21ST CENTURY SKILLS IN COLLABORATIVE WEB-BASED INSTRUCTION:

THE EFFECTS ON HIGH SCHOOL STUDENTS' DYNAMIC INQUIRY AND

UNDERSTANDING OF GENETICS CONCEPTS

by

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ABSTRACT

In order to advance in the 21ˢᵗ Century, students must be able to develop complex inquiry skills and apply critical thinking while mastering understanding of concepts. The purpose of this study was to determine the effects of Web-based collaboration on students' essential inquiry skills and understanding of genetic concepts. The effects on critical thinking, student involvement, and teacher attitudes were also determined.

This project considered the effects of using a Wikispaces platform in an introductory biology class at a small rural high school in Northwest, Colorado. Students content understanding and inquiry skills was assessed using pre and postunit assessments, student interviews, and collaborative projects. Students'critical thinking skills was measured through their ability to express with triggering, exploration, integration, and resolution on class posters and discussion post utilizing the Community of Inquiry Framework. Student involvement was determined through the use of teacher observations, student interviews, post on class posters, and Wiki projects.

Results indicated that although students initially struggled using a Web-based platform, increases were achieved in concept understanding and critical thinking, while involvement had mixed results. The overall development of collaborative Web-based inquiry improved my teaching attitude and strengthened my ability to lead and conduct inquiry investigations.

INTRODUCTION AND BACKGROUND

In 2009 the Colorado Department of Education revised the states standards to include essential 21st Century Skills. Twenty-first Century Skills are a method to improve students' ability to utilize Web-based inquiry to develop critical thinking, invention, collaboration, information literacy, and self-direction. Utilizing the Internet and collaboration tools to advance educational content through inquiry can be essential to increasing 21st Century skills (Colorado Deparment of Education, 2010).

With today's technology, the Internet can serve as a platform for students to combine 21st Century skills into their education. The Internet and personal computers have redefined how we provide education for K-12 students and prepare them for colleges and universities. Web-based activities and collaborative inquiry learning are essential components of 21st Century skills, this is reinforced from studies of Web-based collaborative inquiry (Chang, 2003; HSU, 2004; Lunsford, 2008; Zheng, Perez, Williamson, & Flygare, 2008). Collaboration allows students to debate their findings and defend their positions creating relevance for their work (Lunsford, 2008; Rozensazyn, 2009). Group collaboration is part of the 21st Century Skills needed to increase inquiry skills, while also developing important educational skills such as critical thinking, invention, and self-direction. Through using Web-based collaboration, students can learn through an inquiry format, which engages them in the learning process.

Inquiry can be presented in a range of forms from guided to open inquiry. Essential skills that can be measured across both areas are called dynamic inquiry skills (Zion et al., 2004). Dynamic inquiry is measured though students' ability to analyze

science changes, to develop problem expansion, to understand procedures, to manipulate variables, and to gain a better perception of science. Implementing both guided and open inquiry into a curriculum can be essential for students to improve scientific understanding (Sadeh, 2009; Zion et al., 2004).

There is much controversy on the best approaches to implement scientific inquiry instruction into the high school curriculum, however inquiry is considered an effective teaching strategy to increase achievement (Bozin, Cates, & Vollmer, 2001). Recent requirements by state and federal governments have led to higher standards of education, therefore requiring teachers to be accountable and use effective teaching strategies (Colorado Deparment of Education, 2010). Currently at West Grand High School (WGHS), in Kremmling, Colorado, establishing academic excellence is the primary focus. Within the last five years, WGHS administrators and teachers have implemented changes in the curriculum to improve higher standards of education and improve educational outcomes. As a result of these changes, WGHS has outperformed all other schools in Northwest Colorado in the academic areas of reading, writing, math, and science (Armstrong, 2010). In an effort to continue with the high standards of science education at WGHS, this project planned to improve critical thinking, to improve content understanding, and to increase inquiry skills by utilizing a Web-based collaborative learning environment. This project was conducted with the introductory high school biology class for sophomores.

To achieve the purpose of this action research study, the following research questions were developed. The focus question for this capstone project explores what are the effects of using collaborative Web-based instruction on students' inquiry skills and

understanding introductory high school genetics concepts? The subquestions are as follows: what are the effects of collaborative Web-based inquiry on students' involvement; what are the effects of collaborative Web-based inquiry on students' critical thinking skills; and what effects will teaching collaborative Web-based inquiry have on my capability to lead and direct inquiry activities?

For the purpose of this study, dynamic inquiry refers to essential inquiry skills that can be measured across both guided inquiry and open inquiry. Dynamic inquiry includes: student's ability to analyze science changes, procedural understanding, variable manipulation, student's perception of science, and problem development (Sadeh et al., 2009; Zion et al., 2004). Collaborative inquiry refers to students' ability to collaborate while completing open to guided-inquiry activities throughout scientific investigations (Rozensazyn, 2009). Web-based inquiry refers to the students using the Internet to discover how to develop science skills through collaboration, research, and completing online scientific investigations (Walker, 2003).

The members of my MSSE capstone project offered insight and feedback throughout the editing and design process. Members of my team include Sharen Wolke, M.S.N. in Nursing Education, Emmylou Harmon, M.S. Science Education, and Gary Birch, M.S. Zoology. Jewel Reuter, Ph.D. served as my education instructor and advisor for the Montana State University Master of Science Education program. Elinor Pulcini, Ph.D., Center for Biofilm Engineering served as my reader for the graduate committee.

CONCEPTUAL FRAMEWORK

Review of literature suggests that Web-based collaboration can have a substantial impact on students' educational experience. Collaborating through online discussions

can integrate critical thinking, dynamic inquiry, and increase involvement while challenging the teacher to promote inquiry. These features are key to producing students that can excel in the 21st Century through developing critical thinking, invention, collaboration, information literacy, and self-direction using a multimedia environment.

Constructivism and scaffolding provide the theoretical framework for this action research project. Social constructivism can be described as a way for students to build ideas through interaction between peers and the teacher. According to Powell and Kalina (2009), "Constructivist teaching strategies have a great effect in the classroom both cognitively and socially for the student" (p. 241). Examples of teaching strategies that require cognitive or individual constructivism, based on Piaget's theory, emphasize memorization of facts to construct knowledge. Lev Vygotsky's theory of social constructivism is based on social interaction of teachers and students. "Vygotsky (1962) also used scaffolding in his theory, to understand that children learn more effectively when they have others to support them" (Powell & Kalina, 2009, p. 244). Scaffolding is structured learning so that students can progress through levels of understanding, and support the student when performing a task or bridging the gap between what the students can do on their own and when they need assistance (Powell & Kalina, 2009).

Applying problem solving with technology to create an environment for students to build knowledge through sharing and reflecting was established utilizing Jonassen's constructive perspective (Drexler, 2010). In a design-based research case study, Drexler (2010) "applied a networked approach to a seventh grade science class at a public school in southeastern United States" (p. 2). This study utilized a constructivist learning environment survey to examine the nature of personal learning environments and their

effectiveness with the use of widgets. Results of this study showed students improved in socialization, collaboration, organization of content, and improved digital literacy (Drexler, 2010). A constructivist theory can be used across many different content areas including genetics within a high school biology course.

Understanding of genetics concepts can enhance students ability to problem solve and reason, which is central to students understanding of modern molecular genetics (Stewart, 1994). Open-ended simulations have allowed students with a weak understanding develop a deeper understanding of concepts through problem solving. This has increased the use of simulations to teach high school genetics (White et al., 2007). Internet use in education, has led to many different platforms that can be used to study genetics in a Web-based environment. Bio Quest (2011) has designed genetic simulations such as *Case it*!, which increases student conceptual knowledge, understanding of genetic concepts, and utilizing inquiry skills following the "3 'Ps: Problem Solving-Posing, Problem Solving and Peer Persuasion" (p.1). In 2006, Bergland et al., used the *Case It!* simulation and found that university and high school students were able to increase their skills in scientific problem solving, understanding of genetics, and how science affects society. The problem solving skills that can be gained through online simulations can be increased with Web-based collaboration.

Web-based collaborative inquiry is a teaching strategy that encourages students to make sense of new knowledge by relating it to their prior knowledge through online discussions. Online discussion allows students to network, to integrate critical thinking skills, and to form understanding of genetic concepts. In a study by Bodzin, Waller, Santoro, & Kale (2007), combining specific instructional activities with Web-based

inquiry animations and modeling laboratory skills proved to be effective. This study was conducted with 48 high school students in biology (Bodzin et al., 2007).

Web-based collaborative environments allow students to discuss, develop, and defend their ideas within investigations where they can manipulate models and data. This environment allows students to become active in the learning process increasing their involvement. This was studied with college freshman during a study combining collaboration, inquiry, and concept mapping. It was determined that students may struggle to expand knowledge that is less relevant to them when using inquiry, but enjoyed using concept maps to express their increase in knowledge (Chang, 2003). A commonly used Web-based collaboration environment is a Wiki, which is a fast way for students to share and discuss knowledge in an online format. Collaborative inquiry through a Wiki allows students to draw on each other's experiences and combine their understanding for a new approach to concepts, therefore increasing their critical thinking skills (Witney & Smallbone, 2011). Students may struggle at critically analyzing others work at first, but over time they become more comfortable with the process of peer review and learn the value of how it can increase their problem solving skills (Su & Beaumont, 2010).

The concept of critical thinking was first introduced by Bloom's taxonomy as a higher level of cognitive ability. According to Choy & Cheah, (2009), critical thinkers are described "as those who are able to analyze and evaluate information" (p.198). Online discussion questions, online case studies, and collaborative learning activities are teaching strategies that can impact critical thinking levels (Richardson, 2010). The Practical Inquiry Model (PIM) as part of the Community of Inquiry (CoI) framework, has

been used to analyze and measure critical thinking skills. The PIM focuses on students'

responses within an online environment where cognitive presence is expressed through

triggering, exploration, integration, and resolution. Cognitive presence can be described

by the degree to which participants can construct meaning utilizing communication tools.

The four categories of the PIM can be described as: triggering which is when a student

recognizes problems and expresses new ideas, exploration is when a student is able to

contradict others and explore their own ideas with previous knowledge, integration is

when a student is able to tie together their ideas with the class to create a solution, and

resolution is when a student defends their solutions to the problem with real world

application (Garrison, Anderson, & Archer, 2000). Richardson (2010) used the PIM

model with undergraduate technology students to examine students' experience with

online discussion throughout a debate, a case study, and a topical discussion. The

researcher found the majority of the students' may not be able to identify the best method

of learning. In this study students preferred open-ended discussion (47%); however, the

students scored lower on achievement levels when open-ended discussions were used

(Richardson, 2010). This has been reinforced when looking at how students advance

through the PIM model. Stein et al. (2007), using the PIM model, conducted a study with

a blended online course of undergraduate students. The results of the study showed

students moving from levels of triggering and exploratory statements to integration

statements resulted in shared meaning between students. In conclusion, this study

showed that students were able to see the progression of their statements using the online

environment to develop their higher order thinking skills (Stein et al., 2007). These same

levels of critical thinking can be measured through online collaboration, with the use of Web-based simulations.

Web-based collaboration can be used for incorporating guided and open inquiry into a science curriculum, but measuring science skills within inquiry needs to be flexible. In a study conducted by Zion et al. (2005) using high school biology students, open inquiry was analyzed to identify a process that has dynamic features including procedural understanding, affective points of view, changes occurring during the research, and the learning process. It was found that measurement of these aspects with student responses allows for a process that becomes meaningful to students and successful at incorporating guided and open inquiry (Zion et al., 2005). In (2005), Winters & Azevedo found that Web-based simulations and collaborative environments allowed students to use active problem solving as part of the science process, which allows them to advance their essential inquiry dynamics (Sadeh, 2009; Walker, 2003). In 2009, Sadeh used 11th and 12th grade students studying ecology to measure dynamic inquiry components within open and guided inquiry activities. In this action research study, the researcher showed that open inquiry students' outcomes were greater than guided inquiry students' outcomes, but both inquiry skills greatly improved the student's ability to analyze changes and develop procedures. This study did not show a difference in students' perceptions or students' understanding the learning process between guided versus open inquiry (Sadeh, 2009). Because dynamic inquiry focuses on skills beyond guided or open inquiry, it creates a measurement for the science process as it changes and how the students perceive the change (Zion et al., 2004). Dynamic inquiry is an

essential component to measuring inquiry as a teacher works toward measuring science processes as they implement guided and open inquiry assignments.

Many science educators struggle in implementing Web-based inquiry because of the difficulties in classroom management and student preparation (Spector, Burkett, & Steffen, 2002; Timmerman, 2008). To overcome this, the teacher must become a facilitator of learning. As a facilitator the teacher provides guidelines, mentors, monitors, and suggests improvements to students through the Web-based inquiry process. This requires the teacher to be flexible, creative, and demonstrate encouragement to each student through the process (Zion & Slezak, 2005). Teachers also struggle with the facilitation of the inquiry process, especially in a Web-based format (Spector et al., 2002). The most common obstacles for teachers to overcome when teaching collaborative Web-based inquiry include: a lack of student participation, a lack in the ability for students to get started, a lack of ability for the student developing relevance, and lack of self-thought in the process (Lawson, 2000). The platform should be easily managed with scaffolding, which allows students to browse content along with sharing files and other media (Seng Chee Tan, 2005). Scaffolding is a way of organizing content in a series of steps in a navigation window, which brings up activities as the students need to complete them (Walker, 2003). Scaffolding within the learning environment is important for students to be able to avoid just surfing through the wrong information; it reduces distractions to keep students on task, but also allows them to regulate their own learning by creating goals and managing their time (Walker, 2003; Winters & Azevedo, 2005).

Educators today have numerous resources available to integrate online learning as a teaching strategy; however, basic principles and functionality of online instructional tools are not well understood. The Department of Educational Psychology at the University of Utah (Zheng et al., 2008) recently investigated teachers' perception of using Web Quest and the implications for online teaching and learning. There were 226 teachers from 20 states that participated in this study. Results of this study (Zheng et al., 2007) revealed "three constructs perceived by teachers as critical to Web Quests: constructivist problem solving, social interaction and scaffolded learning" (p. 295). Implementing these factors can be essential to improving students ability to utilize collaborative Web-based inquiry to develop critical thinking, collaboration, and scientific understanding in the 21st Century.

Using Web-based collaborative inquiry in a classroom setting requires extensive planning and organization. The platform should be designed to encourage inquiry and collaboration between students, while still providing enough structure using scaffolding. Collaboration is an essential skill for students to develop critical thinking and dynamic inquiry skills, which will help them to be more critical self-directed learners.

METHODOLOGY

Project Treatment

To determine the effects of using a Web-based collaborative inquiry environment, collection of data occurred in one nontreatment unit and two treatment units. The nontreatment unit involved collaborative projects without the use of the Internet, using class whitepapers. The two treatment units used Internet collaboration through a Wiki

site as the basis for discussing, and sharing project information while running Internet simulations.

In the nontreatment unit, students collaboratively discovered how DNA sequences code for proteins and genetic traits through an inquiry investigation. Within collaborative groups, they were required to create an Investigation Report (IR), which is found in Appendix A. Students presented their results on large paper sheets around the room and then commented on each other's investigations with sticky notes. This is referred to as "class whitepapers" for this study. The IR served as a comprehensive way to measure dynamic inquiry, critical thinking, and understanding. Dynamic inquiry in the report was assessed according to the rubric in Appendix B. Critical thinking was also assessed from the IR and students' responses through using the PIM framework (see Appendix C). Student understanding was measured through two different methods: scores of the IR using guidelines in Appendix D, and scores from pre and postunit assessment questions found in Appendix E.

The groups in the nontreatment unit conducted three investigations to explore Deoxyribonucleic acid (DNA) and how it leads to specific traits. In the first activity, students extracted their DNA using a given protocol; applying inquiry skills students designed their own investigation extracting DNA from another substance. This activity is found in Appendix F (Doran, Chan, Tamir, & Lenhardt, 2002). Students shared their results using the IR with the class whitepaper format. After comments were posted, students reflected on the postings and feedback was given to the class regarding their investigations and collaborations.

In the second activity found in Appendix G, students explored how DNA sequences code for proteins through an Internet simulation adapted from the University of Utah (Genetic Science Learning Center, 2011). Following the Internet simulation, the students built their own protein model and presented it in the class whitepaper format. The project was evaluated for dynamic inquiry using the rubric found in Appendix B, critical thinking using the rubric found in Appendix C, and content understanding using the guidelines found Appendix D. In the final activity, adopted from the University of California Los Angeles curriculum (Oltmann, 2011), students were given a DNA sequence with codes for a specific genetic disorder. They used the DNA sequence to complete a Basic Local Alignment Search Tool (BLAST), searched for the disorder, then researched the genetic disorder and described it (Oltmann, 2011). This activity, which is found in Appendix H, was used to generate an IR in the class whitepaper format. As the nontreatment unit was concluded, student interviews were conducted to measure student understanding, dynamic inquiry, critical thinking, and involvement (see Appendix I).

Throughout the treatment units students used a class Wiki site for collaboration; the site used scaffolding with a navigation column covering specific content areas to be discussed (Tangient, 2011). During the treatment units students were monitored, and guidance was given to address the following concerns: ensuring students were making posts as they were completing investigations, asking probing questions to prevent students from getting discouraged, and encouraging deeper understanding. Group members were evaluated based on participation of online posting and group discussion. Guidance was given to encourage students' to post comments online with a minimum of three postings. For each topic area, student groups were required to generate an IR that

was assessed according to the rubrics in Appendix B, C, and D. Students completed a pre

and postunit assessment that served as a method of measuring understanding, critical

thinking, and dynamic inquiry skills. The pre and postunit assessment for treatment unit

1 can be found in Appendix E. Student interviews were conducted to measure

understanding, involvement, and critical thinking (see Appendix J).

In treatment unit 1, students conducted investigations using an online simulation

to determine methods of inheritance in the fruit fly, *Drosophila* (The Virtual Courseware

Project, 2011). The *Drosophila* simulation allowed students to choose and experiment

with different traits in an open inquiry format. The student introduction and guidelines

for experimenting with the simulation can be found in Appendix K. The project requires

students to test the following traits to determine the method of inheritance: eye color,

wings, body color, and antennas. During this simulation students were given probing

questions to improve procedural development, hypothesis development, and variable

manipulation. With each individual trait, students posted their results to the Wiki page so

that others could discuss their data and scientific process (Tangient, 2011). Students

were prompted on the class Wiki site to focus their questions and discussion of individual

problems, hypothesis development, development of procedures, and development of

conclusions. Students were prompted when they seemed to veer off track, or when more

expansion of content was needed. Examples of probing questions to further student

critical thinking include: Do you have any evidence for that? What effect would that

have? Does anyone else have a different conclusion? What else would someone who

disagrees say (MacKnight, 2000)?   These features were evaluated using the rubric for

Dynamic Inquiry in Appendix B. After students collected and presented all of their data,

students completed a pre and postunit assessment (see Appendix L).

In treatment unit 2, students used a downloaded simulation called *Case It*

(BioQuest Curriculum Consortium, 2011). The simulation description is found in

Appendix M. This simulation allowed students to research genetic disorders and

experiment through electrophoresis and genetic engineering simulations. In the first

experiment, students used a tutorial to learn the different methods of studying genetic

disorders. They explored the techniques used in gel electrophoresis, Southern Blot,

Polymerase Chain Reaction (PCR), and Restriction Enzyme digest. For the second part

of the simulation, students developed and designed their own case study using the best

method within the simulation (Bergland et al., 2006). Students generated an IR

throughout the process and were required to comment on class members investigations

using the class Wiki page discussion board (Tangient, 2011). Pre and postunit

assessments were conducted to measure understanding, dynamic inquiry, and critical

thinking (see Appendix M).

Data Collection Instruments

Participants for this capstone project were sophomore students (N= 36) attending

West Grand High School, Kremmling, Colorado. Participants were enrolled in the

introductory biology course and divided into three sections of 17, 11, and 8 students.

Participants for this project were chosen because they are a group with mixed academic

abilities. The students participating in the project are 60% boys and 40 % girls, with less

than 15% of Hispanic origin and the remaining 85% Caucasian. The males in the class

tended to outperform the females in math and science, while the females outperformed

the males in reading and writing according to their 2010 Colorado Standardized

Assessment Program data (School View, 2010). This class is the largest class in WGHS

with 36 students making up approximately one-fourth of the high school population of

120 students. WGHS is a rural school district located in the Rocky Mountains in

Northwest Colorado.   The community has a population of less than 2,000 with the main

sources of income from ranching, hunting, service industry, and mining.

In order to accurately measure the effects of Web-based collaborative inquiry,

three methods of data were gathered for each focus area. Skills within the collaborative

structures that were evaluated are dynamic inquiry, student understanding of content,

involvement, critical thinking, and the effects it will have on teaching inquiry. The

Triangulation Matrix in Table 1 expresses the collection item for each focus.

Table 1
Triangulation Matrix

Project Questions	Data Source		
	1	2	3
Dynamic Inquiry	Pre and Postunit Assessment	Pre and Postunit Interviews	Poster IR Report with treatment and nontreatment units
Student Understanding	Pre and Postunit Assessment	Posters IR Nontreatment and online collaborations	Pre and Postunit Interviews
Student Involvement	Class Observations	Evaluation of online collaborations with treatment and nontreatment units	Interviews with treatment and nontreatment units
Critical Thinking	PostIt Note from IR posters and online discussion boards	Pre and Postunit Interviews	Pre and Postunit Assessment
Teaching Attitude	Teacher Journal	Likert Survey	Observations

Dynamic inquiry was assessed analyzing the effects of collaborative Web-based instruction on procedural understanding, hypothesis development, student's perception of science, problem expansion, and development of conclusions. These elements were analyzed through three different assessment methods: a pre and postunit assessment, pre and postunit interviews, and evaluation of the IR. The IR was fully analyzed for dynamic inquiry using Appendix B. The pre and postunit assessment questions 3 and 4 as well as interview questions 8-10 were analyzed by also using Appendix B.

Nine students were chosen for the pre and postunit interviews with three from high-achieving academic levels, three middle-achieving academic levels, and three from low-achieving academic levels. To provide an unbiased sampling of the students, one student from each academic level was chosen from each section, this provided a variety of data without interviewing all students. The interview questions can be found in Appendices I and M.

Critical thinking assessment also utilized a pre and postunit assessment, pre and postunit interviews and evaluation of the IR reports. PostIt note responses were used to measure critical thinking throughout the nontreatment unit by categorizing them as triggering, exploration, integration, and resolution. In the treatment unit, student discussion posts were evaluated using the same categories of triggering, exploration, integration, and resolution. The rubric for analyzing these components is found in Appendix C.

Student involvement was measured and analyzed by tallying of whitepaper post, online discussions, observations from WGHS administration, and interview questions. Student interview questions focused on group involvement, individual involvement, and

what increased involvement from the students' perspective (Appendices I and M). Student involvement was also measured using classroom observations by WGHS administration, the observation form is found in Appendix P.

Student understanding was measured using several different methods across the pre and postunit assessment, interviews and IR. Essential elements of content understanding were created and measured through the rubric found in Appendix D. These same elements were applied to concept maps within interviews, ranking scales on pre and post assessments, and evaluation of IR (Appendix A, D, E, I, J and N).

To measure the effects that the project had on the ability to teach inquiry a ranking scale was designed to measure the effects of activities on: class involvement, student frustration, teacher frustration, and teacher excitement (Appendix O). Weekly reflections about the process and how it affected teaching strategies were completed. The final method of data collection was through classroom observations that were conducted by administration (Appendix P).

All data entries were tallied and averaged with a comparison of the nontreatment units with the treatment units. Quantitative data were compared with qualitative to analyze students improvement and identify any trends in collaborative Web-based inquiry. This was compared with the percent change from the nontreatment to the treatment unit.

The current study was conducted over a six-week time frame. During the first two weeks, the students completed the nontreatment unit on DNA to Protein. Weeks 2 to 4 were treatment unit 1 on Mendelian Genetics using *Drosophila*. Weeks 4 to 6 was

treatment unit 2 on Biotechnology and Human Genetics. A detailed outline can be found in Appendix Q.

DATA AND ANALYSIS

Throughout this action research project, data were collected in nontreatment and treatment units to determine the effects of using Web-based collaborative inquiry within high school genetics concepts. The data were collected using triangulation of the focus questions with data collection instruments.

The triangulation of data showed that students were able to achieve increases in dynamic inquiry, content understanding, critical thinking, and involvement through Web-based collaborative inquiry. Students struggled through the first treatment, showing decreases in dynamic inquiry, content understanding, and involvement. In the second treatment, they achieved increases over the nontreatment in most areas.

Students' dynamic inquiry skills were measured through analysis of student investigation reports (IR) throughout the nontreatment and treatment units, responses on the IR were quantified using the rubric found in Appendix B. An average of student procedural understanding, hypothesis development, expression and analysis of data, and development of conclusions were calculated. Data from these reports can be found in Table 2, which shows students achieved higher percentages in treatment 2, with the most increase occurring in hypothesis development. Students struggled with procedural development leading to a decrease in both treatment units. They also struggled with analyzing and making conclusions from their data across both treatment units. Students

struggled with the course content in treatment 1, therefore many students were unable to complete all tasks which resulted in low scores across all areas of treatment 1.

Table 2

Average Dynamic Inquiry Skills from Investigative Reports in the Nontreatment and Treatment Units (N=36)

Dynamic Inquiry Aspects	Nontreatment	Treatment 1	Treatment 2
Purpose	69	46	76
Hypothesis	64	53	81
Procedural Development	64	53	57
Data	71	60	75
Analysis and Conclusion	60	42	54

The activities in treatment 1 required students to manipulate many different variables to determine a solution; this led to students having difficulty managing time to get all tasks completed by the given deadline. These declines in the IR scores could be attributed to the extensive nature of the simulations, and students struggling with time management. Further analysis of the IR suggests that although students were able to give great detail in the conclusion, they lacked important details in the scientific process. For example, was the hypothesis supported? An example of this from student IR reports was: "Because Fragile X is a syndrome dealing with the X chromosome, more women will have it, but it will affect boys more. When we test A, B, and C cases we will find that a greater percentage of girls will be more likely to have it. Of course, if we were able to observe the subjects in real life, few of the females would show symptoms of Fragile X, whereas the males who inherit it would show more symptoms of the syndrome." Further examples can be found in Appendix R.

Dynamic inquiry was also measured and analyzed for growth using pre and postunit assessments. Percent of growth in the area of dynamic inquiry was calculated by

taking the postunit assessment scores minus the preunit assessment scores, then dividing

by the postunit assessment score and multiplying by 100. Figure 1 shows percent growth

in dynamic inquiry using the pre and postunit assessments.
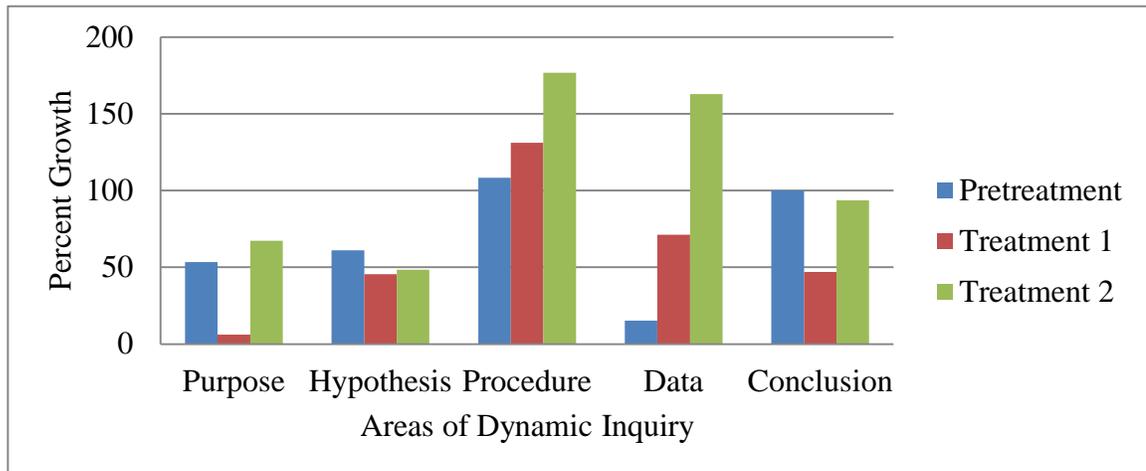
Figure 1. Percent growth of dynamic inquiry from pretreatment to treatment 2, (*N*=36).

Analysis of data showed that in treatment 1, students showed improvement in

developing procedures, and expression of data, but decreased in development of purpose,

hypothesis development, and developing conclusions. These discrepancies between the

pretreatment to treatment 2 could have been due to wording of the questions when

students didn't realize that they should express the full scientific process. When asked to

design an investigation through the pre and postunit assessments and student interviews,

students usually responded with a basic procedure rather than the complete scientific

process. An example of this would be when a student was asked to design an

investigation for determining the probability of inheriting a trait, the student would

respond with "Have a kid with their parents come in and be examined for similar and

different traits, then put traits in a Punnett square and find the probability of each trait in

the offspring." This response showed that the student was able to give a procedure for

the investigation, but might leave out a purpose and hypothesis for that investigation. This could easily account for the lack of showing increased scores in all areas of dynamic inquiry from the pretreatment to the treatment 2.

These results were also supported through student interviews when students would leave out essential components to the scientific process, but with further probing they would easily come up with a hypothesis and purpose. An example of weakness in identifying a hypothesis, an average student responded with "If I test the traits from the mom and dad, then the dad will have more dominant traits." In this case, probing would have been used to ask a student to elaborate more about why they thought the dad would have more dominant traits. During student interviews low-achieving students had the most difficulty in developing a purpose and hypothesis; they did not seem to be able to form a hypothesis for a given problem and responded with "I am not sure." When the low-achieving students were probed for more information, they continued to struggle with the hypothesis because they were struggling to grasp the basic concepts of dynamic inquiry.

Pre and postunit assessments were also used to measure students understanding of genetics concepts. Responses on the pre and postunit assessment were scored and data were analyzed to determine improvement, and then subdivided according to student achievement levels. Table 3 illustrates that students made improvement across most achievement areas from the nontreatment to treatment 2, but they decreased in concept understanding in treatment 1. Overall, there was little difference between the results of the nontreatment and treatment units. One group that did not show improvement in

treatment 2 was low-achieving students; this could be due to the overwhelming amount of new technology and information.

Table 3

Genetics Concepts Percent Growth from Nontreatment to Treatment on Pre and Postunit Assessments (N=36)

Student Achievement Levels	Nontreatment	Treatment 1	Treatment 2
High	63.8	40.3	77.9
Middle	65.2	59.8	66.1
Low	56.0	64.9	49.8
Average	61.7	55	64.6

This data were verified with student interviews when a student actually said, "students who didn't understand what was going on would allow others to do the work, and it was more difficult for the teacher to notice". High-achieving students responded with "they like the hands-on format of learning independently and felt they learned more, and participated more". They also expressed that "using the fruit fly lab was more difficult to gather and analyze data than it was using the *Case It* simulation."

Further analysis was done to determine if students were able to express genetics concepts through IR. The IR's were scored for content understanding and percentages were compared with student academic levels. Figure 2 shows students at all levels struggled to effectively integrate content knowledge into their IR reports for treatment 1, but made larger gains in integrating content knowledge for treatment 2 when compared to the nontreatment. Analysis of individual academic levels shows all students struggled with the second task of treatment 1, with medium and low-achieving students struggling the most. The decrease in scores from the first part of treatment 1 to the second task,

showed that students across all levels struggled at getting the second task of the treatment

1 completed. This decrease is perceived to be due to the complexity of the tasks and lack
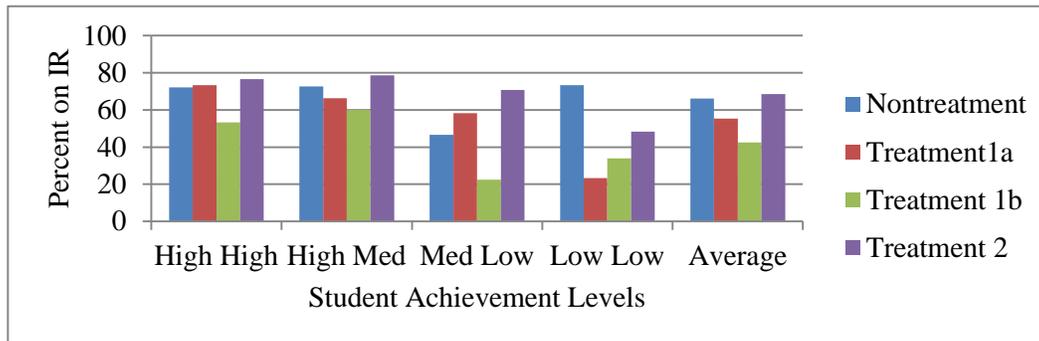
of time management by the students.

Figure 2. Genetics concepts investigative report scores analyzed for content
understanding, (*N*=36). *Note*. Treatment 1a= data collection on dominant and recessive
traits, treatment 1b = data collection on sex-linked and codominant traits.

The increases in content understanding in treatment 2 show that students did get

more comfortable with the process and were able to make gains in content. This is due to

the nature of integrating technology, where students struggled at first and then as they

became more comfortable with the process they were more efficient in expressing

themselves. Low-achieving students did better in the nontreatment unit, medium-low

students did the best with the second treatment unit, and the class average had slight

increases in students understanding.

Student involvement data were collected through posts, student interviews, and

teacher Likert. Discussions were tallied using PostIt notes, which were posted on the

whitepapers in the nontreatment, while online discussion post were tallied throughout the

treatment units. Figure 3 illustrates the compared amount of posts from the nontreatment

to the treatment units. The total amount of posts actually increased throughout the

treatment 1 while it decreased in treatment 2. The increase in treatment 1 was evident

with students' who naturally carried on a conversation on the Wiki page and the

introduction of using a discussion board.   These conversations sometimes veered off

topic or were basic information exchanges, which resulted in increased exploration

responses. There was an overall decrease in posting during treatment 2, this seemed to be

due to the fact that students were more involved in the simulations and IR, giving them

less time to make discussion posts.
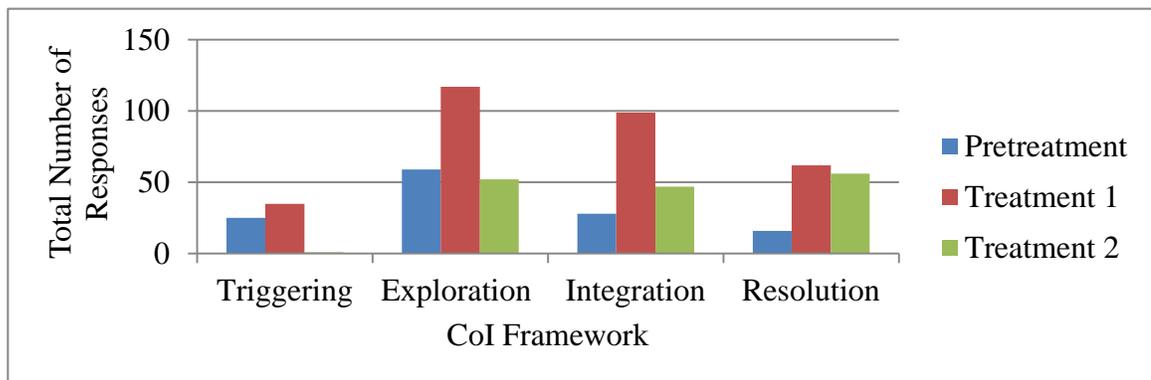
Figure 3. Comparison of student responses using community of inquiry framework,
(N=36). Note. Triggering= students recognizing problems and expressing new ideas,
Exploration= students able to contradict others and explore their own ideas with previous
knowledge, Integration= student is able to tie together their ideas with the class to create
a solution, Resolution=student defends their solutions to the problem with real world
application.

A comparison of average responses per student, within student academic areas

was done to measure participation. Table 4 shows a higher participation in the treatment

than the nontreatment. The average students participated more in the nontreatment unit

compared to treatment 1 and treatment 2. Low-achieving students participated more than

the average level students in treatment 1, but not in the nontreatment or treatment 2.

Contributing factors of these results may be due to the average students focusing on

completing the task of the simulation, rather than participating in the online discussion

board. A student that was interviewed responded with, "that most of the time students

were involved and participated equally but there were those students that would just let others do the work". This was also observed by teacher observations and Likert surveys when some students appeared to be on task while others took multiple redirections, and encouragement. Likert survey responses showed that when the teacher would redirect students, students would then make post on the discussion boards, while the other students may be working on the IR. Redirection occurred more with low-level students which is why they had a higher average response per student than the average student in treatment 1.

Table 4
Average Responses Per Student, Within Student Academic Areas (N=36)

Student Academic Areas	Nontreatment	Treatment 1	Treatment 2
High	1.3	11.7	12
Average	10.6	3.23	5
Low	3.7	5.69	4.25

The inconsistencies in these data can be attributed to the student frustration with utilizing technology within the classroom. Student frustration caused students to lose interest in the subject, decreasing their involvement. This was especially true when students were using classroom netbooks, which had slower processing speeds than traditional computers. The results of the teacher Likert surveys identified issues with the simulations and use of computers, particularly in treatment 1 when students were overwhelmed by the amount of data that could be collected. The results of the Likert survey were tallied and averaged for the nontreatment, treatment 1, and treatment 2 units. Figure 4 shows the results for student involvement from the teacher Likert survey. Through my observations, I strongly felt students were 100% involved more in treatment

2. The nontreatment was the second highest and treatment 1 was the lowest. Treatment 1 was lower in all categories of involvement, excitement, and attitude. Treatment 2 was higher in all categories except excitement where it was only slightly higher than the nontreatment. The involvement, excitement, and attitude scores were in direct correlation with all other data when students struggled in treatment 1 and made gains in treatment 2.
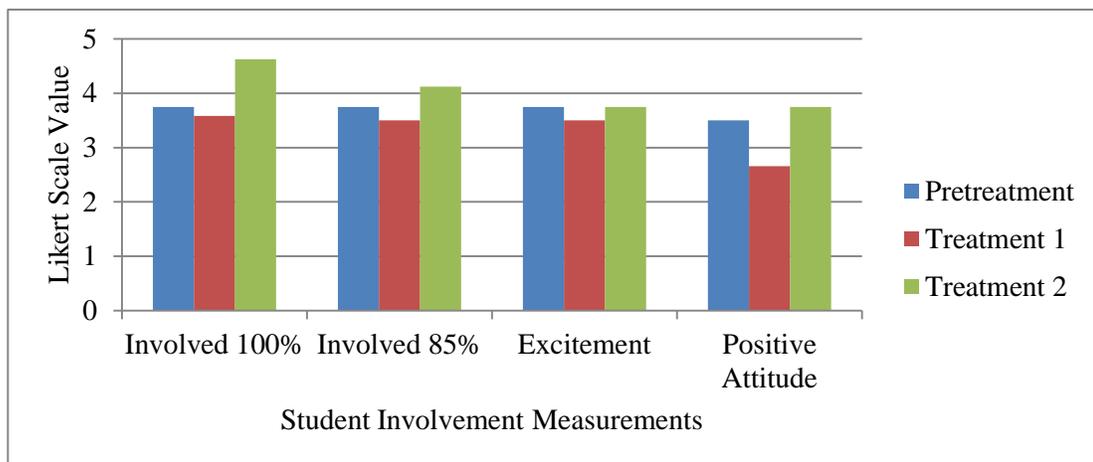
Figure 4. Teacher Likert results for student involvement, (*N*=36). *Note.* Likert scale 5=strongly agree to 1=strongly disagree.

Pre and postunit assessments were used to calculate the percent change in critical thinking; critical thinking was scored separately from student understanding using Appendix C for critical thinking. The assessments were formulated with five short answer questions, which were analyzed for triggering, exploration, integration, and resolution. Percent change for each question was calculated and averaged for comparison. Figure 5 shows that students had consistent improvement from the nontreatment to the treatment units with the largest increase occurring in treatment 2 in the areas of triggering, exploration, and integration. There were some decreases within the resolution category moving from 58.5% in the nontreatment to 54.8% in the treatment. Treatment 2 had significant increases over both the nontreatment and

treatment 1 across all areas except for the category of resolution. The decrease percent

for resolution could be due to wording of the questions on the assessment, or the lack of

the ability to reflect on their comments on the assessment.
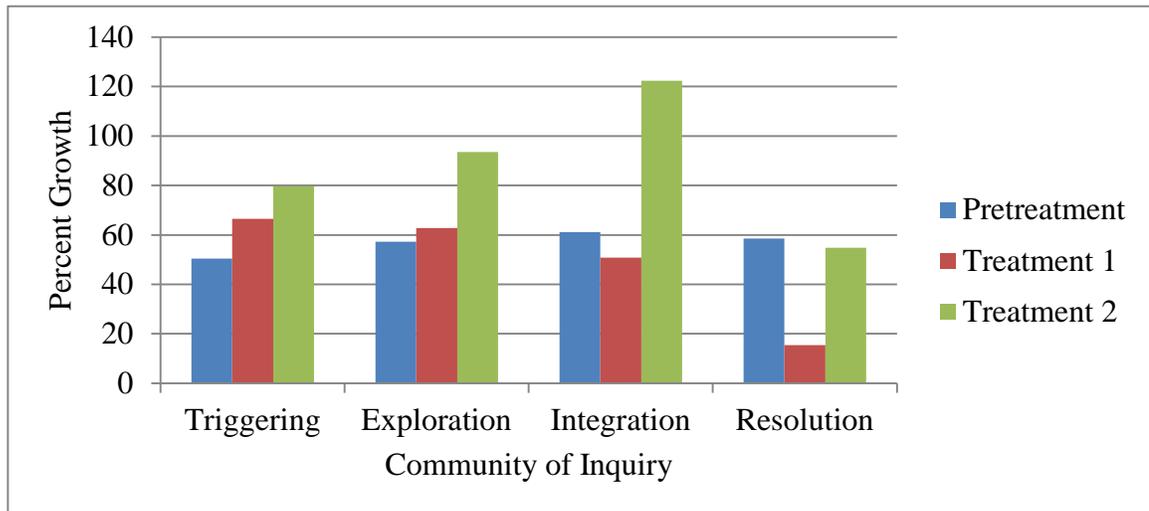
Figure 5. Average percent growth on pre and postunit assessments using critical thinking
analysis, (*N*=36). *Note.* Triggering= students recognizing problems and expressing new
ideas, Exploration= students able to contradict others and explore their own ideas with
previous knowledge, Integration= student is able to tie together their ideas with the class
to create a solution, Resolution=student defends their solutions to the problem with real
world application.

Critical thinking was also measured by tallying student postings on the Wikipage

and class whitepapers. These posts were categorized according to the rubric found in

Appendix C. To determine an accurate reflection of whether students were able to move

from lower level triggering and exploration, to higher level thinking using integration and

resolution the percentages of the responses from the nontreatment to the treatment were

compared. The data, which is found in Figure 6, show that students had the highest

amount of responses in exploration (46 %) and integration (30%), with lower responses

in triggering (19%) and resolution (5%). In treatment 2 integration remained high, but

the highest number of responses were in exploration and resolution, and triggering was

the lowest. These results conveyed there was a decrease in triggering and increased in

resolution from the nontreatment to the treatment 2, indicating that students are including

more higher level critical thinking skills.
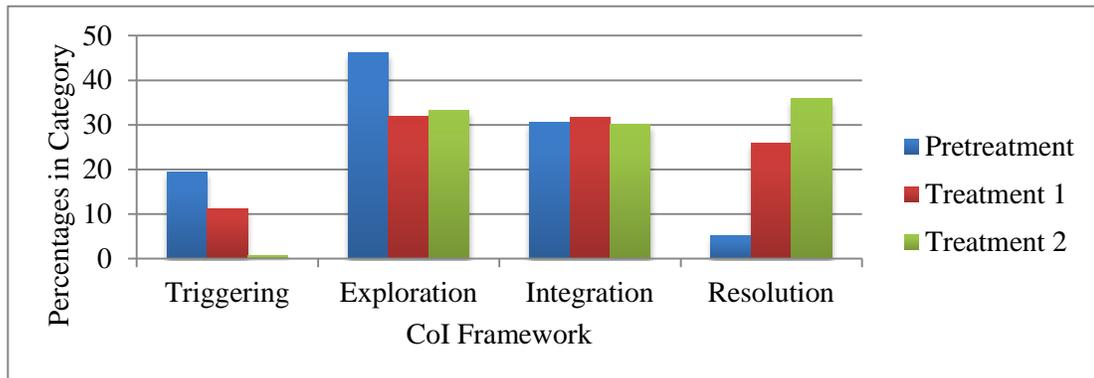
Figure 6. Critical thinking categorization using the CoI framework, comparing
percentages of treatment and nontreatment units, *(N=36)*. *Note*: Triggering= students
recognizing problems and expressing new ideas, Exploration= students able to contradict
others and explore their own ideas with previous knowledge, Integration= Student is able
to tie together their ideas with the class to create a solution, Resolution=Student defends
their solutions to the problem with real world application.

Data were then broken down according to student academic levels and student

responses were tallied within the CoI framework areas. Table 5 shows that higher level

students decreased in triggering responses, but had increased scores in resolution.

Average students showed the least progression, with most responses staying within

exploration and integration, but they also had slight increases in responses for resolution

in treatment 2. The lower achieving students showed a similar progression to the higher

level student with a decrease in triggering responses but an increase in resolution

responses. An example of students moving from lower level exploration to resolution, in

the nontreatment exploration responses included "nice listing method," and the same

student in treatment 2 gave responses like "You guys did a super great! I really like the

whole layout of your lab and what not, but I would really love it if you had an overall

conclusion and not just a conclusion for each case."

Table 5

Transition From Triggering to Resolution Within Student Academic Areas (N=36)

	High			*Middle*			*Low*		
	Non treat	Treat 1	Treat 2	Non treat	Treat 1	Treat 2	Non Treat	Treat 1	Treat 2
Triggering	15	13	4	21	2	13	19	4	2
Exploration	38	21	29	37	40	48	68	49	39
Integration	31	37	26	28	33	18	5	31	37
Resolution	15	29	38	14	18	20	8	16	22

Note. Nontreat = Pretreatment, Treat 1 = Treatment 1, Treat 2 = Treatment 2.

Students who moved from exploration to integration had responses in the

nontreatment like "maybe use different colors for this" and in treatment one responded

with "Your guys stuff looks good! Could you clarify what is most dominant?" With the

example responses you can see that students were able to include essential elements that

are necessary to increase critical thinking. I observed that students are more inclined to

include more detailed responses when they can type and revise as they are working

versus writing it out. This ability to critique their own responses as they go, and have

other students' critiques, allows them to increase their critical thinking skills. In

summary, high and low-achieving students made much progress from triggering to

resolution between the nontreatment and treatment units 1 and 2, and middle achieving

students made slight progress. The lack in progress of the middle achieving students

could be due to the overwhelming nature of using technology, and taking on the

responsibility of the projects so they had less time to make and revise post.

When looking at how utilizing Web-based collaborative inquiry affected my attitude and my ability to lead Web-based inquiry, I found that my attitude did improve over the process. The data in Figure 7, showed that in the nontreatment I strongly agreed that I was excited about teaching the classes, this dropped in treatment 1 and climbed in treatment 2. This correlates with student involvement where the nontreatment was high with a slight decrease in treatment 1 and an increase in treatment 2.
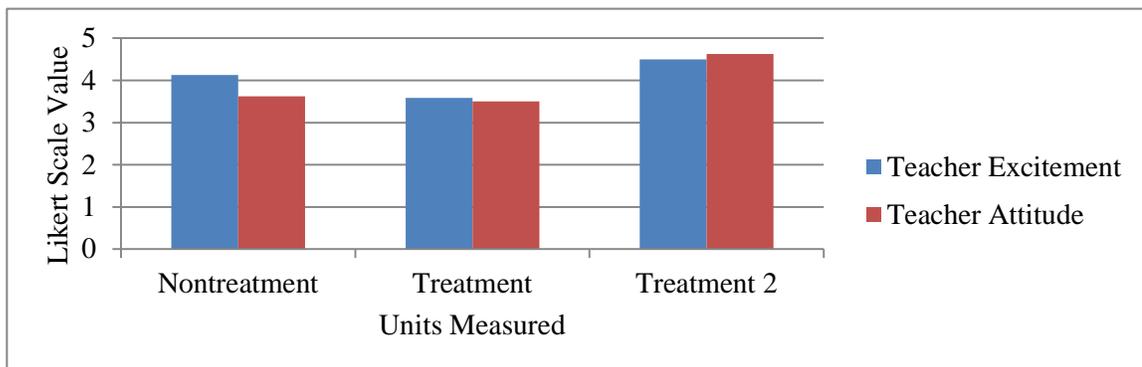
Figure 7. Teacher daily Likert results averaged throughout the nontreatment and treatment units, (*N*=36). *Note*. Likert scale 5=strongly agree to 1=strongly disagree.

In my journal, I found that struggling with getting netbooks to work added to the lack of involvement and excitement. In classes where each student had a netbook, involvement and excitement was higher than in the large class where students had to share netbooks. I frequently found that students would ask me questions rather than referring to the Wikipage to allow for a written exchange. This could be a downfall of using Wikipages as a discussion board within the regular classroom. When I look at my ability to lead Web-based inquiry activities, I feel that even though it may have been a struggle in treatment 1, it improved in treatment 2. I heard from many students that they liked the online format, but would have preferred it be mixed throughout the year so that they are not on the computers everyday. I saw the frustration within the students but as they overcame the frustration I observed students becoming more engaged with the

content which lead to increases in content understanding. I had one student comment "this class seems that it has changed, I am still learning, but it is less lecture and notes." I asked him to expand on it and he said that "he liked some of the format but it does get tiring after a while." As I reflect on my ability to balance the classroom inquiry with Web-based discussions, I feel that I am making progress, but it takes time for students to become comfortable utilizing the technology they are given.   It may also take more time than the study period to fully develop the use of Web-based collaborative inquiry within the classroom, to develop a balance for optimum involvement and engagement of the students.

Administrator observations comments supported the data gathered from my daily Likert survey and journaling, which showed some lack of student participation during treatment 1 but then more engagement in treatment 2. My administrator gave feedback that I was able to handle any discipline problems easily, and I always showed a positive atmosphere encouraging students to give input and come to the correct conclusions. Overall his responses have indicated that there were times where students appeared to struggle, but with teacher guidance students were directed back on task and were engaged in their learning. He also added that when he discusses content with the students they were able to discuss their learning with him and defend their investigations. I feel that this supports the fact that even though there were a few issues within dynamic inquiry, and overall content knowledge, students gain in critical thinking skills allowed them to better demonstrate their learning when asked.

In conclusion, I feel that I am making progress using collaborative Web-based teaching strategies in the traditional classroom. Collaborative Web-based inquiry may

require integration overtime within the curriculum. Long-term incorporation of collaborative Web-based teaching strategies with traditional classroom activities that encourage active participation will provide the optimum educational outcomes for the students and the teacher.

INTERPRETATION AND CONCLUSION

Analysis of data was structured to determine the effects of using collaborative Web-based instruction on students' inquiry skills and understanding introductory high school biology concepts. Triangulation of data showed that students made some gains in utilizing dynamic inquiry skills, critical thinking and understanding of concepts. Results of data collected for this research project showed high-achieving students showed the most increases across all levels, whereas low-achieving students achieved the least gains in all areas. Student understanding of genetic concepts also showed the same trends through triangulation, where higher achieving students were able to show increases and low-achieving students actually decreased.

Utilizing collaborative Web-based inquiry improved student involvement and critical thinking throughout treatment units, despite the initial struggles with using technology. Analysis of critical thinking showed that students not only became more involved as the treatment progressed, but their involvement allowed them to advance from introductory level questions to answering questions with more resolution and conclusions. This allowed students to become more involved in their learning, therefore increasing their understanding.

The increases in students understanding of concepts, involvement, and critical thinking also allowed for me to have increased involvement and engagement as a teacher. Having a platform where students can be actively involved in their learning, and then having to defend the results of their investigation, proved to be the most rewarding for me as an instructor. Utilizing collaborative Web-based inquiry allowed students to demonstrate their work while analyzing and comparing data. The ability to incorporate the online environment allowed me as a teacher to facilitate student learning by helping my students to understand the importance of expressing knowledge scientifically, but also meet the course objectives of introductory high school biology.

There were some things that I would change about the data collection methods for this project if further data were to be collected. The first thing I would change, would be to have more of a case study approach for measuring scientific inquiry on pre and postunit assessments. To measure specifics of scientific inquiry including: development of hypothesis and purpose, analysis of data, and developing conclusions, each component needs to be addressed to measure specific outcomes. This would provide more clarity in student answers allowing them to not leave out details that they would normally include in a report. Another major factor that affected the data was lack of time management by students in treatment 1. Teaching strategies to improve Web-based collaborative learning include: provision of more structure for students, address specific traits to be tested, and provide example of how to express their data. Students struggled within the simulation to breakdown their data to address the specifics of dominance and recessive. This lead to a lot of time wasted with data that did not address the problem.

To improve data collection methods on student involvement, I would actually include minute papers at the end of class in addition to interviews. I feel that getting data from all students would have provided me with more feedback throughout the process. I would improve the interview questions to create open-ended responses, especially for the scientific process. For instance, I might have them do a concept map of the process to study a problem, rather than questions which were based on content and open-ended responses. I would also offer more questions online as debate questions and demonstration of content to get students to interact, instead of assigning students to analyze and provide feedback to other students' IR. This would provide more of a format for students to relate content to the inquiry investigations they are completing.

To improve analysis of critical thinking, I would have chosen a more defined rubric for analyzing critical thinking. The CoI framework lacks the ability to determine critical thinking in open-ended responses on assessments. It works well to categorize online responses on discussion boards, but is difficult to use in triangulation with other methods. Further research into types of rubrics to measure critical thinking would have been helpful. I found a rubric from Intel Teach Elements: Thinking Critically with Data, which would have been a better measurement tool for this type of project (Intel, 2011).

Lastly, to determine the effects on my teaching I also would have included questions on minute papers from the students. Minute papers would allow students perception to be expressed throughout the process. I feel that this would provide more specific feedback to better correct and guide issues that may arise within instructional time.

VALUE

As an educator this capstone project has allowed me to advance my teaching

techniques to keep pace with a technology driven society through integrating Web-based

collaborative inquiry into a high school biology curriculum. The implication of this

project for students is to develop collaboration and critical thinking skills while

improving science process skills utilizing Web-based collaborative inquiry. This

approach demonstrated students ability to analyze their own learning, to compare their

work to others, and then defend the work that they have presented. These are essential

components for students to become active in their learning process, allowing them to be

more successful in the 21st Century.

These skills are difficult to address in traditional instruction methods, which is

why incorporating Web-based collaborative inquiry into education is becoming an

increasing trend. The results of this project can be a teaching and assessment tool that

teachers, administrators, and even parents, can use to see the progress their students are

achieving. Utilizing a Wiki page allows parents not only to see their own students work,

but then students can defend that work to provide more understanding. This can be an

effective way for teachers to communicate what is expected of their students in a

platform that everyone can see. Effectively using online instruction as a method of

learning will be important for students as they become professionals in the 21st Century.

Utilizing a Wikispaces page for Web-based collaborative inquiry can be difficult

to implement for educators in a demanding career. I do feel that to effectively

incorporate collaborative Web-based inquiry into instruction takes much time, more than

a semester. I see myself incorporating it throughout a full school year, however it may take several years to fully integrate collaborative Web-based inquiry into the curriculum to get the full understanding of the impacts. Although we see our students today as technology savvy, results of this project indicate students do not want their instruction to be solely online. The challenge for a high school biology teacher is to find the correct balance of using Web-based collaborative inquiry with other traditional methods.

As a result of this study, I identified one of the most difficult challenges is for students to let go of the traditional methods of just providing the basic answer to a question. Through this study students have been able to use critical thinking to expand their problem solving skills within scientific inquiry. Utilizing critical thinking, collaboration, and problem solving is essential for students to apply themselves in a way that can restructure their way of thinking and understanding of their education.

As a professional I have found that with more time and practice, I feel that I could take students to another level with Web-based collaborative inquiry. I feel that it directly allows me to interact with my students on an intellectual level, advancing their ability to think instead of just providing me with the correct answer. I feel that my administration sees this and respects that I am trying to advance students' education with nontraditional and cutting edge methods.

Completion of this capstone project has allowed me as a teacher to increase my professional ability to facilitate student centered learning and develop effective assessment tools. This capstone project has also given me a new passion of integrating technology into my curriculum through challenging my students to gain the skills that will allow them to succeed in the 21st Century.

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APPENDICES

APPENDIX A

INVESTIGATION REPORT QUESTIONS

Appendix A

Investigation Report Questions

Activity evaluation

1. What was the item you wished to discover? Why?
2. What evidence do you have that formed your statement?
3. What did you hypothesize, based on your evidence?
4.   What did you test for your activity?
5. What were your variables?
6. What tools did you use to gather, and collect your data?
7. Analyze your data?
    a. What are the trends?
    b. Is there any component that does not follow a trend?
8. What can you conclude from your evidence. Why?

APPENDIX B

STUDENT DYNAMIC INQUIRY RUBRIC FOR IR REPORTS

Appendix B
Student IR Report Rubric for Analyzing Dynamic Inquiry

Points	Problem Expansion
6pts	Problem is expanded using information from prior investigations, using variable manipulation.
4pts	Problem considers variable manipulation but does not expand on prior investigations.
2pts	Problem does not include variable manipulation.
0pts	Additional problem was not attempted.
Points	**Hypothesis**
6pts	Uses if then approach comparing independent and dependent variables. Draws inferences from cause and effect.
4pts	Uses an if then approach but does not infer cause and effect relationships.
2pts	Hypothesis does not include independent and dependent variables in hypothesis statement.
0pts	Hypothesis is not included.
Points	**Procedure**
6pts	Procedure considers all variables, follows a sequential plan, is described in detail so that someone else could repeat.
4pts	Procedure considers all variables, is sequential but lacks some detail.
2pts	Procedure leaves out some variables lacks a sequential order and lacks detail.
0pts	Procedure does not manipulate variables, is not sequential and cannot be repeated.
Points	**Data Expression**
6pts	Data is expressed in an easy to read format, has all trials and measurements accurately labeled, follows sequentially with procedure.
4pts	Data could be organized to be read more easily, it has all trials and measurements labeled and follows sequentially with the procedure.
2pts	Organization in data could be improved, less than half of trials and measurements are not labeled accurately and less than half of the data is ordered non-sequential with procedure.
0pts	Data could be organized better, more than half of the trials and measurements are not labeled accurately, the data does not follow sequentially with the procedure
Points	**Analysis and Conclusion**
6pts	The analysis and conclusion express the correct correlation of data expressed, it includes the possible changes in the data relating it to the cause effect relationship. It determines sources of error and possible expansion of future studies, it includes a correlation to the natural world and the effects it could have.

4pts	The analysis and conclusion express only portions of correct data correlation, excluding part of the cause effect relationship. It determines sources of error and possible expansion of future studies, it includes a correlation to the natural world and the effects it could have.
2pts	The analysis and conclusion express only portions of correct data correlation, excluding part of the cause effect relationship. It does not determine sources of error and possible expansion of future studies, it includes a correlation to the natural world and the effects it could have.
0pts	The analysis and conclusion do not express correct data correlation, excludes the cause effect relationship. It does not determine sources of error and possible expansion of future studies, it does not includes a correlation to the natural world and the effects it could have.

APPENDIX C

RUBRIC FOR ANALYZING STUDENTS CRITICAL THINKING

Appendix C

Rubric for Analyzing Students Critical Thinking

	1	2	3	4
Analytic rubric for assessing critical thinking using COI				
Triggering	Student is not able to express any background information or new ideas	Student expresses a sense of puzzlement without developing a new idea	General triggering occurs with the development of a weak idea	Student recognizes there is a problem and expresses new ideas that apply to it
Exploration	Student does not offer any exploratory ideas or questions	Student offers ideas of basic information exchange	Student offers suggestions for consideration without including their input	Student is able to contradict others ideas and explore their own ideas utilizing previous knowledge
Integration	Student does not correctly link ideas and conversations together.	Student ties together their ideas with one other idea in the class	Student ties together their ideas with multiple other ideas in the class	Student is able to tie together their ideas with the class to create a thorough solution.
Resolution	Student does not offer any solutions to the problem	Student offers solutions to the problem.	Student defends their solutions to the problem	Student defends their solutions to the problem with real world application

APPENDIX D

STUDENT CONTENT RUBRICS

Appendix D
Student Content Rubrics

DNA to Protein Content Non-Treatment

- 50pts Students relate the production of proteins to the structure and code of DNA. Protein production is related to the processes of transcription and translation.
- 40pts Students relate the structure and code of DNA to the production of proteins but only include a synopsis of protein synthesis leaving out 1 or more steps.
- 30pts Students relate DNA with out including the structure and code to protein production without including the process of transcription or translation.
- 20pts Students describe DNA and how proteins can cause genetic disorders but leave out the correlation to protein synthesis.

Mendel's Genetics Content Treatment 1 Through an Online Format

- 50pts Students are able to describe how dominant, recessive, incomplete dominance, co-dominant and sex-linked traits are inherited. They include identifiable inheritance patterns for each of the inheritance conditions.
- 40pts Students are able to describe how dominant, recessive, incomplete dominance, co-dominant and sex-linked traits are inherited but do not explain patterns of inheritance for more than one of the above.
- 30pts Students are able to describe how traits are inherited but cannot identify patterns.
- 20pts Students can only determine three out of the five inherited conditions and cannot identify patterns.

Genetic Engineering and Biotechnology Treatment 2 Through an Online Format

- 50pts Students are able to describe the process of gel electrophoresis, the function of restriction enzymes, PCR amplification and Southern Blot.
- 40pts Students can describe the process of PCR amplification with gel electrophoresis and restriction enzymes.
- 30pts Student can describe gel electrophoresis and restriction enzymes.
- 20pts Student can only describe gel electrophoresis.

APPENDIX E

STUDENT PRE TO POSTUNIT ASSESSMENT NONTREATMENT

Appendix E

Student Pre and Postunit Assessment Nontreatment

This assignment will be used as part of a research project, participation in this research is voluntary and participation or non-participation will not affect a student's grades or class standing in any way. If you choose not to participate in the research project you will still be graded on the completion of the project, but your data will be excluded from the research.

1. What criteria would you use to design a DNA model? Explain.

2. What is the significance of DNA and RNA to protein production?

3. What data would be necessary to validate if DNA is isolated? Explain.

4. What would you conclude about the role of mRNA in protein production? Explain.

5. Design an investigation to determine whether proteins can be produced from DNA alone? Explain your reasoning.

APPENDIX F

STUDENT DNA ISOLATION

<u>Appendix F</u>

Student DNA Isolation

BACKGROUND INFORMATION: DNA stores genetic information, which controls cellular growth and reproduction in all living cells and organisms. DNA is found in the nucleus of plant and animal cells. DNA can be extracted from plant and animal cells by breaking apart the nuclear membrane.

Detergents are used to break apart the nuclear membrane, allowing the DNA of a cell to be collected for analysis. During the collection of DNA, enzyme activity must be inactivated so the DNA strands are kept intact as long thin fibers. The collected DNA in the shape of long, thin fibers allows for ease of observation and analysis. DNA can be detected using a diphenylamine solution; it is an indicator that turns blue in color when in the presence of DNA.

Problem: How can you isolate DNA from your cheek cell?

Materials:

- Dixie cup
- Human saliva swished and acquired with salt water or swishing water
- 2 small test tubes,
- 6 mL ice cold 95% ethanol
- 5 mL clear, colorless detergent
- Glass stirring rod
- 1 mL pipette
- 30 mL distilled water
- Filter paper
- Graduated cylinder
- 9 mL Diphenylamine solution
- standard DNA solution

Using the ingredients above design an experiment to isolate DNA from a cheek cell? Check with your instructor before completing the investigation.

- Students will be guided to ensure that they first start with the DNA from a group member's cheek, then add detergent to break apart the nuclear membrane. A short demonstration will be done as members finish up their procedures on the proper way to pipette alcohol on top of the detergent DNA sample.

Observation and Analysis Questions (These should be completed in your lab notebook and on the white paper.)

1. Describe the appearance of the DNA strands.
2. What can you infer about the solubility of DNA in ethanol in your observations?
3. Calculate the yield of your DNA.
    a. Mass of filter paper
       Mass of filter paper + DNA
       Mass of DNA
    b. DNA yield (mass of DNA extracted/mass of wheat germ)
4. Why is it important to thoroughly mix the DNA with the detergent?
5. Why is ice-cold alcohol used instead of room-temperature alcohol?
6. Were you able to isolate your DNA, what was your indicator?
7. From the information you now have regarding DNA extraction, develop a hypothesis you can test in a controlled experiment that will allow you to gather quantitative data.
8. Write out the procedures for testing your hypothesis.

APPENDIX G

TRANSCRIBE AND TRANSLATE A GENE

Appendix G

Transcribe and Translate a Gene

1. Using your netbooks go to the following website:

    http://learn.genetics.utah.edu/content/begin/dna/transcribe/

2. Explore the website. Your task is to create an illustration showing how Proteins are made from DNA.

3. Your illustration will posted on white paper sharing for a later class discussion.

4. You will be graded based on the completeness of the process, creativity and content.

APPENDIX H

CONNECT THE DOTS…DNA TO DISEASE

Appendix H
Connect the dots…DNA to DISEASE

UCLA, GK-12 Science & Mathematics in Los Angeles Urban Schools
http://www.nslc.ucla.edu/STEP/GK12/

INTRODUCTION

We've learned that DNA is the genetic material that organisms inherit from their parents, but have you ever thought about what exactly this DNA encodes for? How do our cells use DNA as a set of instructions for life? How is the information in our DNA/genes used by our bodies? And what happens when the DNA is mutated or not used properly? Your answers to this project will go on white sharing paper to be presented in class.

MATERIALS (PER GROUP)

DNA sequence

Computer with an internet connection

PROCEDURE

1. Obtain your DNA sequence from your teacher.
2. Convert your DNA sequence into a complementary mRNA sequence.

    EXAMPLE: DNA: T A C G G C T A G

                  mRNA: A U G C C G A U C

Your DNA sequence:

mRNA sequence:

3. Determine the codons.

    EXAMPLE: mRNA: A U G C C G A U C

                  Codons: AUGCCG AUC

Codons:

_____ _____ _____ _____ _____ _____ _____ _____ _____
_____ _____ _____ _____ _____ _____

4. Translate the codon sequence into an amino sequence. Use the chart provided.

    Codons: AUG   CCG   AUC

Amino Acids: Methionine   Proline   Isoleucine

Amino Acid Sequence:

_____ _____ _____

_____ _____

_____ _____ _____

_____ _____

_____ _____ _____

_____ _____

5. Write out the one-letter abbreviations for the amino acids in the sequence. Use the chart provided.

____ ____ ____ ____ ____ ____ ____ ____ ____ ____ ____ ____ ____ ____ ____

6.   Go to http://www.ncbi.nlm.nih.gov/BLAST/ and choose Protein-Protein BLAST (top of the second column).

7.   Enter the one-letter abbreviations for your amino acid sequence in the SEARCH box – be sure to enter them in the correct order!

8.   Click on the "BLAST" button.

9.   At the next page, click on the "FORMAT" button. It may take a few minutes to process your sequence.

10.   At the next page, scroll down to the list of proteins that matched your sequence. Choose one that matches one on the list of possible proteins that was given to you.

11.   The protein our DNA sequence encodes is (should be in the list provided):

_____

12.   Now search www.google.com with the name of your protein to find out the disease your protein is involved in.

13.   This protein is involved in the following disease:

_____

14.   Write a brief paragraph explaining the disease caused by this protein or a mutation in this protein.

15. List 3 things you learned in this activity (either technical concepts, such as using the computer or scientific concepts).

AMINO ACID CHARTS AND PROTEIN NAMES

AMINO ACID	Abbreviation	Possible Proteins
Alanine	A	Presenilin 2
Arginine	R	Synuclein
Asparagine	N	Laforin
Aspartic acid	D	Leptin
Cysteine	C	BRCA 2
Glutamine	Q	Dystrophin
Glutamic acid	E	Apolipoprotein E
Glycine	G	
Histidine	H	
Isoleucine	I	
Leucine	L	
Lysine	K	
Methionine	M	
Phenylalanine	F	
Proline	P	
Serine	S	
Threonine	T	
Tryptophan	W	
Tyrosine	Y	
Valine	V	

APPENDIX I

STUDENT INTERVIEW QUESTIONS NONTREATMENT UNIT

Appendix I

Student Interview Questions Nontreatment Unit

This assignment will be used as part of a research project, participation in this research is voluntary and participation or non-participation will not affect a student's grades or class standing in any way.

1. Create a concept map beginning with the nucleus, which shows the relationship between the terms of this unit, add any linking phrases which show how the concepts are related. The terms you will use are: Genes, Traits, Transcription, Translation, Protein synthesis, Genes, DNA, mRNA, tRNA, Ribosome, and Nucleus.

2. Do you feel you participated a lot in this group project? Explain why.

3. Do you felt everyone participated equally? If not what roles were not completed a why do you feel they did not participate?

4. What increases your involvement in class activities? Can you please give-examples?

5. Did the activities help increase your curiosity about the subject? Explain.

6. Do you think that group collaboration helped you understand concepts better? If so why? If not explain why?

7. Can you give me an example of how you would apply the knowledge learned in this activity to something not related to this course? Explain.

8. What can you conclude about the density of DNA?

9. If you were to test how proteins are made what could you do?

10. What would your hypothesis be for this test?

11. Are there other questions I should ask and please answer the questions you ask.

<u>APPENDIX J</u>

STUDENT INTERVIEW QUESTIONS TREATMENT UNITS

<u>Appendix J</u>

Student Interview Questions treatment units

This assignment will be used as part of a research project, participation in this research is voluntary and participation or non-participation will not affect a student's grades or class standing in any way.

1. Create a concept map beginning with Alleles in treatment 1 and Genetic Disorders in

    treatment 2, which shows the relationship between the terms of this unit, add any

    linking phrases which show how the concepts are related. Treatment unit 1 terms will

    use are: Alleles, Dominant, Recessive, Sex-Linked, co dominant, homozygous,

    heterozygous, F1 Generation, F2Generation, Offspring, Probability.   Treatment unit 2

    terms are: patient, restriction enzymes, gel electrophoresis, southern blot, Tay Sachs,

    Alzheimer's, Polymerase chain reaction, Genetic Disorders, Biotechnology,

    Huntington's chorea.

2. Do you feel you participated a lot in this group project? Explain why.

3. Do you feel everyone participated equally? If not what roles were not completed and

    why do you feel they did not participate?

4. What increases your involvement in class activities? Can you give an example?

5. Did the activities help increase your curiosity about the subject? Explain.

6. Do you think that group collaboration helped you understand concepts better? If so

    why? If not explain why?

7. Can you give me an example of how you would apply the knowledge learned in this

    activity to something not related to this course? Explain.

8. What can you conclude about how genetic traits are inherited?

9. If you were to test traits that are inherited what could you do?

10. What would your hypothesis be for this test?

<u>APPENDIX K</u>

FRUIT FLY INHERITANCE PROJECT

Appendix K

Fruit Fly Inheritance Project

For this project you will be using the class wiki site to discuss your results to share your investigation journal. You will be assigned to a group on the project section of the wiki page, each group needs to establish roles for each person, one person will need to run the simulation, one person will be the data collector, and another person is the facilitator of discussions.

You will use the investigation report rubric to create a working document of your findings. This should be posted under your page on the wiki site. You will need to answer all questions for each characteristic that you are studying. These traits include:

 In these investigations you will be testing fruit fly's online at the following website:

- http://www.sciencecourseware.org/vcise/drosophila/

Timeline and Expectations

- You will take the first day to explore around the site to determine how you cross different traits and the general process you should use.

- On the second day you will begin studying the following traits:

Dominant, recessive, incomplete dominance, co-dominant and sex-linked traits

- You should analyze the results and determine how each trait is inherited and then determine the patterns of inheritance throughout generations. Your analysis should be presented on the wiki site under your project page using the IR report as a guideline. This is how you will be graded; you will receive a grade for the IR report for each trait.

- As you are working through the process you should post on your page what you are testing and the results that you obtained. This should follow the IR report for each variable that you are testing.

- As you are posting your results look through other groups' results and include at least three responses to other members post.   Your responses should focus on their scientific aspects of the investigations utilizing critical thinking skills.

- Expand on the first studies for several generations to find trends of inheritance.

APPENDIX L

STUDENT PRE TO POSTUNIT ASSESSMENT TREATMENT 1

Appendix L

Student Pre to Postunit Assessment Treatment 1

This assignment will be used as part of a research project, participation in this research is voluntary and participation or non-participation will not affect a student's grades or class standing in any way. If you choose not to participate in the research project you will still be graded on the completion of the project, but your data will be excluded from the research.

1. What criteria would you use to evaluate the inheritance of traits? Explain.

2. What is the significance of traits that are not dominant or recessive? Explain.

3. What data would be necessary to determine how a trait is inherited? Explain.

4. What would you conclude about how traits are inherited? Do you have any evidence for your conclusion? Explain.

5. Design an investigation that allows you to determine the probability of inheriting a trait. Explain your reasoning.

APPENDIX M

CASE IT GENETIC TECHNOLOGY SIMULATION

Appendix M

Case It Genetic Technology Simulation

In this activity you will use a program that is downloaded to your netbook. The program is called *Case It*. You will utilize group collaboration as in the last simulation with the same roles, simulation director, data collector, and discussion facilitator.

1. The first thing you will do is follow a tutorial that shows you how to use the program to study Huntington's Disease.

     Here is the link to the tutorial: http://caseit.uwrf.edu/tutorialv5/t2.htm

2. As you go through the tutorials you will learn about several different processes for analyzing DNA.

3. You need to take notes and create an investigative report online as you go through the tutorial. Be sure to focus on the investigative report fully analyzing the scientific investigation.

4. Be sure to include aspects in your report that express all aspects of biotechnology including Southern Blot, Enzymes and Restriction Analysis, PCR, and Gel electrophoresis.

5. Once you have complete the tutorial that shows you how to use the simulation you will then need to design your own investigation to study one of the following genetic disorders:

    Alzheimer's

    Breast Cancer

    Cystic Fibrosis

    Duchenne's Muscular Distrophy

    Fragile X

    Huntington's Disease

    PKU

    Sickle Cell

    Tay Sach

6.   As you are working on your investigation you need to use an IR report to present your findings on the class wiki page. You also need to look at others research an comment on their findings.

APPENDIX N

PRE AND POSTUNIT ASSESSMENT TREATMENT 2

Appendix N

Pre and Postunit Assessment Treatment 2

This assignment will be used as part of a research project, participation in this research is voluntary and participation or non-participation will not affect a student's grades or class standing in any way. If you choose not to participate in the research project you will still be graded on the completion of the project, but your data will be excluded from the research.

1. What criteria would be necessary for choosing the correct biotechnology for studying a genetic disorder? Ex. Southern Blot vs. Gel electrophoresis, Explain.

2. What is the significance of using biotechnology to study genetics? Explain.

3. What data would be necessary to determine how a trait is inherited? Explain.

4. What can you conclude about how genetic traits are analyzed? Explain.

5. Design an investigation that allows you to test a genetic disorder for a specific protein.

Explain your reasoning.

APPENDIX O

TEACHER LIKERT

Appendix O

Teacher Likert

1. Rank Student involvement, excitement and time on task on a scale of 1-5. With 5 being the best for each of the following:

	5	4	3	2	1
	Strongly Agree	Agree	Neither	Disagree	Strongly Disagree

   a. _____ Students were actively involved in class

   Explain.

   b. _____ Students were on task more than 85% of the time

   Explain.

   c. _____ Students were excited. Explain.

   d. _____ Students seemed to have a positive attitude. Explain.

   e. _____ As a teacher I was very excited. Explain.

   f. _____ As a teacher I had a positive attitude. Explain.

2. Were there any student ah ha moments? Explain;

3. Were there any teacher ah ha moments? Explain

   Other comments.

APPENDIX P

OBSERVATION FORM

Appendix P

Observation Form

Day _____ Class Period _____

Time observed (circle one): Beginning of class

Middle of class

End of class

1. Rank Student and teacher involvement , excitement and time on task on a scale of 1-5. With 5 being the best for each of the following:

5	4	3	2	1
Strongly Agree	Agree	Neither	Disagree	Strongly Disagree

1. _____ Students were actively involved in class
    i. Give any observed examples:
    Comments:
    List the activities that the students were doing.

2. _____ Students were on task more than 85% of the time
    i. Give any observed examples:
    Comments:
    List the activities that the students were doing.

3. _____Students were frustrated preventing learning.
    i. Give any observed examples:

4. _____ As a teacher I was very frustrated
    i. Give any observed examples:

5. _____As a teacher I was very excited
    i. Give any observed examples:

6. _____ Higher cognitive level questions were asked by students
    i. Give any observed examples:

7. _____ Higher cognitive level questions were asked by teacher
    i. Give any observed examples:

2. Where there any student ah ha moments? Explain;

3. Where there any teacher ah ha moments? Explain

Other comments

APPENDIX Q

TIMELINE OF DATA COLLECTION

Appendix Q

Timeline of Data Collection

Week 1-2 Students will explore DNA and Proteins: January 9-19

- **January 9- Students will complete a pre unit assessment.**
- **Start nontreatement preunit concept interview**
- January 10 Students will use Lab Assessment NSTA to isolate their own DNA,
    - **1st observation by colleague**
- January 11 In Groups Students will create a project which applies the following, each of these will have a guide using the Investigation Report Questions ; Then graded using
    - **investigative report rubric and tallying of responses**
- January 12 Students will learn about transcription and translation through a simulation from the website (1.5 hours).
- How are your traits determined from your DNA? Research the following link to make a protein from DNA? http://learn.genetics.utah.edu/content/begin/dna/transcribe/
- January 16th As a group make your own DNA sequence and through transcription and translation create a protein sequence. Group posters and collaboration and completion of Investigative Report Rubric. Tally group responses to posters
- **January 17th** Students will complete the DNA to Disease activity using BLAST Tool (Word Document)
- **January 18th** As the Group Project Students will be required to record data on their findings for each activity. They will be presented around the room for collaboration using sticky notes they will then and complete post unit assessment and **Investigative Report Rubric tallying of responses**
- January 19th **Postunit Assessment and post unit interviews**

Weeks 3-4 Mendelian Genetics with Drosophilia Treatment Unit 1

- Week 2 -4 Mendel's Genetics: January 23-Feb 8
- **January 23rd Complete preunit assessment and concept interview** begin introduction of online group collaboration format.
- January 24th -Begin Drosophila simulation using wiki for discussion
- January 25th Lead, monitor and gather data from online dominant vs recessive

- January 26th Lead, monitor and gather data from online dominant vs. recessive 1st IR report analysis
- January 30th **2nd observation by colleagu**e begin sex-linked
- January 31st Lead, monitor and gather data from online sex linked traits
- February 1st Lead, monitor and gather data from online sex linked traits **2nd IR report analysis**
- February 2nd Lead, monitor and gather data from online co-dominant
- February 7th finish up all testing online conclusions
- February 6th final IR Report Analysis
- February 8th **post unit assessment and concept interview**

Weeks 4-6 Biotechnology and Human Genetics: Feb 9-Feb 23 Treatment Unit 2

- **February 9th Complete preunit assessment and concept interview** begin introduction of Case It simulation.
- February 13th, Begin Case It tutorial guiding through the simulation and genetic technology process
- February 14th Continue with Case It simulation
- February 15th Continue with Case It simulation
- **Februrary 16th IR Report analysis**
- February 20th Begin student pick of genetic disorder own investigation.
- February 21st Continue student pick of genetic disorder own investigation. **3rd Observation by colleague**
- February 22nd Continue student pick of genetic disorder own investigation.
- February 23rd Continue student pick of genetic disorder own investigation.
- **February 27th Finish up investigations Evaluation of IR report**
- **February 28th Post unit assessment and concept interview**

APPENDIX R

EXAMPLES OF STUDENT RESPONSES FROM IR

Appendix R

Qualitative examples of student responses to the dynamic inquiry in investigative reports (N=36)

	Nontreatment	Treatment 1	Treatment 2
Purpose	*How can you isolate DNA from your check cell.*	*Determaning the inheritence of bristles, body color, antennae, eye color, eye shape, wing size, wing shape, wing vein, and wing angle in fruit flies*	*What is Fragile X, who does it affect and how is inhereted?*
Hypothesis	*If we swish water around in our mouths we will gain saliva with DNA in it. If we get DNA in the solution we will be able to isolate the DNA using ethanol to stop enzyme activity.*	*If we mate fruit flies and try out specific traits like bristels, body color, antennae, eye color, eye shape, wing size, wing shape, wing vein and wing angle to see of their dominant or recessive then I think most of the traits will be dominant.*	*Because Fragile X is a syndrome dealing with the X chromosome, more women will have it, but it will affect boys more. When we test A, B, and C cases we will find that a greater percentage of girls will be more likely to have it. Of course, if we were able to obseverve the subjects in real life, few of the females would show symptoms of Fragile X, whereas the males who inheret it would show more symptoms of the syndrome.*
Conclusion	*I conclude that we can isolate DNA and we did. Austin had the best spit sample. We stirred his spit with soap. This broke up the cheek cells, then, we drizzled ethanol down the side of the test tube. This extracted the DNA and the DNA floated to the top. Therefore, we isolated the DNA from the check cells. Some errors that might have occurred were, we didn't measure out the exact amounts of swishing water, some students swished longer and better than other students so his sample was far superior. My hypothesis was correct and yes we did isolate DNA.*	*We conclude that our Fruit Flies had many dominant and recessive traits for the ones we have tested. The traits that we tested were Bristles, Body Color, Antennae, Eye color, Eye Shape, Wing Size, Wing shape, Wing vein, Wing angle. The traits that were recessive when we tested them were the, eye color, wing size, wing shape, and wing vein. The traits that were dominant in the testing were, the bristles, and the body color. If the gender dominance affected anything the traits that were effected were, antennae, eye shape, and the wing angle. There were only two generations in the testing. If we were to do more breeding it could've affected our results. Although, we could breed the flies three times before we had to clear out our lab for more room.*	*In conclusion, we found that our hypothesis was somewhat correct. In all of the cases it was males who originally showed signs of Fragile X syndrome, which we had predicted. However, we also thought that more girls would have the syndrome, even if they did not show signs, but none of the females seemed to have the full mutation. Some errors that could have been made during this experiment would be the reading and understanding of our data. Since this was a computer simulation, inaccurate data would be hard to get, however there are certain variables within the simulation that can be changed, such as the run time of the gel. Our main issue though, was that in some cases it can be hard to tell whether a particular sample is closer to the normal sample or the premutation etc. so a lot of our analysis was based on our best guess as to whether or not a particular subject had the premutation, full mutation or the normal X chromosome.*