under half of the students surveyed considered themselves as such (48.94%). The survey also showed that the majority of students (83.96%) own a personal computer and therefore most would be able to participate in GeoWorlds outside of the classroom if required to. However, the amount of Internet access at home is unknown and could be a limiting factor. The questions relating to Final Fantasy, The Sims and Second Life were selected because the games are comparable to the themes found in GeoWorlds. While results show that the majority of students have never (55.08%) or seldom (16.40%) played any of these games or ones of similar nature, over a quarter (28.52%) of students have played these games sometimes, frequently or often. When asked about a more specific representation of the students' individual video-game-playing skills, a little over half (58.80%) of students considered themselves non-, novice or occasional players, while frequent and expert players represented the remaining students (41.21%). These findings demonstrate that about half of the population is comfortable and familiar with video games, but are not necessarily familiar with games similar to GeoWorlds. However, the questions posed on the specific game usage can be limiting to the student, as the games on the survey, though the most popular, still do not encompass all games that may have similar characteristics of GeoWorlds.

Overall, these results not only provide baseline information for the population, but also supports the possibilities of pairings and groupings of students in the classroom. This information could be used to ensures that at least one student would feel comfortable using a computer and a video game as a learning tool in each pair or group. To better match or group students of different abilities, may provide a better learning environment

for all participants. By putting students in groups of four could ensure that at least one student is comfortable with computers and at least one is familiar or has experience in games similar to that of GeoWorlds. Creating groups with varied skills and comfort will force students to assist and teach one another in using Second Life and mastering GeoWorlds components and material.

Educational Impact

The educational impact was measured through the pre- and post-Time Period Quizzes (Appendix F) and the Geoscience Concept Inventory (Appendix D). Each test attempted to uncover the knowledge gained from working in GeoWorlds and which areas needed a closer look.

The participating students showed a significant increase in Time Period Quiz scores after participating in the GeoWorlds program. This result was expected, as pre-quizzes for the Time Periods were particularly low and the sample population had little to no background in the subject content. The reinforcement aspect of presenting information to the class could have potentially contributed to higher post-test scores, but this act also supports the concept of collaborative learning beyond the scope of working in GeoWorlds as a group. Therefore, the reinforcement of presenting the material likely had little to no affect on their post scores and it would be safe to say students gained a significant amount of new information and concepts that were retained in order to be successful on the post-quizzes from GeoWorlds alone.

The GCI group results, however, demonstrated no significant increase in post-assessment scores. While disappointing, insight was gained that the GeoWorlds Time Periods in which the classes participated (Precambrian, Permian, Eocene and Pleistocene) may have not covered all the concepts that were selected for this GCI subset. If the students would have participated in all eight time periods (including Cretaceous, Cambrian, Triassic and Devonian) class scores may have increased significantly as the subset questions were originally designed for the execution of all eight time periods.

Although the overall scores of the GCI did not show a significant increase in post assessments, when questions were looked at individually, those that were most congruent with the material covered did show a significant increase in correct answer responses.

Therefore, the GCI results acted as an indicator that not all the subset questions were closely connected with the concepts covered in the GeoWorlds Quests these classes participated in. This is clear evidence that two instruments that are independently created may not always fit. Questions 1, 8, 12, 15 showed no improvement or a worsening there of, demonstrating that these questions were likely not covered in time periods the students participated in. While questions 4, 6, 13 and 14 showed the greatest increases in correct answer responses. Questions 4 and 6 referred to what the Earth's surface looked like when it was first formed and showed an increase of 18 and 14 respectively in additional correct responses. Question 13 asks to explain why the ocean basins look the way they do today (an increase in 15 correct responses) and question 14, showing the greatest improvement with 26 additional correct responses, asked how many years back in time would you have to travel to witness when the Earth first formed as a planet. It can be assumed that large individual question improvements were a result from participating in GeoWorlds alongside the material that may have been taught in the classroom.

As for determining the effect of how the act of reinforcement of material through presentations played out on test scores, the results showed that the presenters of the Precambrian and Pleistocene scored significantly better on their post tests than than the non-presenters. As for the other two time periods, the Permian and Eocene, there were no differences in scores between the presenters and non-presenters. This does not mean that the non-presenters scored higher on the Permian and Eocene, but the difference in scores of the presenters and non-presenters could not be identified Why did the two time periods who partcipated in GeoWorlds score better, and the other two not? From a qualitative standpoint, better scores may have been a result of four (but not limited to) potential reasons: 1) how the groups of students interacted and participated, 2) the ease/hardness of the period tests, 3) the functioning of the Internet during those periods when groups were participating or 4) the time periods in GeoWorlds have have been less developed, less interesting or contain less descriptive content.

Affective Response

Interviews with both teachers and students (Appendix E) were conducted before and after participating in the GeoWorlds program. Through these interviews, perceptions and attitudinal reactions emerged about the program and its functionality in the classroom. While the emerging themes provided by an external consultant shed light on key points, further study of the transcripts in combination with attitudinal observations had an impact on the success of the curriculum from both teacher and student responses.

Teacher Interviews

Teacher A's pre-interview showed some concerns and disinterest in using technology in the classroom. The major concern was the time constraints of trying to fit the program into the curriculum that Teacher A was already required to teach. The teacher had no experience using video games in the classroom and admitted to not having dedicated much time to becoming familiar with GeoWorlds. The participating teacher said the most exciting part of the program was getting "a set of computers to keep (i.e., the incentive for participation)." Concern with working in groups also was discussed, as well as that Teacher A asserting the curriculum did not have a "clear and concise goal."

Teacher A's initial reaction and skepticism to the program may have contributed to not fulfilling all aspects of the study in their classroom. Class A students were allowed, as instructed by the teacher, to only participate in one time period as Teacher A grew increasingly frustrated with the hardware/Internet issues as time progressed. Fortunately, the post-interviews were still able to be conducted despite the growing impatience of the participating teacher. In addition to the technical issues, Teacher A did not feel the program covered enough "geology" and did not think it met any of the state's Department of Education "geology standards." The impression was that it was more biology-oriented. The students' reactions to the program, as described by the teacher's point-of-view was, "very excited before, disappointed during and relieved after [using GeoWorlds] – knowing they did not have to do it anymore." Overall, Teacher A's reaction before and after the program was perceived to be pessimistic, skeptical and unaccommodating as evidence of not being able to complete the study.

Teacher B's pre-interview showed more enthusiasm about introducing a new teaching tool into the classroom as well as a welcoming attitude toward technology. Major concerns of Teacher B were "if the content to be covered in each time period would be thorough enough for the kids and how the computers would work." Teacher B admitted to not spending a lot of time in GeoWorlds at the time of the pre-interview, but vowed to be "very well prepared" and "will have gone through it and do the Quests" before it was introduced in class. Excitement about GeoWorlds for Teacher B came from the "students being able to do learning on their own and so they can think and apply concepts and do problem solving."

Teacher B's post interview concluded that if time allowed, the classes would have liked to do all periods from beginning to end. Technical issues, such as slow Internet speed was a problem, but Teacher B worked to accommodate the areas of concern through restructuring the classroom to meet the goals of this study. Students were observed, on behalf of Teacher B, to be very excited about participating prior to actually using GeoWorlds, and then it was a mixed bag of emotions during. A mixed bag as described by Teacher B was that, "…some kids really liked it; some kids didn't and thought it was confusing…" GeoWorlds, according to Teacher B, went above and beyond what is normally taught in the classroom about geologic time. Overall, Teacher B's reaction before and after the program was perceived to be excited, optimistic and felt GeoWorlds was a great educational tool.

Overall, it appeared that the initial reaction to participating in the program overlapped throughout the use of GeoWorlds. While it was frustrating for both classes in aspects to hardware/Internet issues, one teacher appeared to be more accepting of technology and willing to work with the facilitator as shown in the pre-interviews, while the other teacher was more resistant to putting energy towards making it work. Teacher B, knowing that technology in the classroom has its setbacks, took problems in stride and said in the post-interview that while hardware/Internet issues caused some frustration, the students still learned a plethora of material that went above and beyond what was normally taught in the classroom.

Student Interviews

Teacher A's students, in the pre-interviews, all stated that they had never played a video-game or computer game in the classroom before and were excited to use GeoWorlds as a classroom activity. Students did not express any real concerns, except perhaps working in groups and staying on task. Most were enthusiastic about the idea of not listening to lectures and taking notes and several students also commented on how GeoWorlds may accommodate their different learning styles. Pre-interviews indicated a majority of positive feedback and very little concern for trying something new in the classroom.

After attempting to work in GeoWorlds and encountering Internet issues, Teacher A dismissed GeoWorlds from the class. Class A students were interviewed after Teacher A opted out of the study and appeared very disappointed that the technological difficulties limited their use and prohibited their experience. Many students said they would try GeoWorlds at home or had already. Though they could not actively learn in the world, students said they learned material that was provided on the Quest Worksheet and what they could find using Internet resources. All agreed that if the Internet was more compatible with GeoWorlds they would have learned and understood more of the material. Even with these problems, students' perceptions were still positive regarding the possibilities of GeoWorlds in their classrooms. One student said, "It was pretty inspiring to see how it was like back then and see what kind of creatures, plants and stuff were around there." A few students were able to recall specific material they encountered while participating in the World, such as stromatolites and cyanobacteria. Overall, the students were very frustrated with the technological issues and being unable to be an active avatar in the world and explore, but still saw the potential in the program.

Teacher B's students had a similar reaction to the idea of playing a computer game as an activity in class. Many said they were excited about trying something new in the classroom and that it would be a good experience. One student said that the class "would be able to experience something in a new way, instead of looking in the textbooks and worrying about falling asleep and not getting their class work done…I think it will keep our attention span longer better than anything else." There was little concern about implementing GeoWorlds in the classroom, but one student mentioned the possibility of

classmates taking advantage of the opportunity and the hardships of adapting to a new routine.

Teacher B's students also encountered some technological difficulties at times, but the majority of the students were able to participate in the manner which is desired for GeoWorlds to be a successful program. Students spoke of the playing-to-learn concept and how GeoWorlds was a more fun and creative way to learn. Several students mentioned that it was "cool to see what was like here [on Earth] before." Suggestions for improvement made by the students included making it easier to find the plants and animals to answer the Quest questions and a faster Internet connection. Other students said it worked well and could not suggest any improvements. The most difficult part of GeoWorlds, according to Class B students (beyond a slow Internet), was getting lost and wandering outside their designated time periods. Overall, students said they would probably investigate GeoWorlds at home on their own time or if it was required as an assignment. Most said they would have liked to have done more time periods if class time allowed.

Teacher A's students' experiences differed from Teacher B's in respect to support from the teacher, the classroom environment and the organization in which GeoWorlds was implemented. This was reflected in the post-interviews of the students, with the outward frustrations of Teacher A likely transferring to the attitude of the students and their perceptions of the program. Fortunately, both classes of students saw potential in the GeoWorlds and understood what the program was trying to accomplish. Teacher A started and ended pessimistically/negatively and Teacher B started positive and ended perhaps more excited and interested in using GeoWorlds again.

Success of the Curriculum

From reviewing the student's Quest Worksheets and making notes of their interactions and participation in the program in the classroom, the success of GeoWorlds as a tool for learning was assessed. These two factors helped determine if the worksheets were a satisfactory tool in helping students navigate, understand, comprehend and explain the geologic concepts being taught and if GeoWorlds can function effectively in the classroom in respect to group work, staying on task and completing the assignment.

Quest Worksheets were completed individually by students with the help of their time-period specific group members. Through classroom observations made by the facilitator and discussions with the participating teachers, the Quests appeared to have successfully navigated the students to particular areas, species and sites in a timely manner. Questions on the worksheets were answered thoroughly in most cases, but answers received verbally from students to the facilitator perhaps showed more understanding than that of the written word. Communication between students within the virtual world and in the classroom demonstrated great teamwork skills in helping one another find and answer questions and explaining concepts to one another. Observations made on the group dynamics were noted to have one or two students playing an active role in the navigation of the avatars, another student or two reading the Quests outloud and providing advice to the navigators and a minimal number group members who appeared entirely disinterested. However, the Quests overall appeared to meet the goals of desired group work, yet would still be able to be achieved on an individual level and were a great tool in navigation and "telling the story" of the time period through student collaboration/action/reaction in GeoWorlds.

Groups of five or six students around one laptop proved to be a barrier to some student participation. Though students were encouraging participation and involvement of their classmates, there were still restrictions on how much each individual could actively participate in the world through controlling the avatar. Students communicated through text chat within the world describing to one another what they were seeing and doing, as well as assisting other groups in letting them know they were in the "wrong space" when flying or walking around. For the majority of the time, students stayed on task and followed instruction. There were some students who were more comfortable navigating the avatars than others, but the facilitator and teachers encouraged students who may not be as comfortable to be in control as well. Overall, the observations made in the classroom support that GeoWorlds is a viable resource and educational tool for ninth grade classes and promotes collaborative learning and functional group work.

Suggestions for Improvement

The largest issue in this study was the lack of resources as provided by Junction City High School's technology department. The slow Internet speed prohibited students from actively exploring the world without concern about the program slowing down, freezing or getting kicked off the Internet entirely. A well-established relationship between the participating school's technology department and that of the researcher in virtual gaming curricula needs to be developed well in advance of any communication with potential teachers within the school. Without this capability, the success of GeoWorlds or any similar virtual-learning environment is unlikely or highly restricted.

Requiring teachers to play a larger role in the implementation of GeoWorlds should also be addressed. Teacher B's self-motivated attitude in understanding the material and goals of the program before introducting it to the students proved beneficial. Teacher B was then able to help direct students, explain content and objectives as well as be comfortable and flexible with potential faults in the curriculum. Teacher A's resistance to the program could be attributed to the lack of time becoming familiar with GeoWorlds, the Quests and objectives of the program. Requiring that teachers go through and complete each Quest Worksheet on their own time prior to any agreements to accept classroom laptops, would ensure that they understand the material being covered and how GeoWorlds and Second Life function. It can then be assumed that participating teachers will be more accommodating of the program being implemented and should be able to facilitate their students during the time spent on this curriculum.

A developed timeline for implementation in the classroom for teachers to have would also be helpful. Adjustments can be made to the schedule as the teacher sees fit, which is what occurred in this study as time restrictions allowed only four of the eight developed time periods to be used. The teacher knowing the estimated amount of time required for each Quest would be beneficial, as well as the amount of time needed for pre- and post-testing, surveys and interviews if another study were to be done.

There is also room to improve in TerraWorld and GeoWorlds as it was not fully functioning or complete before the start of this study. As a result, large restrictions on content alongside misinformation within the time periods were present. Misinformation included mislabeled organisms, missing species and incomplete media sources, all which

could have impacted post-test scores and the ability to participate in all time periods. It is recommended that these issues be resolved prior to the next study or use of the GeoWorlds curriculum.

Upon suggestions of the students and their observed problems, the time period areas within GeoWorlds need defined virtual boundaries. Whether these boundaries are on the maps used for navigating or on the land/water itself, either would help prevent students from wandering aimlessly in the wrong area until they finally get reoriented. This issue may also be resolved if additional time were provided for students to become more familiar with the world and become highly oriented in the location of each time-period-area. However, it is unlikely that any classroom provide an significant amount of time to explore. Therefore, boundaries would be an easy fix in preventing wasted time on students finding themselves in the incorrect section of the world.

Another suggestion provided by the student participants is that there be indicators on the maps showing where plants and animals are located. While this may seem to detract from the search and explore component of GeoWorlds, a compromise could be made that the animals are labeled without the need to click/touch them. From observations made in the classroom, students were often seen getting frustrated by the inability to locate particular organisms. They would either give up or get fixated on locating the species and time would be wasted in completing the Quests. Readily available labels above the organisms, without requiring students to click on them, would eliminate some of this frustration yet provide the search and explore component.

A last suggestion is that perhaps the Geoscience Concept Inventory Assessment should be removed as an assessment tool from future studies of GeoWorlds, unless 1) the world is complete and 2) the participating classrooms are willing to dedicate the required amount of time to complete *all* time periods. The other option would be to select questions from the GCI to develop time-period-specific assessments on broad geologic concepts. The findings in this study were not significant most likely due to the discrepancies between the selected time periods and the original questions selected from the GCI, but the particular questions relating to the time periods covered were promising, as evident of their significant results and therefore could be useful in the future.

Conclusions

GeoWorlds' impact on the ninth graders of Junction City High school was found to be positive. Students gained geologic knowledge as demonstrated through the significant findings in the Time-Period Quiz scores and the 11 questions in the GCI, their active participation in the program, use of collaboration skills and as presenters of the material they learned. This being a pilot study, there is much room for improvement but the overall findings demonstrate there is definite potential and support for virtual-learning environments to be used as an Earth science teaching tool in the classroom.

The significant findings in the Time Period Quiz scores strongly support that students are learning and retaining geologic concepts and the interviews demonstrate a genuine interest and acknowledgement of potential for the GeoWorlds curriculum if technological functionality was attained.

Beyond the questions presented in this study, several other questions have stemmed from the findings and execution of this research. Questions such as: Would results for the Time Period Quizzes be the same if reinforcement initiatives were not taken through presentations and test reviews? Reinforcement of the material may have played a role in improvement of test scores, but by how much is unknown.

Would GCI scores improve if the material in GeoWorlds better coincided with the questions? Or if students were able to complete all eight time periods (when/if they are fully developed) would student scores reflect a gain of broad geologic concept knowledge?

Would students gain better knowledge and understanding if they worked in pairs instead of groups of five or six? The increased action/participation time as individuals working in GeoWorlds may enhance understanding and allow all students to better conceptualize what Earth was like throughout geologic time.

If it were possible to find differing populations, would experience and comfort with the use of video games and computers have an impact on testing results and observations of group dynamics? Perhaps students with more experience will perform better in seeking out information and be more efficient at learning, as they would not be as consumed in learning how to function as an avatar and move about the world, but more focused on the learning of geologic content.

With further study that incorporates the findings and addresses the challenges presented here, perhaps GeoWorlds will eventually evolve into a curriculum that is easily adaptable by high school Earth Science classrooms nationwide.

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Appendix A – Demographics Survey

DEMOGRAPHICS:
Please answer the following questions about your background.

Gender____ **High School G.P.A._____**

Birthdate: Day_____ Month_____ Year_____

Anticipated Major_____

Racial Background: ___White ___Hispanic ___Asian
___African-American ___Pacific Islander
___American Indian ___Other_____

In which high school grade did you take:

Physics	8	9	10	11	12	Never
Chemistry	8	9	10	11	12	Never
Biology	8	9	10	11	12	Never
Earth Science	8	9	10	11	12	Never

Highest degree of:

Female Parent:
___Elementary School
___some High School
___High School
___some College
___Bachelor's Degree
___some Graduate School
___Master's Degree
___Doctoral Degree

Male Parent:
___Elementary School
___some High School
___High School
___some College
___Bachelor's Degree
___some Graduate School
___Master's Degree
___Doctoral Degree

Demographics Results Tables

Table A.1: Gender

Class A

Male	n = 51	50.00%
Female	n = 51	50.00%

Class B

Males	n = 46	51.11%
Females	n = 44	48.89%

Table A.2: Age

Class A

14 Years	n = 2	1.96%
15 Years	n = 64	62.74%
16 Years	n = 36	35.29%

Class B

15 Years	n = 44	49.44%
16 Years	n = 33	37.08%
17 Years	n = 10	11.24%
18 Years	n = 1	1.12%
19 Years	n = 1	1.12%

Table A.3: Ethnicity

Class A

African American	n = 17	16.67%
American Indian	n = 0	0.00%
White	n = 36	35.29%
Pacific Islander	n = 1	0.98%
Hispanic	n = 19	18.63%
Asian	n = 2	1.96%
Other	n = 27	26.47%

Class B

African American	n = 16	18.18%
American Indian	n = 3	3.41%
White	n = 37	42.05%
Pacific Islander	n = 0	0.00%
Hispanic	n = 15	17.05%
Asian	n = 2	2.27%
Other	n = 15	17.05%

Table A.4: Anticipated Major

Unknown	n = 74	38.54%
Science/Engineering	n = 26	13.54%
Fine Arts	n = 14	7.29%
Education	n = 8	4.17%
Business	n = 5	2.60%

Political Science	n = 8	4.17%
Medicine	n = 29	15.10%
Other	n = 21	10.94%
Military	n = 7	3.65%

Table A.5: Mother's Education Level

Class A

Elementary	n = 0	0.00%
Some High School	n = 2	2.35%
High School	n = 21	24.71%
Some College	n = 31	36.47%
Bachelor's Degree	n = 15	17.65%
Some Graduate School	n = 3	3.53%
Master's Degree	n = 12	14.12%
Doctoral Degree	n = 1	1.18%

Class B

Elementary	n = 0	0.00%
Some High School	n = 7	9.21%
High School	n = 25	32.89%
Some College	n = 23	30.26%
Bachelor's Degree	n = 4	5.26%
Some Graduate School	n = 0	0.00%
Master's Degree	n = 14	18.42%
Doctoral Degree	n = 3	3.95%

Table A.6: Father's Education Level

Class A

Elementary	n = 0	0.00%
Some High School	n = 3	3.49%
High School	n = 27	31.40%
Some College	n = 24	27.91%
Bachelor's Degree	n = 19	22.09%
Some Graduate School	n = 4	4.65%
Master's Degree	n = 9	10.47%
Doctoral Degree	n = 0	0.00%

Class B

Elementary	n = 0	0.00%
Some High School	n = 8	11.27%

High School	n = 24	33.80%
Some College	n = 15	21.13%
Bachelor's Degree	n = 12	16.90%
Some Graduate School	n = 4	5.63%
Master's Degree	n = 7	9.86%
Doctoral Degree	n = 1	1.41%

Appendix B – Video Game Survey

The purpose of this survey is to assess your level of familiarity with video games and your gaming habits. Please read each question carefully and answer as accurately as possible. Your response to each question represents a critical aspect of this research, so please try to answer each question as best you can. If you have any questions, please ask the experimenter.

Please circle one answer per question.

How many times in the past year have you done the following:

1. Played a PC based video game?

Never Seldom Sometimes Frequently Often

2. Played a console video game system (e.g., Playstation 2, Game Cube, X-Box, etc…)?

Never Seldom Sometimes Frequently Often

3. Played a video game in an arcade?

Never Seldom Sometimes Frequently Often

4. Played an online java-script video game (e.g., www.popcap.com)

Never Seldom Sometimes Frequently Often

6 Do you consider yourself to be an active video game player?

Yes No

7. During an average week, how many hours will you spend playing video games ?

< 1 hour 1-3 hours 3-5 hours 5-7 hours 7-9 hours > 9hours

8. If you play videogames, at what age did you first begin playing? _____

9. How often did you play video games as a child?

Never Seldom Sometimes Frequently Often

10. Do you own a personal computer?

Yes No

11. Please list any videogame systems in your household:

_____
_____
_____
_____
_____
_____
_____

12. Please estimate the number of hours per week you :

A. Play PC based video games: _____hrs
B. Play console video games (e.g., Playstation 2, Game Cube, X-Box, etc…): _____hrs
C. Play video games in an arcade: _____hrs
D. Play online java-script games (e.g., www.popcap.com): _____hrs

Specific Game Experience:

How frequently do you do the following:

1. Play DOOM, Quake, Halo, Half-Life, or similar first-person shooters?

Never Seldom Sometimes Frequently Often

2. Play Medal of Honor (any version, e.g. Medal of Honor Allied Assault, Medal of Honor Pacific Assault, etc…)?

Never Seldom Sometimes Frequently Often

3. Play Starcraft, Warcraft, Command and Conquer, Age of Empires, Civilization, Sim City, or similar strategy games?

Never Seldom Sometimes Frequently Often

4. Play Rise of Nations?

Never Seldom Sometimes Frequently Often

5. Play Tetris or variants of Tetris?

Never Seldom Sometimes Frequently Often

6. Play Final Fantasy or similar role-playing video games?

Never Seldom Sometimes Frequently Often

7. Play simulator video games (e.g., flight simulator or racing simulator games)?

Never Seldom Sometimes Frequently Often

8. Play The Sims or similar video games?

Never Seldom Sometimes Frequently Often

9. Play Grand Theft Auto or similar action/platform games?

Never Seldom Sometimes Frequently Often

10. Play sports video games (e.g., NBA Live, Madden NFL, FIFA Soccer, SSX, Tony Hawk, or similar games)?

Never Seldom Sometimes Frequently Often

11. Play in Second Life?

Never Seldom Sometimes Frequently Often

12. Play Dance Dance Revolution?

Never Seldom Sometimes Frequently Often

13. Play computer Solitaire, Free Cell, or Minesweeper?

Never Seldom Sometimes Frequently Often

14. Have you ever purchased a video game?

Yes No

15. Approximately how many video games do you own? _____ games

16. If you own video games, please list as many videogames you own in the space provided below.

_____
_____
_____
_____
_____
_____
_____

_____
_____
_____

17. I prefer:
Strategy video games
Action video games
Puzzle video games
Role-playing video games
Sports video games
No preference

18. I consider myself:
A non-video game player
A novice video game player
An occasional video game player
A frequent video game player
An expert video game player

19. Compared to five years ago:
I play video games more frequently now.
I play video games less frequently now.
There has been little change in the frequency of my video game playing.

20. Please list the five video games you have the most experience with. If you have little or no experience with videogames, please write "None".

_____
_____
_____
_____

Survey Source: Boot, W., Kramer, A., Simons, D., Fabiana, M., and Gratton, G. (2008) *The effects of video game playing on attention, memory, and executive control*, Acta Psychologica, Vol. 129, Issue 3, p.387=398.

Appendix C – Consent Forms

Junction City High School
Principal Consent for Participation in a Research Study

GeoWorlds: The Integration of Collaborative Virtual Learning Environments, Problem-Based Education in the Geosciences and Facilitator Development

P.I	Molly Davies	Assoc. Professor, College of the Liberal Arts
Co-PI(s)	Iris Totten,	Assoc. Professor, College of the Liberal Arts, Kansas State University
	Donna Russell	Asst. Professor, School of Education

Invitation to Participate
You are invited to participate in a research study with Dr. Davies with the Geosciences department at UMKC, Dr. Totten in the Geosciences department at Kansas State University and Dr. Russell from the UMKC School of Education. The overall purpose of this research is to understand the impact of high school science students' participation in the Geoworlds virtual learning environment on their problem-solving ability and knowledge of geosciences.

Who will Participate
There will be 3+ classrooms participating in the Geoworlds project at Junction City High School.

Purpose
The purpose of this research is to identify productive responses of students working in the virtual Geoworlds learning environment.

Description of Procedures
The teacher has consented to facilitate the implementation of a 3D virtual environment for approximately 3-6 weeks. The Geoworlds program will involve 2-3 sessions each week. The students will spend 45-90 minutes in the Geoworlds program during each session. The students will take pre/post geosciences tests. The students will complete a pre/post online survey about their ideas and attitudes about science and technology. Each test will take approximately 30 minutes. The teacher will give scaled assessments of the students' problem-solving processes 4 times over the Geoworlds projects.

Voluntary Participation
Participation by the students in this study is voluntary at all times. The students may choose to not participate or to withdraw their participation at any time. Deciding not to participate or choosing to leave the study will not result in any penalty or loss of benefits to the students. If the students choose to withdraw, they can contact Dr. Russell. All data related to their participation will be destroyed and not used in the study.

Fees and Expenses
There will be no cost to students to participate in this research study.

Compensation
There is compensation for the participating in the Geoworlds project. Each classroom will receive laptops and the online access needed to implement the Geoworlds project. The teacher will receive professional development on problem-based learning instructional design and geosciences pedagogy in the summer. The teacher will also receive ongoing professional development throughout Geoworlds project.

Risks and Inconveniences
There are no risks to the students for participation in this study. The students will be asked to complete surveys during the workshops or online in the website. The time spent responding to the surveys is the only inconvenience for the students.

Benefits
The possible benefits to the teacher for participating in this research include knowledge that the data collected during this study are contributing to our understanding about professional development, instructional design in science and engineering, and assessment. This can help other educators design instructional units to foster higher-order thinking skills (e.g., problem solving in science) in their students.

Confidentiality
All reasonable measures to protect the students' confidentiality and their identity will be taken. The students' identity will not be revealed in any publication that may result from this study. The confidentiality of all study related records would be maintained in accordance with State and Federal laws. All information gathered will be destroyed one year after the study is complete.

While every effort will be made to keep confidential all of the information the teacher completes and shares with researchers, it cannot be absolutely guaranteed. Individuals from the University of Missouri-Kansas City Institutional Review Board (a committee that reviews and approves research studies), Research Protections Program, and Federal regulatory agencies may look at records related to this study for quality improvement and regulatory functions.

In Case of Injury
The University of Missouri-Kansas City appreciates the participation of people who help it carry out its function of developing knowledge through research. If the teacher have any questions about the study that you are participating in you are encouraged to call **Donna Russell,** the investigator, at **816.232.2232.**

Although it is not the University's policy to compensate or provide medical treatment for persons who participate in studies, if you think you have been injured as a result of participating in this study, please call the Kathylene Siska, Ph.D of UMKC's Social Sciences Institutional Review Board, at (816) 235-1764.

Questions
If you have any questions or concerns regarding this study, or if any problems arise, you may call Donna Russell at 816.235.2232 or 314.210.6996. You can also email her at russelldl@umkc.edu.

Approved
Principal of Junction City High School

_____
Printed Name

_____
Signature

Parental Consent/Student Assent Form
Consent for Participation in a Research Study

vGeoWorlds: The Integration of Collaborative Virtual Learning Environments, Problem-Based Education in the Geosciences and Facilitator Development

P.I.	Caroline Davies	Assoc. Professor, Department Geosciences, UMKC
Co-PI	Iris Totten	Asst. Professor, Department Geology, KSU

Invitation to Participate
You are invited to participate in a research study with Dr. Davies, Department of Geosciences, UMKC and Dr. Totten, Department of Geology, KSU. The overall purpose of this research is to understand the impact of high school science students' participation in the Geoworlds virtual learning environment on their problem-solving ability and knowledge of geosciences.

Who will Participate
There will be 3+ classrooms in Junction City High School chosen to participate in the Geoworlds project.

Purpose
The purpose of this research is to identify impacts on student learning working in the virtual Geoworlds learning environment.

Description of Procedures
In the Geoworlds project you will work online in the 3D virtual environment for approximately three or more weeks. The Geoworlds program will take three weeks of interactions with 2-3 sessions each week. You will spend 30-40 minutes in the Geoworlds program during each session. You will take pre/post geosciences surveys. You will complete a pre/post online survey about your ideas and attitudes about science and technology. Each survey will take approximately 30 minutes. You will be given scaled assessments of your problem-solving processes four times over the Geoworlds projects.

Voluntary Participation
Participation in this study is voluntary at all times. You can choose to not participate or to withdraw at any time. Deciding not to participate or choosing to leave the study will not result in any penalty or loss of benefits to you. If you choose to withdraw you can contact the Project Principle Investigator, Caroline Davies, at (816) 235-1335 or email daviesc@umkc.edu. All information related to your participation will be destroyed and not used in the study.

Fees and Expenses
There will be no cost to you for you to participate in this research study.

Compensation
There is no compensation for you.

Risks and Inconveniences
There are no risks to participation in this study. You will be asked to complete a pre and post test and surveys to participate in the study.

Benefits
You will participate in an innovative online 3D virtual environment to learn advanced geosciences knowledge and interact with other students as a character in the virtual scenarios. Your school will receive advanced technologies as a result of the grant supporting this project. You will be able to participate in an innovative technological program.

Confidentiality
All reasonable measures to protect your confidentiality and identity will be taken. Your identity will not be revealed in any publication that may result from this study. The confidentiality of all study related records would be maintained in accordance with State and Federal laws. All information gathered will be destroyed one year after the study is complete.

While every effort will be made to keep confidential all of the information you complete and share, it cannot be absolutely guaranteed. Individuals from the University of Missouri-Kansas City Institutional Review Board (a committee that reviews and approves research studies), Research Protections Program, and Federal regulatory agencies may look at records related to this study for quality improvement and regulatory functions.

In Case of Injury
The University of Missouri-Kansas City appreciates the participation of people who help it carry out its function of developing knowledge through research. If you have any questions about the study that you are participating in you are encouraged to contact the Project Principle Investigator, Caroline Davies, at (816) 235-1335.

Although it is not the University's policy to compensate or provide medical treatment for persons who participate in studies, if you think you have been injured as a result of participating in this study, please call the IRB Administrator of UMKC's Social Sciences Institutional Review Board at 816-235-1764.

Questions
If you have any questions or concerns regarding this study, or if any problems arise, you may contact the Project Principle Investigator, Caroline Davies, at (816) 235-1335 or email daviesc@umkc.edu.**Parental Consent/ Student Assent Form**

Title of Project
vGeoWorlds: The Integration of Collaborative Virtual Learning Environments, Problem-Based Education in the Geosciences and Facilitator Development

Project Directors/Researchers

Caroline Davies
Iris Totten

I have read this consent form and have been given the opportunity to ask questions. I will also be given a signed copy of this consent form for my records. I hereby consent to participation in the research described above.

_____
Student's Name

_____
Signature of Student

_____
Parent's Name

_____
Signature of Parent

_____
Date

Appendix D – Geoscience Concept Inventory

GCI TEST QUESTIONS
Please answer the following questions to the best of your ability.

1. Some scientists claim that they can determine when the Earth first formed as a planet. Which technique(s) do scientists use today to determine when the Earth first formed? **Choose all that apply.**
(A) Comparison of fossils found in rocks
(B) Comparison of different layers of rock
(C) Analysis of uranium and lead in rock
(D) Analysis of carbon in rock
(E) Scientists cannot calculate the age of the Earth

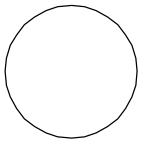
2. Which of the following can greatly affect erosion rates? **Choose all that apply.**
(A) Rock type
(B) Earthquakes
(C) Time
(D) Climate

3. Which technique for determining when the Earth first formed as a planet is most accurate?
(A) Comparison of fossils found in rocks
(B) Comparison of different layers of rock
(C) Analysis of uranium and lead in rock
(D) Analysis of carbon in rock
(E) Scientists cannot calculate the age of the Earth

4. What did the Earth's surface look like when it first formed?

A

A. One large landmass surrounded by water

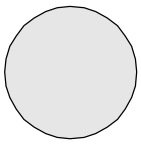


B

B. All water and no land

C

C. Similar to today



D

D. Mostly molten rock and no water

E

E. We have no way of knowing

5. Some people believe that they have evidence that can prove whether the very center of the Earth is a solid, liquid, or gas. Which of the following is an accurate statement about the innermost part of the Earth?

(A) The very center of the Earth is mostly made up of gases
(B) The very center of the Earth is mostly made up of liquids
(C) The very center of the Earth is mostly made up of solids
(D) Scientists don't have enough evidence yet to indicate whether gases, liquids, or solids make up most of the very center of the Earth

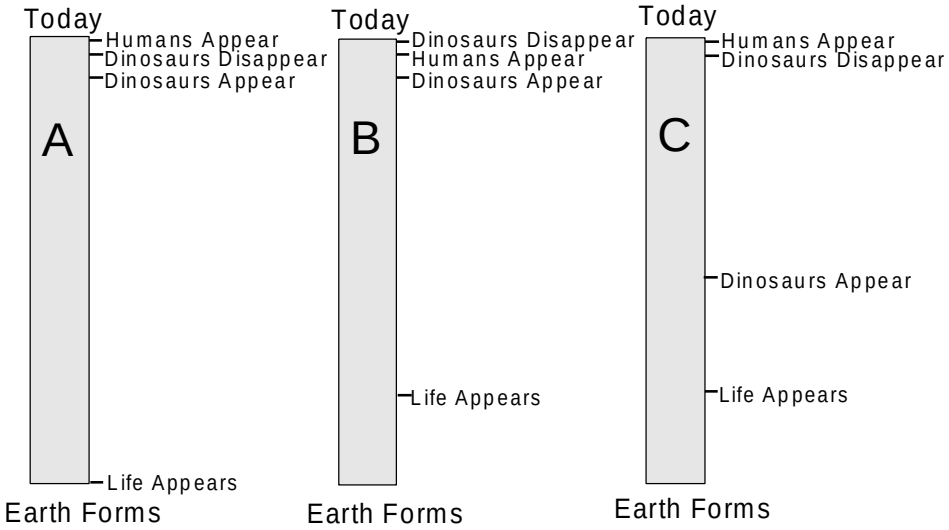
If you could travel back in time to when the Earth first formed as a planet:

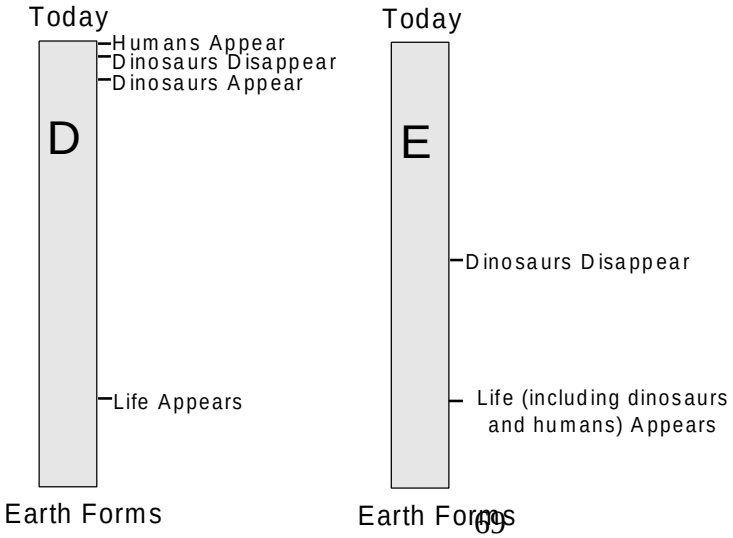
6. What would the Earth look like

(A) The Earth would be mostly covered with water
(B) The Earth would be mostly molten
(C) The Earth would be mostly covered with ice
(D) The Earth would be mostly rocky

7. Which of the figures below do you think most closely represents changes in life on Earth over time?

Choose one: **A** **B** **C** **D** **E**





8. Which of the following statements do you think best describes the relationship between people and dinosaurs?
(A) People and dinosaurs co-existed for about five thousand years
(B) People and dinosaurs co-existed for about five hundred thousand years
(C) Dinosaurs died out about five thousand years before people appeared on Earth
(D) Dinosaurs died out about five hundred thousand years before people appeared on Earth
(E) Dinosaurs died out about 50 million years before people appeared on Earth

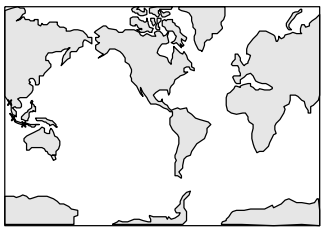
9. If the single continent in #73 did exist, how long did it take for the single continent to break apart and form the arrangement of continents we see today?
(A) Hundreds of years
(B) Thousands of years
(C) Millions of years
(D) Billions of years
(E) It is impossible to tell how long the break up would have taken

10. Fossils are studied by scientists interested in learning about the past. Which of the following can become fossils? **Circle all that apply.**
(A) Bones
(B) Plant material
(C) Marks left by plants
(D) Marks left by animals
(E) Animal material

11. Scientists have discovered fossils of four-legged creatures called dinosaurs. How much time passed between the appearance and extinction of these creatures?
(A) Hundreds of years
(B) Thousands of years
(C) Millions of years
(D) Billions of years
(E) Some of these creatures still exist

12. Why do tectonic plates move?
(A) The eruption of underwater volcanoes pushes the tectonic plates
(B) Currents in the ocean push against the tectonic plates
(C) Earthquakes push the tectonic plates
(D) Material is moving beneath the plates
(E) Magnetism moves the tectonic plates

13. The map below shows the position of the Earth's continents and oceans today. The gray areas represent land, and the white represents water. Which of the following best explains why the ocean basins look the way they do?



(A) Meteor impacts caused the ocean basins to form this way
(B) Ocean basins form as continents move
(C) The ocean basins formed in cracks that were created as the whole Earth cooled after its formation
(D) The ocean basins formed in cracks that were created as the whole Earth heated after its formation

If you could travel back in time to when the Earth first formed as a planet:

14. How many years back in time would you have to travel?

(A) 4 hundred years
(B) 4 hundred-thousand years
(C) 4 million years
(D) 4 billion years
(E) 4 trillion years

15. Some people believe there was once a single continent on Earth. Which of the following statements best describes what happened to this continent?

(A) Meteors hit the Earth causing the continent to break into smaller pieces
(B) The Earth lost heat over time and cracked, causing the continent to break into smaller pieces
(C) Material beneath the continent moved, causing the continent to break into smaller pieces
(D) The Earth gained heat over time and cracked, causing the continent to break into smaller pieces
(E) Only a small number of people believe there was once a single continent, and it is more likely that the continents have always been in roughly the same place as they are today

GCI Question #	Key
1 (1)	C
2 (2)	A,D
4 (3)	C
7 (4)	D
14 (5)	C
23 (6)	B
28 (7)	D
36 (8)	E
37 (9)	C
40 (10)	A,B,C,D,E
53 (11)	C
58 (12)	D
65 (13)	B
68 (14)	D
73 (15)	C

Table A.7: Geologic Concepts

Class A

n = 102	
Average	4.75
Median	5
Mode	5
St. Dev.	2.29
Maximum	10
Minimum	0

Class B

n = 92	
Average	4.47
Median	4
Mode	4
St. Dev.	2.65
Maximum	11
Minimum	0

Appendix E – Interview Questions, Transcripts and Emerging Themes

Interviews are designed to describe the predicted and actual experience that teachers and students had with working with GeoWorlds; working to discover logistical and classroom issues, as well as student interests, motivational and attitudinal thoughts regarding GeoWorlds.

Pre-Interview Questions: Teachers

1. What were your major concerns when deciding to participate in this study and using the GeoWorlds curriculum?

2. Have you ever used any type of video-game before in your classroom? If so, what kinds?

3. From your experience in the past, what would you predict the outcome to be for your students – in areas such as working together in groups, learning content and staying on task during an activity such as this?

4. Were you able to spend much time within GeoWorlds to help prepare? How prepared do you feel leading up to GeoWorlds being introduced to your class? If you felt like you could be better prepared, how can we help?

5. What are you most excited about – in relation to GeoWorlds being a part of your classroom?

Pre-Interview Questions: Students

1. When I first told you guys that you would be playing a video game to learn Earth Science content, what was your reaction?

2. Do you think using a video game as a way of teaching is beneficial and will help you learn the material? Why or why not?

3. What concerns (if any) do you have about "going off the beaten path" of what your teacher usually does from day to day?

4. Have you ever used a game as a way of learning new material? If so when? Was it helpful?

5. Is the idea of using a video game as a way to learn, make you more excited about your science class? Why or why not?

Pre-Interview Transcripts: Teachers

Carmen Hewitt
Teacher
9th Grade Earth and Space Science

1. My major concern was the time constraints of trying to fit this into the curriculum that I am already required to teach.

2. I haven't really used a video game before. I have done some technology things like Quests online and my students have used movie maker on windows before, but no video games.

3. Working together in groups has its advantages and disadvantages. When you work together in a group, and it's a large group, I would say any more than 3 students, you usually have one student usually does the work, and the other two kind of goof off and have the other person work. Smaller groups of two, like we're planning on doing, usually work much better because they both have an investment in it and both of their ideas can be heard. As far as, the learning content, I think that they'll learn as long as they have a clear and concise goal and activity to do while they're doing it. If they are just in there, just kind of exploring and told to go to these different worlds without answering questions and without understanding their purpose, then they're not going to learn as much. And then staying on task is always difficult with freshmen especially, and that's where the goals come in - "You need to get this completed in the amount of time allowed."

4. No. Yes, I have passwords now and created my avatar. The last time I went in, something was going on in which something was being uploaded and kicked me out of the program. Miss Fenwick, while you're going over this stuff, I'll be a student too, just watching, going, "Oh! This how it works." Yeah, I think that we did the best we could with what we had. I think it kind of rests on me, I should have been a bit more prepared than what I have. And I still have some time to do that.

5. Well, originally I was most excited about getting my own set of computers that I get to keep. And then of course, I am interested to see what the kids have learned and if this really did help them, by having fun and playing a computer program; did they really learn what they needed to learn.

Brian Sturges
Teacher
9th Grade Earth and Space Science

1. I guess just what content would be covered in each world, would be thorough enough for the kids and how the computers work.

2. I have only used review games such as, "Who Wants to be a Millionaire" or, "Are You Smarter Than a 5th Grader," those kind of computer based games before.

3. I would hope that with them being able to interact with each other inside the GeoWorld that they'll be able to do kind of student based learning, where they can learn on their own instead of having the teacher telling them what they need to learn. Hopefully they can work together as far as being in pairs on the computer.

4. Not a lot of time, but I plan to spend a lot more time on it. I had a couple question answered that helped me get myself started. I think before the first day before we actually do it, I will be very well prepared and I will have gone through it and do the quests myself, plus the pre-post tests. Not right now, I am sure I will have questions in the future. As of right now, I'm good.

5. My students being able to do learning on their own and so they can think and apply concepts do some problem solving in areas like that. Kind of like them teaching themselves the content.

Pre-Interview Transcripts: Students

Tierra - Student
Hewitt
Earth and Space Science

1. I was pretty excited. I just wanted to get to know what the game was actually going to be about. That's basically it.

2. I think so, most of it, I mean, the game; I am a visual learning, like when I see stuff I learn it better. So, I mean, people like me will be able to probably learn it better, but if they learn out of the textbook better, probably won't learn it as well.

3. When we do this video game, is it going to be like the labs? Are they going to help us like the labs do? That's mostly it. I am excited to do something different, because I mean, it's a new routine. But I mean it will be just be different, because we're used to doing Daily Challenges when we come to class. It just depends exactly when we first get started doing it [if I will feel uncomfortable or not].

4. Well, maybe when I was in 8th grade at the end when I took computers class. I used Type to Learn. Man, I mean, it helped me learn how to type good and fast. But that's it. [No other games; but sometime use the Internet for labs.]

5. Yes, because I mean, like I said before, I am a visual learner and I like to learn different and I like to learn better when I see it. So I think when we use the video game on the computer it might help us better to learn it because it's like when we watch a movie, we see the movie and we actually, you know, learn it and see what was in it. If you just hear it and you might not get the full understanding of it. It makes me more excited to come because I am learning in a different way than I am usually am.

Raadamez - Student
Hewitt
9th Grade Earth and Space Science

1. I didn't kind of expect like some of the teachers to actually trying to make a little video game like on class. So I was kind of a little bit surprised.

2. Well, yeah, I think so. A little bit. Because I am a little gamer, most of the time, so I learn a lot of stuff from playing and stuff like that.

3. Well, I guess it would be like a new experience in classroom and stuff like that. Well, I guess like on the first day we are playing, I guess a little bit [uncomfortable] but I will get used to it after on.

4. Yes. I guess when I was playing "Type to Learn" which is just a little game by like typing the letters like really fast. Yeah, it was a little bit [helpful].

5. Pretty much, because it will probably make studying and classroom much funner and easier to come in. Yeah, I would [work on Geoworlds at home if I could].

Monique - Student
Hewitt
9th Grade Earth and Space Science

1. I was happy, because, like it's something different. And we never do anything fun. Not that fun. We do activities, but not like this.

2. Yeah, because it will probably explain [the material] better if we play it.

3. I will be comfortable. I think it'll be fun because we don't really do nothing. We do our little Daily Challenge, activities and taking notes, and labs.

4. "Type to Learn" when I was in elementary [school]. Yes [it was helpful], it helped me type faster and learn new words because it will like, I dunno, it was helpful in some way. It was fun.

5. Yes. Because it makes me want to come to class more to try something new and different.

Peaario - Student
Hewitt
9th Grade Earth and Space Science

1. Well, honestly, I only heard the words video game. So I was like "Oh yea, that'd be kind of cool." Exciting.

2. Yes, does Wii Sport and Wii Fit count as like…? Well, I got a Wii Fit at home and I learn different stretches and stuff. [Learn by having fun]. [Learn easier by actively participating].

3. I don't have any concerns. Just happy to be playing a video game.

4. Yes, "Type to Learn," "Wii Sport," "Wii Fit," "Just Dance." Its where you dance, dance to songs.

5. Yes, definitely. It's different than what we do. Doesn't really make me want to do [science] in college. [Maybe after playing the game].

Seth - Student
Hewitt
9th Grade Earth and Space Science

1. I was kind of shocked because I have only done that once with another class. That was with Computers Class. We did "Type to Learn."

2. Yes, because it's easier to learn while playing a game. Instead of reading out of the textbook and doing worksheets.

3. I don't have any concerns. Yes, [I am pretty excited about changing it up].

4. In computer class, "Type to Learn," it didn't really help me because it was making me type specific words, at a specific time, with a specific fingering. This was in 7th grade.

5. Yes, because it seems like it's going to be fun.

Allison – Student (sophomore)
Sturges
9th Grade Earth and Space Science

1. My reaction was this will probably be more fun than sitting through lecture notes all day long. It will be a new experience.

2. I think it will, I mean it depends on your learning. I mean, some people do better with visual [learning], like I do, some people do better with different things. I am a visual learner so I think this will help me a lot.

3. It doesn't really both me that much. I think it will be more fun to do something different and something new. Instead of what we do every other day especially because this is something I have never heard of before. I would really like to try it. I think it will be pretty easy to go ahead and get in to it; it seems like an easy thing to get into.

4. When I was younger, we used to do a game kind of thing, guess you could call it, we used to do this thing on the computer where we would learn how to type without looking down on at the keyboard and stuff like that and I mean my little sister uses games to use her numbers and her letters and stuff, but other than that, not that much.

5. Yes, it's exciting to do something different. And this seems like it would be fun to try and not doing notes all day long would be better.

Robert – Student (sophomore)
Sturges
9th Grade Earth and Space Science

1. I thought it would be fun because I play video games, but not all the time, but throwing this in class it will probably be a good experience.

2. I think will because, like, if you do things that you like to do and you're good at it, I think some good could come of it.

3. I don't have any concerns. I think it will be better, in my honest opinion. Because video games, people have fun, but if you're learning and having fun at the same time it can be very effective.

4. Yes, I used it to learn how to do recording software and typing and it helped me today so I don't have to look at the keyboard all the time.

5. Yes, of course, it just gives you a different outlook on things and different feel in that class. Like you look at it differently.

Tara - Student
Sturges
9th Grade Earth and Space Science

1. I thought it was really cool, because I thought that kids would be able to experience something in a new way, instead of looking in the textbooks and worrying about falling asleep and not getting their class work done and stuff like that. I think it will keep their attention span longer rather than anything else.

2. As for our generation, I think yes, because all the technology and stuff like this. So it's more beneficial, I guess you can say, because [its something we are more used to]. We play more video game than read books.

3. My concern is that because we usually take notes, so usually look to my notes to answer questions. But if this is going to be a new way, I am pretty sure that it's going to be a lot more helpful and stuff in understanding more, rather than being thrown at a bunch of information and trying to figure out what's what.

4. Back through 6th grade until now I have taken typing classes and that's about the only one I can think of, that has done anything for us, to learn how to do anything.

5. It makes me want to come to my science class more, I mean, granted, yes, Mr. Sturges' class is fun and I love coming to his class, but something different is more fun you could say a lot more helpful.

Dean - Student
Sturges
9th Grade Earth and Space Science

1. I was happy because I like playing video games and I knew that when we would play in the class we will learn it easier.

2. Yes, it will be helpful because we'd be interested in this subject and we'd pay more attention instead of falling asleep in class and not paying attention.

3. I just hope that some kids don't take advantage of this and not do what they're supposed to do and if everyone does this right, it'll be a good experience.

4. In elementary school I used a game to type, but other than that, I haven't used a game to learn. But I have learned from games. This may be an inappropriate game, but I have learned how to count money and math stuff from games. It was Grand Theft Auto.

5. Yes, because we usually just take notes and that's a little bit fun, but to do it this way would be a lot more fun and I'd be more likely to come to his class more often.

Payton - Student
Sturges
9th Grade Earth and Space Science

1. I thought it would be really cool; we've never really done anything like that in there.

2. I think it will be, because kids will pay attention more. I think they will [stay more on task].

3. I don't think there are really any big concerns, kids might be a little weirded out by it, but we'll adjust.

4. I have never really used a video game or computer to learn.

5. I think it does because it's just not reading out of the book like it usually is. We usually come in, do our "Daily Starter" which is just 5 questions, then we take notes, go to lunch, and then we come back and do a lab or worksheet or something.

Anthony - Student
Sturges
9th Grade Earth and Space Science

1. It was pretty cool. I'd prefer that than doing the regular stuff we do. Most likely everyone will stay on task; it's probably funner than notes and stuff.

2. In a way it will help, I think it'd help, probably, most likely. Because aren't we learning about history? It will help us.

3. Everyone will probably get used to it after awhile. I'm not worried about it. [My classmates] will probably follow directions; they might fall off because it is a game. But I think they'll stay on task.

4. No, I have never used a game [as a way of learning new material]. We've used a computer for a lab, but never a video game type of thing like you're talking about.

5. Yeah, I'll probably look forward to coming to our class now, most likely. Probably, [would use it at home] if I had time.

Morgan - Student
Sturges
9th Grade Earth and Space Science

1. I thought it would be pretty cool, like, be more interesting than notes I guess.

2. I think it is, it's kind of just stepping around what we usually do, so more interesting.

3. I really don't have any concerns; I think it will be pretty cool. I think [people will stay on task]. Most people don't take notes, so people will probably pay more attention.

4. I used a game, but not like a video game; just on different websites for math or whatever. I just remember it was in 7th grade.

5. Yeah, I mean it's a pretty good class, I mean, I usually don't play video games, but I think it will be pretty cool. I'm not really [intimidated to play, however].

Marcus - Student
Sturges
9th Grade Earth and Space Science

1. I thought it was going to be fun, because I usually play video games. And I played the Sims and I am looking forward to it.

2. Yes, because I used video games like this before in classes.

3. I think I will get the hang of it really fast. Some [students] will joke around and not take it seriously, but I think everyone will get the main idea and do it right.

4. Yes, basically in all the grades I have been in we have at least used a game off the Internet to learn about the class.

5. Yes, because I video games everyday.

Katie - Student
Sturges
9th Grade Earth and Space Science

1. I was actually excited because I like The Sims, so this is kind of like The Sims, so I was excited.

2. Yes, I do, because it's showing us kind of the pre-life and things before then.

3. I don't really have any [concerns], I think we will adjust to the new schedule and it will be fun.

4. I have, but it was only in elementary school, so it was a long time ago. I don't [remember what it was], but it was kind of just a little fun kid math game.

5. Yes it does, because it's always fun to play games rather than just sitting there learning.

Post Interview Questions: Teachers

1. What did you like about using GeoWorlds in your classroom? What would you change about GeoWorlds?

2. Do you think the time you spent using GeoWorlds was too little, too much or just right to get the desired material covered?

3. How did you perceive your students' attitudes before, during and after using GeoWorlds about Earth Sciences?

4. Was the curriculum for GeoWorlds complimentary to what you would be teaching in the classroom? Do you believe students gained more understanding of the material being presented in this way, or your traditional way?

5. Would you implement GeoWorlds again? If so, how often would it be useful throughout the school-year? If not, why?

Post Interview Questions: Students

1. What did you like about GeoWorlds? What would you change about GeoWorlds?

2. If given the option, would you like to spend more time working in GeoWorlds than regular days in the classroom? How much more/less time and why?

3. Would you work/play in GeoWorlds at home if given the opportunity? If yes, how much time? If not, why?

4. What was most challenging about working in GeoWorlds?

5. What did you learn from working in GeoWorlds?

Post Interview Transcripts: Teachers

Carmen Hewitt
Teacher
9th Grade Earth and Space Science

1. GeoWorlds didn't really work in my classroom, so I don't think I can answer that question. The first thing I would change is that I would make it more geological. And none of the curriculum met any of the geology standards, it was more biology. There wasn't a lot about rocks and other geology processes.

2. If it worked correctly I would probably, probably use about 3-4 class periods at the most. I think the kids would really enjoy it if they could fly around and move. Probably no more than that because we don't spend a whole lot of time on geologic time.

3. They were very excited <before>, disappointed <during> and relieved <after> they don't have to do it anymore.

4. Kind of like I said earlier, it overlaps a little bit but I would like to have more geology – with rock layers, fossils, and less about the biology. The students would probably better understand the material better – they would get a good feeling of what the time periods were like (if it was working). Understand it more because it would be like they were actually there.

5. Yes, if it were working, I would try to implement GeoWorlds again. I would implement it one time, late April.

Brian Sturges
Teacher
9th Grade Earth and Space Science

1. I liked how the interactive software let the kids be hands on, move around and enjoy a videogame that was something new to them. They could better understand what was going on. I wish it would worked a bit better with the Internet, but that's just an issue with the school. I would say maybe being able to do more worlds, instead of just 4 so they can experience all of geologic time.

2. I would say too little. I would have liked to do more on the geologic time, maybe do all the periods so we can start from the beginning and go all the way to the end.

3. They were excited about it because we showed them what they can do and participating in a virtual video game. So they were very excited. It was mixed emotions during, some kids really liked it, some kids didn't and thought it was confusing and they didn't like it. So it was kind of 50/50 on that. After, I would say what they learned was good and they got a lot of good information.

4. Yes, as long as geologic time is taught – it actually went above and beyond what I normally teach. Few more detailed things about it…than what I teach about it, but would like to do more periods in geologic time. I would say this way is more hands-on and they like the video games they didn't take it as learning, but more as having fun <while learning>.

5. If the a few glitches to get worked out, I would love to do it again. I would do it during my geologic time period – for a month or a month and a half.

Post Interview Transcripts: Students

Tierra - Student
Hewitt
Earth and Space Science

1. Well, I kind of like, the whole letting us being on the computer instead of work. And the hand-written thing. I would change, like, the way it functions and that's about it, and maybe how you have to stay in one place for the whole time, you should be able to travel everywhere.

2. I probably would. I think a week to a week and a half, like every class period for a week.

3. Yeah, because I have already done it at home and I would do it because I kind of get frustrated now if I didn't get the stuff done in class. I would do it, but then I would play only for a couple days because we have a lot of the same stuff going on in class.

4. I would say basically the functioning, not being able to move and basically that you gave us a paper that was useless because it wasn't working.

5. Well, I learned basically whatever was on the paper and what GeoWorlds would be able to do and what we would have been able to learn. If we would have been able to work and use it more, then I probably would have learned more.

Raadamez – Student
Hewitt
Earth and Space Science

1. It was a good experience and I learned. And pretty much, I guess I would like to explore things more I guess.

2. Just a little <better than regular class>, I guess. Probably like less time, the GeoWorlds game was very laggy and slow, and we would probably wouldn't be able to move around or stuff like that, and we would just have to do the worksheet.

3. No. Because I would be too busy with work and stuff like that and probably wouldn't have time for it.

4. The lag…it always lagged a lot. The character would probably just freeze up.

5. It was pretty inspiring to see how it was like back then, and see what kind of creatures, plants or stuff was around there, so I know what it looked like and what is was like back then.

Seth – Student
Hewitt
Earth and Space Science

1. I really didn't like it because it kept messing up. The way it works, if you can actually have a faster Internet, we could actually learn from it.

2. Yeah, I would want to spend a month on it.

3. No. Because I have too much math homework.

4. The whole moving part, and not being able to move. Working in groups was good and was helpful.

5. Nothing.

Peaario - Student
Hewitt
9th Grade Earth and Space Science

1. I liked the names and the figures of people that was cool, that was really cool. I would change like the programming. I liked working in groups because we could help each other and think about what we're learning and I would change the function of the Internet.

2. Yeah. Just like, a month so we can do all the time periods.

3. -----

4. I didn't find anything challenging, except that it was hard to be patient and wait for it to work.

5. I didn't learn anything from GeoWorlds – but I know we can chat and fly. But I learned a lot from that big paper. The paper was pretty easy.

Student A (no pre-interview)
Hewitt
9th Grade Earth and Space Science

1. Personally, nothing. Because we couldn't really do anything. I would change the connection you know, so we could move a centimeter.

2. Yeah I would. 3-4 times would be good.

3. I do have the Internet speed, but personally, I don't want to waste space. So, probably wouldn't spend anytime on that. Because I don't feel like wasting my memory/time in GeoWorlds.

4. Probably, well I would just have to say, we couldn't really do anything, so it was challenging and made me angry because I didn't want to waste my time.

5. I learned that there was those things that…I forgot what they are called…stromatolites. They are bacteria and sediment. I learned about those little bacteria too.

Student B (no pre-interview)
Hewitt
9th Grade Earth and Space Science

1. I liked learning about different things because I enjoy science and that we were able to chat with each other and help each other to answer the questions, help one another. I would change the process, it was really slow and it would be better if it worked faster.

2. Yeah, sometimes its boring in class and this could keep us a little more focused. I think for a month.

3. -----

4. The slowness and not being able to move.

5. I learned about bacteria, where they lived and the different kinds.

Morgan - Student
Sturges
9th Grade Earth and Space Science

1. I liked the Earth science view and learning and playing at the same time I guess. Maybe if you are looking for an animal there'd be or have a dot or something, so we wouldn't have to go look for it I guess. I mean, it was hard to find some of the animals.

2. I would do half and half, because its more fun to play, but sometimes you don't get as much work done. Yeah, I would like to do more.

3. Probably not, I don't spend that much time on the computer.

4. Just finding the animals, everything else was fine.

5. We learned about the different animals and climate stuff in the Pleistocene. Group work is fine.

Peyton – Student
Sturges
9th Grade Earth and Space Science

1. I liked how it was a more fun and creative way to learn, it was better than taking notes. I think if like you have dots for on the little map to tell you where the animals you need to go are instead of clicking on everything.

2. Yeah. I would like that. I think about half and half, there's some other stuff that isn't included in GeoWorlds. I would have liked to have done every time period.

3. If it was a part of an assignment, but on my own…I probably wouldn't.

4. Not getting lost <was challenging>.

5. I learned about everything I now know about our time period, because I knew nothing about those animals before. I did the Pleistocene – it had really big animals, the giant armadillo, the cretin owls, giant swans and homo-erectus.

Katie - Student
Sturges
9th Grade Earth and Space Science

1. I liked in GeoWorlds how you find the animals before because I am a big animal fan, so it was cool to see what was here before. I would probably change like, make it more real-life and have the animals walking around and stuff.

2. Yes I do, because taking notes can be kind of boring. 2/3 of the class period would be good. I would have liked to have done all the time periods.

3. Yes I would, because getting on the computer is always kind of fun.

4. The most challenging thing about working was probably getting out of your area into a different time period, you would end up in the wrong time period. That's probably the only thing, getting lost.

5. My time period, I learned that some of the animals there are kind of similar to the animals we have today.

Allison – Student (sophomore)
Sturges
9th Grade Earth and Space Science

1. I liked that it is a fun game and we can use it to learn at the same time. And it reminds me of other games, Like, when I look at it, it think of World of Warcraft for some reason. I wouldn't change much. I didn't get to really work with it as much, because it

was really slow and we were basically frozen the whole time. But from what I did see, it looked pretty good.

2. Yeah, only because, I mean, its more fun than taking notes all day. Yeah, not every single time period, but not every day, every other week or so.

3. Maybe, I was going to because with out group it froze up and didn't get the chance in class, but if I get the chance <I would at home>.

4. Mostly because it didn't work and it was frozen in one spot most of the time. I got to kind of look at it, but most of the time it was frozen.

5. Not really since we didn't do much, I mean, I remember like going to Google and looking things up, other than that , I don't remember.

Robert – Student (sophomore)
Sturges
9th Grade Earth and Space Science

1. I liked it, it was fun. And we got to get on the computers and do it, instead of regular class. Not really, I just started and it worked well.

2. Yeah, I think it would probably be more fun. Because like, in regular class we just take notes and that's kind of boring and this has more action. Maybe if we do it like we did, twice a week.

3. Well, I really don't have much free time, so I probably would spend 15-20 minutes <checking it out.>

4. I believe the whole point is more action, so looking for stuff gave us more action, so I think moving around was kind of fun.

5. I had already know about the prokaryotes and eukaryotes, but I learned more stuff about it and how you can find other stuff by just looking around.

Tara - Student
Sturges
9th Grade Earth and Space Science

1. I thought it was pretty interesting getting to see the different time periods. Not really, I actually thought it was pretty fun.

2. I think it would be cool I think if we did it in other classes too, we could be a little bit more active than reading out of the book. I think if we did every time period, I think it would be pretty nice.

3. If it was for homework. Probably to see what it is about.

4. Trying to find the little creatures or whatnot we didn't have any direction and had to click on everything to find it.

5. The different things, prokaryotes and eukaryotes and how they lived and where.

Student C (no pre-interview)
Sturges
9th Grade Earth and Space Science

1. I liked how it involved the past time, before we were created and how it explains the life the life we never got to see before. If we could move around more.

2. Yeah, I think we would be a lot more funner than taking notes all day. Like an hour a day or more.

3. Yes, I would. Because it's a lot of fun. Yeah, I learn more at home than in the classroom.

4. Mainly moving around, it was kind of hard to look at the pictures.

5. There is a lot of different animals, and a lot of animals that lived during our time that still live today.

Emerging Themes

Pre-Test Themes

TEACHERS

1. What were your major concerns when deciding to participate in this study and using the GeoWorlds curriculum?

    a. Time constraints (1)
    b. Content covered (1)
    c. Functioning of computers (1)

2. Have you ever used any type of video-game before in your classroom? If so, what kinds?

    a. Quests online (1)
    b. Students used Windows movie maker (1)
    c. Review games (1)

3. From your experience in the past, what would you predict the outcome to be for your students – in areas such as working together in groups, learning content and staying on task during an activity such as this?

    a. Smaller groups work better in comparison to larger groups (more than 2-3) (1)
    b. Work better with questions to guide them and keep them on task (1)
    c. Need a time frame and due date to ensure they stay on task (1)
    d. Hope for student based learning by interacting with each other inside GeoWorld (1)

4. Were you able to spend much time within GeoWorlds to help prepare? How prepared do you feel leading up to GeoWorlds being introduced to your class? If you felt like you could be better prepared, how can we help?

    a. Should have been more prepared (1)
    b. As you're going over it, I'll be a student too (1)
    c. I will go through and do the quests and pre-post tests before the first day (1)

5. What are you most excited about – in relation to GeoWorlds being a part of your classroom?

    a. Getting my own set of computers (1)
    b. Interested to see if kids learn what they needed to learn (1)
    c. Students being able to learn on their own and teach themselves the content (1)

STUDENTS

1. When I first told you guys that you would be playing a video game to learn Earth Science content, what was your reaction?

a. Fun (4)
b. Excited (3)
c. Surprised (2)
d. Happy (2)
e. New experience (5)

2. Do you think using a video game as a way of teaching is beneficial and will help you learn the material? Why or why not?

a. Visual learners will benefit more than others (2)
b. Learn by actively participating in material (6)
c. Learn from doing things you like (2)
d. Beneficial to this generation (1)
e. Used video games in class before (1)
f. Showing us pre-life and things before then (1)

3. What concerns (if any) do you have about "going off the beaten path" of what your teacher usually does from day to day?

a. Concerned if it'll be like the labs (1)
b. Used to doing Daily Challenges in class (2)
c. New experience (1)
d. A little uncomfortable at first (5)
e. No concerns (6)
f. Fun to do something different (3)
g. Concerned because they usually look to notes to answer questions (1)
h. Hope people don't take advantage and abuse new privilege (3)

4. Have you ever used a game as a way of learning new material? If so when? Was it helpful?

a. Used 'Type to Learn'- in elementary school. Helped learn to type well and fast (5)
b. Wii Sport and Wii Fit (1)
c. Just Dance (1)
d. Typing games in grade school (7)
e. Grand Theft Auto- helped in learning to count money (1)
f. Haven't used a game to learn (2)

5. Is the idea of using a video game as a way to learn, make you more excited about your science class? Why or why not?

a. Excited to learn in a different way than usual (7)
b. More fun (5)
c. Makes me want to come to class more (6)
d. More excited because I play video games every day (1)

Post Test Themes

TEACHERS

1. What did you like about using GeoWorlds in your classroom? What would you change about GeoWorlds?

a. Make it more geological (1)
b. Liked how the interactive software let kids be hands on (1)
c. Wish it would have worked better with the Internet (1)
d. Would like to be able to do more than four worlds (1)

2. Do you think the time you spent using GeoWorlds was too little, too much or just right to get the desired material covered?

a. 3-4 class periods at most (1)
b. Too little time- would have liked to do more on geologic time (1)

3. How did you perceive your students' attitudes before, during and after using GeoWorlds about Earth Sciences?

a. Excited before (2)
b. Disappointed during (1)
c. Relieved after (1)
d. Mixed emotions during (1)
e. After had a lot of good information (1)

4. Was the curriculum for GeoWorlds complimentary to what you would be teaching in the classroom? Do you believe students gained more understanding of the material being presented in this way, or your traditional way?

a. Overlaps a little with teaching (1)
b. Students may understand it better because it's like they were there (1)
c. Went above and beyond what I normally teach (1)
d. This is more hands on- having fun while learning (1)

5. Would you implement GeoWorlds again? If so, how often would it be useful throughout the school-year? If not, why?

a. Would use it again if it were working (2)
b. Would use it once- in late April (1)
c. During m geologic time period- a month to a month and a half (1)

STUDENTS

1. What did you like about GeoWorlds? What would you change about GeoWorlds?

a. Like being on the computer (2)
b. Allow them to move (4)
c. Improve the Internet (3)
d. Liked the names and figures (1)
e. Liked working in groups (2)
f. Liked learning and playing at the same time (3)
g. Improve animals (3)
h. Liked getting to see the different time periods (2)

2. If given the option, would you like to spend more time working in GeoWorlds than regular days in the classroom? How much more/less time and why?

a. A week to a week and a half (1)
b. Less time (1)
c. Can't move around much and its slow (2)
d. A month (3)
e. 3-4 times (1)
f. Two-thirds of the time (1)
g. Half and half with regular class work (2)
h. Twice a week (1)
i. Want to do it in other classes too (1)
j. An hour a day (1)

3. Would you work/play in GeoWorlds at home if given the opportunity? If yes, how much time? If not, why?

a. Yes- for a couple days (2)
b. No- too busy (2)
c. No- too much homework (1)
d. Don't want to waste memory space (1)
e. Don't spend much time on the computer (1)
f. Yes- because it is fun (3)

g. Yes if it was for homework (2)

4. What was most challenging about working in GeoWorlds?

a. Not being able to move around (5)
b. The functioning (2)
c. The slowness (4)
d. Finding the animals (2)
e. Not getting lost (2)

5. What did you learn from working in GeoWorlds?

a. Learned what GeoWorlds would have been able to do (1)
b. Learned from the paper (2)
c. Learned what it was like back then (1)
d. Nothing (3)
e. Learned about a bacteria (3)
f. Animals (4)
g. Climate (1)
h. Expanded on prior knowledge (1)

Appendix F – Geologic Time Period Quizzes and Answers

PreCambrian

1) The "Oxygen Catastrophe" was a time in the Earth's history that
   A) there was no oxygen present in the atmosphere.
   B) there was to much oxygen in the atmosphere.
   C) there was very little free oxygen in the atmosphere.
   D) there was more hydrogen than oxygen in the atmosphere.
   E) there was more oxygen than hydrogen in the atmosphere.

2) What caused the levels of oxygen to change over time?
   A) respiration
   B) photosynthesis
   C) development of multi-celled organisms
   D) plant life
   E) animal life

3) What element combined with oxygen is evidence for the "Oxygen Catastrophe"?
   A) sulfur
   B) copper
   C) magnesium
   D) potassium
   E) iron

4) What type of organisms existed at this time?
   A) single-celled organisms
   B) multi-celled organisms
   C) fish
   D) birds
   E) reptiles

5) How old are the oldest fossils?
   A) 3,600 years old
   B) 3.6 million years old
   C) 3.6 billion years old
   D) 4.6 billion years old
   E) 5.6 billion years old

6) Organisms at this time sustained themselves through
   A) hunting
   B) gathering
   C) respiration
   D) photosynthesis
   E) eating

7) Which one of the following did not live during the PreCambrian?

A) Bacteria
B) Eubacteria
C) Archaea
D) Cyanobacteria
E) Foraminifera

8) Which one of the following did live during the PreCambrian?
A) Grypania spiralis
B) Ammoniods
C) Climatius reticulates
D) Cladoselache
E) Cheirloepis

9) What are the oldest known living fossils today?
A) humans
B) stromatolites
C) dinosaurs
D) reptiles
E) mammals

10) Stromatolites are formed in what type of water environment?
A) rivers
B) deep water
C) streams
D) shallow water
E) lakes

11) What type of organisms form stromatolites?
A) bacteria
B) eubacteria
C) archaea
D) cyanobacteria
E) grypania spiralis

12) What type of organisms are very thin and lacked any mineralized hard part or well developed organs or organ systems?
A) Ediacaran
B) Kimberella
C) Spriggina floundersi
D) Dicksonia Costata
E) Cloudinahartmannae

13) How many different locations around the world can these organisms be found?
A) 10
B) 20
C) 30
D) 40
E) 50

14) Stromatolites are layered accretionary structures formed by the trapping, binding and cementation of _____ grains by _____?

A) metamorphic, cyanobacteria
B) sedimentary, cyanobacteria
C) igneous, cyanobacteria
D) sedimentary, brown algae
E) metamorphic, brown algae

15) These types of organisms are best preserved in what types of conditions?
A) bottom of the sea
B) ocean shores
C) grasslands
D) river beds
E) lake bottoms

16) The fossils are preserved as thin impressions on bedding surfaces of
A) fine to medium grained sedimentary rocks
B) medium to coarse grained sedimentary rocks
C) fine to medium grained igneous rocks
D) medium to coarse grained igneous rocks
E) fine to medium grained metamorphic rocks

17) _____ were the first life forms on Earth ever (that we know of).
A) Eukaryotes
B) Insects
C) Cycads
D) Prokaryotes
E) Ferns

18) The most significant difference between prokaryotes and eukaryotes is?
A) their sizes
B) where they live
C) the presence of skin
D) their lifespan
E) the presence of a nucleus

19) What percent of Earth history took place within the PreCambrian time period?
A) 90%
B) 70%
C) 50%
D) 30%
E) 10%

20) There are several theories on the origin of life, which, if any, are the most recognized in the scientific community?
A) Life arose in underwater hydrothermal vents.
B) Life was created by God and God alone.
C) Life's building blocks were carried to Earth within meteorites.
D) Life is a result of the sun heating rocks to create microorganisms.
E) A & C

Answers

1) C
2) B
3) E
4) A
5) C
6) D
7) E
8) A
9) B
10) D
11) D
12) A
13) C
14) B
15) B
16) A
17) D
18) E
19) A
20) E

Cambrian

1) What was the mean oxygen level in the Cambrian?
   A) 11.5%
   B) 12%
   C) 12.5%
   D) 13%
   E) 13.5%

2) What was the mean carbon dioxide level in the Cambrian?
   A) 4500 ppm
   B) 5000 ppm
   C) 5500 ppm
   D) 6000 ppm
   E) 6500 ppm

3) The volume % of oxygen today is higher than in the Cambrian, and carbon dioxide is much lower.
   A) True
   B) False

4) Periods with high volcanic emissions generate higher levels of
   A) NO_2
   B) SO_2
   C) CaO_2
   D) O_2
   E) CO_2

5) During the Cambrian period the continents were located
   A) at the north pole
   B) at the south pole
   C) in the northern hemisphere
   D) in the southern hemisphere
   E) at the equator

6) The largest land mass was called
   A) Pangaea
   B) Gondwanaland
   C) Laurentia
   D) North America
   E) South America

7) The second largest continent during the Cambrian
   A) Pangaea
   B) Gondwanaland
   C) Laurentia

D) North America
E) South America

8) How many land masses were there during the Cambrian?
A) 2
B) 3
C) 4
D) 5
E) 6

9) The continent distribution during the Cambrian affected the climate?
A) True
B) False

10) The climate in the Cambrian was
A) an ice age
B) warmer than it is today
C) cooler than it is today
D) drier than it is today
E) wetter than it is today

11) What was the average global surface temperature in the Cambrian?
A) 17
B) 18
C) 19
D) 20
E) 21

12) What is the average global surface temperature today?
A) 13
B) 14
C) 15
D) 16
E) 17

13) What formation were organisms that you see in this scenario preserved in?
A) Mississippi Sandstone
B) Atoka Limestone
C) Riley Sandstone
D) Burgess Shale
E) Winston Limestone

14) Which organism from this time period does not have a skeleton?
A) Vauxia
B) Nisusia
C) Ottoia

D) Scenella
E) Marella

15) Which organism from this time period does not have a skeleton?
A) Canadia
B) Pikaia
C) Aysheaia
D) Hallucigenia
E) Sidneyia

16) Most organisms that lived in the past left no record of their existence.
A) True
B) False

17) To become preserved as a fossil, an organism must do all of the following except
A) eat a certain food
B) have preservable parts
C) be buried by sediment
D) escape physical, chemical, and biological destruction after burial
E) live in a suitable environment

18) Our fossil record used to create the time scale is very biased towards organisms with
A) heads
B) tails
C) backbones
D) hard parts
E) soft parts

19) Which organism lived during the Cambrian?
A) Orthida
B) Dinomischus
C) Spiriferida
D) Pentamerida
E) Anaspida

20) Which organism did not live during the Cambrian?
A) Canadia
B) Pikaia
C) Aysheaia
D) Hallucigenia
E) Cheirolepis

Answers

1) C
2) A
3) A
4) E
5) D
6) B
7) C
8) C
9) A
10) B
11) E
12) A
13) D
14) C
15) B
16) A
17) A
18) D
19) B
20) E

Devonian

1) What time range did the late Devonian period last?
   A) 417-354 years ago
   B) 417-354 thousand years ago
   C) 417-354 billion years ago
   D) 417-354 million years ago
   E) 4,170-3,540 years ago

2) The continents were clustered stretching from the _____ to the _____?
   A) northern hemisphere, southern hemisphere
   B) equator, southern hemisphere
   C) equator, northern hemisphere
   D) western hemisphere, northern hemisphere
   E) none of the above

3) What feature did fish evolve during this time period?
   A) Fins
   B) Tails
   C) Jaws
   D) Scales
   E) Gills

4) What life-forms never recovered the extinction periods?
   A) Mollusks
   B) Trilobites
   C) Crinoids
   D) Brachiopods
   E) All of the above

5) Lycophyte trees are….?
   A) Vascular plants that reproduce by shedding spores/seeds.
   B) Non-vascular plants that reproduce by shedding spores/seeds.
   C) Vascular plants that reproduce asexually.
   D) Non-vascular plants that reproduce asexually.
   E) None of the above.

6) Which of the following is not one of the first trees?
   A) ctenorhabdotus
   B) horsetails
   C) ferns
   D) wattieza
   E) asteroxylon mackiei

7) Non-vascular plants are those plants that have lignified tissues for conducting water, minerals and photosynthesis products through the plant. Non-vascular plants include ferns, club mosses, flowering plants and conifers. Water transport happens in either xylem or phloem.
   A) True
   B) False

8) Vascular plants is a general term for those plants without a vascular system (xylem and phloem). They have no roots, stems or leaves, but possess tissues specialized for internal transport of water. Mosses and algae are vascular plants.

A) True
B) False

9) Which one was not a fish during the Devonian?

A) Climatius reticulates
B) Cladoselache
C) Rhyncodipterus
D) Hemicyclaspis
E) Mesonyx

10) Which of the following characteristics would not be an attribute of the strongest predator?

A) Teeth structure
B) Size
C) Nocturnal
D) Armor
E) Aggressiveness

11) Heavily armored, scaled or naked bodies, jawed-fish, bottom feeder, predators, dominant vertebrate group during the Devonian, 8-11 meters long describes which of the following?

A) Placoderm
B) Ray-finned fish
C) Lobe-finned fish
D) Shark
E) Cladoselache

12) These fish contain "fin rays," their fins being webs or skin supported by bony or horny spines as opposed to fleshy, in terms of numbers, the most dominant class of vertebrates and they are found in fresh and marine waters.

A) Placoderm
B) Ray-finned fish
C) Lobe-finned fish
D) Shark
E) Cladoselache

13) These fish are fleshy finned, consisting of lungfish, lobed-paid fins are joined to the body by a single bone. These fins evolved into legs of the first tetrapod land vertebrates.

A) Placoderm
B) Ray-finned fish
C) Lobe-finned fish
D) Shark
E) Cladoselache

14) Which two continents moved closer together during the Devonian?

A) Laurentia and Pangaea
B) Laurentia and Baltica
C) Pangea and Laurasia
D) Laurasia and Gondwanaland
E) Baltica and Laurasia

15) Horsetails and ferns produced the first seed trees reaching up to how many meters tall?
A) 12 meters
B) 8 meters
C) 4 meters
D) 1 meter
E) 20 meters

16) What super-continent existed in the south?
A) Pangaea
B) Laurasia
C) Baltica
D) Laurentia
E) Gondwana

17) Based on your predictions, how many land form(s) will be present in the Permian?
A) 1
B) 2
C) 3
D) 4
E) 5

18) Which type of rock formation are the insect fossils found in?
A) Cockroaches
B) Spiders
C) Centipedes
D) Millipedes
E) All of the above

19) Early vertebrates developed all of the following to live on land except,
A) limbs
B) stronger backbones
C) limb girdles
D) lungs
E) teeth

20) Humans are tetrapods because they have four limbs and a backbone.
A) True
B) False

Answers
1) D
2) B
3) C
4) E
5) A
6) A
7) B
8) B
9) E

10) C
11) A
12) B
13) C
14) D
15) B
16) E
17) A
18) E
19) E
20) A

Permian

1) During the Permian how much of the marine life went extinct?
   A) 92%
   B) 93%
   C) 94%
   D) 95%
   E) 96%

2) During the Permian what percentage of land dwelling animals went extinct?
   A) 50-60%
   B) 60-70%
   C) 70-80%
   D) 80-90%
   E) 90-100%

3) How many continents were there during the Permian?
   A) 1
   B) 2
   C) 3
   D) 4
   E) 5

4) What was the name of the super continent at this time?
   A) Baltica
   B) Gondwana
   C) Laurentia
   D) Pangaea
   E) Rodinia

5) Where was the super continent located?
   A) western hemisphere
   B) eastern hemisphere
   C) equator
   D) north pole
   E) south pole

6) What were the oxygen levels at this time?
   A) 10%
   B) 20%
   C) 30%
   D) 40%
   E) 50%

7) What were the carbon dioxide levels like at this time?
   A) >100ppm

B) <100ppm
C) <200ppm
D) >200ppm
E) <210ppm

8) How do the oxygen and carbon dioxide levels compare at this time?
A) the same
B) both are more
C) both are less
D) oxygen is less and carbon dioxide is more
E) oxygen is more and carbon dioxide is less

9) Tetrapods are…
A) 2-limbed invertebrates
B) 4-limbed invertebrates
C) 2-limbed vertebrates
D) 4-limbed vertebrates
E) invertebrates with more than 4 limbs.

10) Towards the middle of the Permian the Earth's climate began to resemble what modern day country?
A) Africa
B) Russia
C) North America
D) Asia
E) Antarctica

11) What two seasons most likely occurred at the interior of Pangaea?
A) cold and hot
B) hot and wet
C) wet and dry
D) dry and cold
E) hot all year long

12) Which of the following was not a plant species during the Permian?
A) Tree-Ferns
B) Cordaites
C) Lycopods
D) Conifers
E) Placoderms

13) Humans are tetrapods.
A) True
B) False

14) The creation of the amniotic eggs meant…

A) fewer eggs produced
B) fewer offspring
C) having a water impermeable membrane
D) vertebrates could now colonize on land
E) All of the above

15) An air-breathing, cold-blooded, egg-laying organism with scales for skin are…?

A) Amphibians
B) Reptiles
C) Synapsids
D) Mammals
E) Fish

16) Modern conifers, the most familiar gymnosperms of today, first appear in the fossil record of the

A) Precambrian
B) Cambrian
C) Devonian
D) Permian
E) Triassic

17) Animals that are mammals or animals that are closer to mammals than other egg-laying animals and are often referred to as mammal-like reptiles are….?

A) Reptiles
B) Amphibians
C) Fish
D) Mammals
E) Synapsids

18) Animals that are cold-blooded and metamorphose, lay-eggs in water and become tetrapods at adulthood are….?

A) Reptiles
B) Amphibians
C) Fish
D) Mammals
E) Synapsids

19) Which two organisms from the Permian can still be found today?

A) Nautiloids and Cyanobacteria
B) Blattodea and Rodinia
C) Lobatannularia and Gigantopteris
D) Gigantopteris and Nautiloids
E) None of the above

20) Which of the following was not a plant during this time period?
A) Diptera
B) Conifer
C) Cycad
D) Lycopod
E) Gingko

Answers
1) E
2) C
3) A
4) D
5) C
6) C
7) E
8) D
9) B
10) A
11) C
12) E
13) A
14) E
15) B
16) D
17) E
18) B
19) A
20) A

Triassic

1) Based on Pangaea's location in the Triassic, the climate was much cooler in the summer and much warmer in the winter.

A) True
B) False

2) Which of the following was not a plant that lived at this time?

A) Evergreen Conifers
B) Gymnosperms
C) Pikiai
D) Cycads
E) Ginkos

3) How did most of the plant life at this time reproduce?

A) wind pollination and seed exposure
B) bee pollination
C) birds eating the seeds, and then dropping them
D) self reproduction
E) mammals eating the seeds, then dropping them

4) What group of organisms first appeared during this time?

A) Cycads
B) Fish
C) Reptiles
D) Birds
E) Mammals

5) Teeth fossils provided evidence that ____ foraged at night out of reach of early dinosaurs?

A) Monkeys
B) Insects
C) Shrew-like animals
D) Sharks
E) Birds

6) Where was the Tethys Sea located?

A) Opposite of Pangaea
B) Above Laurasia
C) Between Antarctica and Australia
D) Between Laurasia and Gondwanaland
E) None of the above

7) Which of the following plants, from the Triassic, is still around today?

A) Cycads
B) Kimberella

C) Burgessochaeta
D) Canadia
E) Ottoia

8) What continents made up Laurasia?
A) Antarctica and sub-continent India
B) North and South America
C) South America, Africa and Australia
D) North America, Asia and Europe
E) Africa and Asia

9) What percent of plants in the northern regions went extinct during this time?
A) 95%
B) 75%
C) 55%
D) 35%
E) 15%

10) How many continents did Pangaea break up into?
A) 2
B) 3
C) 4
D) 5
E) 6

11) What were the names of the continents present?
A) Gondwana, Laurasia, Laurentia
B) Gondwana, Laurasia
C) Laurentia, Rodinia, Laurasia, Gondwana, Baltica, Gondwanaland
D) Baltica, Laurentia, Laurasia, Gondwana
E) Laurentia, Rodinia, Laurasia, Gondwana, Baltica, Gondwanaland, Pannotia

12) What caused the spreading of the continents?
A) earthquakes
B) sea floor spreading
C) ice age
D) rivers
E) oceans

13) Dominant vertebrate animals of terrestrial ecosystems, can be generally described as arch saurian reptiles with limbs held erect beneath the body.
A) Dinosaurs
B) Pelycosaurs
C) Plesiosaurs
D) Pterosaurs
E) Ichthyosaurs

14) Amniotes not growing much beyond 3 meters, some had a tall sail consisting of elongated vertebral spines covered by skin. They lacked epidermal scales and parts of the skin were known to be naked.

A) Dinosaurs
B) Pelycosaurs
C) Plesiosaurs
D) Pterosaurs
E) Ichthyosaurs

15) A carnivorous aquatic reptile with both long and short necks. They had a broad body and short tail, retained two pairs of limbs which evolved into large flippers.

A) Dinosaurs
B) Pelycosaurs
C) Plesiosaurs
D) Pterosaurs
E) Ichthyosaurs

16) Meaning "winged lizard" were flying reptiles. They are the earliest vertebrates known to have evolved powered flight. They had long, toothy jaws and long tails.

A)Pelycosaurs
B) Plesiosaurs
C) Pterosaurs
D) Ichthyosaurs
E) Mosasaurs

17) Meaning "fish lizard" were a giant marine reptile that resembled fish and dolphins. Averaged 2-4 meters in length and had a porpoise-like head and long toothed snout.

A)Pelycosaurs
B) Plesiosaurs
C) Pterosaurs
D) Ichthyosaurs
E) Mosasaurs

18) A serpentine marine reptile that were ferocious marine predators. These were a type of reptile with overlapping scales that breathe air and were powerful swimmers. They also gave birth to live young.

A)Pelycosaurs
B) Plesiosaurs
C) Pterosaurs
D) Ichthyosaurs
E) Mosasaurs

19) What did the Triassic period end in?

A) Ice age
B) Flood

C) Volcano
D) Extinction
E) Drought

20) What part of the world did this particularly affect? ~ 50% of the animals in this area went extinct…
A) Land
B) Oceans
C) Rivers
D) Deserts
E) Forests

Answers
1) B
2) C
3) A
4) E
5) C
6) D
7) A
8) D
9) A
10) A
11) B
12) B
13) A
14) B
15) C
16) C
17) D
18) E
19) D
20) B

Cretaceous

1) During the break-up of Pangaea during the Cretaceous, it broke up into,
   A) two continents
   B) present day continents
   C) Rodinia and Gondwana
   D) North and South America
   E) Laurentia and Baltica

2) What two land masses remained intact at this time?
   A) Antarctica and Australia
   B) Antarctica and South America
   C) North and South America
   D) India and Madagascar
   E) Australia and India

3) Australia, Antarctica, North America, South America, Europe, Asia, and Africa are the present day continents.
   A) True
   B) False

4) How has the climate changed due to the break up of Pangaea?
   A) hotter
   B) cooler
   C) warmer
   D) drier
   E) all of the above

5) What evolved organism helped particular plants reproduce?
   A) T-Rex
   B) Pterosaurs
   C) Bees
   D) Rays
   E) Teleosts

6) Insects did not play a huge part in the spreading and reproduction of flowering plants.
   A) True
   B) False

7) What two groups dominated at this point in the Cretaceous?
   A) Mammals and birds
   B) Reptiles and insects
   C) Fish and Insects
   D) Dinosaurs and Insects
   E) Dinosaurs and Pterosaurs

8) The Cretaceous period occurred between…?

A) 14,000-6,500 years ago
B) 144-65 years ago
C) 144-65 thousand years ago
D) 144-65 billion years ago
E) 144-65 million years ago

9) Which of the following is a dinosaur?

A) Edmontonia
B) Placodern
C) Anaspida
D) Cheirolepsis
E) Rhyncodipterus

10) Which one of the following was not an insect at this time?

A) Ants
B) Termites
C) Butterflies
D) Aphids
E) Brachiopods

11) Which one of the following was an insect at this time?

A) Wasps
B) Ginkgos
C) Brachiopods
D) Bryozoa
E) Pteraspis

12) What other species did Pterosaurs face competition from? (reading question #13 may help you answer this question)

A) mammals
B) reptiles
C) fish
D) birds
E) insects

13) What was one of the things that this species and Pterosaurs did not compete for?

A) food
B) land for shelter
C) land for reproduction
D) territory
E) mates

14) When did the dinosaurs become extinct?

A) At the beginning of the Cretaceous
B) In the middle of the Cretaceous

C) At the end of the Cretaceous
D) At the beginning of the Tertiary
E) In the middle of the Tertiary

15) Species which depended on photosynthesis declined or became extinct because of the reduction in solar energy reaching the Earth's surface due to atmospheric particles blocking the sunlight.
A) True
B) False

16) When sunlight is blocked, and photosynthesis can no longer be utilized what organisms are the ***first*** to be affected?
A) Plants
B) Birds
C) Insects
D) Herbivorous animals
E) Carnivorous Predators

17) When sunlight is blocked, and photosynthesis can no longer be utilized what organisms are the ***last*** to be affected?
A) Plants
B) Birds
C) Insects
D) Herbivorous animals
E) Carnivorous Predators

18) Marine life was affected in the same way that Dinosaurs were in regards to extinction at the end of the Cretaceous.
A) True
B) False

19) Which one of the following is not one of the marine species during the Cretaceous.
A) Scavenger
B) Predator
C) Herbivore
D) A or B
E) Omnivore

20) Which of the following was not a species during the Cretaceous?
A) Ants
B) Gall Wasps
C) Magnolias
D) Ferns
E) Giant Swans

Answers

1) B
2) D
3) A
4) E
5) C
6) B
7) E
8) E
9) A
10) E
11) A
12) D
13) E
14) C
15) A
16) A
17) E
18) B
19) D
20) E

Eocene

1) The Eocene time period occurred between…?
   A) 55-34 years ago
   B) 55-34 thousand years ago
   C) 55-34 million years ago
   D) 55-34 billions years ago
   E) 5,500-3,400 years ago

2) During the Eocene, the continents began to drift toward
   A) the northern hemisphere
   B) the southern hemisphere
   C) their present positions
   D) each other
   E) separate locations

3) The oxygen level at this time was
   A) 20%
   B) 21%
   C) 22%
   D) 23%
   E) 24%

4) The carbon dioxide level at this time was
   A) 190 ppm
   B) 200 ppm
   C) 210 ppm
   D) 220 ppm
   E) 230 ppm

5) The oxygen and carbon dioxide levels during the Eocene are the same as they are today.
   A) True
   B) False

6) At the start of the Eocene the Earth
   A) cooled down
   B) stayed the same
   C) rained a lot
   D) heated up
   E) dried up

7) Why was grass hard for the herbivores at this time to consume?
   A) Tough to chew
   B) Low in nutrients
   C) Their digestive systems had not yet adapted

D) A and C
E) All of the above

8) How did the climate affect the animal life?
A) extinction
B) they moved to cooler regions
C) they moved to warmer regions
D) they thrived
E) it did not affect them

9) How did the warming trend affect the plant life?
A) extinction
B) they moved to cooler regions
C) they moved to warmer regions
D) they thrived
E) it did not affect them

10) Fossils and preserved remains of trees such as swamp cypress and dawn redwood have been found where?
A) South America
B) Africa
C) North America
D) Asia
E) the Arctic

11) How large were the mammals during the Eocene?
A) under 10 kg
B) under 20 kg
C) under 30 kg
D) under 40 kg
E) under 50 kg

12) What was not one of the characteristics of the new mammals?
A) long legs
B) thin legs
C) hands and feet capable of grasping
D) differentiated teeth
E) backbones

13) Mammals in the Eocene were smaller because they were able to manage the heat better.
A) True
B) False

14) Diatriyaformes
A) could fly and was an herbivore

B) could fly and was a carnivore
C) could not fly and was an herbivore
D) could not fly and was a carnivore
E) lived the in the water and was a carnivore

15) Which one of the following birds was not around during the Eocene?
A) Eagles
B) Pelicans
C) Quail
D) Vultures
E) Pteranodons

16) Australia and Antarctica used to be connected. When they were connected the climate on Antarctica was
A) the same as it is today
B) colder
C) warmer than it is today
D) covered in ice
E) covered in water

17) Which of the following is no longer around today?
A) Deciduous forests
B) Sea cows
C) Camels
D) Pelicans
E) Brontotherium

18) Inhabitants of the Eocene are very similar to some of the inhabitants of today.
A) True
B) False

19) During the Eocene the Earth
A) had about the same number of forests that it has today
B) had no forests
C) was covered in ice
D) was covered in forests
E) was covered in water

20) The Thermal Maximum provoked a sharp extinction event that distinguishes Eocene Fauna from the ecosystems of the
A) Paleocene
B) Pleistocene
C) Permian
D) Triassic
E) Cretaceous

Answers

1) C
2) C
3) B
4) C
5) B
6) D
7) E
8) A
9) D
10) E
11) A
12) E
13) A
14) D
15) E
16) C
17) E
18) A
19) D
20) A

Pleistocene

1) How fast do continents move?
   A) Fifteen miles an hour
   B) Ten miles an hour
   C) Five miles an hour
   D) About as fast as a snail
   E) About as fast as fingernails grow

2) How much have the continents moved from their present positions, compared to the beginning of the Pleistocene?
   A) 10,000 Kilometers
   B) 1,000 Kilometers
   C) 100 Kilometers
   D) 10 Kilometers
   E) 1 Kilometer

3) During the Pleistocene, what was the Earth covered in?
   A) ice
   B) water
   C) land
   D) forests
   E) desert

4) Due to the conditions described in #3, how did these impact sea levels?
   A) they raised
   B) they remained the same
   C) they dropped
   D) they fluctuated often
   E) None of the above

5) How did the glacial periods impact animals on land?
   A) Reduced land space
   B) Reduced food resources
   C) Limited time for animals to adapt to new conditions
   D) All of the above.
   E) None of the above.

6) Glaciers developed and receded _____ known times during this period.
   A) 2
   B) 3
   C) 4
   D) 5
   E) 6

7) How thick did the glaciers become?

A) 1500-3000 feet thick
B) 1500-3000 meters thick
C) 1500-3000 kilometers thick
D) 15-30 miles thick
E) 150-300 miles thick

8) During the development and recession of the glaciers, how much would sea level rise and fall?

A) 40 meters
B) 60 meters
C) 80 meters
D) 100 meters
E) 200 meters

9) A major event is a general glacial excursion, termed a "glacial". Glacials are separated by "_____".

A) subglacials
B) interglacials
C) warm periods
D) dry periods
E) cool periods

10) Compared to animals in the Eocene, the animals in the Pleistocene were

A) smaller
B) more furry
C) larger
D) tougher
E) more aggressive

11) Which were not one of the animals that showed up in the Pleistocene?

A) mammoths
B) mastodons
C) saber-toothed cats
D) sea cows
E) ground sloths

12) A major extinction event of large mammals (mega fauna) began _____ the Pleistocene.

A) late in
B) early in
C) in the middle of
D) before
E) after

13) The extinction took place due to the severe _____ changes during the ice age and its major impacts on the flora and fauna.

A) weather pattern
B) seasonal
C) ocean depth
D) river course
E) climatic

14) What animal that lived during the Pleistocene, closely resembles humans?

A) Megafauna
B) mammoths
C) Homo erectus
D) mastodons
E) glyptodons

15) Which of the following is not a difference in physical characteristic between humans and Homo erectus?

A) physical size
B) brain size
C) ability to communicate
D) tetrapod
E) diet

16) Homo erectus gave rise to many variations of humans, which developed elaborate _____.

A) tools
B) muscles
C) jaw bones
D) hands
E) feet

17) Why did animals grow to a larger size as compared to the Eocene critters?

A) Less predators
B) Fair climate
C) Increased food resources
D) All of the above
E) B and C

18) Which of the following do not allow scientists to compare plants with modern ones?

A) pollen grains
B) spores
C) seeds
D) water
E) leaves

19) Which was not a creature during the Pleistocene?
A) Armadillo
B) Cretan Owl
C) Giant Ostrich
D) Mene
E) T-Rex

20) Which animal that was alive during the Pleistocene, is no longer alive today?
A) ground sloth
B) lion
C) armadillo
D) owl
E) swan

Answers
1) E
2) C
3) A
4) C
5) D
6) C
7) B
8) D
9) B
10) C
11) D
12) A
13) E
14) C
15) D
16) A
17) D
18) D
19) E
20) A

Appendix G – GeoWorld Quests

PRECAMBRIAN QUESTS

(4.5 billion years ago – 550 million years go)
(remember that!!)

90% of Earth's history took place within the PreCambrian time period – as it lasted nearly 4.5 billion years. During this time, Earth was strikingly hostile. Meteorites bombarded the surface, volcanoes erupted lava and gas and heavy rains condensed into vast oceans.

Amongst the chaos, two theories of the origin of life are presented: 1) life arose in underwater hydrothermal vents or 2) life's building blocks were carried to Earth within meteorites. Evidence of extraterrestrial organism compounds (life's building blocks) is displayed in a rare meteorite from Australia.

The first forms of life – prokaryote cells – were unicellular organisms with a very simple structure. These cells evolved the ability to photosynthesize transforming the atmosphere of early Earth by producing oxygen. These small cells also are responsible for stromatolites which are structures formed in shallow water by the trapping, binding and cementation of sedimentary grains layered by microorganisms, usually cyanobacteria.

These small cells and bacteria are a huge contributor to how our world is today and most date back to the PreCambrian.

Be on the landmass that has the volcano and **no** "home-base." You are searching for a small water-hole with PRECAMBRIAN written on the ground just before it. When looking at your Mini-Map, the hole is just west of the volcano towards the central quadrant.

When you are in front of the water-hole, you're ready to begin.

1. Oxygen levels at the beginning of the Precambrian contained very little free-oxygen (or oxygen to breath). Hypothesize how you think the organisms you see in the water-hole survived if there was so little

oxygen? Hint: think about how plants breathe….what is that process called and how does it work?

2. After determining how organisms evolved to survive a world without oxygen during the early Precambrian, how might the atmosphere and oxygen levels change after billions of years? Some scientists call this "The Oxygen Catastrophe."

3. Find and touch the Stromatolites and describe where they are situated within the water hole. Follow the link to the Wikipedia page and IN YOUR OWN WORDS explain how these structures are made and why they are a significant part of geological studies.

4. Find and describe the following organisms using your observations within GeoWorlds and the information provided by the link after you touch them. Below, you will be advised to pay closer attention to particular sections of the Wikipedia articles and pick out 4 facts that you believe are most important to know about these species.
   - **Eukaryotes (and Eukaryote Algae): Origin and Development**
     - 1._____
       _____
     - 2._____
       _____
     - 3._____
       _____
     - 4._____
       _____
   - **Grypania: Entire Article**
     - 1._____
       _____
     - 2._____
       _____
     - 3._____
       _____
     - 4._____
       _____
   - **Kimberella: Ecology and Preservation**
     - 1._____
       _____
     - 2._____
       _____
     - 3._____
       _____
     - 4._____
       _____
   - **Spriggina: Morphology and Fossil Occurrences**
     - 1._____
       _____
     - 2._____
       _____

- 3._____
  _____
- 4._____
  _____

- **Tribrachidium: Entire Article**
  - 1._____
    _____
  - 2._____
    _____
  - 3._____
    _____
  - 4._____
    _____

- **Dickinsonia: Introduction Paragraph and Ecology**
  - 1._____
    _____
  - 2._____
    _____
  - 3._____
    _____
  - 4._____
    _____

5. Prokaryotes were the first form of life…ever. They are unicellular with a very simple structure. These cells evolved the ability to photosynthesize, helping transform the atmosphere of the Precambrian to the oxygen rich atmosphere we have today.

   Find the prokaryotes in the water-hole. How are prokaryotes different from Eukaryotes? You can refer to your description of facts in Quest #4 of Eukaryotes and compare and contrast that to what is described in the Wikipedia linked supplied for Prokaryotes.
   _____
   _____
   _____
   _____

_____
_____

"Cyanobacteria" is the name given to the photosynthetic prokaryotes. Where else have you seen the term cyanobacteria? What did cyanobacteria contribute to the growth of?

_____
_____
_____
_____

6. Most of the organisms you found in Quest #4 are considered Ediacaran organisms – meaning they are very thin and lack any hard parts or well developed organ systems. Despite being so thin, and having no hard parts – the fossil records of these species are pretty good! At nearly 30 locations worldwide, especially on ocean shores, scientists are finding well preserved fossils of these Ediacaran organisms.

   Why do you think these fossils are best preserved along ocean shores? Are fossils better preserved among large rocks and sediments or fine/medium sedimentary rocks? Why? Explain how shorelines, sediments and well-preserved fossils are connected. Try to think beyond the benefits of grain size and other reasons why shorelines are great spots to be preserved.

   _____
   _____
   _____
   _____
   _____
   _____
   _____
   _____
   _____

CAMBRIAN QUESTS

(543-490 million years ago)
(remember that!!)

During the Cambrian, the continents occupied very different positions than they do today and were covered by extensive shallow seas. It was a world of water. After more than three billion years of evolution, the stage was set for multi-cellular life to diversify; sometimes referred to as the "Cambrian Explosion." Nearly all major animals groups suddenly appear along with the first animals to possess hard skeletons.

Most species in this section are based on the famous Burgess Shale fossil deposit (British Columbia, Canada). Trilobites also arise with astonishing numbers, which are one of the first organism to evolve hard skeletons and they ruled the Cambrian seas. Some trilobites are spiny, lumpy and bumpy, as tiny as a few millimeters or as long as three feet.

During this time, squid-like cephalopods were also present and vertebrates appear as small jaw-less fish. However, you will notice that many of the species are very unique looking, for the face that no species today closely resemble them today. Enjoy the diversity of the Cambrian!

On the landmass with the volcano, you need to find the body of water to the far north middle quadrant. Go there and jump down into the water. You will be surrounded by many swimming critters, scattered Quest Cards and some slide shows alongside the walls. You are in the Cambrian area – where you are going to wander around, touch quest cards and perform the tasks as advised. Instead of submitting your answers via the T-Rex Footprint as instructed, you are going to answer the 5 Quest Cards on the paper provided.

It doesn't matter which order you complete the Quest Cards in, so go ahead and click on the first one you see and begin! When you touch the card, click "Keep" and take note which Quest Card number you're answering. Example: CAMBRIAN QUEST 3. When you are answering the Quests on the space below make sure to leave a space or mark where you are beginning to answer a new question within that particular Quest Card.

It may be more effective to go around and look through the slideshows along the walls. Remember you can click "m" to get a closer look at the slides and read the texts there are on them. This may help you answer the Quests more efficiently.

1. Use your atmosphere indicator to measure the oxygen and carbon dioxide levels.
2. How do the levels compare to the modern levels? Describe some factors that you think would affect the levels of oxygen and carbon dioxide. Use your resource kiosk as needed.
3. Find the kiosk with the globe. Determine where the continents were during the Cambrian.
4. Sketch a map of the continents during the Cambrian.
5. How many continents/land masses were there and where in relation to the equator and poles were they situated?
6. How does the continent distribution affect the climate?
7. Based on where the continents were, what kind of temperatures do you think the Cambrian period had? Use your temperature indicator to measure the temperature in the Cambrian and compare it to the average modern global climate.
8. Go to your resource kiosk to research how continental movement affects global temperature. Describe some examples of climate change that were related to continental positions.
9. All of the organisms that you see in this scenario were preserved in the Burgess Shale. The Burgess Shale is a rock formation, discovered in 1909 in western Canada; it contains examples of the variety of life that existed in the Cambrian period. You have already identified 5 organisms in this scenario that have skeletons. Now identify 3 organisms that do not have skeletons.
10. Compare how the preservation would different for the organisms with skeletons and those that are soft-bodied. Make sure to watch the video on fossil preservation at the base camp. This will help you.
11. After watching the fossil preservation video and comparing the organisms in this scenario, what can you deduce about what is or is not preserved in all of the fossil record?

DEVONIAN QUESTS

(417-354 million years ago)
(remember that!!)

Your goal is to locate the Devonian Area on the landmass that has the volcano. Using your Mini-Map, the Devonian Area takes place in a body of water that is far north and slightly to the west. Once you jump down into the water you should see tons of fish. While exploring, look in the pool and the surrounding shorelines. There will be organisms that may be crawling out of the water and a bit inland as well.

During the Devonian the continents clustered together stretching from the equator into the Southern Hemisphere. As continents moved into tropical and subtropical zones, massive reefs appeared, hosting a diverse community of corals, trilobites, crinoids, brachiopods and mollusks. Also, new groups of fish evolved, some with an innovative feature among vertebrates – jaws!

Small spore-reproducing plants evolved into leafy trees called lycophytes, creating Earth's first forests. Lycophytes, growing to heights of over 90 feet, towered over low-growing plants that blanketed the forest floor.

Exploiting this new habitat, early insects and their relatives appeared including dragonflies, cockroaches, centipedes, millipedes and spiders.

However, the biggest story of this period is the evolution of the tetrapods – four-legged vertebrates. Early amphibian and reptiles evolved and colonized terrestrial environments.

1. Enter the water, find and describe the 5 fishes listed below. Touch them and following the Wikipedia link to make note of a few distinguishing features that they hold unique. Which of the ones you chose do you believe were the strongest predators of the ocean? Why?

- **Cladoselache**:_____
  _____
  _____

- **Rhynchodipterus**:_____
  _____
  _____
- **Dunkleosteus**:_____
  _____
  _____
- **Hemicyclaspis**:_____
  _____
  _____
- **Climatius:**_____
  _____
  _____
- **Strongest Predator Hypothesis:**
  _____
  _____
  _____
  _____

2. Find Ichthyostega and Tikaalik. What features make these species than the ones you described above?

_____
_____
_____

What you should have described is what we call tetrapods. Tetrapods are four-legged and have a backbone. The organisms you see are evolving and adapting to a terrestrial environment. Beyond developing limbs, what else would these evolving organisms need to be successful on land?

_____
_____
_____

Are humans tetrapods? Why or why not?

_____
_____

3. During the Devonian, horsetails and ferns produced the first seed trees that could reach up to 8 meters tall and created the first forests. Find the plant species Archaeopteris, Baragwanathia, Rhynia, Asteroxylon and Lycopodium and open the Wikipedia link and skim through the articles and find whether the plant is vascular or non-vascular and if it is a lycopod. Write your findings next to the corresponding species below:

- **Archaeopteris:**_____
- **Baragwanathia:**_____
- **Rhynia:**_____
- **Asteroxylon:**_____
- **Lycopodium:**_____

From the articles you read, you should now be able to define the following:

- **Vascular Plants:**_____
  _____
  _____
- **Non-Vascular Plants:**_____
  _____
  _____
- **Lycopods:**_____
  _____
  _____

PERMIAN QUESTS

(290-249 million years ago)
(remember that!!)

Be on the landmass with the volcano. You're goal is to go to the farthest NW Corner of your Mini-Map, where you will see a slide-show screen of a map of super-continent Pangaea which took place during the Permian. This is where you will begin exploring this time period.

The Permian was a time of continental collisions, evolutionary innovation and catastrophic extinctions. By the end of the Permian, most of the major continents had drifted together to form a giant super-continent called Pangaea. As this vast landmass formed, the amount of coastline shrank along with the tropical swamps it supported. Great mountain ranges where formed as continents collided. In this new world, tetrapods (four-limbed vertebrates) evolved new forms and synapsids - the group that would one day include mammals.

A new type of reproduction also occurred – the amniotic egg. This adaptation allowed newcomers to exploit habitats on dry land. Plant fossils from this period indicate that Pangaea was a patchwork of different environments, from arid deserts to lush tropics to cool temperate forests.

The Permian period also ended with the world's most devastating extinction event of all time. Over 90% of the Earth's species, including insects, plants, marine animals, amphibians and reptiles were destroyed worldwide. The Permian is therefore remembers as the time when life came the closest to being wiped off the face of the planet. Estimates vary, but it's believed that 96% of all marine life and 70-80% of all land dwelling animals perished.

1. Find the blue diamond, which is an "atmospheric indicator" telling you the oxygen and carbon dioxide levels. Record what you find and do you think these stats compare to our atmosphere today? _____
_____
_____
_____
_____

2. Go to the shore-line and find the large egg with slides inside. Review the slides relating to the benefits of evolving the amniotic egg and write down your findings. _____
_____
_____
_____
_____

3. Inland from the farthest northwest corner of your Mini-Map where we first began, you can another map demonstrating the make-up of Pangaea. In the space provided below, sketch Pangaea.

What to you think the interior climate of Pangaea was? Think of what usually dictates climate – mountains, oceans, seasonal fluctuations, etc. There is a large continent today that's interior is similar to that of what Pangaea was – what is this continent? Knowing this might help you decide what the climate may have been like. _____
_____
_____
_____
_____
_____

_____
_____
_____

4. Are there any organisms that are still alive today that were in the Permian (there's at least 2)? Which are still alive and why do you suppose they were able to survive several mass extinctions?

_____
_____
_____
_____
_____
_____
_____
_____
_____
_____
_____

5. Find and describe the following five organisms and click on the link to the Wikipedia site. List four important facts from the sections of the Wikipedia article suggested below.

- **Eryops: Introductory Paragraph and Locomotion**
  - 1._____
    _____
    _____
  - 2._____
    _____
    _____
  - 3._____
    _____
    _____
  - 4._____
    _____
    _____

- **Dimetrodon: Introductory Paragraph and Description**
  - 1._____
    _____
    _____
  - 2._____
    _____
    _____
  - 3._____
    _____
    _____
  - 4._____
    _____
    _____
- **Archegosaurus: Entire Article**
  - 1._____
    _____
    _____
  - 2._____
    _____
    _____
  - 3._____
    _____
    _____
  - 4._____
    _____
    _____
- **Dicynodon: Entire Article**
  - 1._____
    _____
    _____
  - 2._____
    _____
    _____
  - 3._____
    _____
    _____

- 4._____
  _____
  _____

6. From reading the articles above you will have probably seen the terms reptile, amphibian and synapsid. Write a definition for each IN YOUR OWN WORDS and be able to compare and contrast the three. Use the Internet if needed.

- **Reptiles:**_____
  _____
  _____
  _____
  _____
  _____
  _____
- **Synapsids:**_____
  _____
  _____
  _____
  _____
  _____
  _____
- **Amphibians:**_____
  _____
  _____
  _____
  _____
  _____
  _____

TRIASSIC QUESTS

(248-206 million years ago)
(remember that!!)

The Triassic marks the beginning of the Mesozoic Era. Life rebounded after the greatest mass extinction in Earth's history (during the Permian). From the few survivors, new life developed. During this time dinosaurs began their 160 million year success story, mammals appears, flowering plants bloomed and reptiles diversified on land and in the oceans.

Earth's continents continued to move. Pangaea assembled completely during the Triassic period before beginning to break apart during the Jurassic period.

Different groups of tetrapods – phytosaurus, rhynchosaurs and metoposaurs – evolved and disappeared, leaving fossils and no descendents. The first mammals appeared at this time as well. Fossil evidence, mostly in the form of teeth, tells us they were small, shrew-like creatures that foraged at night, out of reach of early dinosaurs. By the end of this period, around 50% of marine animal species and around 95% of plants in northern regions went extinct.

Be on the landmass that has the volcano and ***no*** "home-base." You are searching for the Triassic area of this island. Your goal is to find the **Triassic Map** showing two large landmasses sitting within the buttresses of a tree. If you find a quest card with a Triassic label you are in the correct area – just keep looking for the map. It might be helpful to use your Mini-Map…direct yourself to the most westerly middle quadrant and search for the Triassic Map this way. This will be your starting point to navigate through this time period.

When you get to the Triassic Map, you're ready to begin.

1. To take a closer look at the map, press the letter "m" on your keyboard. This will put you in the mouse-view. Push "m" again to step back. In the space provided below, draw the map. Note that before the Triassic was the Permian period in which Pangaea was present. Be sure the label your map thoroughly.

2. Referring to your map-sketch, note where the Tethys Sea is located relative to the continents and the equator. What can you deduce from the location of this sea is the active agent that is causing these landmasses to separate? In other words, what is the process that is created the Tethys sea and ***spread*** (hint! hint!) the continents apart? After identify the process, describe how it works.

_____
_____
_____
_____
_____
_____
_____
_____
_____

3. Wander around the surrounding area. Be sure not to explore too far away from the Triassic Map, or you will end up in a different time period and be confused! You can check to make sure your in the correct area by "touching" the Quest-Cards (that we aren't using) to

make sure they are labeled "Triassic." If they aren't, make sure to regain your bearings by finding the Triassic Map were we started.

Now, find the organisms Lagosuchus, Herrerasaurus, Lystrosaurus, Ornithosuchus, Scaphonyx and Saurosuchus (it's not labeled, but it's in there…so look up a picture on Wikipedia and try to find it). Compare and contrast them in the chart below. Make use of the web-links to help fill in the blanks beyond the observations you make yourself.

You may want to take other notes on their appearance as Quest #4 is going to have you refer to these same species and place them into certain categories.

Species Name	Upright or All-Fours	Size - S, M, L	Carnivore, Herbivore, Omnivore

4. The first dinosaurs evolved in the Triassic, but many people mistake pelycosaurs, plesiosaurs, pterosaurs, ichthyosaurs and mosasaurs as dinosaurs. From the species you observed and the definitions given below do the best you can in placing them in the correct category.

*__DINOSAURS__: dominant vertebrate animals of terrestrial ecosystems (living on land), can often be described as reptiles with limbs held erect beneath the body._____

*__PELYCOSAURS:__ don't grow much beyond 3 meters; some have a tall sail consisting of long spines down their back covered by skin. They did not have scales and parts of the skin were known to be "naked."_____

*__PLESIOSAURS:__ a carnivorous aquatic reptile with both long and short necks. They had a broad body and short tail, retained two pairs of limbs which evolved into large flippers._____

*__PTEROSAURS:__ the word means "winged lizard" – they were flying reptiles. They are the earliest vertebrates known to have evolved powered flight. They had long, toothy jaws and long tails._____

*__ICHTHYOSAURS:__ meaning "fish lizard" – they were giant marine reptiles they resembled fish and dolphins. Averaged 2-4 meters in length and had a porpoise-like head and long toothed snout._____

*__MOSASAURS:__ a serpentine marine reptile that were ferocious marine predators. Mosasaurs were a type of reptiles with overlapping scales that breathe air and were powerful swimmers. They also gave birth to live young._____

*__DICYNODONT:__ mammal-like reptiles. Dicynodonts were small to large herbivorous animals with two tusks, hence their name, which means 'two dog tooth.'_____

**__RHYNCHOSAUR:__ a diapside reptile related to archosaurs. Herbivores with stocky bodies and powerful beaks and a lizard-like build.
_____

**__ARCHOSAUR:__ group of diapsid amniotes represented by modern birds and crocodilians. Includes non-flying dinosaurs, pterosaurs and relatives of crocodiles._____

**__CRUROTARSAN:__ has a massive skull with a snout that narrows and tends to be elongated. The neck is short and strong and the limb posture ranges from a typical reptilian sprawl to an erect stance like that of dinosaurs or mammals. The body is often protected by two or more rows of armored plates._____

5. In the same area, observe the vegetation around you. Do you recognize any plants? What are they and can you still find these plants today?

_____
_____

All the species you see have exposed seeds – meaning they have minimal protection from herbivores and weather. Knowing this trait, how do you suppose these kinds of plants reproduce? Explain the process.

Open Internet Explorer or Mozilla. Google Search: Conifers, Cycads and Gingko and write a short descriptive blurb on the biological traits of these plant species:

Conifers:

Cycads:

Gingko:

CRETACEOUS QUESTS

(144-65 million years ago)
(remember this!!)

Using your Mini-Map, navigate to the far southwest corner and look for the Cretaceous slideshow which is on the ground. This is where you will begin exploring the Cretaceous time period.

During the Cretaceous life had endured a fourth mass extinction at the end of the Triassic that decimated plants, marine invertebrates and some vertebrates. But survivors diversified in the Cretaceous seas, especially mollusks called ammonoids, snails, crabs, lobsters and sea urchins.

With new marine species also came new reptilian predators – the mosasaurs and plesiosaurs. On land, dinosaurs co-existed with lizards, snakes, turtles and crocodiles. In the air, insects evaded early birds and pterosaurs. Plants were also part of the picture as angiosperms – flowering plants – diversified around the world.

1. You should be facing the slideshow. Click on each slide and read its contents. For each slide, write a statement which sums up the main idea of each slide.

Slide 1:

_____

_____

Slide 2:

_____

_____

Slide 3:

_____

_____

Slide 4:

_____

_____

2. While dinosaurs ruled the land during this time, the ocean was very active. Enter the ocean water and observe and describe 5 organisms you see.

1. _____
_____
_____

2. _____
_____
_____

3._____
_____
_____

4._____
_____
_____

5._____
_____
_____

3. Exit the water and explore for dinosaurs and other organisms. When you find the T-Rex, pause for a moment and answer this question before "Touching" it:

a. How do you perceive the T-Rex? As a ferocious predator? Or, more like a docile cow? Support your opinion with what you already know from movies, books and the appearance of the animal. _____
_____
_____
_____
_____
_____
_____
_____
_____

b. Now touch the T-Rex and continue on to the Wikipedia article. Click on the section "Feeding Strategies" and read. Has your opinion changed? Why or why not?_____
_____
_____

_____
_____
_____
_____

3. Find the Blue Diamond, which represents the Atmospheric Indicators. Fill in the following blanks (label your units):

a. Temperature_____
b. Oxygen_____
c. Carbon Dioxide_____

4. There is a map near the Atmospheric Indicator. Take a look at this map using your Mouse-View. Pangaea completed its breakup into present day continents during this time, though their positions and locations were substantially different at the time. During the Cretaceous which continents can you observe to be forming? And how are they different in locations in comparison to today?

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_____

EOCENE QUESTS

(55-34 million years ago)
(remember that!!)

At the beginning of the Eocene, high temperatures and warm oceans created a moist balmy environment, with forests spreading throughout the Earth from Pole to Pole. Apart from the driest deserts, Earth must have been entirely covered with forests. Fossils and even preserved remains of trees such as swamp cypress and dawn redwood from the Eocene have been found in the Arctic. The preserved remains are not fossils, but actual pieces preserved in oxygen-poor water in the swampy forests at that time and then buried before they had the chance to decompose.

The oldest known fossils of most of the modern mammal orders appear within a brief period during the early Eocene. At the beginning of the Eocene, several new mammal groups arrived in North America. These modern mammals had features like long, thing legs, feet and hands capable of grasping, as well as differentiated teeth adapted for chewing.

Dwarf forms reigned, all the members of the new mammal orders were very small – under 10 kg. Eocene mammals were only 60% of the size of the primitive Paleocene mammals that preceded them. They were also smaller than the mammals that followed them. Reptile fossils from this time, such as pythons and turtles, are abundant. Plants and marine faunas became quite modern and many modern bird orders first appeared during the Eocene.

Go to the landmass **without** the volcano and has a building with four hubs and an amphitheatre. Go into the building and find the hub that has the sign "Eocene" above it. Go inside.

Go to the kiosk within the hub and click on the slide show and read through the slides. You may take notes now or review the slides again when trying to answer the following questions IN YOUR OWN WORDS:

1. There was a lot of continental movement that took place during the Eocene. Explain how the continents moved during this time. Use the slideshow and the map around the corner to help you answer.

2. Why do you think grasslands and forests dominated during this time? Write down why you think grasses might be able to survive the climate of the Eocene better than other vegetation. Use your brain and the slideshow to answer.

3. How did the changes in climate and vegetation affect the herbivores? And as a result, affect the carnivores?

4. Move away from the slide show and observe the animals in the room. Click on 5-6 animals and take short notes on their profiles. Why do you think most of the animals are short in stature during this time? Think how your answers of the last few questions on vegetation relate to this one…

5. What animals do you see that can still be found today? Why do you think these species have survived so long and others gone extinct?

Teleport by clicking on the globe to S4 – the Eocene Scenario.

6. Explore the landscape and write down what the vegetation looks like – the color, height, etc. Does this look like a wet or dry environment and why? Why kind of forest/trees do you see (Pine? Deciduous? Rain?)

_____
_____
_____
_____

7. Note that most the animals at Home-Base are in this environment. There are a few that were not. One is definitely a carnivore. Can you find that species? What is it consuming? Take notes on both species.

_____
_____
_____
_____
_____
_____
_____
_____
_____

8. The atmospheric levels at this time are 21% oxygen and 210 ppm carbon dioxide. How does this compare to today's levels? What factors do you think impacted the changes in carbon dioxide levels most recently? _____

_____
_____
_____
_____
_____

Through time, oxygen and carbon dioxide levels have fluctuated. What environmental causes could have resulted in these changing levels? Think about what you have learned about biology, geology and the atmosphere.

_____
_____
_____
_____
_____
_____
_____

9. The Eocene endured a Thermal Maximum. From the just the term "Thermal Maximum" – what do you think this means? Create a definition.

_____
_____
_____
_____

10. This Thermal Maximum was an episode of rapid intense warming that lasted less than 100,000 years. The Thermal Maximum provoked a sharp extinction event that distinguishes Eocene Fauna from the ecosystems of the Paleocene. From the organisms you have seen so far, what physical characteristics do they hold they may have helped them adapt to or survive this intense warming? _____

_____
_____
_____
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_____

PLEISTOCENE QUESTS

(1.8 million – 10,000 years ago)
(remember this!!)

Be on the landmass which has the volcano and campsite. Near the southeast (SE) corner of your Mini-Map you will find a pond full of swans and turtles and the word "PLEISTOCENE" on the ground nearby. Find this location – this is where you will start your Quest.

During this time, both marine and continental faunas were essentially modern. There were severe climatic changes during the ice age which had major impacts on the fauna and flora. With each advance of the ice, large areas of the continents became totally depopulated, and plants and animals retreated southward in front of the advancing glacier facing tremendous stress.

The stress was due to the drastic climatic changes, reduced living space and a dwindling food supply. A major extinction event of large mammals (megafauna), which included mammoths, mastodons, saber-toothed cats, glyptodons, ground sloths, and short-faced bears, began in the late Pleistocene and continued into the Holocene.

Neanderthals also became extinct during this period. At the end of the last ice age, cold blooded animals, smaller mammals, migratory birds and swifter animals (like deer) had replaced the megafauna and migrated north.

Scientific evidence indicates that humans evolved into their present form during the Pleistocene. However, the only hominine species found in fossil records is Homo erectus – which migrated through much of the old world, giving rise to many variations of humans.

1. Find 7 animals (don't forget to look in the ocean and ponds) and follow the Wikipedia article and write down a description of each species. Also include if there are similar animals that are still around today – and how these Pleistocene animals are similar/different.

1. _____
_____
_____

2. _____

3. _____

4. _____

5. _____

6._____

7._____

2. You should notice there are a ton of organisms in the Pleistocene – all with one underlying physical trait. What is it?

3. Hypothesize why these animals developed this particular trait during the Pleistocene. Remember, during the Eocene dwarfism reigned until the mass extinction. Fully develop your guess…

4. Find the animals that most resembles yourself. What is it? Use the Wikipedia article under "Classification and Special Distinction" to compare and contrast yourself to this species. Are there many differences? What were the noted differences between the hominid species found thus far?

_____
_____
_____
_____
_____
_____

Look up Neanderthals in Wikipedia – who is the more recent ancestor? Homo erectus or Neanderthals? Neanderthals occurred 516,000 years ago – how are they similar to us?

_____
_____
_____
_____
_____
_____
_____

5, Think about the impact that glacial and interglacial periods had on land area. Each glacial advance tied up huge volumes of water in continental ice sheets up to 1500-3000 meters thick, resulting in temporary sea level drops. Four major glacial events have been identified, as well as many minor intervening events. How do you think this impacted the animals living on land or in the oceans during these events? Name at least 2 impacts that this ice age had on the animals. _____

_____
_____
_____
_____
_____

How did the Pleistocene Ice Age impact the types of animals we see today? How are the animals different? _____

Appendix H – Supporting Documents

Document A:

CLASS PERIOD: _____

REAL NAMES:

1)_____

2)_____

AVATAR FIRST NAME:_____

AVATAR LAST NAME: _____

AVATAR PASSWORD: _____geo42world_____

At the end of the class period, please return this sheet to Miss Fenwick for safe keeping!

Document B:

SECOND LIFE
Getting Started…

If you HAVE Second Life downloaded on your computer…

- Open Mozilla Firefox and type in this link:
  - secondlife://GeoWorlds/128/128
    - We are using this link and NOT the desktop icon because when you login, it will automatically take you to GeoWorlds.
    - It will tell you that "This Link Needs to be opened with an Application." Second Life should be highlighted already, if not, select Second Life and click OK.
- Second Life will start up automatically. Put in your assigned First Name, Last Name and the password: geo42world
- Click "Log In"
- If it asks what gender you want your avatar to be, click on your desired gender.
- If a box appears that asks if you if you want to teleport due to "the lack of a description of this region" – ignore it and close out of it.
- You are now in GeoWorlds, wait for further instruction from your teacher.

If the link from Mozilla doesn't work….

- Click on the Second Life "Hand" icon on your desktop.
- At the bottom of your screen, there are blanks at the bottom asking for your First Name, Last Name and Password (geo42world).
- It may ask you to agree to the "Terms of Service" – Click that you accept them and continue.
- Once logged in, you need to get to GeoWorlds (unless you're already there).
  - If you're **NOT** in GeoWorlds:
    - Click on the "Search" bottom on the bottom left side of your screen.
    - Type in GeoWorlds and click "Find"
    - Click on the first link (there are three that are a part of GeoWorlds…they will all take you to the same place…)
    - Then click on Teleport.
  - If you **ARE** in GeoWorlds:
    - Start exploring!

If you DO NOT HAVE Second Life downloaded on your computer…

- Go to www.secondlife.com
- At the bottom-right of the page, you will see a hand and "Download Second Life" – click this.
- Click "Download Now"
- Click "Save File"
- Depending on how your computer is set-up, an icon will appear on your Desktop or in a Download File named "Second_Life Setup" – click this icon.
- A window will open. Click "Run"
- Choose "English" or any desired language…click OK
- Another window will appear, click the "Install button."
- The Second Life Icon Hand should appear on your desktop after it downloads, or will appear as a program in your Start Menu.

How to register your own avatar…

- Before beginning, make sure you have access to a mobile phone (yours or your parents) or a PayPal account. You need this because people under 18 years of age need to be cleared to enter the "Teen World" where GeoWorlds is located and so creepy people can't bug you! It's a security issue ~ if you have neither of these, talk to your parents about setting up a PayPal with them (www.paypal.com)
- You will also need an e-mail address…if you don't have an e-mail account, I suggest setting up one (for free) at www.gmail.com

---

- Once you have gotten all that taken care of--- Go to www.secondlife.com
- Click "Join Now"
- Enter in the required information…as last name will be assigned to you, you can't choose your own last name.
- After you enter your birthday in, a box will pop up request a mobile phone number or PayPal information.
    - If you use a mobile phone number, a text message will be sent to you containing a confirmation code. Follow the instructions and input the confirmation code as directed.
- After you fill out the required information, click "Create Account"
- Be sure to write down your First Name, Last Name and Password and keep it in a safe place.
- Now you're all set up and you can go back to the top of this handout and login to GeoWorlds.

Document C:

TELEPORTING AND OTHER HELPFUL HINTS

TELEPORTING:

1) On the bottom menu, open the Map
2) In the space next to Search, type GeoWorlds. Click Search.
3) Under Location, the Teleport button will be highlighted. Click Teleport to bring you to the central kiosk in GeoWorlds.

TIME OF DAY:

1) Go to "Worlds" at the menu at the top of your screen.
2) Then click on Environment Settings and select Midday.

WALKING, FLYING, RUNNING

1) You will be in "walk" mode to start with, unless you go to the menu at the top of your screen and click "World" and "Always Run."
2) You can also fly if you prefer by clicking on "World" and "Fly" – or by clicking on the "Fly" button at the bottom of your screen.
3)

TAKING A CLOSER LOOK:

1) When trying to look at slideshows or at organisms closer, it may be helpful to go into "Mouse-view."
2) Click 'm' to go into and out of mouse-view.

MINI-MAP

1) Use your mini-map to your benefit to find your classmate or instructor and remain oriented when learning to get around.

COMMUNICATING

1) We will only be using text-chat to talk with one another. On the bottom menu you can click "Communicate" to open a box to see "Local Chat" conversations.
2) Or, right next to the "Communicate" button is a symbol to open the Chat Bar and you can communicate this way – and your conversations will show up as bubbles on your screen.

Document D:

First	Last
Raadamez	Abbot
MonNique	Abbot
Emily	Cahir
Allyson	Cahir
Amber	Adagio
Arik	Alderton
Matthew	Imari
Seth	Bouvier
Dasia	Blaylock
Brian	Coveria
Brittani	Ashmoot
Mireina	Gauntley
Joshua	Florian
Tierra	Elcano
Sylvanna	Mistwood
Jessica	Hollysharp
Alanna	Bloobury
Samuel	Lapis
Johnny	Icanadi
Brittany	Farquart
Peaario	Cyannis
Shaquan	Macbeth
Password	geo42world