

THE EFFECTS OF ONLINE COLLABORATION ON STUDENT DEVELOPMENT  
OF HIGHER ORDER THINKING SKILLS

by

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In presenting this professional paper in partial fulfillment of the requirements for a master's degree at Montana State University, I agree that the MSSE Program shall make it available to others under the specified rules of the MSSE program.

Brandon Fritz

July 2011

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**ABSTRACT**

In this investigation online collaboration was used to see if improvement occurred in students' development of higher order thinking skills. Weekly scientific or environmental problems or discoveries were posted on a blog and students were asked to collaborate in groups to devise solutions on a wiki page. Discussion posts, student surveys and student interviews were analyzed to see the change in higher order thinking skill development. Results revealed online discussions encouraged the development of higher order thinking skills. When given the opportunity and time, students' examining others' comments encouraged the practice and development of thinking skills of analyzing and evaluating.

## INTRODUCTION AND BACKGROUND

### Introduction

According to Baylor and Ritchie (2002), traditional teaching tends to focus on imparting knowledge with the goal that students become a part of an educated society. In the 21<sup>st</sup> Century, the “educated” society is becoming more technologically advanced. For instance, Russell et al (2008) notes in the United States alone, more than 68% of the two hundred million people regularly use the Internet, and on average, over ninety-four million Americans use the Internet daily. With an ever changing, technologically driven society, the education needed to be successful in this environment demands different knowledge and skills from today’s students. Therefore, students not only need technology literacy but the skills to use technology to analyze, synthesize and create. In other words, K-12 education needs to infuse the use of technology and the development of higher order thinking skills in its best practice, particularly in science education.

### Rationale and Focus

Roschelle, Pea, Hoadley, Gordon, and Means (2000) argue that one of the failures of education from the 20<sup>th</sup> Century is the frequent lack of application of what students have learned in school to problems they encounter in the real world. Technology literacy coupled with higher order thinking skills can help bridge that gap. Hirose (2009) argues that technology skills learned in the classroom are transferrable to the workplace as most

employment opportunities today require the use of technology. Furthermore, Roschelle et al. (2000) states that technology can bring opportunities for students to participate in similar experimentation, design and reflection that professionals routinely do, using similar technology tools. The challenge, then, becomes that teachers carefully incorporate the use of technology with the purpose of developing higher order thinking skills so students are better prepared for the demands of the 21<sup>st</sup> Century.

Roschelle et al. (2002) further defend this argument by stating computer technology is useful in developing higher order thinking skills of critical thinking, analysis and scientific inquiry. Higher order thinking skills can be defined as the ability to synthesize information, solve problems, think critically, combine or generalize information, evaluate, hypothesize and arrive at logical conclusions. Astleitner (2002) adds critical thinking is the purposeful, self-regulatory judgment which results in interpretation, analysis, evaluation and inference. Furthermore, he adds that critical thinking is simply exercising higher order thinking skills including evaluating arguments.

The primary focus question of this study consisted of testing the effects of online collaboration on student development of higher order thinking skills. Would online discussions with a discussion prompt initiating deeper discussion have an effect on the development of the higher order thinking skills of analyzing, evaluating and creating? Furthermore, of these higher order thinking skills previously mentioned, which will be developed more? Finally, does a relationship exist between some types of discussion prompts and the thinking skill developed? The types of higher order thinking skills as outlined by Bloom's Revised Taxonomy can be seen in Table 1 below.

Table 1  
*Bloom's Revised Taxonomy of Higher Order Thinking Skills as seen in technology*  
 (Adapted from Churches, 2004)

Bloom's Digital Taxonomy	
Creating	Designing, constructing, planning, producing, inventing, devising, making, programming, blogging, wiki-ing, publishing
Evaluating	Checking, hypothesizing, critiquing, experimenting, judging, testing, detecting, commenting, posting, collaborating
Analyzing	Comparing, organizing, deconstructing, attributing, outlining, finding, integrating
Applying	Implementing, carrying out, using, executing, loading, playing, sharing, editing
Understanding	Interpreting, summarizing, inferring, paraphrasing, classifying, comparing, explaining, searching on web, blog journaling, twittering
Remembering	Recognizing, listing, describing, identifying, retrieving, naming, locating, bookmarking, social networking, googling

### CONCEPTUAL FRAMEWORK

Hirose (2009) states that engaging students in discovery based learning, reasoning, organizing and argumentation helps foster an environment where higher order thinking skills can be developed. Roschelle et al. (2002) argue technology can enhance how children learn by supporting four fundamental characteristics of learning:

- active engagement
- participation in groups
- frequent interaction and feedback
- connections to real world contexts.

Clearly having students engage in online collaboration evaluating arguments of real world problems can help foster higher order thinking skills. Chittleborough, Jobling, Hubber, and Calnin (2008) argue that using Web 2.0 activities that include problem solving, reflection and cooperation promote the development of higher order thinking skills. In Chittleborough's study, students from a variety of subject areas of all various ages were monitored while participating in a variety of Web 2.0 activities to see if the development of higher order thinking skills improved. The results of this study showed that when teachers use Web 2.0 technology in a student centered classroom rather than a technology centered classroom, students have a greater chance at developing thinking skills of analyzing, evaluating and creating.

In a study done by Hopson, Simms, and Knezek (2001-2002) with fifth and sixth grade students, pretests and post-tests were used to measure if students working in a technology enriched classroom had an effect on students' acquisition of higher order thinking skills. Hopson and colleagues found the learning environment consisting of the use of spreadsheets, databases, the Internet, and multi-media software caused students to score higher for analysis, synthesis and evaluation thinking skills. This study supports Baylor and Ritchie's (2002) argument that when technology is used as a tool to help students analyze, compare, contrast, and evaluate, the computer facilitates the students' internal cognitive processes by serving as an extension to their intellectual capacity which helps them thinking more critically. While the collaboration component was not included in this study, this study did show a positive influence the use of technology has on higher order thinking.

In a case study conducted by Yang (2009), a technology enhanced historical inquiry lesson promoted the use and development of critical thinking skills. The computer-based historical inquiry emphasized the “doing” of history and encouraged students to read, interpret, evaluate and synthesize different primary resources. Students used higher order thinking skills of planning and problem solving. Yang found this technology enhanced inquiry project challenged learners to conduct inquiry while facilitating the development of:

- historical thinking
- computer literacy
- critical thinking
- problem solving
- interpersonal skills
- teamwork skills.

This same pedagogical method of incorporating the use of technology in an inquiry-based learning experience in a collaborative setting can also develop higher order thinking skills.

Furthermore, technology can allow students to develop problem solving skills that can be used in social contexts. For instance, Neo and Neo (2009) found in one study the use of web-based communication allowed students to practice problem solving skills when confronted with collaboration challenges. In addition, a study completed by Chu, Hwang, and Tsai (2009) in an undergraduate computer programming class found that

students who were allowed to use a web-based communication forum experienced more success in collaboration and sharing of articles need for a project.

Barak and Shachar (2008) add with new educational goals of higher order thinking skills like problem solving, schools need to shift from traditional methods of delivering content to more constructivist-based instruction. Web based technology can be infused into a constructivist setting to develop higher order thinking skills through methods consisting of problem-based learning, project-based learning, reflective self-assessment, inquiry based teaching, web-based communication, experiment-based learning, as well as others. For instance, Hou, Chang, and Sung (2008) conducted a study analyzing the development of problem solving skills in an undergraduate information management course and found students' problem solving skills and collaboration skills increased when allowed to use the Internet for online collaboration while trying to solve a problem-based scenario. Furthermore, these researchers also found this coupling of constructivist teaching method with online collaboration was more helpful for student knowledge construction. Lastly, Baylor and Ritchie (2002) found in their study of 94 classrooms that if teachers used technology in a collaborative, constructivist manner, students developed higher order thinking skills more than if students were isolated or not learning in a constructivist setting. Clearly the use of Web based technology in collaborative settings can promote the development of higher order thinking skills.

A more specific use of technology that can be used in a variety of constructivist-consistent manners is the use of web-based blogs. Fessakis, Tatsis and Dimitracopoulou (2008) explain that blogs can be used to:

- collect learning resources
- share ideas or experiences
- log notes or observations during inquiry
- manage a project
- publish news
- develop online dialogue
- develop writing skills
- and develop collaboration skills.

They further argue that the use of blogs can engage students in in-depth learning, engagement and participation. Hirose (2009) adds that blogs can easily be used to have students develop higher order thinking skills such as evaluation-based thinking. Ferdig and Trammell (2004) note blogs can provide opportunities for reflection, analysis, comparison and contrast, knowledge construction and the development of content meanings. Teachers can incorporate the use of blogs for a variety of constructivist-based methods while having the opportunity to monitor the development of content understanding, communication skill development as well as the development of higher order thinking skills. Astleitner (2002) highlighted a study where discussions were compared between a traditional course to an Internet-based discussion forum and found the students to develop better critical thinking skills in the Internet-based discussions. Regardless of the platform for online discussion or collaboration, MacKnight (2000) argues that online discussions promote the development of critical thinking. Saeed, Yang and Sinnappan (2009) found in a study of approximately two hundred students in a web-

based programming course that students are more willing to collaborate online following the course demonstrating the benefits of using online discussions extend beyond the immediate learning.

Roschelle et al (2000) state computer technology can provide students with an excellent tool for applying concepts in a variety of contexts. Neo and Neo (2009) found in their study incorporating the use of multimedia in a constructivist learning setting that the technology allowed students to demonstrate creativity and problem solving skills. The demonstration of such skills provides the teacher with evidence to measure learning. Ferdig and Trammell (2004) also argue that the use of blogs provide students with the opportunity to publish their knowledge allowing the teacher and a public audience to review a student's learning. Furthermore, Neo and Neo found in their study the use of multimedia to present their learning and project findings developed positive attitudes towards learning and the use technology in the assessment.

While the literature seems to support the use of technology in developing students' higher order thinking skills, researchers have also discovered some concerns. Hirose (2009) argues that a necessity exists to find a balance between using the newest technology and traditional teaching methods. Hirose's concern has more to do with not under-valuing the content. However, as mentioned before, Liao and She (2009) have shown that the use of technology in a constructivist manner actually refines content understanding. Hirose also noted that some teachers have expressed frustrations of how to incorporate the use of technology in the classroom and not having enough time to learn the technology themselves.

It's important to add here the use of technology must be coupled with constructivist-based instructional methods. Simply adding technology use into traditional based teaching methods may only produce minimal results, if any. For example, McMahon (2009) conducted a study conducted in a metropolitan, independent all girls' school of one hundred and fifty students, a statistically significant correlation existed between the students' computer skills and the level of higher order thinking skills. In a study done in an undergraduate physiology class, Brahler, Quitadamo, and Johnson (2002) found students developed critical thinking skills by using online learning modules that required students to develop exercise prescriptions. While these studies support the development of higher order thinking through the use of technology, not all studies show this strong of a relationship. Cheong and Cheun (2008) in a study with thirty-five 13 and 14 year old students divided into six groups who were asked to solve ill-structured problems through online discussions found more than half of the responses demonstrated in-depth understanding. The authors did note that asynchronous online communication allows students to have more participating time to reflect on what others have said and how they wish to respond. Furthermore, Cheong and Cheung stated that electronic discussion can be used to effectively to teach critical thinking. Barak (2005) and Roschelle et al (2000) note that computer technologies in the classroom promote meaningful learning only when learners are engaged in knowledge construction, conversation, articulation, collaboration, authentication and reflection.

McLoughlin and Luca (2000) conducted a study with final year students at Edith Cowan University, students participating in online discussions were monitored and

analyzed to refine the structure of tasks of the course. The major goal of this study was to investigate the interactions that occurred in the online discussion forum and whether these contributed to knowledge creation. The researchers found that most of the forum messages were comparing and sharing of information where students elaborated on existing beliefs and knowledge. In other words, students expressed their own ideas and understandings and exchanged views with their peers without ever testing or revising anyone's ideas. The researchers concluded that the forum did not appear to foster some of the higher order thinking skills. To foster the support of higher order thinking, teachers should design tasks to require such thinking and teachers may need to scaffold such thinking. MacKnight (2000) also adds to this conclusion by stating teachers must use questions to start online discussions that focus on the fundamentals of thought and reasoning to develop critical thinking.

As Roschelle et al (2000) argued, the use of technology cannot only help students *how* to learn but the use of technology is helping students learn more and better things, such as the development of higher order thinking skills. Hirose (2009) adds the use of technology to develop higher order thinking skills is not only something that is expected all teachers to incorporate as outlined by the standards of the International Society for Technology in Education, but the use of technology in the classroom is better preparing students for the future. Just as technology is quickly advancing, so teachers must also make a shift in their pedagogical approach to enable students to develop higher order thinking skills. The use of technology in constructivist-based, collaborative methods creates an environment to promote the development of higher order thinking skills

needed to operate successfully in the 21<sup>st</sup> century. More specifically, Zawilinski (2009) adds when students are discussing with other students online through the use of Web 2.0 technology such as blogs or wiki discussion platforms, students are practicing higher order thinking skills when creating a comment that synthesizes a thought of others' previous comments. While a lot of research seems to support the use of Web 2.0 technology in collaborative means to develop higher order thinking skills, there also seems to be a body of research supporting the need that teachers need to exercise wisdom in implementing the use of technology.

## METHODOLOGY

My capstone project spanned over approximately three months beginning in January and ending in March. My primary question under study was, "What is the effect of online collaboration on the development of higher order thinking skills through the analysis of real-world problems?" Second, I looked to see which of Bloom's higher order thinking skills were developed more. Third, I looked specifically if the discussion prompt provided in the weekly blog had any influence on the level of thinking the students demonstrated in their online discussions.

This study was done with two ninth grade earth science classes in a rural district in Iowa. The school district is considered a Class 3A level consisting of slightly over four hundred students grades nine through twelve. The students' academic abilities ranged between the lowest achieving levels up to about the upper twenty-five percent in the class. The upper twenty percent took the class a year earlier. The classes consisted mostly

of Caucasian students and found in an agriculturally based rural community. Specifically, the demographics of this population are as follows:

Table 2  
*Class Demographics: Ethnicity*

Race	Latino	African	Caucasian	Asian	Multi
		American			
2 <sup>nd</sup> Block n=13	0%	0%	92%	0%	8%
3 <sup>rd</sup> Block n=28	0%	4%	96%	0%	0%
Total n=41	0%	2%	96%	0%	2%

Table 3  
*Class Demographics: Gender*

Gender	Male	Female
2 <sup>nd</sup> Block n=13	54%	46%
3 <sup>rd</sup> Block n=28	54%	46%
Total n=41	54%	46%

The project consisted of three phases. The first phase lasted one week and consisted of the introduction to the project. I spent three class periods demonstrating how the activity would be conducted over the next eight weeks. I started by showing the students the blog I created where students read about an existing, real environmental problem or discovery. Then, I showed the students the wiki page where the online discussions occurred. I also showed the students how to use the wiki page and even let them log in with their user names and passwords to do a “test run” prior to the first week of online collaboration. The students were randomly arranged in groups and these groups were given time each week in class to participate in the online conversations.

The next phase consisted of eight weeks where students participated in weekly collaborative online discussions. Following each new weekly blog post, a discussion prompt was given to promote the use of higher order thinking skills and online collaboration. This is an important component as MacKnight (2000) states that a question that focuses on the fundamentals of thought and reasoning must be used to promote the development of critical thinking. The first blog post used to introduce students to the project can be seen in Appendix A. The following is an excerpt from the first blog where students were asked to converse on the wiki page for the first time.

In the Djurab desert of central Africa, scientists have discovered two new species of saber-toothed tigers. In this same region, scientists have also found fossils of a 6.5 to 7.5 million year old human-like, chimp-like human ancestor...Finding fossils of early human ancestors with fossils of saber-toothed tigers in similar fossil beds enough to argue that these early human ancestors would have been prey to these tigers? Defend your view. Also, consider what evidence one would expect to find if this were a real possibility.

Students read the blog post and then started researching and presenting their ideas and comments on a wiki page. Each group was encouraged to comment beyond the usual "I agree" type comments and contribute something that could keep a discussion going. I requested that each student post a minimum of two times per week, but I encouraged students to post more until a discussion seemed complete. At the end of each week, I

analyzed the student conversations and categorized each comment as one of Bloom's higher order thinking skills (Appendix B). The following descriptions of Bloom's Higher Order Thinking Skills were used to maintain consistency in analyzing the student comments.

Table 4  
*Bloom's Revised Taxonomy (Adapted from Westphalen, 2011)*

<b>Bloom's Revised Taxonomy of Thinking Skills</b>	
<b>Thinking Skill</b>	<b>Description</b>
Creating	Generating original ideas, products or ways of viewing things; Designing, constructing, planning, producing, inventing.
Evaluating	Justifying a decision or course of action; Checking, hypothesizing, critiquing, experimenting, judging
Analyzing	Breaking information into parts to explore understandings and relationships or patterns; Comparing, organizing, deconstructing, interrogating, finding
Applying	Using information in another familiar situation; Implementing, carrying out, using, executing
Understanding	Explaining ideas or concepts; Interpreting, summarizing, paraphrasing, classifying, explaining
Remembering	Recalling information; Recognizing, listing, describing, retrieving, naming, finding.

For example, the following wiki post made by a student exemplifies the thinking skill of analyzing as she was seeking to find a solution to why oyster populations have decreased by nearly 90% in many locations around the world:

I think that they should take a small population of the oysters from the ocean and study the disease that they might have. Maybe they can find a

possible cure for it. They could also try to raise the population by keeping a small amount in captivity (Student Wiki Comment, 2/11/2011).

While this comment does demonstrate the lower three thinking skills, it was categorized as analyzing because she is interrogating the problem and breaking the situation down into investigative parts. Each student's individual comment in each week's conversation was read and analyzed in a similar manner.

Each Monday, I provided feedback on students' comments and introduced the next blog post. McLoughlin and Luca (2000) concluded that student collaboration online needed scaffolding with a clear direction provided by the teacher to support higher order thinking development. Therefore, I used the Monday of each new week to give some constructive feedback on good discussions that exemplified higher order thinking skills. Some discussions were presented to the class to help them see exemplary discussions for each of the higher order thinking skills.

The final phase consisted of the final data collection consisting of the student surveys and student interviews. Students involved in this study completed a survey using a Google docs form (Appendix C). Student interviews were also conducted (Appendix D). The application of the survey and interview, along with the data collected during the eight weeks of discussion, are summarized in Table 5 below.

Table 5  
*Triangulation Matrix*

<b>Probing Questions</b>	<b>Data Source 1</b>	<b>Data Source 2</b>	<b>Data Source 3</b>
Primary Question: What is the effect of online collaboration on student development of higher order thinking skills?	Number of Bloom's taxonomic levels identified in responses to weekly wiki discussions	Student Surveys	Student Interviews
Secondary Question: Of Bloom's taxonomic higher order thinking levels, which seems developed more?	Number of Bloom's taxonomic levels identified in responses to weekly wiki discussions	Student Surveys	Student Interviews
Secondary Question: Is there a relationship between the type of Discussion Prompt and the thinking skill developed?	Comparisons of higher order thinking skill use frequency among students	Student Surveys	Student Interviews

## DATA AND ANALYSIS

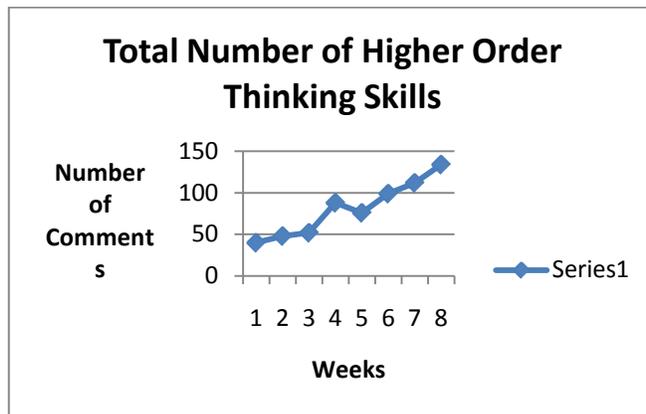
Each of the study questions will be looked at more in depth by examining data from student comments, student surveys and student interviews.

### Effects of Online Collaboration on Higher Order Thinking Skills

Following the first week of data collection, I found forty of the sixty-eight comments (nearly 59%) were analyzed as one of Bloom's top three higher order thinking skills. However, I was a little disappointed in the low number of student responses. By

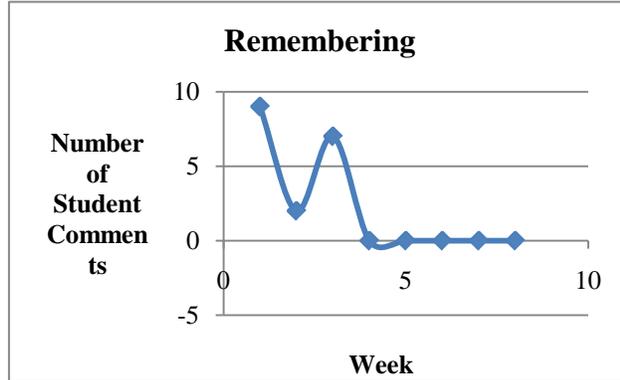
week eight, I found that 134 of the 156 (nearly 86%) of the student comments were categorized as higher order thinking skills. After eight weeks of analyzing the comments posted by forty-one students, the following trends surfaced.

First, the overall number of comments demonstrating higher order thinking skills increased in thirty-seven of the forty-one students. Frequency of each higher order thinking skill for each student was plotted over the eight weeks and linear trend lines were applied to see if a positive increase existed over the eight weeks. Figure 1 demonstrates the increase in the number of comments demonstrating thinking skills categorized either as analyzing, evaluating or creating.



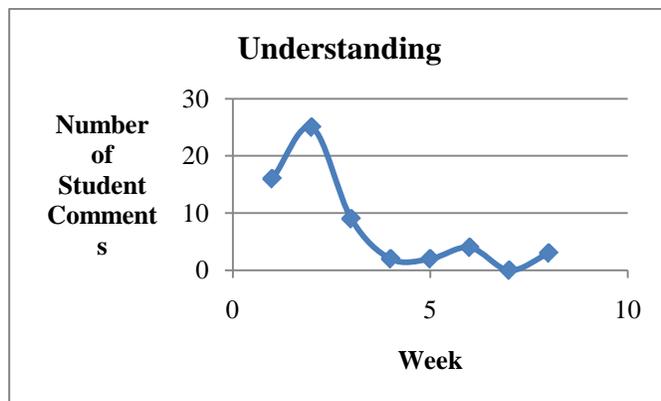
*Figure 1.* Total Number of Higher Order Thinking Skills.

The frequency of student comments for each taxonomic level of thinking skill was plotted individually over the eight weeks as seen in the following graphs. All three of the higher order thinking skills showed increases over the eight weeks. These trends are shown in figures 5, 6, and 7.



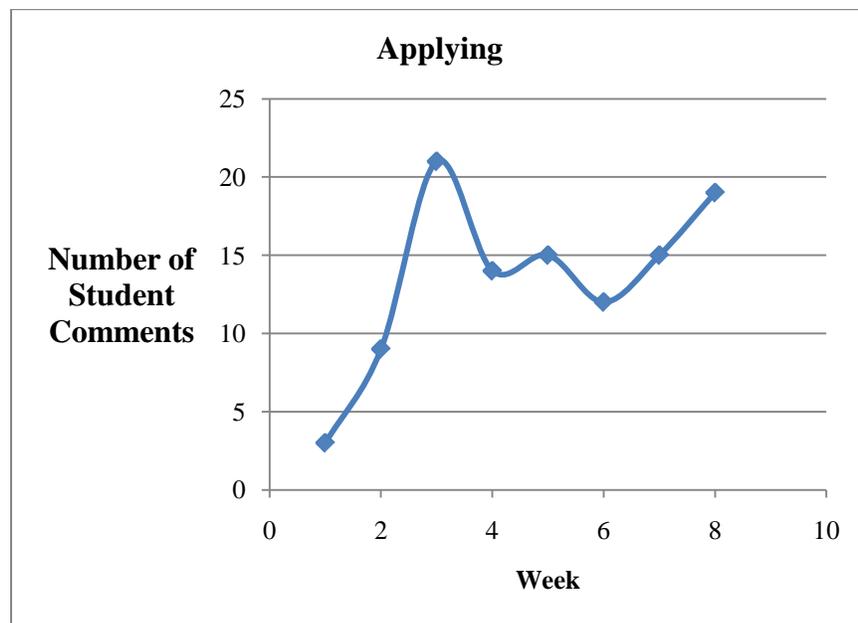
*Figure 2.* Student Comments Categorized as “Remembering.”

Initially, a large number of student comments could only be categorized as “remembering.” Examining a discussion between two students from week one of the project revealed students were only reading and reporting on what was posted in the blog without in-depth discussion (Appendix E). One particular student (Student B) attempted to go beyond the remembering level by introducing a new idea. However, the new idea was not justified in any way. Responses that would have been categorized at a higher level would have included discussion identifying possible cause and effect relationships justified with evidence to support their hypotheses. Further evidence of the lack of higher order thinking skills demonstrated in student conversations is seen in Figure 3.



*Figure 3.* Student Comments Categorized as “Understanding.”

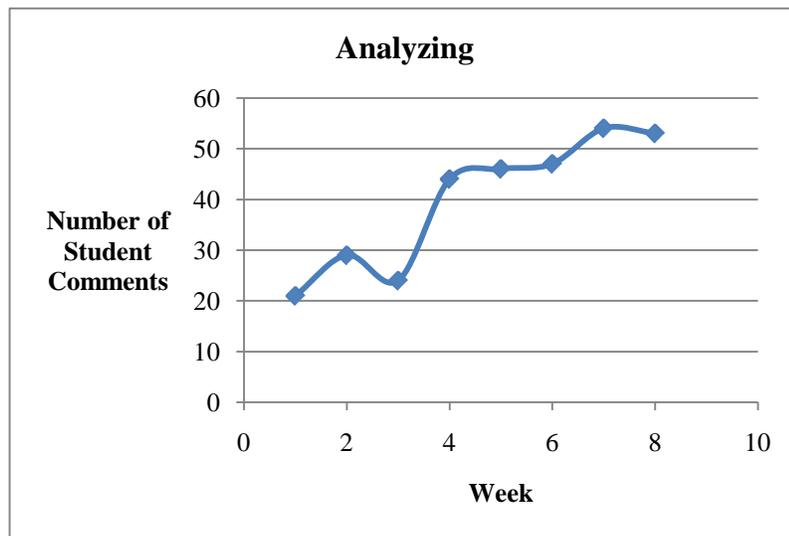
The third week online conversations showed an increase in the number of responses that went beyond the remembering or understanding levels of higher order thinking skills. On Monday of that week, I presented the new blog post again but encouraged the students to “dig deeper” into their discussions. Furthermore, I encouraged students to explore possible cause-effect relationships and to deconstruct the event on the blog post into parts and relationships.



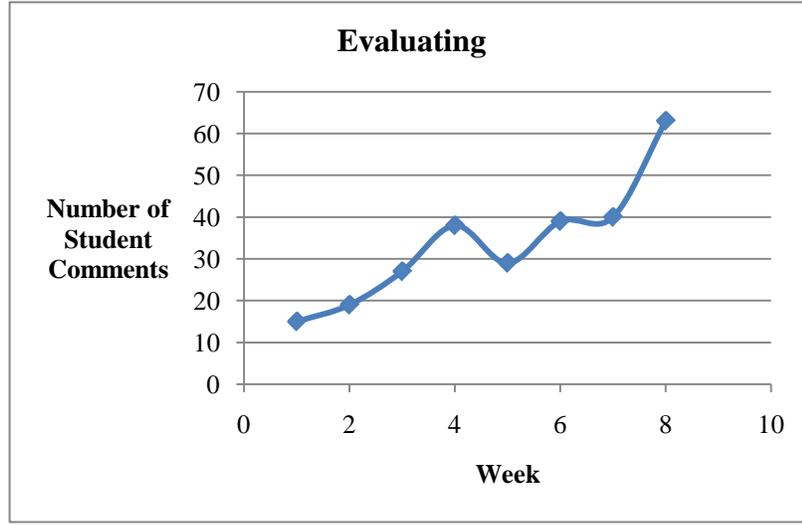
*Figure 4.* Student Comments Categorized as “Applying.”

A full discussion (Appendix F) of one group from week three demonstrated an increase in both the total number of comments as well as those categorized as applying and analyzing. This discussion revealed a greater use of higher order thinking skills. All three students were applying knowledge and understanding from their personal lives to try to solve this mystery. Personal experiences were referenced in an attempt to understand and solve the mystery demonstrating a use of thinking higher than the remembering and understanding levels.

The last few weeks of the project revealed an improvement in the development and use of analyzing and evaluating thinking skills. Student comments demonstrated a greater use of investigating cause-effect relationships and a critique of each other's ideas and arguments. I also witnessed students demonstrating research by posting website links in their discussion posts. Figures 5 and 6 show the increase in these thinking skills. Furthermore, Appendix G logs a discussion where students demonstrate the use of analyzation and evaluation.

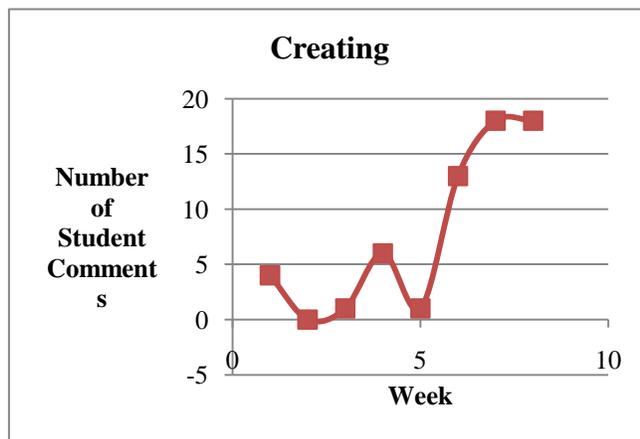


*Figure 5.* Student Comments Categorized as “Analyzing.”



*Figure 6.* Student Comments Categorized as “Evaluating.”

In the final two weeks of the project, there was an increase in students’ use of Bloom’s highest level of thinking, as seen in Figure 9.



*Figure 7.* Student Comments Categorized as “Creating.”

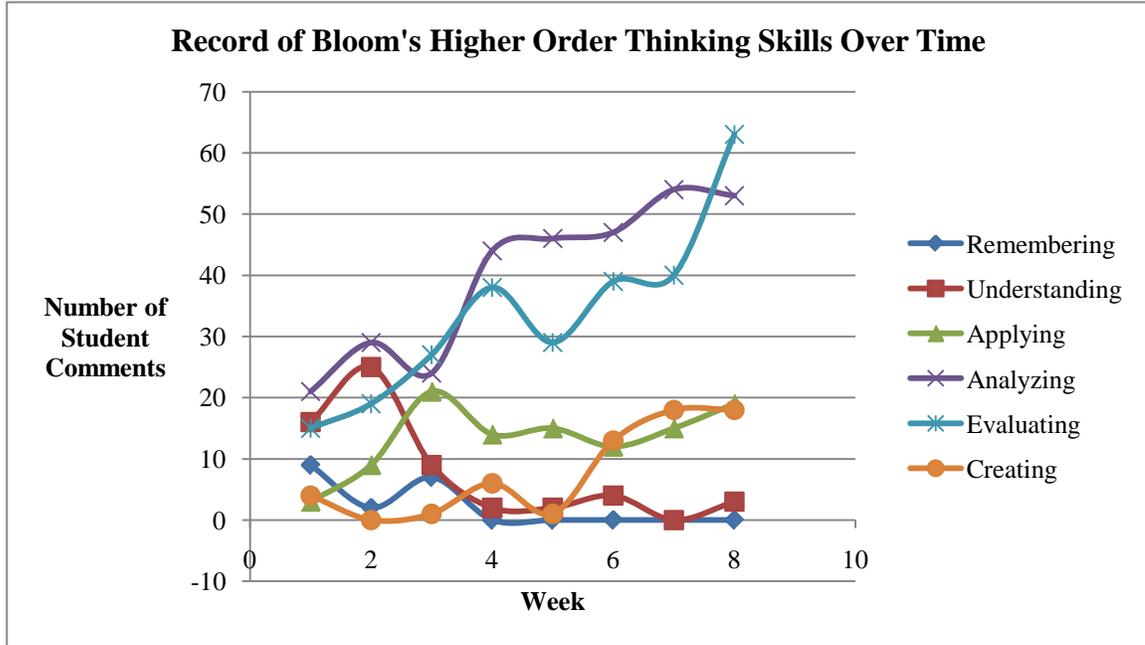
In Appendix H, a discussion between three students demonstrates thinking characterized as creating, such as planning and designing ways to solve a problem. An excerpt from this discussion is in Table 6 below. The discussion demonstrates the thinking

needed to generate a plan or system to solve the problem of controlling a violent crustacean.

Table 6  
*Group Discussion Excerpt Demonstrating the “Creating” Thinking Skill*

Student “A”	Maybe we could use some type of fishing net to catch the shrimp like creatures. After all that is how we catch our shrimp...Also, Interactions between villosus and native gammarid species can result in displacement or local extinction of native species, thereby reducing biodiversity.
Student “B”	Yes, maybe if we find a way they are helpful to humans and money can be made off of them more fisherman will fish for them and if enough fisherman do that it will control the spread
Student “C”	Yes, that could help is that way we could study them and figure out how they came about.
Student “A”	I don't know how much help they would be to the fishermen. Yes, we probably could make money from them, but I don't see how they would help us. These killer shrimp are killing the fish that the fishermen try to capture. So I'm sure the fishermen just want these killer shrimp to disappear.
Student “B”	I think if we could learn how to control the shrimp they could possibly be a good thing because we might be able to use them to control other organisms that are got out of control or something like that.

Figure 8 below combines the individual graphs of Thinking Skills into one chart.



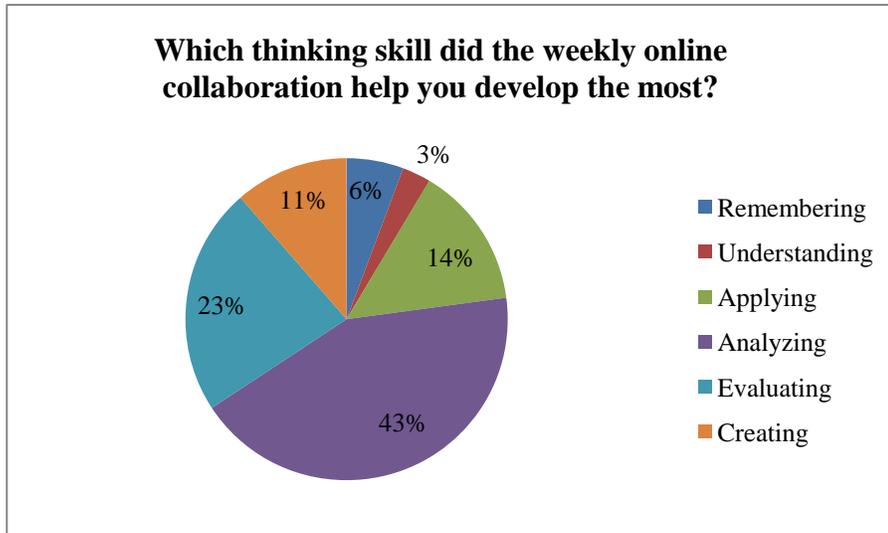
*Figure 8.* All Six Thinking Skills over the Eight Weeks.

The data in Figure 8 reveals that over the duration of the capstone project, students increased their use of higher order thinking skills. Furthermore, the use of the lower two thinking skills of remembering and understanding seemed to be replaced with comments that could be characterized as deeper or more critical in nature.

Using the wiki page as a means for students to collaborate online seemed to have a direct, positive impact on the development of higher order thinking skills, particularly analyzing and evaluating. However, before cementing this hypothesis as a conclusion, student surveys and interviews were examined to support this claim.

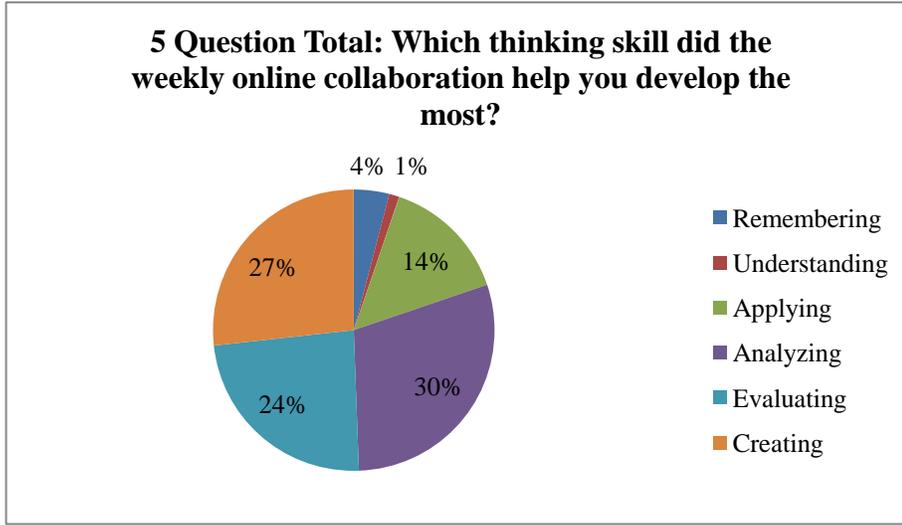
The student survey (Appendix C) began with questions regarding which thinking skill the weekly blog and wiki discussions helped develop the most. I asked this question five times but substituted a different word for each type of thinking skill. For example, in question one, I used the words, “remembering, understanding, applying, analyzing,

evaluating and creating” and in question three I used words, “define, paraphrase, solve, contrast, formulate and summarize.” This was done to obtain enough evidence to see from the students’ perspective which of Bloom’s six thinking skill categories the students felt was developed the most.



*Figure 9.* Student survey results on which thinking skill was developed the most.

Results from question one demonstrate that 77% of the students felt that the weekly blog and wiki discussions promoted one of Bloom’s top three thinking skills. Furthermore, analyzing scored the highest. Results of the repeated question are summarized in Figure 10.



*Figure 10.* Five Question Summary of Which Thinking Skill was Developed the Most.

Seventy-one percent of the students felt the weekly blog and wiki discussions developed one of the top three higher order thinking skills the most. This is consistent with the previously analyzed student discussion data.

Further support came in an interview with one student as seen in Appendix I. When asked specifically how wiki discussions helped her thinking, the student responded,

They made me think more about what we were reading, not just repeating what we were reading but had to think about a solution to the various problems. Reading others' posts helped contribute to my own ideas and combine them into one. And, they made me refine my own ideas better.

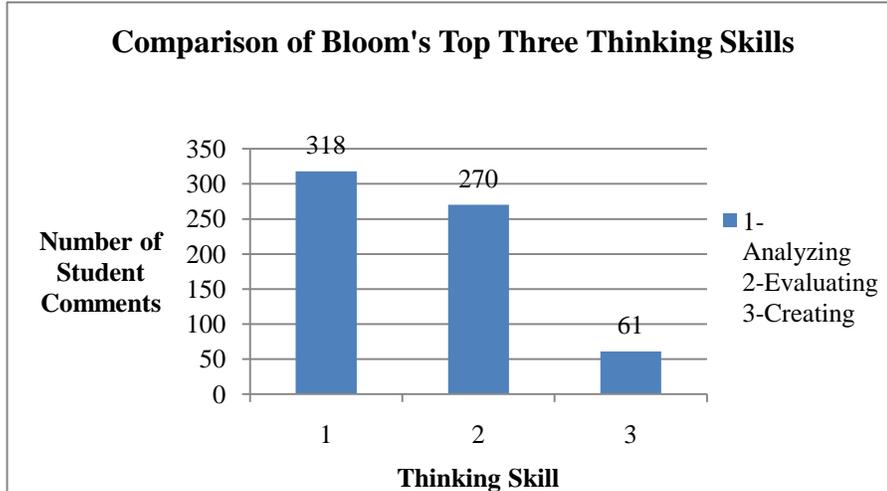
This response supports what MacKnight (2000) stated, “online discussions provide a platform where students can exchange ideas, increase participation among group members and promote the use of critical thinking.”

Another student commented, “The online discussions helped me to think in depth and I needed to consider others’ opinions which only helped me make mine more clear.” She also added the online discussions gave her more time to think rather than trying to think of things on the spot.

The student comment data, student surveys and student interviews all support that online collaboration does aid the development of higher order thinking skills, particularly analyzing and evaluating.

#### Determination of Which Thinking Skill was Most Developed Through Online Collaboration

When examining the secondary question, “Of Bloom’s higher order thinking skills, which one seems to be developed more?” the same three data sources indicate that analyzing and evaluating were more developed among students than the other thinking skills. When comparing the data between the top three thinking skills (analyzing, evaluating and creating) students made more comments categorized as analyzing than the either evaluating or creating. Figure 11 demonstrates this.



*Figure 11.* Comparison of Bloom's Top Three Thinking Skills.

In addition to this data, examining the results from the student surveys, students felt the thinking skill of analyzing was developed the most receiving thirty percent of student responses as seen in Figure 10.

Furthermore, a student commented in an interview:

The weekly discussions online helped me to talk things out and solve problems. It not only helped with explanations but they gave me more time to think and plan. I had more time to look things up on Google and base my opinions on specific things using what I found along with what others thought. They also helped me be more open minded.

In this thorough explanation, this student is demonstrating that he gained abilities to break things into parts to explore understandings and relationships, which is consistent with the thinking skill of analyzing.

The third question that I studies involved the relationship between the type of blog discussion prompt and the thinking skill developed. Using the descriptions for the higher order thinking skills in Table 4, I analyzed the type of question in my blog discussion prompt. A table showing the category of Bloom's thinking skill associated with the blog discussion prompt is in Table 7.

Table 7  
*Comparison of Blog Prompt and Bloom's Taxonomy*

<b>Blog Discussion Starter</b>	<b>Required Activities</b>	<b>Highest Level of H.O.T.S Promoted by Question</b>
Is finding fossils of early human ancestors with fossils of saber-toothed tigers in similar fossil beds enough to argue that these early human ancestors would have been prey to these tigers?	Research, Discover, Retrieve, Infer, Search Deeply	Understand
Are the UFO advocates too fictional in their thinking or do they really have an argument?	Dissect, Judge, Evaluate, Test	Evaluate
Discuss in your groups what solutions could be implemented to allow these populations to recover (if they can) and WHY these solutions would work	Research, Choose, Evaluate, Test, Hypothesize, Devise	Create
Will these nets work? How would you go about making sure something like this will work? Are the nets a waste of time?	Research, Test, Compare, Judge, Evaluate, Predict	Evaluate
Have swarms occurred in Arkansas before? If so, were these related to increases in well drilling or the New Madrid Fault? Could there be other causes? What evidence exists?	Research, Discover, Dissect, Defend, Debate, Judge, Predict,	Create

Evaluate, will this work? Why or why not? Are sheep the only animal with this capability?	Judge, Discuss, Debate, Test, Evaluate	Evaluate
If you were a scientist invited to investigate this claim, what would be your next step? How might you go about verifying if this claim is really true or accurate	Compose, Hypothesize, Devise, Conduct or Experiment, Role-Play	Create
What are some possible solutions to either eliminate or control the spread of this killer species?	Hypothesize, Judge, Evaluate, Predict, Test,	Create

To determine whether a relationship existed between the thinking skill promoted by the blog prompt and the actual responses, I compared the percentage of those comments on the week(s) the thinking skill was promoted to the percentage of those same comments on the week(s) a different thinking skill was promoted. Tables 8 through 10 show these comparisons. The top row of each table sums the comments for the week(s) that particular thinking skill was promoted; the bottom row sums the same comments for the week(s) a different skill was promoted.

Table 8  
*Comparison of Understanding Comments*

Weeks	# Understand	Total	% of Total
1	16	68	23.5
2 through 8	45	768	5.9

Table 9  
*Comparison of Evaluating Comments*

Weeks	# Evaluate	Total	% of Total
2,4,6	96	303	31.7
1,3,5,7,8	174	533	32.6

Table 10  
*Comparison of Creating Comments*

Weeks	# Create	Total	% of Total
4,6,7,8	55	502	11.0
1,2,3,5	6	334	1.8

From examining this data, there seems to be some relationship between which thinking skill is promoted and the actual use of that thinking skill in the online discussions. However, this relationship is not a strong one. Higher order thinking skills are being practiced regardless of what thinking skill is promoted in the blog.

When looking at any of the top three thinking skills, higher order thinking skills were demonstrated in student responses 79.3% of the time when they were promoted. In contrast, when a lower thinking skill was promoted as in week one, higher order thinking skills showed up 58.8% of the time. While promoting the higher order thinking skill helps, there seems to be a high frequency of higher order thinking skill use despite what skills are promoted through the blog discussion prompt.

When surveyed, 80% of students polled stated the use of blogs had a positive effect on their development of critical thinking skills. Furthermore, when students were surveyed and asked if the use of blogs and online discussions were more helpful than face to face discussions, 85.3% were in agreement that there was a positive impact.

When interviewing students about the impact the blogs had on the development of higher order thinking skills, one student replied, “Yes, they helped me learn deeper thinking skills better. The variety of stories and situations made me think differently and encouraged me to look online for answers.” Another student replied,

Yes and No. Sometimes I need additional information and would like a teacher explain it to me and I don't have it in front of me. However, there are also times I get annoyed when teachers keep explaining something I already know. With blogs, I can read it once to get what I need.

In conclusion, while the use of blogs, the situations presented in the blogs and the discussion prompts all had a positive impact on the student development of higher order thinking skills, the factor with the most significant impact was the student online collaboration.

#### INTERPRETATION AND CONCLUSION

Students conversing online in collaborative groups improved their abilities to think at higher levels. Over the course of the eight weeks, I witnessed students' abilities to analyze each other's responses improve. As Baylor and Ritchie (2002) found, students working in collaborative groups and receiving feedback from their peers challenged their own thinking and caused students to refine their understanding and improving their higher order thinking. In a discussion centered on the use of sheep to clean up soils contaminated with TNT, students challenged and refined each other's thinking. This discussion is in Table 9 below.

Table 11  
*Discussion Where Students Challenge and Refine Each Other's Thinking*

Student A	"It's possible that this will work but what could happen to the sheep's health?"
Student B	"Yah. If it's not in the feces of the sheep it must be all disintegrated into the meat of the sheep."
Student C	"Well, you are not eating the TNT if you are eating the sheep's meat. The TNT is all broken down and that is why no traces are found in the feces. That

	is why they are using the sheep and I think it will be ok to eat.”
Student A	“Ok, but it still might be possible the sheep could be affected. They should at least put them in a protected area.”
Student C	“Ok, they could at least do that.”
Student B	“So it sounds like our conclusion is that the sheep is a good conclusion to clean up the soils but still protected from being eaten.”

This was also evident in student interviews as numerous students mentioned how the online conversations made them rethink their responses. One student stated, “The wiki discussions allowed me to have others’ input contribute to my own ideas and then combine them into one. They made you refine your ideas.” Furthermore, this encouraged students to do research to develop support for their defenses in the conversations which also helped the development of higher order thinking skills.

Specifically, analyzing and evaluating were the thinking skills which showed the greatest growth. Initiating the discussions by posting a prompt that expected students to use these skills helped; but even when the discussion prompt did not promote either of these skills, a large number of students still demonstrated these thinking skills. While the discussion prompt did impact the level of student thinking, I was encouraged to see an increase in the use of higher order thinking skills, specifically analyzing and evaluating, even when the discussion prompt didn’t necessarily call for the use of these skills.

A few changes for future use of this technology surfaced in my project. First, I learned that if a topic posted in the blog wasn’t very interesting or relevant to students, there was not as much creative, original thinking in the discussions. Moreover, if the blog post covered a topic that was too difficult or complex, the students’ conversations also revealed a lack of interest or participation. Consistent with Chittleborough’s (2008)

findings, I will keep the use of blogs and other uses of Web 2.0 technologies student centered, relevant and problem solving based to promote the development of higher order thinking skills.

Secondly, I realized students need scaffolding to meet these expectations. MacKnight (2000) clearly communicates that teachers must provide adequate support for students in giving timely feedback to help the development of higher order thinking skills. Weekly discussions where I would show student conversations that demonstrated the different thinking skills seemed to have a significant impact on students' understanding of the thinking skill expectations. McLoughlin and Luca (2000) discovered without the scaffolding and promotion of knowledge creation, students basically communicated in lower order thinking. This use of scaffolding positively promotes the development of higher order thinking skills, especially when using Web 2.0 technology in a collaborative setting.

#### VALUE

Moving forward in the 21<sup>st</sup> Century has created a need for students to have abilities to think at higher levels. McLoughlin and Luca (2000) state that students must be able to go beyond the information given and must adopt a critical stance and have the ability to evaluate and problem solve. Having weekly blog posts and online collaborative discussions clearly helps develop these skills in students. Furthermore, when students receive critical feedback from their peers, students are motivated to research, refine and defend their views more carefully.

Personally, this project helped me see how relevancy certainly promotes student interest and participation, which is necessary before any development in thinking abilities can be accomplished. Secondly, communicating and clarifying expectations plays a vital role in scaffolding student progress. Students develop at different rates and some students need additional time and support to develop the same thinking abilities as others.

Teachers wishing to implement more Web 2.0 technology in their classrooms would benefit from the findings of this capstone project. First, online collaboration gives students time to develop sound conclusions and defenses that otherwise wouldn't be developed in a classroom setting. Secondly, teachers need to be careful to provide the necessary support to promote the development of higher levels of thinking.

Often administrators are interested in improving student achievement data. Having students collaborate online provides a platform for students to develop the thinking skills that could help improve their test scores. With the user friendliness of blogs and wiki pages, teachers and administrators could easily implement a strategy of using Web 2.0 technology to improve student achievement data while also learning of classroom content.

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APPENDICES

APPENDIX A

FIRST BLOG POST

## First Blog Post

New Year's Eve in 2011 in Arkansas was not the typical New Year's Eve. People in towns in Arkansas were reported stating they saw birds falling out of the sky on New Year's Eve. Thousands of birds were taken to the National Wildlife Health Center in Wisconsin for further study. Thousands of other birds were reported dead in Louisiana and Kentucky.

What could have caused this mass die-off?

Review the facts and discuss what could have caused this death:

1. The deaths occurred at night
2. Dead birds studied showed signs of bruising
3. Large numbers of birds were dieing at around the same time
4. The deaths occurred on New Year's Eve

Review this list, do your own research, and most importantly, **THINK CRITICALLY** to create a theory on how these birds died.

APPENDIX B

STUDENT "X" CATEGORIZED WEEKLY RESPONSES

## Student "X" Categorized Weekly Responses

Week	Remembering	Understanding	Applying	Analyzing	Evaluating	Creating	Other	Total
1	1	1						2
2					2			2
3		1		1	2			4
4			1	1	2			4
5				1	2			3
6				1	1	2		4
7				1	2	1		4
8				1	2	1		4

APPENDIX C  
STUDENT SURVEY

## Student Survey

Please answer the following questions as accurately as possible.

1. Which of the following words best describes what thinking skill you feel the weekly online collaboration helped you develop the most?
  - Remembering
  - Understanding
  - Applying
  - Analyzing
  - Evaluating
  - Creating
  
2. Which of the following words best describes what thinking skill you feel the weekly online collaboration helped you develop the most?
  - Recite
  - Restate
  - Choose
  - Investigate
  - Hypothesize
  - Critique
  
3. Which of the following words best describes what thinking skill you feel the weekly online collaboration helped you develop the most?
  - Define
  - Paraphrase
  - Solve
  - Contrast
  - Formulate
  - Summarize
  
4. Which of the following words best describes what thinking skill you feel the weekly online collaboration helped you develop the most?
  - Memorize
  - Illustrate

- Modify
  - Investigate
  - Develop
  - Compare
5. Which of the following words best describes what thinking skill you feel the weekly online collaboration helped you develop the most?
- Name
  - Paraphrase
  - Carry out
  - Organize
  - Judge
  - Make
6. The use of blogs helped me think more critically about problems and solutions
- Strongly Disagree
  - Disagree
  - Slightly Disagree
  - Slightly Agree
  - Agree
  - Strongly Agree
7. The online discussions helped me develop the ability to evaluate others' comments, ideas and opinions.
- Strongly Disagree
  - Disagree
  - Slightly Disagree
  - Slightly Agree
  - Agree
  - Strongly Agree
8. The online discussions helped me to learn how hypothesize possible solutions better.

- Strongly Disagree
- Disagree
- Slightly Disagree
- Slightly Agree
- Agree
- Strongly Agree

9. The online discussions helped me develop a better ability to design experiments.

- Strongly Disagree
- Disagree
- Slightly Disagree
- Slightly Agree
- Agree
- Strongly Agree

10. The online discussions helped me develop an ability to compare and contrast two opposing ideas better.

- Strongly Disagree
- Disagree
- Slightly Disagree
- Slightly Agree
- Agree
- Strongly Agree

11. The use of blogs and online discussions were more helpful in learning problem solving skills than if I was working in a group in person.

- Strongly Disagree
- Disagree
- Slightly Disagree
- Slightly Agree
- Agree
- Strongly Agree

12. The online discussions were helpful in learning problem solving skills
- Strongly Disagree
  - Disagree
  - Slightly Disagree
  - Slightly Agree
  - Agree
  - Strongly Agree
13. I gained a better understanding about the problems and solution ideas by discussing them online rather than in person with a group
- Strongly Disagree
  - Disagree
  - Slightly Disagree
  - Slightly Agree
  - Agree
  - Strongly Agree
14. I gained a greater ability in designing possible experiments through online discussions rather than group discussions in person
- Strongly Disagree
  - Disagree
  - Slightly Disagree
  - Slightly Agree
  - Agree
  - Strongly Agree
15. Discussions online help me learn better than group discussions in person
- Strongly Disagree
  - Disagree
  - Slightly Disagree
  - Slightly Agree
  - Agree

Strongly Agree

16. Using the Internet to work in groups has advantages in learning over group work in person

Strongly Disagree

Disagree

Slightly Disagree

Slightly Agree

Agree

Strongly Agree

17. I feel I can think at my own pace better when discussing ideas with a group online rather than in person

Strongly Disagree

Disagree

Slightly Disagree

Slightly Agree

Agree

Strongly Agree

18. I feel safer to make comments and participate in group discussions online rather than in person

Strongly Disagree

Disagree

Slightly Disagree

Slightly Agree

Agree

Strongly Agree

19. Most students would benefit from online discussions rather than in person group discussions

Strongly Disagree

Disagree

- Slightly Disagree
- Slightly Agree
- Agree
- Strongly Agree

20. Participating in group discussions online overall benefited my abilities to think in deeper ways

- Strongly Disagree
- Disagree
- Slightly Disagree
- Slightly Agree
- Agree
- Strongly Agree

21. Participating in group discussions online overall benefited my abilities to problem solve

- Strongly Disagree
- Disagree
- Slightly Disagree
- Slightly Agree
- Agree
- Strongly Agree

APPENDIX D

INTERVIEW QUESTIONS

Interview Questions

1. What is your overall impression from participating in online discussions?
2. Did you find discussing things in a group helpful? How so? (or why not?)
3. Did you find any benefits in having these discussions online?
4. Did reading others' comments help your thinking through the problem scenarios? *How* did reading others' comments in group help your thinking?
5. How might your participation been different if you were discussing the problem scenarios in person rather than online?
6. What forms of technology should teachers be using?
7. What forms of technology should you be using now in classes to help you for your future?

APPENDIX E

WEEK ONE DISCUSSION SAMPLE

Week One Discussion Sample

The blog post was reporting on the mysterious number of bird deaths in the Midwest on New Years Eve:

Student A: "I think the dead birds died due to the trees. The birds were found below the trees."

Student B: "It could be because of the trees but it could also be because of the air. Maybe the air was polluted."

APPENDIX F

WEEK THREE DISCUSSION SAMPLE

## Week Three Discussion Sample

Discussion posts from week three exemplifying an increase in application thinking skills

**Student “A”**

I think that they were man-made, because they look like the religious symbols and because people admitted to it being a prank. What do you guys think?

---

**Student “B”**

i think someone could of went out there at night time and did it with a harvester or something. I don't think there are aliens

---

**Student “A”**

So you don't believe in aliens at all?

---

**Student “C”**

I think it's possible aliens are real but most crop circles are man-made because there is no evidence suggesting that aliens have visited our plant.

---

**Student “B”**

I don't think there are aliens on earth but it could be possible I guys what if someone could of went out there in the night and cut all those rice stocks

---

**Student “C”**

Someone could have but think about how much time that would take... They would need more than one person, they would need a team.

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**Student “A”**

Yea, I really think that I was man-made. But I watched a movie one time called The Fourth Kind, and I don't know if it's the movie is fake or not but it was interesting. And there isn't anything that proves that aliens are fake or real so I honestly think it's a possibility.

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**Student “C”**

I agree.

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**Student “B”**

So I think our conclusions should be that they are man-made but a group of people could of went out in the night to do this so it would make people wonder what was going on.

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APPENDIX G

ANALYZING / EVALUATING DISCUSSION SAMPLE

## Analyzing / Evaluating Discussion Sample

**Student “A”**

This is pretty cool how there is new life other than on earth, but now it opens up a new thought about the earth and how we can live in outer space. But was there more bacteria on the meteorite?

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**Student “D”**

I think to see if this is real, they should go look for more DNA. Maybe this bacteria came off of a human that went to outer space. My next step to making sure this is real would be to just verify that it isn't a human's bacteria.

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**Student “C”**

I think that the new life found will make us ask more questions. Like if there is other life somewhere in the universe? And it could possibly lead to new discoveries.

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**Student “B”**

I think if I were one of those scientists invited and we found something I would keep looking at it and not get too excited about life outside of Earth.

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**Student “C”**

I agree with (Student D). We need to start looking for more DNA and other signs of life. We should make sure that this bacteria isn't a harm to humans or animals.

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**Student “B”**

I think it can be good and bad for new life such as we could lose money or get hurt looking. But it could also get us more money and give new alternatives to things.

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**Student “A”**

I'm hoping that the bacteria came from a human and so they can try to find life in outer space and it will lead to more discoveries.

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**Student “B”**

Ya, I agree with both of you because we cannot risk us or other species to get around this bacteria and it be harmful because that would be a lot worse than it is to just look at it.

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**Student “D”**

What kind of life do you think could exist? Wouldn't they need food and water just like any other bacteria cells? And where do they get the food and water?

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**Student “C”**

I think that the bacteria should be tested more to insure that is a new undiscovered form.

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**Student “B”**

It would need oxygen to grow also.

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**Student “A”**

The outer space is too big to be thinking what's out there, there could be everything but no one will ever know because you can't find everything.

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**Student “D”**

And they don't have oxygen in the outer space. So how can life live there?

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APPENDIX H

WEEK EIGHT DISCUSSION SAMPLE

## Week Eight Discussion Sample

The following is a discussion between three students taken from week eight of the capstone project. The week's blog was about a fast growing, uncontrollable killer crustacean interrupting fisheries in eastern countries.

Student "A"

We need to find a way to kill of these crustaceans. To do so we need to capture some of this shrimp and study their habits. We can also do tests on them to figure out what can kill them or help reduce their numbers. Everything can be killed or dies off from something, but we these killer shrimp we just need to find out what that is.

Student "B"

Since we are making improvements in the field of genetic engineering, maybe we could figure out how to genetically alter how much the shrimp is able to reproduce

Student "A"

Maybe we could use some type of fishing net to catch the shrimp like creatures. After all that is how we catch our shrimp. Granted we wouldn't be able to get all the fish from one little net, but it would help a lot.

Also, Interactions between villosus and native gammarid species can result in displacement or local extinction of native species, thereby reducing biodiversity.

Student "B"

Yes, maybe if we find a way they are helpful to humans and money can be made off of them more fisherman will fish for them and if enough fisherman do that it will control the spread

Student "C"

Yes, that could help is that way we could study them and figure out how they came about.

Student "A"

I don't know how much help they would be to the fishermen. Yes, we probably could make money from them, but I don't see how they would help us. These killer shrimp are killing the fish that the fishermen try to capture. So I'm sure the fishermen just want these killer shrimp to disappear.

Student "B"

I think if we could learn how to control the shrimp they could possibly be a good thing because we might be able to use them to control other organisms that are got out of control or something like that.

APPENDIX I

INTERVIEW SAMPLE

## Interview Sample

Interviewer: "What was your overall impression of using wiki spaces?"

Student J: "I liked it. They made me think more about what we were reading, not just repeating what we were reading but we had to think about a solution to the various problems."

Interviewer: "Did your group members feel the same way you think?"

Student J: "No, some of the discussions didn't go well because I think some of the group members didn't care at first."

Interviewer: "Do you think these online discussions were better than face to face group discussions?"

Student J: "Both are good but the online is better because sometimes people don't want to say what they really mean in person."

Interviewer: "Why?"

Student J: "It's easier to be turned down in person. Online discussions allow you to post something you want to say using research to support or prove your point."

Interviewer: "Did the use of online discussions help you develop good critical thinking skills?"

Student J: "Yes, reading a variety of stories and situations, we as a group had to research and come up with different solutions. And, we had to research more."

Interviewer: "Did you learn these thinking skills more from discussions with your group members or simply from the problem scenarios?"

Student J: "Hearing from others because these discussions helped contribute to your own ideas and combine them into one. They made you refine your own ideas."

Interviewer: "Should teachers be using more of this type of technology in the classroom?"

Student J: "Yes and No. It doesn't always work because of computer issues, internet problems, slow progress but if they can have access at school, then yes."

Interviewer: "When learning content, what methods seem to help you the most?"

Student J: "Visual things, drawings, explanations, labs, not as many lectures, reading."

Interviewer: "Can online technology help you learn science?"

Student J: "Yes, it can be very helpful. The research is easier and there is no need to look elsewhere to find what you need."