

WHEN LEARNING ABOUT ENGINEERING, WHAT TYPE OF LEARNING
ACTIVITIES DO SEVENTH GRADE SCIENCE STUDENTS PREFER?

by

C.J. Shields

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Charles Joseph Shields

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ABSTRACT

Engineering has become an integral component of science education in the state of Indiana. Despite the recent inclusion of engineering standards in the *Indiana's Academic Standards for Science*, there is little information about how best to teach engineering in the science classroom. Ascribing to a belief that middle school students learn best from activities that engage them to the greatest degree, this study sought to determine what type of engineering activities seventh grade science students found most and least interesting. To ascertain an answer, students were presented with a sequence of four engineering lessons, two applied, or hands-on, and two virtual. Results were determined using data collected from pretests, posttests, student self-evaluations, student interviews, and a teacher self-evaluation. Initial results indicated a slight preference for applied activities.

INTRODUCTION AND BACKGROUND

Project Background

Teaching Experience & Classroom Environment

During the previous six years, students at Greencastle Middle School (GMS) in Greencastle, Indiana were required to take a yearlong course dealing with the topic of engineering. The GMS engineering course, under my supervision, utilized the Gateway to Technology curriculum of the Project Lead The Way non-profit organization (Project Lead The Way, Indianapolis, IN). For the 2012-2013 school year, GMS opted out of their relationship with Project Lead The Way; thereby ending the engineering focused course. As a result, my teaching duties moved to seventh grade science. In my new role as a seventh grade science teacher, engineering was but one small component of the Indiana science curriculum (Indiana Department of Education, 2010).

When engineering was the focal point of my teaching it was possible to use both computer-based and applied (i.e., hands-on) methods to teach engineering, where computer-based engineering activities typically involved students using the computer to identify a problem and brainstorm possible solutions utilizing an engineering design process. Alternatively, students would use a software program to develop a solution for a teacher created design prompt. Conversely, applied engineering activities centered on the kinesthetic act of creating a physical artifact which the students believed was the best solution for a given set of design criteria. Often the applied design criteria were teacher created; though, in some cases the problems were open-ended and student initiated.

Both methods of teaching engineering yielded desirable outcomes; however, due to time constrictions, the engineering portion of the seventh grade science curriculum must be as

efficient and engaging as possible. Thus, it was my hope that this study would ascertain the best method for interesting middle school students in the subject of engineering. Results of this study will be used to drive future instruction and maximize resources available to future GMS seventh grade science classes.

Assisting me in the endeavor of completing this project were three support team members who each brought a unique quality to the team. The first member of my support team was Rebecca Alexander, a professor of Educational Studies at DePauw University, also located in Greencastle, Indiana. Rebecca has extensive experience in completing science education action research projects, and is currently focused on the social side of education. Her background in science and scholarly research proved extremely valuable for my project design.

Fellow GMS teacher Dawn Tucker was the second member of my support team. Dawn is a highly respected member of the GMS faculty; she is the first person whom I consult when a trusted professional opinion is needed. Currently Dawn teaches seventh and eighth grade language arts, though for the previous three years she taught eighth grade science. Dawn's input was valuable from a grammatical and middle school science standpoint.

The final member of my support team is my sister, Sarah Shields. Sarah is a literacy facilitator for Charlotte Public Schools in Charlotte, North Carolina. Sarah has an eye for detail, spelling, and punctuation, and her insight was valuable for determining how my research will be embraced beyond Indiana.

Focus Question

Student interest and academic performance are innately interwoven; yet, the purpose of this action research project was student interest, specifically interest in applied and computer-based teaching formats. Documenting the link between student interest and classroom performance, Pintrich and De Groot discovered that, “Students who were motivated to learn the material (not just get good grades) and believed that their school work was interesting and important were more cognitively engaged in trying to learn and comprehend the material” (p. 37). Pintrich and De Groot’s (1990) results were especially interesting to me because the study involved mostly Midwestern, White, suburban, middle school science and English students; demographics similar to those of GMS. Also, Pintrich and DeGroot (1990) studied interest and motivation in seventh grade science students. Likewise, Yazzie-Mintz (2007) studied high school students across the country and noted, “Certainly it is possible that engaging students more actively in the life and work of high schools will have an effect on levels of achievement; this is an important issue” (p. 11). Based on previous research, it was indicated that secondary students must find a curriculum interesting before they find it worth learning.

As a result of my review of the previously described engineering centric variables, my academic interest in prior studies focused on interest and engagement, and the need for an engineering curriculum which interests students as quickly as possible, I formulated the following research question: Do seventh grade science students prefer computer-based engineering activities or applied (i.e. hands-on) engineering activities? Out of the primary questions three sub questions evolved. First, for seventh grade students, what is most and least interesting about computer-based engineering activities? Second, for seventh grade students, what is most and least

interesting about applied engineering activities? Finally, what has this project taught me about teaching engineering concepts?

The research questions were framed against the backdrop of a national and state debate concerning how to successfully merge the concept of engineering into the secondary science classroom. Though the two subjects are naturally linked, the establishment of a preferred method for teaching engineering in the science curriculum has aroused much controversy.

CONCEPTUAL FRAMEWORK

A quick glance at the state of Indiana's seventh grade science standards (Indiana Department of Education, 2010) revealed that one of the four content standards was entitled, "Science, Engineering, and Technology," (p. 9) while one of the three process standards was, "The Design Process" (p. 3). These standards, adopted in 2010, became reality during the 2011-2012 school year. While the idea of including engineering concepts as part of a science course may seem cutting edge, the momentum to include such content has been growing for a number of years. In 1983, the Conference on Goals for Science and Technology Education noted that, "The scientific and technological literacy of the population is inadequate to cope with the tasks they must perform and the decisions they must make with respect to environment and human welfare concerns, as individuals and citizens in our technological world (National Science Foundation, 1983, p. 7).

Thus, the inclusion of engineering and technology concepts into the core science curriculum is not a new idea. Indeed, within the last decade several authors have proposed various methods for introducing engineering content into the middle school science curriculum. A literature search revealed numerous ideas, ranging from multi-week units in middle (Harmer & Cates, 2008; Klahr, Triona, & Williams, 2007; Mehalik, Doppelt, & Schuun, 2008) and high school

(Apedoe, Reynolds, Ellefson, & Schunn, 2008; Kaya & Geban, 2011) to a yearlong middle school curriculum model (Kolodner, Camp, Crismond, Fasse, Gray, Holbrook, Puntambekar, & Ryan, 2003).

Regardless of model, two philosophies for teaching engineering exist. One trajectory involves teaching engineering using physical materials and projects to reinforce engineering concepts (Mehalik, Doppelt, & Schunn, 2008; Kolodner, et al., 2003; Kaya & Geban, 2011; Apedoe, et al., 2008). Conversely, others (Klahr, Triona, & Williams, 2007; Harmer & Cates, 2008) advocate that students garner as much useful information from participating in virtual engineering projects.

Advocates for both methods of teaching engineering and the engineering design process have valid opinions, but evidence in support of one approach versus another is lacking, for example, Klahr et al. (2007) noted,

Surprisingly little is known about the instructional consequences of this physical-virtual distinction because almost all of the empirical investigations of the relative effectiveness of computer-based versus non-computer based science instruction include differences in addition to the instructional medium being compared (Klahr, Triona, & Williams, 2007, p. 185).

The previous quote highlighted to me the need for an action research study which compared the two primary methods for delivering engineering content. A comparison of the two methods was needed; but, it should be noted, that the definition of what constituted the design process also varied among sources (Apedoe, et al., 2008; Kolodner, et al., 2003; Mehalik, Doppelt, & Schunn, 2008), and could potentially confound my own results. Thus a clear definition of each method within my own research context was essential.

Klahr, Triona, and Williams (2007), as well as Harmer and Cates (2008), both extolled the virtues of using computer-based activities to teach engineering focused scientific inquiry. One reason, as noted by Klahr and his colleagues (2007), was that virtual science learning may “ameliorate” (p. 190) the gender difference which makes female middle school students less interested in science. Klahr et. al (2007) believed virtual activities were viewed, by females, as non-gender specific. Additionally, when each student has a computer, a further benefit was identified when it was observed that, “We expected children in the physical condition to take about 20 minutes to complete the fixed-number condition, whereas children in the virtual condition were expected to take much less time” (Klahr, Triona, & Williams, 2007, p. 192). The studies (Klahr, Triona, & Williams, 2007; Harmer & Cates, 2008) noting an increased engagement through virtual methods were conducted in one-to-one computing situations. Certainly there are many positives associated with using virtual methods to teach students the concepts of engineering. However, studies (Klahr, Triona, & Williams, 2007; Harmer & Cates, 2008) that advocated for the use of virtual learning also noted the perils which plague virtual education. In particular, Harmer and Cates (2008) stated, “Despite our belief that the technology-based inquiry was manageable by one teacher, many operational, technical, and task-related questions kept the teacher, an aide, and the first author (AJH) continuously busy” (p. 112).

While some advocated for the use of virtual methods (Harmer & Cates, 2008; Klahr; Triona, & Williams, 2007) to teach engineering and science concepts, others (Kaya & Geban, 2011; Apedoe, et al., 2008; Kolodner, et al., 2003) advocated using applied methods for teaching such concepts, and the design process associated with them. Indicating such a belief Kolodner et al. (2003) stated,

Too often, science instruction fails to engage students' interest and is divorced from their everyday experience. Traditional science instruction has tended to exclude students who need to learn from contexts that are real-world, graspable, and self-evidently meaningful (p. 496).

While Apedoe et al. (2008) and Kaya and Geban (2011) provided evidence that applied activities further student engagement in science; Kolodner and colleagues (2003) noted that engaging students in applied science went beyond creating unique lessons and involved the establishment of a classroom atmosphere which was conducive to engaged learning. It was stated,

In classes where our teachers have helped students learn from the beginning that they are responsible for each other's learning, where the teacher makes clear that he or she respects the students as learning partners, where the teacher engages with students in addressing the design challenge, and where the teacher insists on respect towards everyone, the students respond quickly, engage enthusiastically, and learn much more, even when the teachers skills and knowledge are deficient (Kolodner, et al., 2003, p. 539).

Though the Kolodner et al. (2003) study was cited as a major influence by Apedoe and co-authors (2008) the question must be asked, if the project based learning (PBL) curriculum model was successful why has it not been expanded in a decade? Perhaps one of the factors limiting PBL's success is the belief (Kolodner, et al., 2003) that applied education is very taxing on the teachers involved. Time and resources may be too consuming to sustain applied forms of engineering education.

In addition to philosophical differences, each study measured engagement in a different manner. Kolodner and colleagues (2003) provided very rich detail about the collection, coding, and use of qualitative data. Furthermore, Harmer & Cates (2008) stated,

Observational data, along with student, teacher, and aide comments and reaction, provided information about operation, technical, managerial, class staffing and curricular issues. The students' responses written before and after the study, along with their journal entries, comments, and interview responses provided information about the learning design and its effect on students' engagement with technology-based inquiry. (Harmer & Cates, 2008, pp. 113-114). Conversely, Kaya and Geban (2011) and Apedoe et al. (2011) utilized a pre and posttest to gather data which was largely quantitative. As a result, all of the previously described data collection methods became central to this action research study.

Whether it is due to the aforementioned reasons; or, a yet unexplored reason, the United States has fallen well short of the goal the National Science Foundation (NSF) set in 1983. It was then that NSF indicated the infusion of engineering content into the science curriculum should be complete within 10-20 years (Foundation, National Science, 1983). Now, 30 years later, there is as much debate about how to integrate engineering into science education as there was the day the initiative was proposed.

Perhaps the reason these ideas have not taken root is because there are so many ways to teach engineering and the engineering design processes. All methods for teaching engineering concepts have advocates which support their method as the most engaging. Such claims have been supported by both qualitative and quantitative data. Additionally, technology and engineering are innately intertwined, and technology is constantly changing; thus, the methods for creating and integrating an engineering curriculum are difficult. Kelley and Kellam (2009) noted that engineering, through its inherent nature, is a problem based discipline which often lacks significant structure and requires problem solving skills. As a result, teaching such a topic is a time consuming process which requires much forethought and planning. It is probably for

these reasons that there is lack of data about what most interests students in an engineering focused curriculum (Klahr, Triona, & Williams, 2007).

METHODOLOGY

Treatment

The research methodology for this project received an exemption by Montana State University's Institutional Review Board (IRB) and compliance for working with human subjects was maintained. The Montana State University IRB approval can be found in Appendix A.

Additionally, the principal of GMS (Appendix B) provided exemption for working with GMS seventh grade science students.

The focus of this action research project was not one specific type of treatment; but, instead, a comparison of two approaches to teaching engineering. The comparison of the two methods comprising the treatment involved two sequences of engineering activities.

In the first sequence, students designed a working bridge using the West Point Bridge Designer software program created by the United States Military Academy at West Point (United States Military Academy, West Point, NY). The bridge had to meet certain, teacher stipulated, design criteria. Among those criteria were cost, material usage, and functionality. Next, the students used the blueprint generated by the West Point Bridge Designer to physically construct a bridge made of paper and tape. The physical artifact again centered on design criteria and the process included a component where students stress tested the bridge until failure and completed associated calculations.

In the second sequence students used Google Earth (Google, Inc., Mountain View, CA) to take a virtual tour of various mines and mining locations in the United States. Along the way, students were introduced to many of the positive and negative human, environmental, and economic

impacts of the mining industry. After touring the Berkeley Pit in Butte, Montana, students brainstormed, within the confines of design constraints, a possible engineering solution for filtering the polluted water. Following the second computer-based activity, students engaged in an applied cookie mining activity which required them to plan, execute, and understand the effect of mining a cookie for chocolate chips. The mining process resulted in a student calculated profit or loss. The profit or loss was dependent on how well students extracted chips and whether they caused an environmental disaster with their extraction technique.

The sequences of treatments for this study were curricular in nature and contained elements previously used in the GMS engineering classroom. The course for which the lessons were originally developed was almost entirely project based. Therefore, the lessons underwent significant modification to fit into the reduced parameters engineering was afforded in an Indiana seventh grade science course.

Each of the lessons used for this study can be found in Appendices C, D, E, and F. Appendix C contains the computer-based civil engineering lesson and rubric. Appendix D contains the applied civil engineering lesson and associated rubric. Appendix E contains the computer-based mining engineering lesson and rubric. Finally, Appendix F contains the applied mining engineering lesson and associated rubric.

Though it was after the students had completed the lessons, two members of my support team, Dawn Tucker and Sarah Shields, evaluated the lessons for readability and grade level appropriateness. Dawn believed all of the activities were, “Grade level appropriate,” and that the applied mining engineering activity rubric was, “Lengthy, but clearly written.” Also, concerning the applied mining engineering activity, Dawn stated, “Larger graph [paper] would allow for a more user-friendly format.”

Sarah echoed similar comments and stated she believed, “All [the activities] could be [readable for grades] 4-8 or somewhere in that range.” Sarah noted the computer-based civil engineering directions and activity were somewhat difficult for her to follow. Sarah attributed the initial confusion to her unfamiliarity with the program utilized. However, it was noted that students also entered the lesson with little background knowledge of the program.

Dawn and Sara provided valuable insight. Likewise, the lessons were delivered in a particular order to ensure a pattern. During both sequences of lessons, the computer-based lessons came first and the applied lessons followed. It cannot be assumed that the order of the lessons did not affect the outcome of the study; instead, the lessons were presented in the same order during each sequence to ensure continuity. Table 1 shows the lesson sequence.

Table 1
Time Line of Engineering Lessons

Data Collection Points	Dates of Administration
Civil Engineering Computer-Based Lesson	January 14 -16, 2013
Civil Engineering Applied Lesson	January 17 - 25, 2013
Mining Engineering Computer-Based Lesson	January 30 – February 4, 2013
Mining Engineering Applied Lesson	February 5 – 6, 2103

Research Methods

There were four methods of collecting data for this study, two involved student surveys; the other two consisted of a focus group interview, and, finally, a teacher self-evaluation. All survey

instruments were created using a Google Doc Form (Google, Inc., Mountain View, CA) and administered through the GMS seventh grade Moodle (Moodle Pty Ltd, Perth, Australia) site.

The teacher self-evaluation form and focus group interview questions were created using Microsoft Word (Microsoft Corporation, Redmond, WA).

First, a pretest of student interest was determined using the baseline instrument, which can be found in Appendix G. Following each lesson associated with this study, students completed a lesson engagement survey; which can be found in Appendix H. The focus group interview was conducted using a probing interview based on the questions shown in Appendix I. Furthermore, I completed a self-rating form during the majority of days associated with the engineering activities; the form used to complete those evaluations can be found in Appendix J. Finally, at the conclusion of the project, the baseline survey was administered again and served as a posttest. The data collection matrix, which correlates research questions to data collection methods, can be found in Table 2.

Table 2
Research Questions and Proposed Data Collection Method

Research Question	Baseline Survey	Lesson Engagement Study	Focus Group Interview	Teacher Self Evaluation
Do seventh grade science students prefer computer-based engineering activities or applied (i.e. hands-on) engineering activities?	X	X	X	X
For middle school students, what is most/least interesting about computer-based engineering activities?		X	X	X
For middle school students, what is most/least interesting about applied based engineering activities?		X	X	X
What has this project taught me about teaching engineering concepts?	X	X	X	X

Some may be skeptical of seventh grade students rating their own motivation and interest; yet, in the past, many students have provided rich and beneficial details during an end of course survey, thus I assumed the answers obtained for my action research project were no different. In conclusion, the methods selected for this study provided triangulation because they involved three sets of participants, (teacher, students from two class periods, and focus group students) and two methods of collecting data (quantitative and qualitative). Additionally, validity and reliability for the data collection methods were obtained by working closely with my supervisor, Dr. Walt Woolbaugh, and a member of my support team, Rebecca Alexander. Also, the lesson engagement survey was tested through a pilot administration.

The baseline survey was administered to all seven sections of GMS seventh grade science classes on Tuesday, November 20, 2012. The baseline survey served as a pretest that gauged how students perceived each of the various activities which had occurred in the GMS seventh grade science classroom. Based on those results, it was determined where student interest for a given type of lesson fell on a continuum of all lesson types. The baseline survey was given again at the end of the research project to determine whether student interest had shifted during the research project. Each student responding to the baseline survey (N = 145) was asked to identify their class period. Based on input from the support team, the results were constricted to two class periods (second and seventh) (N = 56) for analysis and subsequent surveys because those periods had demographics most similar to the overall GMS seventh grade population. Though answers were anonymous, it can be assumed that the respondents to the baseline survey were 92% white, 41.8% free lunch, and 10.5% reduced lunch (Indiana Department of Education, n.d.); with an additional 11% having an individualized education plan (IEP). Of the students in second and seventh period during the 2012-2013 schools, twenty-seven (48.21%) were female and twenty-

nine (51.79%) were male. At the time the treatments began, the students had been enrolled in seventh grade science for approximately one semester (18 weeks), during which time they met five times a week for forty-three minute a class period.

Beyond the surveys, ten students were selected for the focus group interviews. The students chosen for the focus group were selected by the teacher, based on specific demographic and grade criteria. Appendix K details the aforementioned criteria. Each of those characteristics was treated as a metric and students were placed in the focus group based on either a demographic or grade criteria. Initially, it had been hoped the students would be selected using a stratified random sampling method. However, due to the low number of students in certain categories, a stratified random method proved infeasible. For example, only one student in the two classes studied was a minority. Other criteria were also nearly as restrictive, including some categories of grade, and reduced lunch. Once a minority, reduced lunch student, or B student was placed in the group they occupied other selection criteria; thereby creating a ripple effect in the selection process.

Included in the focus group were five boys (50%) and five girls (50%). The actual gender ratios of the 2012-2013 GMS seventh grade class were 53.015% male students (N = 88) and 46.98% female students (N = 78). Additionally, four (40%) of the focus group members received a free lunch compared with 41.8% of the GMS population at-large. Ten percent of the focus group received a reduced lunch, compared to 10.5% of the overall GMS population. Furthermore, one focus group member (10%) was a minority; whereas the GMS population consisted of eight percent minority students. Ten percent of the focus group had an IEP compared with 11% of all GMS students.

The demographic categories were pivotal to the selection of the focus group members; however, second quarter science grades were also a factor in determining which students were selected for the focus group. During the second quarter of the 2012-2013 school year, in the periods studied for this project, 27 students (48.2%) received an A, 5 (8.9%) a B, 15 (26.7%) a C, 4 (7.1%) a D and 5 (8.9%) an F. Using the previous percentages as a basis for selection, 4 (40%) students selected for the focus group received an A, 1 (10%) a B, 3 (40%) a C, 1 (10%) a D, and 1 (10%) an F. The percentages for the focus group closely reflect those of the GMS science classes studied for the research project. Such an action shows a commitment to obtain every possible student viewpoint.

The complete list of the focus group, their corresponding demographics, and grades can be found in Appendix K. It should be noted that anytime a student from the focus group was quoted in this paper, the phrase Student Number [insert number of student] was used as a method of identification.

The student focus group met four times, once after each computer-based and applied lesson. The interviews were recorded on my iPod Touch (Apple Inc., Cupertino, CA), backed up to my personal computer, iCloud (Apple Inc., Cupertino, CA), and Google Drive (Google Inc., Mountain View, CA). Transcripts of each interview were created using the Transcribe App available as an add-in for Google Chrome (Google Inc., Mountain View, CA) and later saved as a Microsoft Word document. After transcription, each interview was read, highlighted, coded, and themes sought. According to Mills (2011), the best way to obtain data from an interview is to record, transcribe, and allow themes to emerge.

The final method of collecting data regarding the treatment lessons was a teacher self-evaluation form. The form was designed with the input of my advisor, Walt Woolbaugh, and a member of

my support team, Rebecca Alexander. The form was created using Microsoft Word and was similar to the student instruments due to the fact the form asked for Likert and open-ended responses.

I completed the forms during the majority of the days associated with the research project. The only days data was not gathered were the last two days of the computer-based mining activity when GMS was undergoing a computer network upgrade which required the alteration of the intended lesson. The first two questions on the self-evaluation form were completed before the day began, and the remaining 15 were completed at the conclusion of the day. Completed teacher self-evaluation forms were kept in data binder for later access. The self-evaluation forms proved useful as they allowed me to locate and reflect on the rationale of my thoughts during a given day of the project. Such data might have been lost had it not been for the teacher self-evaluation form. Also, the data on self-evaluation forms allowed for cross-referencing of certain events mentioned by students on the pretest, lesson engagement surveys, posttest, or focus group.

DATA AND ANALYSIS

Primary Research Question

The goal of this research project was to determine whether seventh grade students at GMS preferred computer-based or applied engineering activities. The analysis to ascertain an answer to the first research question was concerned with the overall perception of GMS science students regarding engineering lessons. As a result, the data was investigated as a single entity to discern interest level. Thus, outliers were not discussed for the first research question. The first step in determining the preferred engineering lesson was to determine how students perceived a range of

activities which had previously been conducted in the GMS seventh grade science classroom.

Initial interest level was established by using the baseline instrument as a pretest.

The baseline instrument was first administered on November 20, 2012. The Likert items on the pretest were assigned a numerical value, averaged, ranked, and standard deviations calculated.

The values assigned were strongly disagree equaled a negative two, disagree equaled a negative one, neutral equaled zero, agree equaled one, and strongly agree equaled two. The same procedure was followed for the posttest, which was administered on February 19, 2013.

Table 3 contains the means (M) and standard deviations (SD) of various pre and posttest Likert statements. Interestingly, though the standard deviation and means changed from the pre to the posttest, GMS students rated the statements in the same order during both administrations. The data in Table 3 provides evidence that GMS students preferred labs and hands-on activities to computer-based activities. The preference for applied activities was present both before and after the sequence of engineering lessons which comprised this study.

Table 3
Pretest (N = 46) and Posttest (N = 50) Survey Interest Ratings

Key	M = Mean		SD = Standard	
			Deviation	
Name	Pre M	Pre SD	Post M	Post SD
I find hands-on activities to be interesting	1.37	.986	1.36	0.975
I find working on experiments in the science lab to be interesting.	1.30	.881	1.34	.908
I find working on projects and experiments in the computer lab to be interesting.	.59	.969	0.84	1.007
I find assignments which require writing in the science journal to be interesting.	.39	1.093	-0.24	.991
I find working on assignments from the science textbook to be interesting.	-.48	1.058	-0.84	0.880
I find assignments which require working in the science workbook to be interesting.	-.74	1.009	-1.20	0.849

The rank of student interest ratings shown in Table 3 did not change from pretest to posttest; yet, GMS students' feeling toward each type of activity grew stronger. The growth of stronger feelings toward a specific learning style was true whether the feeling grew either more positive or more negative. The exception to stronger beliefs about each statement was the highest rated statement; which decreased by one-hundredth of a point. Also, for four of the six statements regarding perceived interest the standard deviation shrunk between the pretest and the

posttest. Therefore, it seemed that the stronger opinions regarding each statement also became tighter clustered during the elapsed time of the research project. Consequently, it was determined that student opinion regarding preferred learning method was stronger and more coalesced in the posttest than in the pretest.

The pretest and posttest supplied a starting point for determining which type of engineering activity seventh grade GMS science students preferred; but, other sources of data were needed to support the initial pre and posttest conclusion. The focus group interviews provided additional insight into the student's thoughts regarding engineering activities. During the focus group interviews, students could hear each other's responses; therefore, students could have changed their opinion based on what another student said. The ideas present in the focus group interviews were extremely valuable; however, the percentages presented here may not represent a firm percentage of student opinion. Nevertheless, they are presented for a comparison to other data sources.

In the applied mining engineering focus group interview (Appendix L) seven of the nine students (77.8%) stated that during the course of the research project they preferred the hands-on activities to the computer-based activities. One student (11.11%) dissented, stating he preferred computer-based lessons, and another student (11.11%) was split in their vote. The individual who was split preferred the computer lesson during one phase of the study and the applied lessons for the other.

Reinforcing the belief that seven of nine focus group students preferred applied engineering activities, Student Number Five stated, "I am more of a hands on person, and like whenever we take a test in information technology I was a combo of auditory and kinesthetic, so I like hands on." The information technology course referenced by Student Number Five was a

nine week rotation class each GMS seventh grade student took during the 2012-2013 school year. The GMS information technology course focused on study skills and integrating technology into study habits, and all of the focus group students indicated that during the course they had taken a learning styles test. Some students used results from their learning styles survey to correlate their responses to either the lesson engagement surveys and/or the focus group interviews for this study.

In addition to the pretest, posttest, and the focus group interview, the teacher self-evaluation form also provided information on how the teacher viewed student interest level. Based on the calculated values of the teacher self-evaluation, it was my perception that students were more excited about applied lessons ($M = 1.88$) than computer-based lessons ($M = 0.80$). Though the teacher self-evaluation instrument represented the teacher's perception of student interest, the results coincided with the student pre and posttests results.

Multiple sources indicated that students preferred applied learning to computer-based learning. However, the data concerning the computer-based lessons were likely skewed by network problems incurred as part of a firewall upgrade which occurred during the mining engineering computer-based lesson. The network issues were clearly present in the student responses. For example, in the computer-based mining focus group (Appendix M), Student Number Two stated, "I enjoy the hands on, because like with [Student Number Five] that is just the way I learn to understand things, and with the computers there are so many glitches it just affects the lesson." Nevertheless, it was possible I perceived computer problems to a greater degree than the students due to the fact I encountered those problems across multiple periods and school days; whereas the students saw the issue only once per day.

Exemplifying the belief that computer problems were perceived to a greater degree by the teacher, the first two days of the computer-based mining activity were rated as neutral on the teacher self-evaluation form. Furthermore, the last two the days of the computer-based mining activity were not rated on the teacher self-evaluation instrument because the lesson was greatly altered due to lingering network issues. Therefore, due to the fact that computer problems were encountered during one-half of the computer-based portion of this study, it can be assumed the associated negative ratings altered the rating of that style of learning.

Perhaps because of the computer glitches, data from multiple sources indicated that seventh grade science students at GMS preferred applied engineering activities to similar activities conducted on the computer. It was impossible to change the fact that the computer-based mining engineering activity was conducted during a network upgrade, thereby rendering the data difficult to use. Yet, due to that problem it was necessary to investigate a fourth data source, the lesson engagement surveys. Originally, it was planned that the lesson engagement surveys would be used to ascertain information for the secondary research questions; however, the data became vital for answering the primary research question.

Data garnered from the lesson engagement surveys, and shown in Table 4, did not confirm a student preference for applied learning. On each lesson engagement survey students were asked to self-identify (from choices of strongly agree, agree, neutral, disagree, or strongly disagree) how they perceived each lesson in terms of interest and fun. Table 4 shows the mean and standard deviation of the student rating for interest and fun for each of the four engineering activities.

The data in Table 4 demonstrates that, within the confines of this study, student preference varied by lesson. While an applied lesson was the highest rated lesson, Table 4 shows

no trend toward an overall favoritism of applied lessons. Furthermore, the mean rating for the responses on the lesson engagement surveys revealed a lower overall rating for specific lessons involving applied learning than for the concept of applied learning in general. For example, in Table 4, the highest rated lesson (applied mining engineering lesson) scored a 1.00 for interest. In contrast, Table 3 indicated that students rated hands-on activities as interesting with an average mean rating of 1.37 in the pretest and 1.36 in the posttest. Such a disparity in results was surprising.

Table 4

Self Evaluated Lesson Engagement Interest Ratings (Computer Mining N = 46; Applied Mining N = 51; Computer Civil N = 48; Applied Civil N = 48)

Topic	Interest	Interest	Fun	Fun
	M	SD	M	SD
Applied Mining Engineering Lesson	1.00	0.96	1.23	0.94
Computer-Based Civil Engineering Activity	0.65	1.15	0.93	1.03
Applied Civil Engineering Lesson	0.55	1.23	0.53	1.29
Computer-Based Mining Engineering Lesson	0.25	0.99	0.25	1.15

By using zero as the demarcation point, the data in Table 4 provides little evidence that the majority of GMS science students agreed that any of the lessons, regardless of delivery method, met the threshold of interesting. Demonstrating such, many of the activities were above neutral, but contained a relatively low mean of interest and a fairly wide standard deviation. The wide standard deviations indicated that the three lowest rated activities could have had a majority of students rating the activity near neutral or below neutral. The exception was the applied

mining engineering activity which, based on the same criteria, fell barely within the range of having the majority of students agree that the activity was interesting.

Another unexpected result of the data shown in Table 4 included the fun rating for the applied mining lesson standing nearly a quarter of a point higher than the interest rating. Also, the self-identified fun rating contained a slightly smaller standard deviation. A similar pattern held true for the second highest rated lesson. Examining that inconsistency, such data possibly demonstrated that students have different internal gauges for interesting and fun and did not view those ratings as the same metric.

It was envisioned that interesting would include responses students liked or disliked about the information or content of a given lesson. On the other hand, fun would include what students liked and disliked about the operational components of the activity. In retrospect, fun and interesting are very similar and the division is fine; so, it could have been expected that students would not understand the difference.

In addition to the possibility that students perceived interesting and fun differently, multiple sources of data indicated there was another reason why students rated the individual applied activities lower than the pre and posttest statements regarding applied learning. Both of the applied engineering activities contained a paperwork component which sought to integrate the concepts of math, engineering, and science. The paperwork component was cited by a number of students as a reason they did not find the applied engineering activities interesting or fun.

A belief that the paperwork contributed to the lower than anticipated lesson interest ratings was supported by a student who responded to an open-ended applied civil engineering survey question by stating, "Sometime it [the applied civil engineering lesson] was fun but the

paperwork was boring.” Similarly, five of fifty-one (9.80%) respondents who completed the same survey indicated the paperwork was a factor for whether they had rated the lesson extremely easy, easy, neutral, difficult, or extremely difficult. One student who rated the civil engineering lesson as difficult explained their rating by stating, “Because it [the civil engineering activity paperwork] involved math and measuring and weight and I’m not good with those things.”

The same line of reasoning was furthered during the applied mining engineering lesson engagement survey when eight of forty-eight (16.67%) respondents mentioned some aspect of the paperwork as a reason for rating the difficulty of the mining engineering lesson. One student respondent indicated,

I put easy because all you had to do was tear up a cookie, but it wasn’t extremely easy because you had to try not to get crumbs out of place, and you might not have gotten enough pieces of ‘coal’ to make a profit.

Obviously the calculation of a profit involves math skills, and thus, math and paperwork were factors in how the students rated the activity.

Further evidence that the paperwork associated with the applied lessons was a factor for lower than anticipated lesson interest ratings was presented when all nine (one student was absent the day of the meeting) of the students interviewed for the applied civil engineering focus group (Appendix N) stated the paperwork was their least favorite part of the activity. Student Number Four provided rationale by stating,

Because of the math, I mean the math was just kind of. Well, it was not really that hard because we were allowed to use calculators, but for those who didn’t have calculators and were

finished it [the project] early so they weren't in the computer lab, that must have been really hard.

Evidence that the paperwork associated with the applied engineering lessons, especially the portion of the paperwork involving math, reduced the interest level was also present in the applied mining engineering focus group interview. Student Number One stated, "Um, I like, I didn't like the part with doing the math, cause it was kind of hard to multiply all the stuff and then divide it and subtract it and get the profit and that stuff..."

Based on the previously presented evidence it was highly possible that, due to the paperwork and math components of both applied lessons, some students did not actually view the applied lesson as a hands-on lesson. Or, at least as the type of lesson they envisioned when answering the pretest. However it is hard to make the same argument for the posttest, as students had just completed two applied engineering activities. Yet, in the posttest the overall mean rating of applied learning remained the highest ranked form of student interest.

The pre and posttest, student interviews, and a teacher self-evaluation, depicted a scenario where GMS students preferred applied learning to computer-based learning. However, the data from the lesson engagement survey demonstrated that students are less enthusiastic about actual applied lessons with a paperwork or operational component than the concept of an applied lesson. Consequently, it was necessary to investigate one final piece of information to ascertain the data necessary to answer the primary research question.

The final piece of data used to assist in answering the primary research question was a specific question on the pre and posttest. The question asked students to identify their preferred method of learning about engineering. The results of the data obtained for that question are shown in Figure 1.

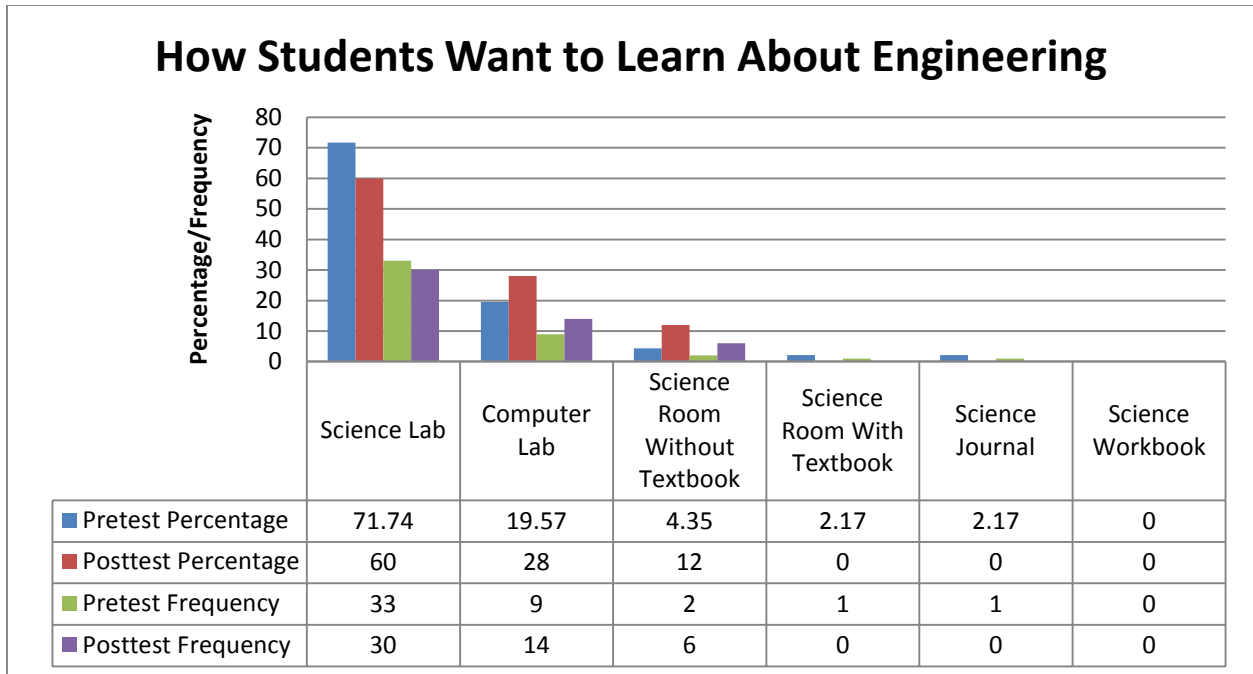


Figure 1: How students want to learn about engineering (Pretest $N = 46$; Posttest $N = 50$).

Regarding Figure 1, students disagreed ($M = -0.33$, $SD = .910$) that they had covered engineering in previous science courses. In doing so, zero students strongly agreed and eight (17.30%) students agreed that they had covered engineering in a previous science course.

Therefore, it can be assumed the remaining (82.7%) GMS seventh grade science students had little prior knowledge of engineering.

The data in Figure 1 reiterates the idea that most students preferred to learn about engineering via an applied method. However, of interest in Figure 1 is the percentage, nearly eight and one-half percentage points, by which computerized methods increased from the pretest to the posttest. Almost certainly, some of that growth was due to the heavy usage of the computer lab during the two computer-based engineering lessons. Also, some of the growth could have been due to the previously documented idea that students like applied activities but did not enjoy the associated paperwork. Thus, the possibility existed that the preference for

computer ratings rose due to the fact students did not enjoy the paperwork associated with the applied engineering activities.

Another area of growth in Figure 1 was the statement, “Science room without textbook.” That option was meant to inquire about hands-on activities which occurred in the classroom, but were not conducted in the science lab. It was likely the students taking the pretest were uncertain of what that question meant. However, during the posttest some students probably recognized that category as the manner in which a portion of the applied civil engineering, and the entire applied mining engineering lesson, had been conducted. Thus, the percentage growth of that category probably correlated to the usage of that mode of learning during the research study. Likewise, the fact that the last three categories of learning styles did not garner any votes in the posttest is understandable; those methods were not used during the engineering unit.

The data analyzed to determine the primary research question were varied and often generated diverse results. As a result, it was difficult to fully cement an answer to the question of whether seventh grade students at GMS preferred computer-based or applied engineering activities. Nevertheless, the data provided many insights which were useful in drawing a final conclusion. The final conclusion will be presented in the interpretation and conclusion section of this paper.

Secondary Research Questions

Beyond the primary research question, three secondary research questions evolved. First, for middle school students, what was most and least interesting about computer-based engineering activities? Second, for middle school students, what was most and least interesting about applied engineering activities? Finally, what has this project taught me about teaching engineering concepts? Due to its nature, the final secondary question will be addressed

subsequently in the values section of this paper. The two questions regarding what students found most and least interesting were analyzed for this section of the research paper. To obtain data to answer the two questions regarding what students found most and least interesting it was necessary to look at the data collected for each activity.

The starting point for analyzing each of the four lessons were the student focus group interviews, which can be found in Appendices L, M, N, and O. Each of the four interviews were recorded and transcribed. After transcription, each of the interviews was read multiple times, themes sought, and thematic codes established. The likes and dislikes present in the interviews were used as a basis for creating the thematic lists for each activity. The interviews were used as the focal point for developing the thematic lists due to the fact it was possible to ask the focus group participants follow-up questions if answers were unclear or insufficient. Each like or dislike that a student mentioned was identified and recorded. However, if a student reiterated or restated the same theme then any instance beyond the first mention was not recorded.

Once the thematic list of likes and dislikes had been established a similar technique was used to analyze the open-ended portion of the Likert surveys. For analysis of the open-ended responses, two categories were studied in depth. The two were the open-ended responses to the Likert statements “This Lesson Was Fun for Me,” and “This Lesson Was Interesting for Me.” As noted in a previous section, it was believed those categories would obtain similar data; yet, not all students necessarily gauged fun and interesting as the same metric. Consequently, when the open-ended responses were analyzed, duplicate answers were not counted as multiple answers representing one theme. Instead, duplicate answers were bundled to represent a single theme. For example, one student noted, “Sometimes it [building the bridge out of paper] was fun but the paperwork was boring,” for the interesting response and, “The bridge building was fun

but the paperwork wasn't," for the fun response. The previous responses were bundled as a single thematic answer. Conversely, another student noted, "It was fun working on [building the paper bridge]," for the interesting response and, "Because we had lots of time to work on it and not in a rush," for the fun response. Those responses were counted as two separate themes.

The open-ended responses yielded valuable data; however, the responses did not lend themselves to follow-up questions. Originally, it was envisioned that student identification numbers would be used as a method of locating students to have them clarify answers. Yet, this task proved impossible within the allotted timeframe. As a result, numerous open-ended responses were unable to be categorized. Such answers often included statements such as, "I didn't like it that much," "I like computers," or "Boring." In some cases, the indecipherable answers indicated a like or dislike, but did not add a specific reason why students held a given belief. Such responses are shown in Tables 5, 6, 7, and 8 as Like or Dislike Non-Descript. Nevertheless, the useful data was able to be triangulated and provided a foundation for reaching conclusions about student likes and dislikes.

The final piece of data used to establish triangulation regarding student likes and dislikes were the teacher self-evaluation forms. The teacher self-evaluation forms were analyzed to determine if I had created any notations concerning topics which GMS students had indicated they either liked or disliked. Specifically, analysis involved reading responses to the questions, "The aspect of this lesson the students found most engaging was," "The primary factor which inhibited all students from being engaged was," "If I were to teach this lesson again I would change," and "Other factors which may have affected the teaching of this lesson." Any notation made on the teacher self-evaluation form which regarded a theme was counted. Such an action

was justified by the fact that I was able to determine the intent of the comment; whereas such an action was not possible with the ambiguous open-ended student responses.

By seeking themes from three sources it was possible to thematically triangulate the likes and dislikes for each engineering activity. The themes which emerged are shown in Tables 5, 6, 7, and 8; the tables are grouped by lesson type. Student likes and dislikes regarding computer lessons are shown in Tables 5 and 6, and the tables indicating applied lesson likes and dislikes are shown in Tables 7 and 8. The first table, Table 5, shows the list of themes and the associated data sources for the computer-based civil engineering lesson. The number to the right of each theme indicates the number used to code the instances of open-ended and focus group responses.

Table 5
Computer-Based Civil Engineering Likes and Dislikes

Themes	Focus Group		Open-Ended		Teacher	Like or
	Interview N = 9		Data N = 46		Eval	Dislike
	f	%	f	%		
Leaving Class/Working on Computers [3]	7	77.77	6	13.04	N	L
Easy to Redo Assignment [4]	4	44.44	2	4.34	N	L
Difficult Design Constraints/Lesson [6]	3	33.33	5	10.87	Y	D
Design Work [7]	3	33.33	7	15.21	Y	L
Different Than Typical Activities [10]	2	22.22	0	0	N	L
Design Constraints Were Helpful [5]	1	11.11	1	2.17	N	L
Enjoyed Lesson Non-Descript [1]	0	0	13	28.26	N	L
Disliked Lesson Non-Descript [2]	0	0	7	15.22	N	D
Challenge of the Activity [4]	0	0	4	8.70	N	L
Other/Indecipherable [9]	0	0	4	8.70	N	

Regarding the computer-based civil engineering lesson, Table 5 shows only one theme which was identified by all three sources as a dislike. The triangulated dislike indicated that, overall, the design constraints associated with the activity were difficult. Thirty-three percent of the focus group and nearly eleven percent of the open-ended respondents felt that the design constraints, and by consequence the activity, were difficult. Disliking the design constraints was probably exacerbated by the fact that the first day of the civil engineering computer-based lesson was conducted on a day when GMS operated under a two hour delay. As a result time in the

computer lab was constricted, requiring an adjustment of the design criteria. On January 15, 2013, the following was recorded on the teacher self-evaluation form, “Some of the design constraints were difficult for some students. These were modified in each class through negotiations.” The latter part of the previous quote was a reference to the fact that each class presented a proposed list of altered design criteria, and then a student negotiator and I brokered an agreement on modified design constraints.

Further echoing the frustration associated with the design criteria, Student Number Five stated, “If you didn’t make it [the design collapsed before the truck made it across] then the bridge would fall and that would kind of made me mad.” Additionally, Student Number Ten stated, “That you could only spend like this much money, but then you like raised it, but in the beginning I did not really like it.” The design criteria of the computer-based civil engineering activity were frustrating and represented a dislike among the students. However, the second triangulated theme indicated something students liked about the same activity.

As shown in Table 5, the second theme found in all three data sources was the fact students enjoyed design work. That finding was interesting, especially given the dislike of the design criteria. Three (33.33%) focus group students and fifteen percent of open-ended respondents indicated they enjoyed design work. Similarly, eight percent of open-ended respondents indicated they enjoyed the challenge of the activity. Design seemed to fall in the like category due to the fact some students enjoyed taking ownership of an item which they had created. Exemplifying that line of thinking, Student Number One stated, “Yes [the activity was enjoyable], because you have to design your own, you have to design your own bridge.” Also, on January 15, 2013, it was noted on the teacher self-evaluation form that the aspect of the computer-based civil engineering lesson which students found most interesting was, “Designing

and testing their own bridge.” An open-ended respondent further indicated, “It was fun to learn about how to keep bridges up while a semi-truck goes over.” Such a response was in opposition to many vague responses such as, “I like to design stuff,” which indicate an enjoyment of design, but did not provide a reason why.

Only two items were present in all three computer-based civil engineering sources; yet, three themes garnered responses from two of three data sources, and one worthy of note. Primary among those three was the idea that students enjoyed leaving the science classroom. Seventy-seven percent of the focus group students and thirteen percent of the open-ended respondents indicated they enjoyed leaving the classroom and working in the computer lab. Forty-four percent of focus-group students noted the computer allowed them to easily redo assignments. Only four percent of open-ended responses concurred that the ease of redoing assignments was an enjoyable part of the computer-based civil engineering lesson.

An interesting outlier noted for the computer-based applied learning activity was the theme that the design criteria helped explain the activity. One student (11.11%) in the interview and one (2.17%) in the open-ended response indicated the design constraints were helpful. The frequency and percentage of students who believed the design criteria helped them was low; yet, this was of particular interest due to the fact that it directly opposed the only triangulated data point, which centered on the difficulty of the design criteria.

The data for the computer-based civil engineering activity produced one triangulated theme which students liked and one which they disliked. Additionally, despite the fact they were present in only two data sources, there were two additional trends which possibly represented themes that seventh grade GMS science students liked about computer-based activities.

Similar to the data for the computer-based civil engineering lesson, the data for the computer-based mining engineering lesson indicated multiple themes which were present in each of the three data sources. Unlike the computer-based civil engineering lesson, two of the themes present in all three sources represented dislikes and one represented a like. All of the thematic likes and dislikes from the computer-based mining activity can be found Table 6.

Table 6
Computer-Based Mining Engineering Likes and Dislikes

Themes	Focus Group		Open-Ended		Teacher	Like or
	Interview N = 8		Data N = 48		Eval	Dislike
	f	%	f	%		
Design/Challenge of Designing [5]	4	50	0	0	N	L
Hyperlinked Info Useful/Interesting [7]	3	37.5	9	18.75	N	L
Want to Work in Partners [10]	3	37.5	0	0	N	D
Length of the Lesson [4]	3	37.5	0	0	N	L
Using Computer/Google Earth [3]	2	25	8	16.67	Y	L
Other/Indecipherable [9]	2	25	7	14.58	N	
Design Criteria Too Difficult [6]	2	25	0	0	N	D
Computers/Computer Glitches [11]	1	12.5	4	8.33	Y	D
Disliked Lesson Non-Descript [2]	1	12.5	11	22.92	N	D
Enjoyed Lesson Non-Descript [1]	1	12.5	9	18.75	N	L
Reading/Not Using Hands [8]	0	0	6	12.5	N	D
Did Not Understand the Lesson [12]	0	0	1	2.08	N	D

Again, during the second computer-based lesson, data indicated that students enjoyed using the computer lab and the program utilized for the lesson. Twenty-five percent of focus group students enjoyed the computer lab or Google Earth. Student Number Three indicated liking the lesson because, “We didn’t have to stay in the classroom.” Likewise, an open-ended response indicated, “I like using Google Earth to research and learn science.” Also, on the first day of the activity the teacher self-evaluation form contained a notation indicating that a student stated, “This looks like fun,” when they saw the activity involved using Google Earth.

Data associated with three instruments indicated that students liked using the computer lab and Google Earth; yet, three sources also indicated that students did not enjoy some aspect of using the computer, or disliked the software glitches associated with the activity. Indeed, as shown in Table 6, the frequency and percentage of those disliking the computer activity was higher than those who, for similar reasons, enjoyed the activity.

Indicating a belief that the computer was not a source of enjoyment, a respondent stated, “I never really like activities on the computer. I like interacting more and doing stuff in class.” Similarly, indicating a dislike of computer glitches, another student stated, “Google Earth doesn’t have the places show up to well.” During the focus group interview, when Student Number Six was asked what should be changed about the lesson, the response was, “Less technical difficulties.” The technical difficulties were especially bothersome for me, as technical glitches associated with the installation of the new firewall were noted on the second and fourth day of the activity.

In addition to the themes identified in all three data sources, there were three interesting outliers. Surprisingly, thirty-seven percent of focus group students and eighteen percent of open-ended respondents indicated they enjoyed reading the data which was hyperlinked from Google

Earth. The hyperlinks did not receive any notation in the teacher self-evaluation form. Regardless, the fact that respondents from two separate data sources rated the statement with double digit percentages made the finding noteworthy. In opposition, twelve percent of open-ended respondents disliked the hyperlinked information, usually because it involved too much reading. Echoing such a belief, one student stated, “There was to much looking up involved.” It was interesting that the belief the hyperlinked information was too difficult to read did not appear in the focus group, despite the fact one of the most vocal members of the group was an ELL student.

In addition to the fact that some students enjoyed reading and some did not, a small but vocal minority disliked the fact they could not work with partners during the computer-based mining engineering lesson. When asked what could have been changed about the project, Student Number Four stated, “Um, you could have, had, um, had, us have partners, because [another student] and I sit right next to each other and we kind of helped each other on the ideas even though we weren’t technically supposed to.” Even though the use of partners was not mentioned in the open-ended responses, two of the focus group students (25%) concurred that partners should have been allowed during the lesson.

Data which centered on the computer-based lessons generated a thematic list of what GMS students liked and disliked about computer-based engineering activities. Similarly, the data collected to ascertain the likes and dislikes associated with the applied learning activities yielded thematic lists concerning what students liked and disliked about applied engineering activities. The like and dislike themes concerning applied engineering activities are shown in Tables 7 and 8.

In Table 7, it can be noted; there were five themes present in all three sources involving the applied civil engineering lesson. Of those five, three were themes which GMS students liked and two were themes which they disliked. Nearly every student (88.89 %) in the focus group cited the paperwork associated with the applied civil engineering as something they did not like. Two statements reflecting such a belief included, Student Number One saying, “I am going to be honest, I really didn’t like the paper, like when you had to make all these problems and answer questions about it,” and Student Number Two stating, “I really didn’t like the paperwork afterward; the math was sort of hard.”

Table 7
Applied Civil Engineering Likes and Dislikes

Themes	Focus Group		Open-Ended		Teacher	Like or
	Interview N = 9		Data N = 51		Eval	Dislike
	f	%	f	%		
Wanted to Work With Partners [12]	9	100	0	0	N	D
Associated Paperwork [3]	8	88.89	2	3.92	Y	D
Challenge of the Activity [6]	4	44.44	6	11.76	Y	L
Did Not Want to Break Bridge [11]	4	44.44	0	0	N	D
Hands On/Building [4]	3	33.33	9	17.65	Y	L
Material Limitations [5]	3	33.33	4	7.84	Y	D
Feeling of Failure/Difficulty [9]	2	22.22	2	3.92	N	D
Talking With Friends [10]	1	11.11	5	9.80	Y	L
Enjoyed Lesson Non-Descript [1]	0	0	17	33.33	N	L
Disliked Lesson Non-Descript [2]	0	0	12	23.53	N	D
Different Than Typical Activity [8]	0	0	4	7.84	N	L
Other/Indecipherable [7]	0	0	3	5.88	N	

The paperwork clearly represented a dislike for the students who constituted the focus group. Likewise, the teacher self-evaluation forms contained two references indicating the paperwork was a source of frustration for GMS students. On January 23, and January 24, it was noted that students failing to understand math and mathematical conversions prevented all students from being engaged in the applied civil engineering activity. The focus group students and I clearly

believed the paperwork associated with the applied civil engineering lesson served as a point of frustration; yet, only two students (3.92 %) indicated similar feelings in the open-ended responses. Perhaps such a disparity was due to the twenty-three percent of students who disliked the lesson but were unable to provide a detailed response. For example, the comment, “It was really hard and boring,” was typical of the ambiguous responses. What remained unclear was whether the reference was to the building of the bridge or the paperwork. Based on anecdotal evidence it was highly likely that some ambiguous responses were trying to indicate that it was the paperwork which they disliked.

The data indicated that students did not like the paperwork associated with the applied civil engineering activity; however, some students liked the challenge of building a bridge out of paper and tape. Forty-four percent of focus group students, and eleven percent of open-ended respondents indicated that the challenge of designing a bridge was something they enjoyed. One student, who represented the eleven percent, stated the lesson was interesting because, “I was always active and I got to choose how I would design the bridge. The fun and most interesting part of the whole thing was testing out the bridges with others.” Furthermore, on January 17, 18, 21, 22, 23, and 24, I noted that some aspect of the design challenge was what students found most engaging for the day.

Very similar to the challenge of designing and building a successful bridge was the idea that students liked working with their hands to accomplish the task. Data from three sources indicated that working with their hands was something GMS seventh grade science students enjoyed. Thirty-three percent of the focus group and seventeen percent of the open-ended respondents specifically mentioned hands-on learning as something they liked. During the focus group interview Student Number One stated, “Oh, I liked it [applied engineering activity]

because you had a chance to make something with your hands and tried to develop your own ideas how you want to make it.” Slightly more vague, but nonetheless reflecting a similar belief, an open-ended respondent typed, “Because I like doing hand on things and plus because I like building things.” Perhaps the categories of hands-on/building and challenge of the activity should have been thematically combined in Table 7. The two previous categories were delineated due to the fact that some students specially mentioned hands-on while others specifically mentioned the challenge of the activity. Though they were separated, the two themes represented a very similar line of thought.

Just as the data indicated that students enjoyed working with their hands and the challenge of the building their own bridge, it also indicated that many students did not like the materials they were given. Thirty-three percent of focus group members and seven percent of open-ended respondents disliked the material they were given. Furthermore, on January 22, 2103, it was noted that the material constraints were a point of teacher frustration. Students had complained about the materials they were given. Reflecting the displeasure with the materials given to complete the project, an open-ended respondent stated,

All it was using paper but we already do that every day but if it was using metal like on the activity [computer-based activity which required students to select various size of metal bridge truss members] then it would have been an interesting projects so that’s why i disagree [that the activity was interesting].

Such data indicated that the line between enjoying a challenge and disliking the material given to undertake the challenge was very fine. Also, the indication that students did not like the materials demonstrated a disconnect between student and teacher in the concept of undertaking an engineering project with non-traditional materials.

Students disliked the materials they were given, but enjoyed talking to each other during the lesson. Eleven percent of the focus group and eight percent of the open-ended respondents indicated that talking with their friends was something they enjoyed about the lesson. One open-ended respondent stated, “We had a little help from our friends.” Talking during a lesson could have been construed as negative; however, on January 24, 2013, my notes indicated that students comparing the amount of weight held by their bridges was a major factor encouraging student engagement. Thus, students talking to each other was listed as a like by the students and me.

An outlier, mentioned by members of the focus group, indicated they would have liked to complete the activity with partners. The prior fact represents one of two major outliers in Table 7. Not a single open-ended respondent indicated that partners would be something to make the lesson more fun or more interesting. Yet, every single focus group member stated such, and many reiterated the point several times. Perhaps the twenty-three percent of students who disliked the activity, but provided a non-descript answer, would have garnered more from the activity had it involved partners.

The second outlier present in Table 7 was the idea that an unsuccessful bridge made students feel a sense of failure or disappointment. Twenty-two percent of the focus group and three percent of the open-ended respondents felt this way. Though the frequency and percentage are small ($N = 2$ for the focus group; $N = 2$ for the open-ended responses), it was worthy of note given the fact the idea was present in two data sources and showed a potential barrier to engaging all students in the concept of engineering.

The applied civil engineering grading rubric indicated that the weight each bridge held was a small (5/50 points) portion of a student’s grade. Even though the bridge constructed by Student Number Three met the criteria for obtaining five points, he stated, “I didn’t like breaking

them [the bridges] because basically the same thing that [Student Seven] said. Just, mine really wasn't very good and it kind of made me feel bad.”

Student Number Three referenced Student Number Seven; who was part of the forty-four percent of focus group students that indicated they did not want to break the bridge. Generally, students did not want to load their bridges until structural failure because they had spent time building the bridge and did not want to see the artifact destroyed. It was also possible that some students did not want to load their bridge as the collapse of their bridge may have brought them distress.

Just as the data for the applied civil engineering lesson generated themes which students liked and disliked; the data from the applied mining engineering lesson did the same. The data associated with the final lesson can be found in Table 8. As Table 8 demonstrates, there were two themes concerning applied mining engineering which manifested themselves in all three data sources. Students enjoyed the challenge and competition of activity, but disliked the follow-up task and associated paperwork.

Table 8
Applied Mining Engineering Likes and Dislikes

Themes	Focus Group		Open-Ended		Teacher	Like or
	Interview N = 9		Data N = 48		Eval	Dislike
	f	%	f	%		
Challenge/Competition [3]	8	88.89	6	12.5	Y	L
Follow Up Task/Paperwork [4]	8	88.89	1	2.08	Y	D
Eating the Cookie [5]	6	66.67	16	33.33	N	L
Hands On/ Nature of Activity [6]	3	33.33	1	2.08	N	L
Other/Indecipherable [7]	1	11.11	12	25	Y	
Comparison to Actual Mine [9]	1	11.11	7	14.58	N	L
Different Than Typical Activity [10]	1	11.11	5	10.42	N	L
Enjoyed Lesson Non-Descript [2]	0	0	16	33.33	N	L
Disliked Lesson Non-Descript [1]	0	0	3	6.25	N	D
Did Not Understand the Lesson [8]	0	0	2	4.12	N	D

The goal of the applied mining engineering activity was for each student to simulate an actual mine by mining a chocolate chip cookie with toothpicks and paperclips, using the mined chocolate chips to obtain a profit (following the formula provided on the worksheet), and reclaim their mine by moving all crumbs back into the original working area. Any crumbs left outside of the designated area would result in an environmental disaster fee and reduce the overall profit. Naturally this type of activity created competition, and eighty-nine percent of the focus group students indicated that competition was something they enjoyed. To a lesser degree, only twelve

percent of the open-ended respondents mentioned that challenging each other was something they enjoyed. Indicating triangulation, it was noted on the teacher self-evaluation form for February 5, 2013 that, “Comparing profit and loss,” was something that engaged GMS seventh grade science students. Evidence indicating that GMS seventh grade science students liked the competitive nature of the activity was shown by one open-ended respondent who stated, “It was fun because of the competitiveness of other classmates.” Relaying a similar belief, Student Number Four stated, “Um, well [another student] and I sit next to each other and we had this kind of challenge going on to see who got the most chocolate chips.”

The data indicated that students enjoyed the competitive nature of the applied mining activity, but disliked the associated paperwork. Eighty-nine percent of the focus group and three percent of the open-ended respondents fell into the category of disliking the paperwork. In the case of the applied mining engineering activity, there were two phases which students did not like. Those phases were the environmental fee associated with reclamation and the math associated with calculating profit and loss.

Very succinctly, Student Number Two stated, “I didn’t like, the, um, thing with the reclamation where you had to put it [cookie crumbs] back in the circle.” It was evident that many students did not enjoy some aspect of the paperwork; however, the aspect which I perceived as the greatest student dislike was the grading rubric. On February 5, 2013, it was noted in the teacher self-evaluation that the grading rubric should be simplified for future use. The reason for simplification was the fact that while assessing another student’s profit and loss some students struggled with understanding how to check the calculations.

Only two of the applied mining activity themes appeared in all three data sources; yet, just as with previous activities, there were some unique outliers. Primary among those outliers

was the rather innocuous enjoyment of eating the mined cookie. Sixty-six percent of the focus group and thirty-three percent of the open-ended respondents enjoyed eating the cookie. It probably could have been assumed that middle school students would enjoy eating cookies. What was unforeseen was that eleven percent of the focus group and fourteen percent of the open-ended respondents liked the fact that the cookie allowed them to visualize an actual mine. Student Number Three stated, “I liked how it was, this is kind of obvious, but it was kind of like an actual mining thing just with a cookie.” Further elaborating on the mining process, especially reclamation, an open-ended respondent noted the lesson was interesting, “Since we were able to experience what is [it] is like to own a mine and what will happen if you mes[s] up.”

Not all students were able to draw a connection between cookie mining and actual mining; yet, many GMS students liked the hands-on nature of the applied mining activity or the fact that the activity was different than typical classroom activities. Thirty-three percent of the focus group and two percent of the open-ended respondents specifically mentioned that they enjoyed the, “hands-on” experience of cookie mining. Similarly, eleven percent of the focus group and ten percent of the open-ended respondents liked the fact the lesson was different than a typical GMS science activity. Echoing the philosophy of the latter, an open-ended respondent stated, “I like doing the hands-on activities where we are allowed to do more than read out of a book.”

Three data sources were analyzed to determine what students liked most and least about computer-based and applied engineering activities. The three sources of data yielded a large amount of useful information. The information was useful across four different lessons, two teaching methods, and assisted with the thematic delineation of what students liked and disliked about applied and computer-based engineering activities.

Each lesson held specific items which the students did and did not like. Yet, there were some themes which were present across all four activities. Among the items which student liked across all the lessons was doing something different than a typical class day, especially if it involved a challenge. Though I try not use the science textbook as the focal point of my teaching, many days were spent in the science room. Consequently students enjoyed doing something different. Also, students enjoyed designing solution to their problems, especially if that task involved competition. However, if the design criteria were perceived as too difficult students do not like the challenge. Similarly, students did not enjoy the paperwork and reading associated with any type of engineering activity; those tasks were viewed as something ordinary and not enjoyable.

The data provided many valuable responses; however, the data set was far from complete as each activity had nearly a quarter of open-ended respondents providing unusable or indecipherable data. Nevertheless, it was possible to define what many GMS seventh grade science students liked most and least about computer-based and applied engineering activities.

INTREPERATION AND CONCLUSIONS

Primary Research Question

As documented in the literature review, there were a number of studies advocating for either computer-based or applied methods to teach engineering concepts. Many of the themes present in the literature manifested themselves in this study. As Harmer and Cates (2008) indicated, using computer-based learning required solving many issues related to technology. Sometimes those issues redirected my focus.

Computer-based lessons did create some technical problems; yet, they often expedited learning. Klahr, Triona, and Williams (2007) noted that students typically completed computer-

based lessons more quickly than applied lessons. As evidenced by Table 1, the computer-based portion of the civil engineering component of the study went much more quickly than the applied lesson. Overall, there were several similarities between this research project and studies already in existence; however, the results of this study were unique. Based on data from several sources, it appeared that seventh grade students, at least those at GMS, preferred applied engineering activities to computer-based activities. The data which supported that finding was not overwhelming, but it was present in four of five (80%) analyzed data sources.

During the pretest, students rated the use of hands-on learning as their favorite type of activity ($M = 1.37$). Likewise, during the posttest the same statement was again the highest rated ($M = 1.36$). Similarly, in both the pre and posttest, lab-based activities (pretest $M = 1.30$; posttest $M = 1.34$) were the second highest rated method of learning. Finally, computer-based learning was the third favorite type of learning activity in both the pretest ($M = 0.59$) and posttest ($M = 0.84$). Computer-based learning was not preferred to applied learning; but, it showed a greater growth during the course of the study. Despite some growth from pretest to posttest, the upward trend of computer-based learning was not enough to place computer activities on the same plane as applied learning activities.

Further evidence of a student preference for applied engineering activities was demonstrated on the teacher self-evaluation forms. During the course of the research study my ratings indicated that GMS students preferred the applied engineering activities ($M = 1.88$) to the computer-based engineering lessons ($M = 0.80$). Though those results reflected the teacher's perception of student ideas, they helped confirm other sources of data which indicated the student preference for applied learning.

Adding to the established trend, when asked on the pretest how they would like to learn about engineering, students indicated in the science lab (71.74%) or in the science room without a textbook (4.35%). Both previous methods reflected a preference for applied methods over computer-based methods. The percentage of students stating they wanted to learn about engineering in the science lab declined from the pretest (71.74%) to the posttest (60%); however, the percentage stating they wanted to learn about engineering in the classroom without a book increased (pretest = 4.35%; posttest = 12%) during the same time span. The percentage of students indicating they would like to learn about engineering using computer-based methods increased from pretest (19.57%) to posttest (28%). Again, despite the growth of student interest in computer-based learning, the data indicated a preference for applied learning methods.

Three data sources showed that students preferred applied activities. Yet, the data for the individual lessons demonstrated that, in some cases, students could prefer computer-based lessons. Based on the metrics of interesting and fun, students rated the applied mining engineering activity as their favorite lesson (interest $M = 1.00$; fun $M = 1.34$), the computer-based civil engineering lesson (interest $M = 0.65$; fun $M = 0.93$) as their second favorite, the applied civil engineering lesson (interest $M = 0.55$; fun $M = 0.53$) as their third favorite, and the computer-based mining engineering lesson (interest $M = 0.25$; fun $M = 0.25$) as their least favorite. Although the lesson engagement surveys provided an aberration in the data trend of preference for applied learning, the results of the qualitative data reinforced the belief that, overall, GMS seventh grade science students preferred applied learning.

Students in the focus group overwhelmingly (77.78%) showed a preference for applied engineering lessons. Due to the fact that students could hear each other's responses, the percentage from the focus group may not represent a firm percentage. However, they are

presented as a means of comparison between other data sources' statistical percentages. The student preference for applied engineering lessons was not with caveats.

First, students preferred the idea of an applied lesson in the pretest ($M = 1.37$) and posttest ($M = 1.36$) to an actual applied lesson with a paperwork component. Such a fact was evidenced by the low rating of the highest overall applied lesson, the applied mining engineering activity (interest $M = 1.00$; fun $M = 1.23$), and a consistent qualitative theme of disliking paperwork. The paperwork appeared regularly in the focus group interviews and in the open-ended survey responses. Both the applied mining engineering lesson (16.67%) and the applied civil engineering lesson (9.80%) had a faction of students who believed the paperwork was difficult and inhibited their ability to understand or enjoy the lesson.

The second caveat was that computer-based activities showed growth during the research study. As previously documented, students who indicated that computer lessons were their favorite type of science lesson increased from the pretest ($M = 0.59$) to the posttest ($M = 0.84$). Likewise, students who indicated they wanted to learn about engineering through computer-based methods increased from pretest (19.57%) to posttest (28%). The growth of a preference toward computer-based activities was true despite the fact the computer-based mining engineering activity was the lowest rated lesson in terms of interest ($M = 0.25$) and fun ($M = 0.25$).

In contrast to the computer-based mining activity, the computer-based civil engineering activity had a high interest ($M = 0.65$) and fun ($M = 0.93$) rating. The high rating coupled with the fact the computer-based civil engineering lesson had a small paperwork section could explain some of the growth of computer-based learning.

There were stipulations for the student preference for applied learning, and there was a growth of preference for computer-based activities. Nevertheless, the data consistently showed that students preferred applied engineering lessons to computer-based engineering lessons. The rating held true across several instruments, and was present before and after the treatment lessons had been implemented. Therefore, it can be assumed that GMS seventh grade science students preferred applied engineering lessons to computer-based engineering lessons.

Secondary Research Question

GMS seventh grade science students preferred applied engineering activities to computer-based engineering activities. However, there were themes which students liked and did not like about both types of activity. Additionally, some liked and dislike themes were universal, regardless of lesson type.

Across all lessons students enjoyed being challenged. That was true in the computer-based mining activity (focus group = 50%), applied civil engineering activity (focus group = 44%; open-ended responses = 11.76%), and the applied mining engineering activity (focus group = 88.89 %; open-ended responses = 12.5%). Challenge was noted slightly differently in the computer-based civil engineering lesson, where it was stated as design (focus group = 33.33%; open-ended responses = 15.21%). The students who mentioned enjoying design made it clear that part of the enjoyment came from the challenge of designing a functioning bridge.

Even though students enjoyed being challenged, or receiving a design challenge, an idea present across three of the four lessons was that students did not enjoy the challenge if it was perceived as too difficult. The element of disliking a challenge that was too difficult was true in the computer-based civil engineering lesson (focus group = 33.33%; open-ended responses = 10.87%), computer-based mining engineering activity (focus group = 25%), and applied civil

engineering lesson (focus group = 11.11%; open-ended responses = 3.92%). Notably absent from the aforementioned list was the applied mining engineering activity. Perhaps, not coincidentally, it was also rated as the most interesting ($M = 1.00$) and most fun ($M = 1.23$) by the students.

Another theme present in only two sources, and then only in the focus group data, raised the issue of working with partners during the engineering activities. Focus group students wanted to work with partners on the computer-based mining lesson (37.5%) and the applied civil engineering lesson (100%). Though it was only noted on one teacher evaluation, when lessons were distributed a common question was, "Do we get partners." The lessons were designed to assess how individual students, and the collective group of GMS students, felt about the activities; therefore, all of the activities were individual activities. Nevertheless, the result indicating that students would have enjoyed working together could have been expected; Kelley and Kellam (2008) indicated that engineering is a team based problem solving discipline.

While some themes manifested themselves across three or four lessons, or across both genres of lesson, others appeared in only one genre, but were worth noting. For example, during the computer-based civil engineering lesson, students (focus group = 77.77%; open-ended response = 13.04%) specifically mentioned enjoying the computer or the software used to complete the activity. Likewise, the same occurred during the computer-based mining engineering activity (focus group = 25%; open-ended response = 16.67%). Similarly, students also mentioned liking hands-on during the applied treatments; that was true for the applied civil engineering lesson (focus group = 33.33%; open-ended data = 17.65%) and the applied mining engineering lesson (focus group = 33.33%; open-ended response = 2.08%).

Just as students enjoyed some elements of the computer-based and hands-on lessons, it was evident they did not enjoy the paperwork associated with the applied learning activities. The dislike of paperwork was true in the applied civil engineering lesson (focus group = 88.89%; open-ended responses = 3.92%) and the applied mining engineering lesson (focus group = 88.89%; open-ended responses = 2.08%). The number of students who mentioned the paperwork in the open-ended responses was minimal; yet, there were many notations (33% of applied learning days) on the teacher self-evaluation forms which indicated that students disliked or misunderstood the paperwork. Overall, the paperwork was a source of displeasure.

Generally, there was less paperwork associated with the computer-based activities; however, they involved more reading. Students did not like the reading aspect of the computer-based lessons. During the computer civil engineering lesson it was indicated (focus group = 33.33%; open-ended responses = 10.87%) that the design criteria were too difficult to understand or follow. Similarly, during the computer-based mining engineering activity (open-ended response = 12.5%) it was indicated the lesson involved too much reading.

A unique dislike to one of the computer-based lessons was the dislike of computer glitches. During the computer-based mining engineering lesson it was indicated (focus group = 12.5%; open-ended response 8.33%), that students did not like the computer glitches or the ripple of chaos they caused. This outlier was of note because there was no such indication of general disorganization displayed during the computer-based civil engineering lesson or either of the applied lessons.

There were many interesting data points regarding what students liked and did not like; however, the focal point of the secondary research questions was to ascertain what students liked most and least about each type of activity.

The most prevalent theme among the activities involving the computer was that students enjoyed working on the computer and using the software programs utilized for the lessons. In contrast, students did not like the reading associated with the computer-based activities; whether that involved reading the design requirements or associated hyperlinks.

Regarding the applied activities, the theme students liked most was working with their hands to create an object they envisioned or designed. In contrast, what students liked least was the paperwork associated with the applied activities. It might be asked why paperwork was even a component of the applied activities. However, without some type of paperwork to tie the activity together, it was my opinion; the lessons would not have generated a true engineering experience. Nevertheless, students struggled with, and disliked, the paperwork as well as the calculations. Those elements of the activities were designed to use the applied lesson format as springboard for understanding engineering concepts.

The data which provided an insight into both the primary and secondary research question yielded a tremendous number of results and insights. The data enabled a trend of favorite lesson type and specific likes and dislikes within each lesson to emerge. However, the use of the data to drive future instruction was the ultimate goal of this research in general, and of the third sub question and in particular.

VALUE

The third of the secondary research questions asked, what this project has taught me about teaching engineering concepts. Regardless of the engineering lesson type, students enjoyed being challenged and having their envisioned design come to fruition. In opposition, students disliked too much reading, restrictive design criteria, and paperwork.

Earlier, during the literature review, it was noted that one of the research teams investigating middle school engineering activities indicated,

In classes where our teachers have helped students learn from the beginning that they are responsible for each other's learning, where the teacher makes clear that he or she respects the students as learning partners, where the teacher engages with students in addressing the design challenge, and where the teacher insists on respect towards everyone, the students respond quickly, engage enthusiastically, and learn much more, even when the teachers skills and knowledge are deficient (Kolodner, et al., 2003, p. 539).

Regarding the previous statement, I would argue that my engineering skills were not deficient. Assisting in making that case are my background in engineering technology and two degrees in that discipline before transitioning to science education. However, as a first year science teacher, the concept of teaching engineering in a science setting was very new. Consequently, I became a firm believer of the Kolodner et al. (2003) quote. Therefore, the answer to the question what has this research project taught me about teaching engineering concepts cannot be addressed without using the lens of how the data can be used to create a classroom emblematic of the Kolonder et al. (2003) quote.

Central to the philosophy of creating an atmosphere described in the Kolodner et al. (2003) quote will be familiarizing students with the concepts of success and failure. Such an action was not accomplished to the greatest extent during this study as some (focus group = 22.22%; open-ended response = 3.92%) expressed a sense of failure associated with the applied civil engineering lesson. Such a feeling should not have occurred; even with an engineering failure there is always a lesson to be learned.

Also paramount in understanding and appreciating the cycle of success and failure, is seeking feedback from teachers and close advisors. Thus, in the future, an effort will be made to have others analyze the work before it is presented to students. Earlier it was noted that Sarah Shields and Dawn Tucker, two support team members, reviewed the lessons after students had undergone the research study. To enhance teaching and further establish a positive classroom environment, such actions should occur before lessons are utilized.

Another idea central to understanding the role of success and failure is striving to teach students the idea that paperwork is integral to the success of an engineering project. Paperwork consistently appeared as a theme which students did not enjoy. However, it was also the way students received credit and were able to compare results. Rather than simply being something to accompany the lessons, an effort will be made to infuse the paperwork into the lesson at every possible juncture. Additionally, students may be given the option of using their data to prepare presentations, create a video, or use another method useful to them in understanding engineering concepts. Hopefully, such actions will reinforce the importance of the task.

A series of failures, and hopefully ultimate success, is central to the idea of the scientific method and the engineering design process. Hopefully a better plan for expressing the necessity of paperwork and presentations of data in that cycle will help create a more dynamic learning environment; an environment conducive to a greater student appreciation of engineering.

In addition to large philosophical changes, many details of the individual lessons will be modified. As a result of the data, all of the activities will continue to be used; but, will undergo modification to enhance the cooperative nature inherent in design challenges. The computer-based civil engineering lesson design constraints were difficult (focus group = 33.33%; open-ended response = 10.87%); yet, more students enjoyed the nature of computerized civil

engineering design work (focus group = 33.33%; open-ended response =15.21%) than found it difficult. Qualitative data suggested that students enjoyed the process of negotiating a change in the activity's design criteria. Negotiating is the type of action which would take place on a real engineering project. Such an action likely assisted in the overall high (interest $M = 1.00$; fun $M = 1.23$) rating of the computer-based civil engineering lesson and set a tone of a mutual respect. To further enhance the computer-based civil engineering lesson, the design criteria will be streamlined. This change is warranted due to its notation both by several sources of student data and the notation of support team member Sarah Shields. The streamlined criteria will include only the price, number of bridge members, type of bridge members, and bridge height. Such a change should still make the activity challenging and relevant for the students; but, reduce the amount of superfluous reading. Streamlining the design criteria will also address issues present in the data (focus group = 33.33%; open-ended respondents 10.87%) concerning the difficulty of the computer-based civil engineering activity design constraints. It is likely that some of the student difficulty was incurred due to the fact the criteria were buried in the reading.

Also, it will be made known to students from the distribution of the activity that they will be able to attempt to negotiate lesser design constraints which will allow them to complete the activity within the allotted time. The negotiation of time, price, and resources are some of the key elements of engineering projects. In addition to creating an atmosphere conducive to learning, the previously mentioned actions would also address a deficiency which Kolodner et al. (2003) noted concerning science education's lack of real world connections.

The computer-based civil engineering activity and the applied civil engineering activity were innately intertwined. Based on student input for this project, the applied civil engineering activity will be modified to include partners. The focus group was unanimous that such an

action was warranted. Furthermore, the use of partners is integral in actual engineering projects and further reflects ideas present in both Kelley and Kellam (2008) and Kolonder et al. (2003).

When changes are implemented, students will choose one of the two (one from each partner) West Point Bridge Designer blueprints and use that as a foundation for constructing a single paper and tape bridge.

Additionally, an attempt will be made to enhance the student connection between building a bridge out of paper and tape and an actual engineer building out of structural steel. Both activities are challenging, and the use of paper and tape was integral to the challenging nature of the assignment. Yet several (focus group = 33%; open-ended responses 7%) expressed frustration over the materials they were given to complete the task. In addition to simplifying the design task and cementing a connection to actual engineering projects, the changes should reduce student frustration associated with the applied civil engineering paperwork.

Harmer and Cates (2008) noted that applied engineering lessons can take too long, thereby reducing a student's capacity for focusing. During the administration of the applied civil engineering project, Student Number Three stated, "I like the computer lesson more, because they are kind of more in depth and the hands-on I think there is a little bit more time socialize, because they are longer." Using a teamwork approach, should, hopefully, shorten the lesson and channel student attention toward their project.

The civil engineering activities contained solid data which directed the focus of how to improve the activities. The changes which will be implemented for the computer-based mining engineering activity are tougher to pinpoint. The computer glitches present during the computer-based mining activity affected many students (focus group = 12.5%; open-ended response 8.33%) and made that treatment a bit of a wildcard. However, the usable data suggested

reducing the scope of the reading (open-ended responses = 12.5%). Also, there was some movement (focus group = 37.5%) to have the students work in partners to complete the design portion of the activity. Therefore, the student research portion of the computer-based mining engineering activity will be reduced in scope by simplifying the data on the hyperlinks.

Likewise, the design challenge will be converted to a partner based exercise. Also, a computerized design element will be added to the design challenge. Ultimately, due to a lack of sufficient data, future changes to the computer-based mining activity will need to be heavily scrutinized.

Finally, regarding the applied mining activity, the majority of the activity will remain the same. Data (interest M = 1.00; fun M = 1.23) indicated that this lesson was the favorite of all of the lessons utilized for the research project. However, two aspects of this lesson were not well received by the students. First, the penalty associated with the mining reclamation was deemed too severe (focus group = 88.89%; open-ended responses = 2.08%). Also, support team member Dawn Tucker, noted the graph paper was small and difficult for students to use. By default, larger graph paper would have lessened the severity of the environmental penalty.

Consequently, that penalty will either be reduced in scope (larger graph paper) or the time allotted for reclamation will be increased. Second, the grading rubric will be simplified to avoid confusion regarding calculation errors associated with students checking each other's work.

The cooperative nature of students working together to ascertain a score and determine a profit harkens back to the Kolonder et al . (2003) quote regarding the establishment of a respectful classroom atmosphere. Additionally, such an action would demonstrate the real world nature of an engineering project.

Overall, this research study provided great insight about how to improve both facets of engineering lessons. The information garnered from this research study will provide a solid foundation for creating a very stable engineering curriculum at GMS. That curriculum will be based on this study, utilize ideas of the literature, and be student driven. A conceptual model is resented in Figure 2.

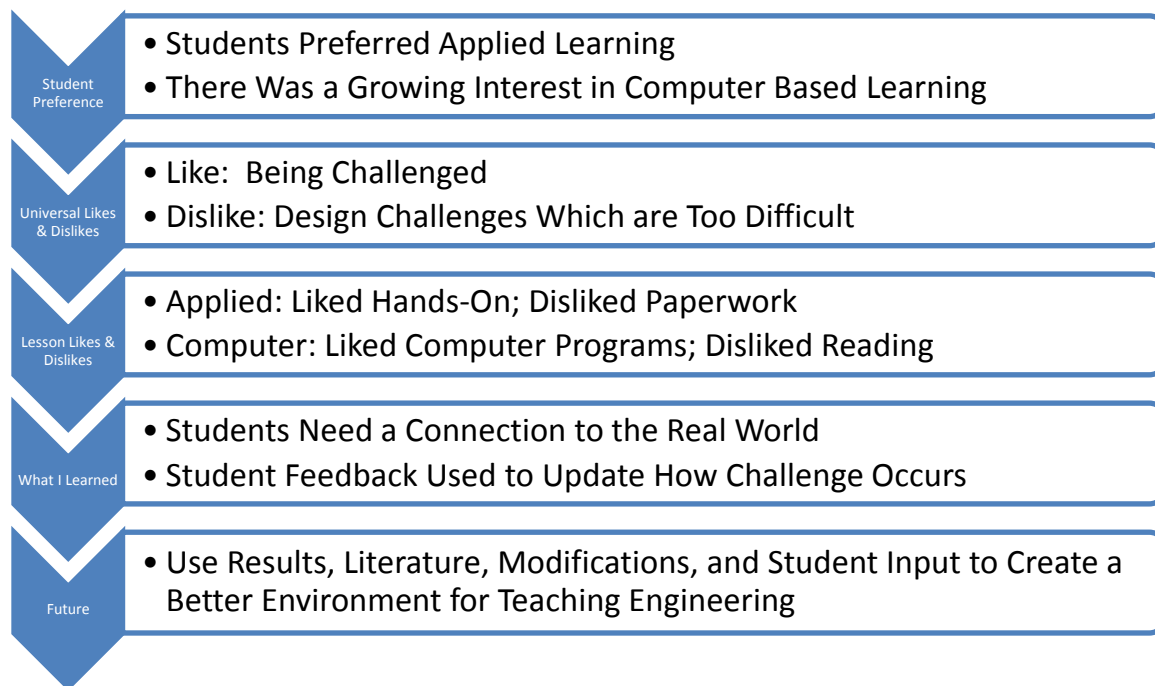


Figure 2: Filtering of the Research Question to Create a Model Engineering Curriculum for Middle School Students.

In addition to the vital feedback for each lesson, and the establishment of data driven curriculum, the data also provided other information of value. However, the data used for this study was not without fault. If the data for this study were collected again the instruments would be simplified. On the pretest and posttest students were asked to identify their preferred method of learning about engineering. When selecting an answer, the options, “In the science room without a text book,” and “In the science lab,” were vague and confusing. The purpose of the study was to

examine applied and computer-based engineering activities; therefore, the choices should simply have been, computer, hands-on, or other with an option to describe any response in the other category. Similarly, on the lesson engagement survey the options, “This lesson was fun for me,” and this “This lesson was interesting for me,” would be combined into a single thematic unit. The distinction between fun and interesting is razor thin. Finally, if the focus group were selected again, a random sampling technique would be used. After selection, the demographic identifiers would be placed in the metric. If done correctly, such an action should have yielded a true cross section of the GMS population. The method used for this study attempted to hedge against the possibility that not all demographics or categories of grades would be represented. Consequently, data may have been skewed.

Finally, several questions grew out of this research study. First, was it truly the method of delivery that interested students; or, was it simply an interesting lesson? That is a question that cannot be answered with the data collection methods used for this study. Such an answer would require the development of new instruments, but would yield useful results. Second, did the order of the lessons have any effect on the outcome? For example, would the results have been the same if the applied lessons had occurred first in the treatment sequence. A replication of the study, with the order reversed, would surely produce interesting results.

Third, how would it be possible to obtain more usable data? The lesson engagement surveys were fraught with data which could not be analyzed because it was indecipherable or non-descriptive. In many cases the lesson engagement surveys contained up to twenty-five percent unusable data. Ignoring one-quarter of the population is exactly the opposite of the type of atmosphere Kolonder et al. (2003) described as integral to a successful science classroom. Perhaps the previously mentioned streamlining of the surveys would have eliminated the

problem of poor data? Or, perhaps a smaller sample should have been investigated. For example, a random sampling of all GMS seventh graders, as opposed to the selection of two classes, could have occurred. Such an action would have created a very small and concentrated group which could have answered very specific questions, both qualitative and quantitative. Such an action would have been in opposition to the 56 students who provided data for this study. In retrospect, 56 students was a little beyond the range of manageable data sets. Additionally, a small group, with a more manageable data set, would have lent itself to a greater depth of statistical analysis.

Despite some shortcomings and the generation of additional questions, the study answered its primary and secondary research questions. Certainly, those answers could have been furthered refined given the body of knowledge present at the end of the study. However, the data proved useful and will be used to drive future instruction. That future instruction will allow the alteration of lessons which are designed to create an efficient engineering curriculum as is possible in a middle school science setting.

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APPENDICES

APPENDIX A
IRB APPROVAL



INSTITUTIONAL REVIEW BOARD
For the Protection of Human Subjects
FWA 00000165

960 Technology Blvd, Room 127
 c/o Immunology & Infectious Disease
 Montana State University
 Bozeman, MT 59718
 Telephone: 406-994-6783
 FAX: 406-994-4303
 Email: cheryl@montana.edu

Chair: Mark Quinn
 406-994-5721
 mquinn@montana.edu
 Administrator:
 Cheryl Johnson
 406-994-6783
 cherylj@montana.edu

MEMORANDUM

TO: Charles Shields and Walt Woolbaugh
FROM: Mark Quinn, Chair *Mark Quinn CQ*
DATE: October 23, 2012
RE: "Seventh Grade Student Interest Level in Computer and Applied Engineering Activities" [CS102312-EX]

The above research, described in your submission of October 22, 2012, is exempt from the requirement of review by the Institutional Review Board in accordance with the Code of Federal regulations, Part 46, section 101. The specific paragraph which applies to your research is:

- (b) (1) Research conducted in established or commonly accepted educational settings, involving normal educational practices such as (i) research on regular and special education instructional strategies, or (ii) research on the effectiveness of or the comparison among instructional techniques, curricula, or classroom management methods.
- (b) (2) Research involving the use of educational tests (cognitive, diagnostic, aptitude, achievement), survey procedures, interview procedures or observation of public behavior, unless: (i) information obtained is recorded in such a manner that human subjects can be identified, directly or through identifiers linked to the subjects; and (ii) any disclosure of the human subjects' responses outside the research could reasonably place the subjects at risk of criminal or civil liability, or be damaging to the subjects' financial standing, employability, or reputation.
- (b) (3) Research involving the use of educational tests (cognitive, diagnostic, aptitude, achievement), survey procedures, interview procedures, or observation of public behavior that is not exempt under paragraph (b)(2) of this section, if: (i) the human subjects are elected or appointed public officials or candidates for public office; or (ii) federal statute(s) without exception that the confidentiality of the personally identifiable information will be maintained throughout the research and thereafter.
- (b) (4) Research involving the collection or study of existing data, documents, records, pathological specimens, or diagnostic specimens, if these sources are publicly available, or if the information is recorded by the investigator in such a manner that the subjects cannot be identified, directly or through identifiers linked to the subjects.
- (b) (5) Research and demonstration projects, which are conducted by or subject to the approval of department or agency heads, and which are designed to study, evaluate, or otherwise examine: (i) public benefit or service programs; (ii) procedures for obtaining benefits or services under those programs; (iii) possible changes in or alternatives to those programs or procedures; or (iv) possible changes in methods or levels of payment for benefits or services under those programs.
- (b) (6) Taste and food quality evaluation and consumer acceptance studies, (i) if wholesome foods without additives are consumed, or (ii) if a food is consumed that contains a food ingredient at or below the level and for a use found to be safe, or agricultural chemical or environmental contaminant at or below the level found to be safe, by the FDA, or approved by the EPA, or the Food Safety and Inspection Service of the USDA.

Although review by the Institutional Review Board is not required for the above research, the Committee will be glad to review it, if you wish a review and committee approval, please submit 3 copies of the usual application form and it will be processed by expedited review.

APPENDIX B

ADMINISTRATOR APPROVAL

Administrator Exemption Regarding Informed Consent

I, Tamra Walker, Principal of Greencastle Middle School, verify that the classroom research conducted by Charles J. Shields is in accordance with established or commonly accepted educational settings involving normal educational practices and that I approve the project. To maintain the established culture of our school and not cause disruption to our school climate, I have granted an exemption to Charles J. Shields regarding informed consent.

Tamra V. Walker Principal
(Signed Name, Title of Position)

Tamra V. Walker
(Printed Name)

10/22/12
(Date)

APPENDIX C

COMPUTER-BASED CIVIL ENGINEERING ACTIVITY AND RUBRIC

West Point Bridge Design Challenge

To Start:

Follow the directions in the screen capture video to start WPBD.

Design Constraints:

- Your Bridge **MUST** be at an Elevation of 24 m
- **You Must Use At Least 1 Piece of Each of the 3 Types of Steel**
 - Carbon Steel
 - Quenched and Tempered Steel
 - High Strength Low-Alloy Steel
- **You Must Use At Least 1 Piece of Each of the 2 Types of Internal Support**
 - Hollow Tube
 - Solid Bar
- Your Bridge May Have no More Than 55 members
- Your Bridge May Cost No More Than \$500,000.00
- You **MAY NOT** Use Any Piece of Metal Larger Than 160 mm

Helpful Hints:

Design Tools:

- ✓ The circle creates joints (a place where two or more pieces of materials come together); you must create joints before you can create columns or beams.
- ✓ The dumbbell looking piece creates columns and beams (they must be connected to joints that have already been created)
- ✓ The eraser will erase columns, beams, and joints
- ✓ The arrow will select either column, beams, or joints
- ✓ Holding the Control (ctrl) key and left clicking will allow you to select more than one member at a time.
- ✓ Members that failed are shown in red or blue (when you return to the drawing board)
 - Red = Tension
 - Blue = Compression

Menus:

- At the top of the page where it says “120 mm,” there is a pull down menu that will let you select different thickness of materials. Remember that bigger is stronger, but it also weighs and costs more.
- At the top of the page where it says “Solid Bar,” there is a pull down menu that will let you select either solid material or hollow tubes. What do you think the advantage of hollow tubes would be?
- At the top of the page where it says “Carbon Steel,” there is a pull down menu that will let you select different types of materials
- To test the bridge click on the truck
- To go back to the drawing board click on the triangle, ruler, and pencil icon

Bridge Grading Checklist

CRITERIA	5 Points	0 Points
Bridge Elevation at 24 m	YES	NO
At Least 1 Piece of Carbon Steel Present	YES	NO
At Least 1 Piece of Quenched and Tempered Steel Present	YES	NO
At Least 1 Piece of High Strength Low-Alloy Steel Present	YES	NO
At Least 1 Hollow Tube Present	YES	NO
At Least 1 Solid Bar Present	YES	NO
Bridges Has \leq 55 Members	YES	NO
Bridge Costs \leq \$500,000.00	YES	NO
Bridge Contains No Members Thicker Than 160 mm	YES	NO
TOTAL POINTS		

APPENDIX D

APPLIED CIVIL ENGINEERING ACTIVITY AND RUBRIC

Bridge Building Project

Goal: To design, build, and test a bridge truss to determine its strength to weight ratio.

Objective: To understand the role forces play in causing a structure to collapse.

Materials:

1. A completed West Point Bridge Design
2. 10 sheets of 8 ½" X 11" paper
3. 2 feet of masking tape

Overview: You have recently experimented with WPBD. Now you will use your knowledge to design a bridge truss and see how much weight it can hold before breaking.

Design Criteria:

- Must have a successful design on WPBD
 - Following the design constraints in the WPBD activity
- Truss must be built:
 - To fit on the designated bridge tester
 - Using no more than 10 pieces of paper and 2 feet of tape
 - To incorporate a truss design inspired by your WPBD project

Deliverables:

- Report Packet which includes:
 - Cover Page
 - Print off of original WPBD design
 - Bridge Tester Data Sheet (available on Moodle)
 - Reflection paragraphs detailing:
 - What is strength to weight ratio?
 - Why did you select the truss design you selected?
 - How did this design help disperse or alter the forces acting on the truss.
 - Hint: Including a sketch which shows the forces acting on the truss at the moment of loading would be a great place to start!
- Rubric (available on Moodle)

BRIDGE TESTER DATA SHEET

Directions: Please record all of the information that is important to the breaking of your bridge. Follow the directions on the sheet. You may need to use your own calculator.

Please Note: ALL NUMBERS AND MATHEMATICAL CALCULATIONS MUST BE ROUNDED TO THE NEAREST HUNDRETH. EXAMPLE: 100.35

Section One: Complete this section *WHILE* you are breaking your bridge.

- 1) The *Bridge* weighs _____ grams
- 2) The weight of the *Testing Block* and *Mechanical Fasteners* is _____ grams
- 3) The weight of the *Empty Bucket* is _____ grams
- 4) The weight of the *Bucket Loaded With Sand* that broke your bridge was _____ lbs.
- 5) Your weight from the scale _____ lbs.

Section Two: You have answers in grams and pounds, in order to do any calculations for your bridge you must have all of measurements with the same labels, so you will need to convert everything that is in grams to pounds. There are 454 grams in a pound.

- 1) In order to convert your answers that are in grams to pounds you will need to take the answers that are in grams and (*Circle One*) [add, subtract, divide, or multiply] by 454 to find the correct answer. **HINT:** Make sure you understand this step. If you don't, ask because if you make a mistake here every problem the rest of the paper will be wrong.
- 2) The *Bridge* weighs _____ lbs.
- 3) The weight of the *Testing Block* and *Mechanical Fasteners* is _____ lbs.
- 4) The weight of the *Empty Bucket* is _____ lbs.

Section Three: From this point on anytime you need to put the weight of something make sure that it is in pounds!!

Section Four: The total weight your bridge held. To find the total amount of weight your bridge held. Add the following.

- 1) #4 From Section 1
- 2) #3 From Section 2

Total Weight Your Bridge Held = _____ lbs.

Section Five: Calculating *Strength to Weight Ratio*. The *Strength to Weight Ratio* shows you how strong something is; specifically how many times stronger it is than itself. For example, if I weighed 200 pounds and I could lift 200 pounds I would have *Strength to Weight Ratio* of 1 to 1. However, if I could lift 600 pounds I would have *Strength to Weight Ratio* of 3 to 1. You are going to calculate the *Strength to Weight Ratio* of your bridge. It should be very large, even if your bridge collapsed easily.

First: Use information from those previous sections in this formula:

$$\frac{(\textit{Weight Held by Your Bridge in Pounds})}{(\textit{Weight of Your Bridge in Pounds})}$$

NOW INSERT YOUR NUMBERS

(_____)
(_____)

Strength to Weight Ratio = _____

Section Six: Strength to Weight Ratio may be hard to think about, but hopefully these two examples will help you see how strong your bridge was.

First: Use information from those previous sections in this formula:

$$(\textit{Your Personal Weight in lbs.}) \times (\textit{Strength to Weight Ratio})$$

NOW INSERT YOUR NUMBERS

(_____) x (_____) = _____ lbs you could hold if you were as strong as your bridge!

Section Seven: The amount of weight that you calculated in Section 6 may be hard to visualize, but a Volkswagen Bug weighs close to 2000 lbs. So you are going to find out how many VW Bugs you could lift if you were as strong as your bridge. You will use the following formula:

$$(\textit{Lbs. you could hold if you were as strong as your bridge}) / (\textit{The weight of one VW Bug})$$

NOW INSERT YOUR NUMBERS

(_____) / (_____)

= _____ number of VW Bugs that you could hold if you were as strong as your bridge!

Be Proud of the Successful and Strong Bridge You Just Built and Tested 😊

Bridge Rubric	Point Total	Checklist	
<ul style="list-style-type: none"> • Truss is Complete 	5	Y	N
<ul style="list-style-type: none"> • Truss is Tested on the Testing Device 	5	Y	N
<ul style="list-style-type: none"> • Truss is Able to Hold Weight 	5	Y	N
<ul style="list-style-type: none"> • Bridge Tester Data Sheet <ul style="list-style-type: none"> • See Bridge Tester Data Sheet for Detail on Points 	20		
<ul style="list-style-type: none"> • Bridge Design Reflections <ul style="list-style-type: none"> • See Reflection Page for Detail on Points 	10		
T O T A L	/45		

APPENDIX E

COMPUTER-BASED MINING ENGINEERING LESSON AND RUBRIC

Introduction to Mining Engineering Google Earth Tour

Directions: After receiving instructions about the use of Google Earth you will load the Mining Tour .kmz file and then follow the self-guided tour of mining locations. At each stop be sure to read all of the information, follow the appropriate hyperlinks, and take note of the pictures. Also, at each stop on the Mining Tour there are questions you should answer; use the space provided to answer the questions. Good luck!

Stop #1: Greencastle Middle School

A. No questions for this stop! Just notice how the school looks from above.

Stop #2: The Berkeley Pit, Butte, Montana

A. What would be your plan for cleaning the Berkeley Pit? Be specific (by including a labeled sketch of a device or mechanism to clean the water) and also include a description of where you would take the toxins.

B. How would you feel if there was an open-pit mine like the Berkeley Pit in Greencastle? Why?

C. Provide 2 examples of how you use copper on a daily basis.

D. What are 2 positives and 2 negatives of open-pit mining?

Positives	Negatives

(Continued on the Back Page)

Stop #3: The Anaconda Smelter Stack, Anaconda, Montana

- A. Why do you think the smelter stack was left when the rest of the facility was torn down?

Stop #4: The Anaconda Slag Pile, Anaconda, Montana

- B. Instead of putting it in a pile brainstorm a list of 3 ways in which you could use the slag. Remember it is non-toxic!

Stop #5: The Old Works Golf Course, Anaconda, Montana

- C. Would you feel safe playing golf at the Old Works Course? Why or why not?

Stop #6: Buffalo Creek Mine, Logan County, West Virginia

- D. What is the major use of coal in the United States?

- A. List 2 positives and 2 negatives associated with mining and using of coal.

Positives	Negatives

- B. What is something you could do every day that would indirectly reduce the amount of coal used in the United States?

Grading Rubric for Google Earth Mining Tour

	Exemplary (5 points)	Acceptable (4 points)	Fair (3 points)	Marginal (2 points)	Not Addressed (0 points)
1. Completion	All questions are answered	One question is unanswered	Two questions are unanswered	Three questions are unanswered	Four or more questions are unanswered
2. Objective Questions	All questions are correct	One question is incorrect	Two questions are incorrect	Three questions are incorrect	Four or more questions are incorrect
3. Subjective Questions	Rationale is succinct and reflects <i>both</i> classroom discussion <i>and</i> hyperlinked material.	Rationale is succinct and reflects <i>either</i> classroom discussion <i>or</i> hyperlinked material.	Rationale lacks focus but reflects <i>both</i> classroom discussion <i>and</i> hyperlinked material	Rationale lacks focus but reflects <i>either</i> classroom discussion <i>or</i> hyperlinked material	Rational not present or does not follow guidelines

TOTAL _____ / 15

APPENDIX F

APPLIED MINING ENGINEERING LESSON AND RUBRIC

COOKIE MINING

OBJECT: Through this game, the students are introduced to the economics of mining. Students will know that mining requires investment before mining begins, plus costs of permits and environmental monitoring.

INTRODUCTION: The introduction of the economics of mining is accomplished through the players' buying their "properties," purchasing the "mining equipment," paying for the "mining operation," and finally paying for the "reclamation." In return the player receives money for the "ore mined." The objective of the game is to make as much money as possible.

MATERIALS:

- Play money
- Cookie Mining data sheet
- Sheet of grid (graph) paper
- Various chocolate chip cookies:
 - Mother's Chocolate Chip
 - Chips Ahoy
 - Chips Deluxe
- "Mining Equipment"
 - Flat toothpick
 - Round toothpick
 - Paper clip
- Clock or timer (5 minutes mining time)

INSTRUCTIONS (for teacher):

- 1) Each player starts with \$19 of play money.
- 2) Each player receives a Cookie Mining data sheet and a sheet of grid paper.
- 3) Each player must buy his/her own "mining property," which is a cookie. One "mining property" allowed per player. Cookies for sale are:
 - a) Mother's Chocolate Chip - \$3.00
 - b) Chips Ahoy - \$5.00
 - c) Chips Deluxe - \$7.00
- 4) Once the cookie is bought, the player places the cookie on the grid paper and, using a pencil, traces the outline of the cookie. The player must then count each square that falls inside the circle. Note: Count partial squares as a full square.
- 5) Each player must buy his/her own "mining equipment." More than one piece of equipment may be purchased. Equipment may not be shared between players. Mining equipment for sale is:
 - d) Flat toothpick - \$2.00 each
 - e) Round toothpick - \$4.00 each



- f) Paper clips - \$6.00 each
- 6) Mining costs are: \$1.00 per minute.
- 7) Sale of a chocolate chip mined from a cookie brings \$2.00 (broken chocolate chips can be combined to make 1 whole chip).
- 8) Reclamation: After the cookie has been "mined," it should be placed back in the circled area on the grid paper, using the mining tools. No fingers or hands allowed.
- 9) Reclamation costs: \$1.00 per square over original count.

RULES:

- 1) No player can use their fingers to hold the cookie. The only things that can touch the cookie are the mining tools and the paper on which the cookie is sitting.
- 2) Players should be allowed a maximum of five minutes to mine their chocolate/rainbow chip cookie. Players that finish mining before the five minutes are up should only credit the time spent mining.
- 3) A player can purchase as many mining tools as the player desires and the tools can be of different types.
- 4) If the mining tools break, they are not longer useable, and a new tool must be purchased.
- 5) The players that make money by the end of the game win.
- 6) All players win at the end of the game because they get to eat the remains of their cookie!

REVIEW:

- The game provides each player an opportunity to make the most money that a player could make with the resources provided. Decisions are made by each player to determine which properties to buy and which piece or pieces of mining equipment should be purchased.
- Each player will have learned a simplified flow of an operating mine. Also, each player will have learned something about the difficulty of reclamation especially in returning the cookie back to the exact size that it was before "mining" started.
 - NOTE: For lower grade levels, squares can be used to color in for costs in one color and income in another color.



COOKIE MINING DATASHEET

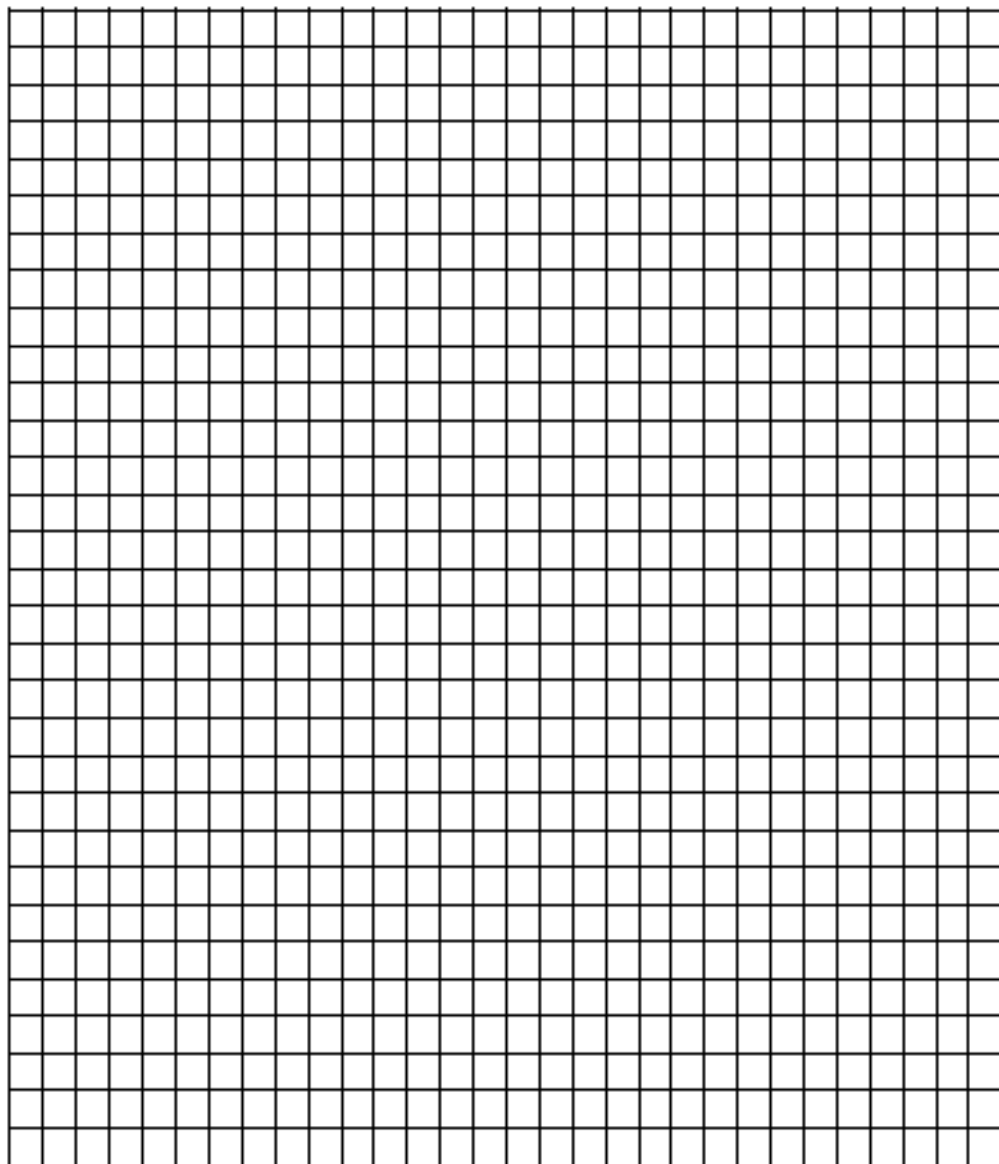
- Name of cookie
- Price of cookie
(Mothers \$3.00, Chips Ahoy \$5.00, Chips Deluxe \$7.00)
- Size of cookie squares covered
- Equipment:
 - Flat toothpick _____ x \$2.00 = _____
 - Round toothpick _____ x \$4.00 = _____
 - Paper clip _____ x \$6.00 = _____
 TOTAL EQUIPMENT COST
- Mining: _____ minutes x \$1.00 = Cost of removing chips = _____
- TOTAL COST OF MINING** (cookie + equipment + mining time) = _____
- Income from chips:
 - Number of chips _____ x \$2.00 = VALUE OF CHIPS = _____

How much did I make?

Value of chips	(±)	_____
Total cost of mining	(-)	_____
Reclamation _____ squares x \$1.00	(-)	_____
PROFIT/LOSS	(±)	_____



COOKIE MINING GRID SHEET, FINEST DETAIL



Introduction to Mining Rubric	Point Total	Checklist			
<ul style="list-style-type: none"> • Cookie is correctly identified 	1	Y	N		
<ul style="list-style-type: none"> • Price of the cookie is correctly identified 	1	Y	N		
<ul style="list-style-type: none"> • Cookie is drawn on the graph paper 	1	Y	N		
<ul style="list-style-type: none"> • Number of squares covered is identified within <ul style="list-style-type: none"> • + or – 2 squares • + or – 4 squares • A variation greater than 6 squares 	2				
	1				
	1				
<ul style="list-style-type: none"> • Flat toothpick calculation is completed correctly 	1	Y	N		
<ul style="list-style-type: none"> • Round toothpick calculation is completed correctly 	1	Y	N		
<ul style="list-style-type: none"> • Paper clip calculation is completed correctly 	1	Y	N		
<ul style="list-style-type: none"> • Mining equipment calculation is completed correctly 	1	Y	N		
<ul style="list-style-type: none"> • Mining minutes calculation is completed correctly 	1	Y	N		
<ul style="list-style-type: none"> • Total cost of mining calculation is completed correctly 	1	Y	N		
<ul style="list-style-type: none"> • Number of chips correctly identified 	1	Y	N		
<ul style="list-style-type: none"> • Value of chips calculation correctly identified 	1	Y	N		
<ul style="list-style-type: none"> • “How Much Did I Make” section calculations completed correctly 	1	Y	N		
<ul style="list-style-type: none"> • Answer to Question 1 makes a connection between the cost of the cookie purchased and the amount of profit 	1	Y	N		
<ul style="list-style-type: none"> • Answer to Question 2 <ul style="list-style-type: none"> • Answer mentions land acquisition cost • Answer mentions labor cost • Answer mentions equipment costs • Answer mentions amount of mined material that is recovered • Answer mentions environmental/reclamation costs 	1				
	1				
	1				
	1				
	1				
T O T A L	/20				

APPENDIX G
BASELINE INSTRUMENT

7th Grade Baseline Science Engagement Survey

Directions: Please answer each question. Remember to select the answer that shows your true opinion. Do not answer how you think you want me to answer; answer with your own honest opinion.

Remember, all answers are anonymous and your participation is not required. Either participation or non-participation will not affect your science grade.
*** Required**

Student ID Number *

Remember that all information is anonymous. Your ID number will only be used if there is a question regarding your answer.

What class period do you have 7th grade science? *

- Period 1
- Period 2
- Period 3
- Period 4
- Period 7
- Period 8

I find working on assignments from the science textbook to be interesting. [] *

Strongly Disagree Disagree Neutral Agree Strongly Agree

Why did you answer the previous question the way you did? *

I find assignments which require working in the science workbook to be interesting. [] *

Strongly Disagree Disagree Neutral Agree Strongly Agree

Why did you answer the previous question the way you did? *

I find assignments which require writing in the science journal to be interesting. [] *

Strongly Disagree Disagree Neutral Agree Strongly Agree

Why did you answer the previous question the way you did? *

I find working on experiments in the computer lab to be interesting. [] *

An example of online experiments would be Gizmo labs

Strongly Disagree Disagree Neutral Agree Strongly Agree

Why did you answer the previous question the way you did? *

I find working on experiments in the science lab to be interesting. [] *

An example of science lab experiments would be the Earth Layers lab

Strongly Disagree Disagree Neutral Agree Strongly Agree

Why did you answer the previous question the way you did? *

I find assignments which require hands-on activities to be interesting [] *

Examples would be the Layers of the Earth assignment and the Landforms of the Earth assignment

Strongly Disagree Disagree Neutral Agree Strongly Agree

Why did you answer the previous question the way you did? *

Previous science courses have covered topics related to engineering. [] *

Strongly Disagree Disagree Neutral Agree Strongly Agree

If you have studied engineering in a previous science course please list the grade level in school during which you learned about engineering
ONLY ANSWER THIS QUESTION IF YOU ANSWERED AGREE OR STONGLY AGREE TO THE PREVIOUS QUESTION.

If you have studied engineering in a previous science course please describe how you were taught the topic of engineering; such as a project, reading, or journal entry.
ONLY ANSWER THIS QUESTION IF YOU ANSWERED THE PREVIOUS QUESTION.

I am MOST interested in science on days in which *

- We work in the computer lab
- We work in the science lab
- We do non-book related work in the science classroom
- We do textbook related work in the classroom
- We do workbook related work in the classroom
- We do science journal related work in the classroom

Why did you answer the previous question the way you did? *

I am LEAST interested in science on days in which *

- We work in the computer lab
- We work in the science lab
- We do non-book related work in the science classroom
- We do textbook related work in the classroom
- We do workbook related work in the classroom
- We do science journal related work in the classroom

Why did you answer the previous question the way you did? *

I find that I put the MOST effort and time into science assignments which *

- Require work in the computer lab
- Require work in the science lab
- Require non-book related work in the science classroom
- Require textbook related work in the classroom
- Require workbook related work in the classroom
- Require science journal related work in the classroom

Why did you answer the previous question the way you did? *

I find that I put the LEAST effort and time into science assignments which *

- Require work in the computer lab
- Require work in the science lab
- Require non-book related work in the science classroom
- Require textbook related work in the classroom
- Require workbook related work in the classroom
- Require science journal related work in the classroom

Why did you answer the previous question the way you did? *

If we were to study engineering what type of engineering project would you prefer *

- One that requires work in the computer lab
- One that requires work in the science lab
- One that requires non-book related work in the science classroom
- One that requires working from the textbook in the classroom
- One that requires working from the workbook in the classroom
- One that requires working the science journal in the classroom

Why did you answer the previous question the way you did? *

What do you like BEST about 7th grade science lessons which require you to use computers? *

What do you like LEAST about 7th grade science lessons which require you to use computers? *

What do you like BEST about 7th grade science lessons which require you to complete a hands-on project? *

What do you like LEAST about 7th grade science lessons which require you to complete a hands-on project? *

APPENDIX H

LESSON ENGAGEMENT SURVEY

Lesson Engagement Survey

Directions: Participation is voluntary, and you can choose to not answer any question that you do not want to answer, and you can stop at anytime. Remember to select the answer that shows your true opinion. Do not answer how you think I want you to answer, answer with your own honest opinion.

Remember, all answers are anonymous and your participation is not required. Your participation or non-participation will not affect your grade or class standing.

* Required

Student ID Number

Remember, all answers are anonymous. Your ID number will only be used if there is a question with your answers.

What period do you have science? *

- Period 1
- Period 2
- Period 3
- Period 4
- Period 7
- Period 8

Are you *

- Male
- Female

My anticipated grade in science this quarter is: *

- A
- B
- C
- D
- F

This activity made me want to learn more about science *

Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>

Why did you answer the previous question the way you did? *

This activity made me want to give my best effort in science class *

Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>

Why did you answer the previous question the way you did? *

This activity made me want to work my hardest *

Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>

Why did you answer the previous question the way you did? *

I found this lesson *

Extremely Difficult Difficult Neutral Easy Extremely Easy

Why did you answer the previous question the way you did? *

I feel like I learned during this lesson. *

Strongly Disagree Disagree Neutral Agree Strongly Agree

Why did you answer the previous question the way you did? *

This lesson was interesting for me. *

Strongly Disagree Disagree Neutral Agree Strongly Agree

Why did you answer the previous question the way you did? *

This lesson was fun for me. *

Strongly Disagree Disagree Neutral Agree Strongly Agree

Why did you answer the previous question the way you did? *

APPENDIX I

FOCUS GROUP INTERVIEW QUESTIONS

Background: Remember, this interview will not affect your grade. The interview will be audio recorded in order for Mr. Shields to use the data in his paper. However, all recordings and answers you provide will be held in the highest confidentiality. Any audio recording will be deleted or destroyed at the conclusion of the project. Please answer honestly and provide me with answers which reflect your thoughts and opinions, not what you think I want to hear.

1. On most days do you enjoying coming to science class?
 - a. Why/Why not?
 - b. Did this lesson change that feeling?
2. On a daily basis do you want to work as hard as possible in science class?
 - a. Why/Why not?
 - b. Did this lesson change that attitude?
3. What did you like most about our most recent lesson?
4. What did you like least about our most recent lesson?
5. What part of our most recent lesson made you want to try your best?
 - a. Why was this more motivating to you than other parts of the most recent lesson?
6. What part of the most recent lesson was not interesting or made you not care about the project?
7. What could have been improved in the most recent lesson to make it more interesting?
8. When you talked to other students during the most recent lesson what did you ask them?
 - a. Questions about the project or something else (socializing)?
 - i. What types of questions about the lesson?
 1. Directions or Something about content?

9. Did you like the format (computer or hands-on) of the most recent lesson?
 - a. Why did you like or dislike this format?
 - b. What other format would you prefer?
 - i. Why would you prefer that format?
10. What did you learn about engineering from our most recent lesson?

APPENDIX J

TEACHER SELF-EVALUATION FORM

Action Research Teacher Self-Evaluation Form

Lesson _____ Day: _____

Directions: For each statement elect the appropriate rating. Use the following scale 1 = Strongly Agree, 2 = Agree, 3 = Neutral, 4 = Disagree, 5 = Strongly Disagree.

Before The Day Begins

1. I am Excited to Teach This Lesson

12345

The reason is:

2. I am Prepared to Teach This Lesson

12345

Two examples to indicate preparation:At the Conclusion of the Day

1. Students were Excited About This Activity

12345

Two ways to indicate student excitement:

2. Students were Engaged by This Activity

12345

Two ways to indicate student engagement:

3. Students were Motivated by This Activity

12345

Two ways to indicate student motivation:

4. Students Complained About This Activity

12345

Examples of complaints:

5. While Working on This Activity Students Spent the Majority of Time on Task

12345

Reasons for selecting the answer:

6. Students Asked Engaging Questions to the Teacher About This Lesson

12345

Examples of the questions asked:

7. Students Asked Procedural Questions to the Teacher About This Lesson

12345

8. Students Asked Engaging Questions to other Students About This Lesson

12345

9. Students Asked Procedural Questions to the Other Students About This Lesson

12345

10. My Frustration Level Was Low Today

12345

11. I Felt the Lesson Went as Well as Anticipated

12345

Directions: Complete the journaling portion of the survey.

1. The aspect of this lesson the students found most engaging was
2. The primary factor which inhibited all students from being engaged was
3. If I were to teach this lesson again I would change
4. Other factors which may have affected the teaching of this lesson

APPENDIX K

STUDENT FOCUS GROUP MEMBERS

Focus Group Participants

Name	Grade	Gender	Free/ Reduced	IEP	Minority	Period
Student #1	A	M	F	N	Y	AM
Student #2	A	F	N/A	N	N	AM
Student #3	A	M	N/A	N	N	PM
Student #4	A	F	R	N	N	PM
Student #5	B	F	N/A	N	N	PM
Student #6	C	M	N/A	Y	N	PM
Student #7	C	F	N/A	N	N	AM
Student #8	C	M	F	N	N	PM
Student #9	D	M	F	N	N	AM
Student #10	F	F	F	N	N	AM

APPENDIX L

APPLIED MINING ENGINEERING FOCUS GROUP INTERVIEW

COMPUTER-BASED MINING ENGINEERING FOCUS GROUP TRANSCRIPT

Interviewer: C.J. Shields **Interviewee:** Action Research Focus Group

Absent: Student Number Seven and Student Number Ten

Date: 2/5/13 **Time:** 11:52 a.m. (EST)

Interview Mode: Group **Recorded:** Apple's iPod Voice Memo software

Mr. Shields: Alright, it is recording. Ok, so today we are going to talk about the Google Earth activity, which I know had some problems because we had computer problems and we had some network problems and those types of things. Uh, but just real quick, maybe somebody tell me, uh, what was something you liked about the Google Earth activity. Student Number Five.

Student Number Five: That we got to get on the computer and we didn't have to stay in the classroom. [3]

Student Number One: I agree with her. [3]

Mr. Shields: Student Number One, why do you agree with her?

Student Number One: Because I like doing stuff on the computer and it was fun to learn, learn about the environment and how we getting our stuff, electrical stuff, and that stuff. [7]

Mr. Shields: So, like electric wire and things?

Student Number One: Yes.

Mr. Shields: Student Number Four.

Student Number Four: I liked the part where you had to draw, the um, the uh whatchamacallit. [5]

Mr. Shields: The brainstorming sketch...

Student Number Four: Yeah.

Mr. Shields: ...for the cleaning device of how to clean the Berkeley Pit.

Student Number Four: Yeah.

Mr. Shields: So, why did you like that Student Number Four? What was interesting about that for you?

Student Number Four: I really enjoy, um, learning about how to help the environment and I really like drawing. So, that was a good combination. [7]

Mr. Shields: Student Number Two, you had your hand up.

Student Number Two: I enjoyed like the little note before the area you went so you had some background information.

Mr. Shields: So, you mean, sorry, on the computer or do you mean on the paper?

Student Number Two: On the computer, where you click on it and it would pop up.

Mr. Shields: Gotcha; so, like the hyperlinks in the Google Earth tour. Student Number Three.

Student Number Three: I liked the information that was on the computer when you clicked on the link, just basically. [7]

Mr. Shields: Any particular type of information you liked that was there?

Student Number Three: I just liked basically the whole thing. I just thought it was interesting.

Mr. Shields: Student Number Six, Student Number Eight, Student Number Nine, anything from you guys? Student Number Six, did you like it?

Student Number Six: Well, I can't really say because I never got on Google Earth.

Mr. Shields: Because you were absent and then we had the computer problems, right?

Student Number Six: Yes.

Mr. Shields: Student Number Eight.

Student Number Eight: [indecipherable]

Mr. Shields: Did you like it or did you not like it?

Student Number Eight: I liked it.

Mr. Shields: Why did you like it?

Student Number Nine: What is this thing?

Mr. Shields: The Google Earth activity.

Student Number Nine: Did you do this last week.

Mr. Shields: Yes.

Student Number Nine: I wasn't here.

Mr. Shields: And you were absent all week.

Student Number Nine: Yeah.

Mr. Shields: Ok, that will explain, probably, your lack of comments. Uh, what could I have done? Uh, what do you think was the most interesting? So you guys kind of told me what you liked about it, so was what you liked the most interesting thing that you mentioned? Student Number One.

Student Number One: The drawing stuff. [5]

Mr. Shields: The drawing.

Student Number One: Yeah.

Mr. Shields: Student Number Five.

Student Number Five: I say no because, err wait. I liked the drawing the best. [5]

Mr. Shields: The drawing. Student Number Four, you already said you liked the drawing the best. Student Number Two, background. Student Number Three.

Student Number Three: Uh, yeah.

Mr. Shields: Yeah.

Student Number Three: Yeah.

Mr. Shields: As in yes, the drawing.

Student Number Three: Yeah. [5]

Mr. Shields: Alright. What was something that I could have improved to make the lesson more interesting for you? Student Number Four, you seem very enthusiastic when I asked that.

[Laughter].

Student Number Four: Um, you could have, had, um, had us have partners because [another student] and I sit right next to each other and we kind of helped each other on the ideas even though we weren't technically not supposed to. [10]

Student Number One: Agree with her. [10]

Student Number Four: Yeah.

Mr. Shields: So Student Number Four, do you mean partners for everything or partners for the brainstorming sketch for the device to clean the Berkeley Pit or both?

Student Number Four: Both.

Mr. Shields: Student Number Five.

Student Number Five: Like, you could have let us use something like magic. [6]

Student Number Nine: What?

Mr. Shields: So, have some magic solution to clean the Berkeley Pit?

Student Number Five: Yeah

Student Number Four: But then like would have...

Mr. Shields: That would have made it too easy though, right.

Student Number Four: Um huh.

Student Number One: Yeah.

Unknown: Way to easy.

Student Number Five: But what if you could have only used one?

Mr. Shields: Other suggestions for improvement? [Pause]. Anybody else have other things that would have made this lesson better for you?

Student Number One: I think so, it would be much better if you can like only, if you didn't let us like explain what the machine does and how does it clean it, cause it was like to much hard words and mine to think about and try to define what, how does it work and where does it go, and that was too hard. [6]

Mr. Shields: Alright, Student Number Six I think you had your hand up and then I will get to Student Number Four.

Student Number Six: Less technically difficulties. [11]

[Laughter]

Mr. Shields: Give me an example of what you mean?

Student Number Six: Um, I couldn't get on the internet.

Mr. Shields: You mean literally the technical difficulties with the computer lab?

Student Number Six: Yes.

Mr. Shields: Not with the assignment.

Student Number Six: Yeah.

Mr. Shields: Gotcha. Student Number Four.

Student Number Four: Um kay, I think it would have been more fun if you had put more, like, places to go on there, like all over the world, so you can learn about different crisis, crisis's. [9]

Mr. Shields: Crises.

Student Number Four: Crises, all over the world and then, um, in doing that you should have, um like extended the time limit so we could have more time to do all of it. [9]

Mr. Shields: Student Number One.

Student Number One: You should like let us, it [indecipherable] fun to look like look at our houses and try to figure out how many we have of land and like try to see how much it cost like that stuff.

Student Number Five: We were allowed to look at our houses.

Student Number One: No we weren't.

Mr. Shields: Student Number Eight, anything for you that would have made it better?

Student Number Eight: Can you repeat the question?

Mr. Shields: What would make, would have made the Google Earth lesson better for you, or more interested, interesting

Student Number Eight: To work in partners. [10]

Mr. Shields: Alright. [Pause] When you talked to, when you were talking to other students during the lesson did you find you were socializing or were you asking them questions about how to do the lesson? Student Number Four.

Student Number Four: Um, as I already said [another student] and I, [another student] and I sit right next to each other so we were talking a lot about the uh, um, Google Earth thingy.

Mr. Shields: So, you were talking about the lesson?

Student Number Four: Um, huh.

Mr. Shields: Student Number Five.

Student Number Five: Oh, like me an [another student] sit right next to each other and we were kind of doing both because like I had a lot of questions and then we would just like socialize about our boyfriends and stuff.

Mr. Shields: Student Number One.

Student Number One: I would say both, because I didn't see with [indecipherable]

Mr. Shields: Sorry, Student Number One can you repeat that for me.

Student Number One: Oh, I would say both because [another student], well [another student] sits be, like the side, excuse me, the side and we really don't talk a lot and I was just start to tell him like, "Here's my house," and we just started like ok and then we just started asking question about....

Mr. Shields: Student Number Three.

Student Number One: ...that.

Student Number Three: I did a little bit of both, I think. I had a couple of questions, but not as much as either one.

[Pause]

Mr. Shields: Student Number Six, Student Number Eight? Student Number Six, I guess you were absent, so Student Number Eight.

Student Number Eight: Can you repeat the question?

Mr. Shields: Did you find that when you were asking questions to other people was it about socializing, or was it about the assignment?

Student Number Eight: I wasn't really talking to anyone during the assignment.

Mr. Shields: Fair enough.

[Pause]

Mr. Shields: Do you like. Two things, do you like the length of this lesson? Like, this was just a couple of days. So, did you like the shorter lesson better or did you like the longer bridge lesson that we did? So, basically, would you prefer a longer lesson or a shorter lesson on the computer? Student Number Four.

Student Number Four: Um, I think the way you did it where you did a really long lesson then we kind of had to review and went over the forces. [4]

Mr. Shields: Um, huh

Student Number Four: and then we had a really short one. I think that is a really good pattern, like long one, short, long, short.

Mr. Shields: Student Number One.

Student Number One: I think so, it is better a short one because we, well, and yeah a short one, cause you go like through more lessons than a short, err, and long one. Cause the one might take longer but it will be perfect but you understand more. But, it's like you; we won't have enough, enough time work in different stuff from the books. [4]

Mr. Shields: Ok, Student Number Four, I want to jump back to you for just a minute.

Student Number Four: Um, huh.

Mr. Shields: What makes you like that long, short, long format?

Student Number Four: Um, because, um I like the long one, um, where you had something on the computer and something that was kind of hands on and then that made it really long and it was a really fun lesson too. And then we had a review day, and then the next day we did just a really short, just kind of brief easy thing, lesson.

Mr. Shields: Student Number Two, you were shaking your head. Do you agree with that?

Student Number Two: Yeah.

Mr. Shields: You like the long, short, long or shorts or longs.

Student Number Two: Um, I like shorter lessons because its, we're trying to, I don't know how to word it, but I just like shorter ones. [4]

Mr. Shields: Alright, if you think of the wording let me know. Student Number Three, haven't heard from you in a while.

Student Number Three: This is kind of more directed to the Google Earth tour thing, but I think it would have been better if it was longer, because, so you could like learn about all the couple little bit more. [4]

Mr. Shields: So, you think you could have learned more about the mines and how they were built.....

Student Number Three: Yeah

Mr. Shields: and the environmental effects if they had been longer? Student Number Eight, what about you? Did you find that you were interested or was it too long or too short?

Student Number Eight: I like long.

Mr. Shields: Why?

Student Number Eight: It gives me more time.

Mr. Shields: So, if you have a longer lesson do you think you are more likely to waste your time, or are you more likely to use it wisely?

Student Number Eight: Use it wisely.

Mr. Shields: Ok, last question. Um, and this is the one we have covered repeatedly. Now, don't confuse what we are doing today, because we will have the interview about that on Thursday, but do you like the format of the most recent. So, I'll back up and summarize. At this point, do you think you like computer lessons better or hands on lesson better and why? Student Number One.

Student Number One: Hand on.

Mr. Shields: Why?

Student Number One: Cause, you get to feel stuff you have never felt before, like something else.

Mr. Shields: Student Number Five

Student Number Five: I think the hands on better because, uh, that is the way I learn, like doing things with my hands, and whenever we are in the computer all you do is click and scroll, but I think I like the hands on better.

Mr. Shields: Ok, so what about hand's on makes you learn more, just because you are doing something and you have to use your mind with it?

Student Number Five: Yeah, and I think. I don't know, it's just amazing.

Mr. Shields: Alright, Student Number Two.

Student Number Two: I enjoy the hands on, because like with Student Number Five that is just the way I learn to understand things, and with the computers there are so many glitches it just affects the lesson.

Mr. Shields: So, you really don't mean you learn as much because of like, the some of the Google Earth sites were blocked and then some people couldn't log on, all of that stuff effects things, where you have less problem with hands on. That is a really good point.

Student Number One: And we have less time to work on it.

Mr. Shields: Because we have to go to the computer lab and we have to log on and all of those things. Ok, Student Number Three, you have had your hand up for a while.

Student Number Three: I like the computer lesson more, because they are kind of more in depth and the hands on I think there is a little bit more time to socialize, because they're kind of longer.

Mr. Shields: So, you think you can kind of lose focus during a hands on.

Student Number Three: Yeah.

Mr. Shields: Alright, now Student Number Six and Student Number Eight, Student Number Nine I know you guys were. I guess, Student Number Eight you were here, which one do you prefer?

Student Number Eight: I like hands on better.

Mr. Shields: Why's that?

Student Number Eight: Cause, I learn more that way.

Mr. Shields: Why do you think you learn more that way?

[Pause]

Student Number Eight: I just concentrate more. [Indecipherable].

Mr. Shields: Student Number Six and Student Number Nine since you were absent, but generally what do you, which one do you guys like more, hands on or.

Student Number Six: I like computers. Like [bell rings], if like the bridge activity, um, instead of having to redo the whole bridge you could just hit like erase on one part and.

Mr. Shields: And click that. Student Number Nine.

Student Number Nine: I like the computer best, because it just [indecipherable].

Mr. Shields: Alright, Student Number Five. Last one then we will wrap it up.

Student Number Five: I was going to ask a question about those?

Mr. Shields: You were going to ask a question about what?

Student Number Five: Those.

Mr. Shields: We can cover that later. Everybody can have a cookie if they want. I forgot, actually I am not going to be here on Thursday, let's do tomorrow. Can everybody do tomorrow and then we will be done and I will not be on your social schedule anymore, everybody ok with that? Everybody cool with that?

END OF INTERVIEW

APPENDIX M

COMPUTER-BASED MINING FOCUS GROUP INTERVIEW

APPLIED MINING ENGINEERING FOCUS GROUP TRANSCRIPT

Interviewer: C.J. Shields **Interviewee:** Action Research Focus Group

Absent: Student Number Seven

Date: 2/6/13 **Time:** 11:52 a.m. (EST)

Interview Mode: Group **Recorded:** Apple's iPod Voice Memo software

PART I

Mr. Shields: Alright, thanks again for coming out today.

Student Number Nine: Hello.

Student Number Ten: To our secret lab in the USK.

Student Number One: In the secret lab.

Mr. Shields: Ok.

Student Number Nine: USA.

Mr. Shields: What, so, today we are talking about the cookie mining activity. So, yesterday we covered the Google Earth tour, but today we are going to cover the cookie mining which we have done, uh, which we did yesterday in class and, and have done today or will finish up today for those of you in seventh period.

Student Number One: Can I finish it (food from lunch).

Student Number Nine: Yep.

Mr. Shields: What, uh, did you like about the cookie mining activity? What were some things that you liked about the cookie mining activity? Student Number Four.

Student Number Four: Um, you got to eat the cookie afterwards. [5]

Several Students: Yes!

Mr. Shields: Ok, Student Number One

Student Number One: You got to make, well not really with your fingers and hands, but you had to, like, take all the chocolate out of the cookie and try to figure out how many you get out of it, how much is around the cookie. [3]

Mr. Shields: So, you like.....

Student Number One: So, yeah

Mr. Shields: ... working with your hands....

Student Number One: Yeah

Mr. Shields: ...to take the chocolate chips out? Student Number Two.

Student Number Two: I liked the challenge of where you had to try to make a profit [indecipherable]. [3]

Mr. Shields: Alright. Student Number Ten.

Student Number Ten: I like that you got to eat the cookie afterwards and you, you had the challenge of you couldn't use your hands, you had to use something to actually get it out, and then you had to get the crumbs back in the circle. So, I like how it was sort of like a challenge. [5,3]

Mr. Shields: Very good. Student Number Three.

Student Number Three: I liked how it was, this is kind of obvious, but it was kind of like an actual mining thing just with a cookie. [9]

Mr. Shields: So, what made you think it was like an actual mine?

Student Number Three: Because you were trying to get things out and those were the chocolate chips and that would be whatever you were trying to find or something like that.

Mr. Shields: Alright. Thank you. Student Number Eight, you said something at the very beginning?

Student Number Eight: They took what I was going to say.

Mr. Shields: Which was?

Student Number Eight: You got to eat the cookie. [5]

Mr. Shields: Alright. Student Number Five, Student Number Nine, I didn't hear from you guys, or Student Number Six. Anything to add from you three?

Student Number Nine: Um, you had to get all the little crumbs off of the chip. [4]

Mr. Shields: Before you could count it, too, for a profit?

Student Number Nine: Yeah.

Mr. Shields: Ok.

Student Number Nine: Which was really kind of [indecipherable].

Mr. Shields: Student Number Six.

Student Number Six: Well, I like digging the chocolate out, I struck like a HUGE chocolate piece. [3]

Mr. Shields: Ok.

Student Number Six: Like that big (making a gesture with his hand)

Mr. Shields: Ok. Student Number Five.

Student Number Five: Um, the eating part. [5]

Student Number Nine: The eating part.

Mr. Shields: So, what were some things you did not like about the cookie mining activity? What were, were things that you did not like? Student Number Four, you were very enthusiastic there, so there must be something you did not like.

Student Number Four: Yes, the part at the end where you had to take all of the tiniest, even the smallest little crumbs back into the circle; because, I had a 198 crumbs... [4]

Student Number Nine: Whoa.

Several Students: Oh my gosh.

Student Number Four: ...and that is, like, not fair.

Student Number Nine: I only had like 40 some.

Mr. Shields: Um, Student Number Three.

Student Number Three: I didn't like that we could not like hold it [the cookie] when we were like trying to get the chocolate chips out. [4]

Mr. Shields: You mean with your hands? Because you could use the tools, so you would rather have been able to hold it with your hands?

Student Number Three: Yeah, like just hold the cookie so you weren't just like pushing it around.

Mr. Shields: Ok. Student Number One.

Student Number One: Um, I like, I didn't like the part with doing the math, cause it was kind of hard to multiply all the stuff and then divide it and subtract it and get the profit and that stuff, and I didn't like when you had to use your hands to clean the little [indecipherable] stuff, that was hard. [4]

Mr. Shields: When you had to use the tools to clean?

Student Number One: Yeah.

Mr. Shields: Uh, somebody down there, Student Number Five or Student Number Ten had your hand up? Which one of you? Ok, Student Number Five go ahead.

Student Number Five: Um, I didn't like the part where you had to like use the tools to get the cookie chip things out, and whenever I tried I went down and then I tried going back up and it flew, and then... [4]

Student Number Ten: Yeah.

Student Number Five: ...I couldn't find it, and I got mad.

Student Number Ten: I accidentally hit someone in the head with that, I think it got stuck in their hair!

Mr. Shields: With a flying chip?

Student Number Ten: Yeah.

Student Number One: Was that [indecipherable]

Mr. Shields: Student Number Two, anything else?

Student Number Two: I didn't like, the um thing with reclamation where you had to put it back in the circle. [4]

Mr. Shields: So, what part of the cookie mining activity made you want to try really hard? Student Number Five.

Student Number Five. [Pause] Um, that I knew as soon as I got done that I can eat it. [5]

Mr. Shields: Fair enough, Student Number One.

Student Number One: Um, the part where we had to get the chocolate out of the cookie. So, that makes you get like more money.

Mr. Shields: So the challenge....

Student Number One: Um, yeah.

Mr. Shields: ...of getting the chocolate chip out? Student Number Six.

Student Number Six: Um, the challenge of getting, um, enough chocolate chips to make a profit.

Mr. Shields: Student Number Three, you had your hand up.

Student Number Three: Um, I forgot. [Laughter]

Mr. Shields: Student Number Ten.

Student Number Ten: Um, getting like the chocolate chips out, but then like I didn't really want to try hard at the same time because if I destroyed my cookie a lot it would be really hard to eat.

Mr. Shields: Student Number Four.

Student Number Four: Um, well [another student] and I sit next to each other and we had this kind of challenge going on to see who got the most chocolate chips. [3]

Mr. Shields: Uh, huh

Student Number Nine: Who didn't?

Student Number Four: And so that kind of made me want to.

Mr. Shields: So, you really liked, really liked the fact you could compete with students near you to challenge you?

Student Number Four: Exactly.

Mr. Shields: Interesting, did anybody else do that? Any other students complete with someone around them?

Student Number Six: Not really, but then whenever we counted I, I got the most.

Mr. Shields: Student Number Two, you said yes as well. So, you competed with somebody? And Student Number One you said yes? So, that would have been four of you that competed. Student Number Ten, five of you. [3]

Student Number One: Competed with [another student].

Mr. Shields: So, what parts of the cookie mining activity, um, did you feel really not, made you not interested. What part of the cookie mining activity made you not interested, if anything? Was there something that you thought really did not interest you that much while you were working on it? Student Number Three.

Student Number Three: That you had to put all the crumbs back in the circle.

Student Number One: Yeah

Mr. Shields: So, Student Number Four you agree with that? Student Number One you agree with that too?

Student Number Four: Yeah.

Student Number One: Um, huh. [4]

Mr. Shields: Alright, anything else that made you uninterested in the activity? Student Number Six?

Student Number Six: Well, how you had to like use the tools to put the crumbs in, not like picking up like the crumbs with your hands, like you actually had to push 'em. [4]

Mr. Shields: Very good, I am going to close this door. What. [Pause]. Uh, Student Number One add what you were going to say.

Student Number One: Um, I don't remember. Oh, that part where you, we just got one cookie and instead of two cookies.

Mr. Shields: So, you had to choose which cookie you liked?

Student Number One: Yeah, so we could just get two of them and try to figure out which one we could get.....

Mr. Shields: More profit from?

Student Number One: Um, yeah

Mr. Shields: Student Number Four.

Student Number Four: Well, this is like, um, it's not really what didn't make me interested, it's more of, um, what I didn't like. The time limit for the, uh, putting...

Mr. Shields: For mining or for reclamation?

Student Number Four: The reclamation.

Mr. Shields: Ok. So, compare the Google Earth and the cookie mining activity. Which one did you like better, which one did you like worse, and more importantly why did you like one better than the other? Student Number Four.

Student Number Four: I liked the, um, cookie mining because, well it's, I am kinesthetic learner.

Mr. Shields: Are you the one who always puts kinesthetic learner on my surveys? That's awesome! Cause, I was like, I was like...

Student Number Four: Wait, I think so, maybe.

Student Number Ten: I have too.

Mr. Shields: Yes, I, I've been wondering who that has been when I have been reading through them cause, I am like that is very impressive that someone has been putting kinesthetic learner. Ok, didn't mean to interrupt you. Sorry, go ahead and finish.

Student Number Four: Anyway, so I am more of a hands on person, so, that's [6]

Student Number One: I like the part...

Mr. Shields: Student Number One

Student Number One: ...with the cookie miner because we get out of the computer and make you like your eyes to, cause when you are at the computer your eyes hurts a lot, it is really hard to look at the computer.

Mr. Shields: So, you find it hard to look at the computer screen for a, a whole period.

Student Number One: And, uh, uh, I use to use my hands to mine a cookie. [6]

Mr. Shields: Alright, Student Number Two.

Student Number Two: I like the cookie mining better because, um, everybody could be included with it, because with computers, ah, Google Earth, eh, some computers have glitches and you could not log on. So, everybody could be included with the cookie mining. [10]

Mr. Shields: Very good. Student Number Ten.

Student Number Ten: Sorry. [Pause]. I like the cookie mining because it is more hands on and you got to eat the cookie. [6]

Mr. Shields: Student Number Three.

Student Number Three: I liked the cookie mining more because there were a lot of constraints, so you had to. [3]

Mr. Shields: Sorry, did you say constraints or restraints?

Student Number Three: Um, constraints.

Mr. Shields: Ok. So, you like the fact that it was kind of a challenge that you had to do that?

Student Number Three: Yeah, you had to really try.

Mr. Shields: Student Number Six.

Student Number Six: Well, it's not about this question, it's that I didn't really like the time for mining because I only got like a quarter of the cookie mined, out of like... [7]

Mr. Shields: So. You would have liked to had more time to mine the cookie?

Student Number Six: Yeah.

Mr. Shields: Student Number Eight, which one did you like better?

Student Number Eight: Can you repeat the question?

Mr. Shields: Did you like Google Earth or cookie mining better?

Student Number Eight: Cookie mining.

Mr. Shields: Why?

Student Number Eight: I liked to eat the cookie. [5]

PART II

Mr. Shields: How many of you would say that you liked the cookie mining activity better than the Google Earth activity?

Student Number One: About all of them, everybody likes the cookie mining better.

Mr. Shields: So, eight of nine. Student Number Six you are on the fence?

Student Number Six: Yeah.

Mr. Shields: Why are you on the fence?

Student Number Six: I, I really like computers. I am just, uh, a tech guy, and.

Mr. Shields: Fair enough, a lot of us are tech guys.

Student Number Ten: Or girls.

Mr. Shields: Even more true, Student Number Ten, I stand corrected; or, tech girls.

Student Number Ten: Thank you.

Mr. Shields: Um, just to recap, and, going back to the bridge again. If you can remember all the way back to when we did the bridge.

Student Number One: Yeah.

Mr. Shields: Just to compare to what we said earlier, how many of you. Which did you like better there? The computer bridge or the actual paper bridge? Student Number One.

Student Number One: I like better the bridge, cause you had to design your own bridge and.

Student Number Nine: Wait, which one?

Student Number Ten: Yeah, the paper one?

Student Number One: Yeah, the paper one. And, you didn't have to use tools to do that.

Mr. Shields: Student Number Four.

Student Number Four: I liked the paper bridge because, again, I am more of a hands on person.

Mr. Shields: Very good. Student Number Nine.

Student Number Nine: Um, I liked the computer one, because you got to like build one that had the, the most amount.

Mr. Shields: So, you liked the computer one first time, but the hands on one second time? Student Number Five. Good.

Student Number Five: Um, I liked the. I am more of a hands on person, and like whenever we take a test in information technology I was a combo of auditory and kinesthetic, so like more hands on.

Mr. Shields: So, you liked them both, you liked them both, the hands on and the cookie mining. Those were the two, alright. Student Number Ten.

Student Number Ten: Um, I liked the paper bridge better because, like Student Number Four and Student Number Five said, I am more of a hands on person.

Mr. Shields: Student Number Two.

Student Number Two: Yeah, I, um, like everybody is saying, with the, I don't want to seem really generic but I am hands on so I like the paper bridge.

Mr. Shields: In info tech do you guys take a survey to find out what type of learner you are?

Numerous Students: Yeah.

Mr. Shields: Excellent! I didn't know you did that. Student Number Three.

Student Number Three: I can't really answer that because I never got to do the computer, um because I was absent that week.

Mr. Shields: Computer bridge, because you were absent that week? Student Number Six.

Student Number Six: Um, well.

Mr. Shields: I guess, I'm, I'm going to guess I know what your answer is, but that is Ok. It is going to be different, and different is good.

Student Number Six: Oh, ok, so you already know and it's the computer....

Student Number Nine: I wouldn't know that.

Student Number Six: ...and I'm a visual and an auditory learner, so, yeah, I learn more if I see stuff or hear stuff, like work.

Mr. Shields: And Student Number One you already told us your opinion.

Student Number One: Yeah.

Mr. Shields: Student Number Eight.

Student Number Eight: Can you repeat the question?

Mr. Shields: Um, thinking back to the bridge which one did you like better, the paper bridge or the computer assignments on West Point?

Student Number Eight: Paper

Mr. Shields: And why did you like the paper better?

Student Number Eight: I liked that it was hands on.

Mr. Shields: So, seven of nine of you liked both hands-on activities better. Student Number Nine was split, he liked one hands on and one computer and Student Number Six liked the computers better. Very good, thank you guys for all of your help, [I] appreciate it.

Student Number Six: Wait, we are done?

Mr. Shields: We're done.

END OF INTERVIEW

APPENDIX N

APPLIED CIVIL ENGINEERING FOCUS GROUP INTERVIEW

APPLIED CIVIL ENGINEERING FOCUS GROUP TRANSCRIPT

Interviewer: C.J. Shields **Interviewee:** Action Research Focus Group

Absent: Student Number Nine

Date: 1/28/13 **Time:** 11:49 a.m. (EST)

Interview Mode: Group **Recorded:** Apple's iPod Voice Memo software

Mr. Shields: The first question. Uh, we will skip the first two because we, uh, kind of covered those last time. So, the most recent lesson; which was making the bridge out of paper, uh, um, tell what did you like about that activity. What are some things that you liked about that activity? So, I think raising your hands is a good way to go. Student Number One.

Student Number One: Ok, I liked it because you had a chance to make something with your hands and tried to develop your own ideas how you want to make it. [4]

Mr. Shields: Student Number Five.

Student Number Five: Like Student Number One said, like you get to like roll paper and you get to do things with your hands, and yeah. [4]

Mr. Shields: Student Number Ten.

Student Number Ten: It was hands on. [4]

Mr. Shields: Student Number Seven.

Student Number Seven: It was, I mean, it was difficult. I mean it wasn't really difficult, but it was. [9]

Mr. Shields: Student Number Three.

Student Number Three: You could be creative and do what you wanted, but you also had constraints that you had to follow. [6]

Mr. Shields: Student Number Six

Student Number Six: You could destroy the bridge that you worked on like two days, or three days, so. [6]

Mr. Shields: Student Number Four, Student Number Two, Student Number Eight, anything to add from you three?

Student Number Two: I really just agree with Student Number Three on everything. [6]

Student Number Four: Um, I like the way how you got to make your own bridge and then, um, most of the actual paperwork stuff was really easy and, um, breaking the bridge is fun. [6]

Mr. Shields: Very good, so, um, what did everyone like least about the most recent...

Student Number One: Oh, Oh, me.

Mr. Shields: ...lesson, which was building out of paper.

Student Number One: Can I answer?

Mr. Shields: You may Student Number One.

Student Number One: I am going to be honest, I really didn't like the paper, like when you had to make all these problems and answer questions about it. [3]

Mr. Shields: So you mean the paper after, not the paper before which was designing the bridge.

Student Number One: Ah, yeah.

Mr. Shields: Ok. Student Number Ten.

Student Number Ten: Um, I liked how there were like, you could only use this much of this much of the material of what we were using. Like, only like 18 sheets of paper and then how many ever feet that we used for tape and everything. I wish it was just more like, you can use how much you want. [5]

Mr. Shields: Student Number Five.

Student Number Five: We had to use a certain kind of tape, but I realize that, like, some people they used like duct tape and scotch tape, and yeah wait, something like that. [5]

Mr. Shields: Student Number Seven.

Student Number Seven: Um. Oh, I didn't like breaking the bridge. [11]

Mr. Shields: Why not?

Student Number Seven: Because we were, we created them, we gave them. We spent time on them for two days and then we just had to go and break them.

Mr. Shields: Student Number Three.

Student Number Three: I didn't like breaking them because, basically the same thing that Student Number Seven said. Just, mine really wasn't very good and it kind of made me feel bad. [11,9]

Mr. Shields: Student Number Four, Student Number Eight, Student Number Two.

Student Number Two: I really didn't like the paperwork afterwards; the math was sort of hard. [3]

Student Number Four: I guess you already mentioned you talked about what you didn't like; so, sorry about that. Student Number Eight?

Student Number Eight: I didn't like breaking it. [4]

Mr. Shields: Why not?

Student Number Eight: I spent two days working on it.

Mr. Shields: Those of you that said you didn't like the paperwork, which were a couple of you. Why did you not like the paperwork? Student Number Four?

Student Number Four: Um, the force diagram. The book didn't really explain what a force diagram is, so it was kind of hard to understand what it is and stuff.

Mr. Shields: Alright, Student Number One.

Student Number One: Well, I do like it because you have to do work, and I do not like doing a lot of math because, like, the next period I have math [indecipherable]. And I didn't like to write the whole sentence and draw stuff, because it just make it hard to understand instead of just making it and then just planning [indecipherable].

Mr. Shields: Student Number Five.

Student Number Five: I didn't like the paper, because like every time you would trying making it and if you moved one little finger it would come like that again. And then.

Mr. Shields: So, you are talking about actually rolling the paper

Student Number Five: Yeah.

Mr. Shields: Not the paperwork at the end.

Student Number Five: Oh, like it bends to easy.

Mr. Shields: Uh, so what part of the most recent lesson made you want to try your best? So, like, was there something about this lesson that made you want to work really hard and try your best in science class. Student Number Four.

Student Number Four: The fact that, um, you had to, uh, have your bridge hold a certain amount of weight and I was kind of scared that it would just collapse when you put the empty bucket on.

Mr. Shields: So, you liked the fact that it had to hold the empty bucket and the testing block.

Student Number Four: Um-uh.

Student Number One: Go, girl, first this time.

Mr. Shields: Student Number Seven.

Student Number Seven: I agree with Student Number Four.

Mr. Shields: Student Number One

Student Number One: Ok, um. It was fun, but I didn't like, to like break my bridge cause I spent like two or three days on it, and it was the most beautiful. [Laughter] And, it didn't hold much cause somebody destroyed it and touched it and it collapsed. I don't want to say names. [11]

Mr. Shields: That would be me.

Student Number One: Yeah, and I was like sure it was going to hold more.

Mr. Shields: Student Number Three. Sorry Student Number One.

Student Number One: And we didn't get to use, uh, like sticks or anything like that to make it harder and not destroy real easy.

Student Number Ten: Well, I think we all agree that Mr. Shields breaks our bridges. [Laughter].

Mr. Shields: Student Number Three.

Student Number Three: Um.

Mr. Shields: You had your hand up.

Student Number Three: I did, but now I kind of forgot the question, sorry.

Mr. Shields: Anybody else, things that were, especially made you want to try very hard on the project. Uh, that you thought really motivated you to really want to do your best. Student Number Three.

Student Number Three: I thought this activity was a little bit harder than the other things we have done, it kind of made you have to, you had to think a little bit more.

Mr. Shields: So, did you say you have to think more on this or when you designed the bridge on the computer.

Student Number Three: Um, I am not sure. I am pretty sure that both of them would be about the same.

Mr. Shields: Student Number Five.

Student Number Five: Uh, like Student Number Three said, I think it was kind of hard because like you had to do, like you had to think of it in math and then you had to divide a lot, and, uh, you had to like take on the bridge thing that you had to take a certain amount and if the truck didn't go by, that made me mad, the truck didn't go by like at all.

Mr. Shields: Student Number Eight or Student Number Two, anything to add. Student Number Eight.

Student Number Eight: [Indecipherable]

Mr. Shields: Sorry what is that?

Student Number Eight: I really don't have anything to add.

Mr. Shields: So, what about the bridge building activity, the paper bridge building activity, was not interesting or what made you, maybe, not want to do your best. So, was there something about the project you did not feel interesting or did not feel you put your full effort into? Student Number Four.

Student Number Four: The paperwork.

Mr. Shields: How many of you would agree the paperwork? So, that would be all 9 of you. Ok. So, what was it about the paperwork that made you not want to try your hardest on that? Student Number Four, I know you have already talked about that a little bit, but if you have anything to add certainly.

Student Number Four: Because of the math, I mean, the math was just kind of. Well, it was not really that hard because we were allowed to use calculators, but for those who didn't have calculators and were finished it early so they weren't in the computer lab, that must have been really hard.

Student Number One: You are wrong, Mr. Shields let us use the phones. Ah, I wasn't supposed to say that you loud, but I did anyway.

Mr. Shields: Yes, you were not supposed to say that I let you use your phones for that.

Student Number Ten: He was allowing us to use our calculators on the phone.

Mr. Shields: Calculators on the phone.

Student Number Ten: We were not supposed to get on Facebook or anything, but were allowed to use the number calculator maker.

Student Number One: Yes, but some people right here

Mr. Shields: Student Number Three.

Student Number One: Were on Facebook while they didn't think others would notice.

Mr. Shields: Student Number Three.

Student Number Three: I thought the paperwork was easier than the rest of it and I was kind of behind so I was doing it quickly, but I thought it was kind of easy.

Mr. Shields: What, uh, I will try to speed up a little here. So, what was the one thing about the paperwork that you did not like? Did you think it was too hard or did you not understand what the purpose of it was, or something else?

Student Number Ten: I didn't really like doing the math, cause I don't like math that much. Don't tell Mrs. Minor.

Mr. Shields: How many of you. Ok, I certainly won't. How many of you did not like it because it involved math?

Student Number Ten: Me

Mr. Shields: How many of you did not like it because it involved writing?

Student Number Ten: Me

Student Number One: Me

Mr. Shields: How many of you were confused by the force diagram?

Student Number One: Me.

Mr. Shields: Ok, so all three of those [questions] were eight out of nine people. [3]

Student Number One: You want me to close the door?

Mr. Shields: Um, alright you can put your hands down, or put your hand up Student Number One. So, what could I have done to make the bridge building? I am going to close that door.

Student Number Seven: Yes, please.

Student Number Ten: Make the bridge building what?

Student Number One: Me want to answer.

Mr. Shields: What could I have done to make it more interesting for you? What would have made it more interesting? Student Number One.

Student Number One: You should have let us paint them, the bridges to make it beautiful and sounds colorful.

Mr. Shields: Student Number Five do you agree with that? Student Number Six, you have been hiding down there, I haven't called on you in a while.

Student Number Six: Um, if you had partners or something, like partners to work with.

Mr. Shields: So, three of you shook your head yes. How many of you would like to have had partners for that project?

Student Number Ten: I also wish we could have.

Mr. Shields: So, all nine of you. [12]

Student Number Ten: I also wish we didn't have to use paper.

Student Number One: Yeah.

Student Number Ten: If we could use other stuff.

Mr. Shields: What is other stuff Student Number Ten?

Student Number Ten: Like plastic or like put, your like pencils, in like the paper to make it more sturdy.

Student Number One: Like recycle.

Student Number Ten: Yeah.

Student Number One: Like the paper and plastic and [indecipherable].

Mr. Shields: Student Number Five

Student Number Five: Like, like there was one like tube, like tube those men use to like work and stuff. I don't know what they are called, something like that. But, they are long white tubes, I wish we could have used those and then tape.

Mr. Shields: Student Number Three.

Student Number Three: Um, I kind of think we should have more materials we could have used, which would have made it more sturdy. [5]

Mr. Shields: What materials Student Number Three.

Student Number Three: Um, I didn't really come up with this, but my friend was thinking, I am not sure if he did or not, but he might have brought his home and try and put water in it, like put little paper wads and water inside of it or something like that so it would be more sturdy I guess.

Mr. Shields: Thank you Student Number Three, that's a good suggestion. Ok, real quick we got three questions left; we will speed up on this one. When you asked questions to somebody else, so when you were talking to your classmates did you ask them questions about the project or did you find yourself socializing? So were most of the questions about the project or were they about socializing, just in a quick word or two.

Undetermined: Socializing.

Student Number Five: Um, I would say socializing, but then the math.

Mr. Shields: Ok, socializing and math.

Student Number Ten: Socializing.

Mr. Shields: Student Number Eight.

Student Number Eight: Project.

Student Number One: Yeah, both.

Mr. Shields: How many of you say project? Raise your hand, if you say project?

Student Number One: Oh, me.

Mr. Shields: Ok, so four of you, five of you Student Number Six. Um, so four of you say you were socializing. How many of you asked questions to someone else about the math?

Student Number One: Not me, because I was smart in that.

Mr. Shields: Four of you asked questions about math, very good. Um [bell rings], ok, sorry. I will definitely write you a pass if I need to. What, uh, do you like this format, like hands on? So, basically, did you like the bridge better when you built it hands on or designed it on the computer?

Student Number Ten, Student Number Four, Student Number One, and several others:
Hands on

Mr. Shields: How many of you liked hands on better? So, seven. How many of you liked computer better? Two of you. What did you two like better about the computer?

Student Number Three: Um actually that doesn't really make sense because I never go to finish that part because I was absent. So, I would guess the hands on.

Mr. Shields: Alright, Student Number Six. Last one, as soon as Student Number Six gets down I will let you guys go. I will write you a pass if I need to.

Student Number Six: You didn't have to like roll the paper and stuff on the computer. I had a very unstable bridge.

Mr. Shields: Thank you guys; I really, really appreciate your help. .

END OF INTERVIEW

APPENDIX O

COMPUTER-BASED CIVIL ENGINEERING FOCUS GROUP INTERVIEW

COMPUTER-BASED CIVIL ENGINEERING FOCUS GROUP TRANSCRIPT

Interviewer: C.J. Shields **Interviewee:** Action Research Focus Group

Absent: Student Number Three

Date: 1/17/13 **Time:** 11:35 a.m. (EST)

Interview Mode: Group **Recorded:** Apple's iPod Voice Memo software

Mr. Shields: Ready?

Student Number Ten: Yes sir.

Student Number One: Yes

Mr. Shields: Alright, um, so first question and, so, feel free to jump in at any time, um, that you want to answer, um, or, we can just kind of go around. On most days do you enjoy coming to science class? Why or why not?

Student Number One: I love it; I love it, coming to science. I love science.

Mr. Shields: So, why is that Student Number One?

Student Number One: Because I can learn more science about earth and the world that we are living in.

Mr. Shields: Ok.

Student Number Ten: I like science sometimes, only if like we are having fun and not homework and everything.

Mr. Shields: Ok, so what is having fun Student Number Ten?

Student Number Ten: Like doing things on the computer

Student Number Nine: Like Building Bridges

Student Number Ten: Gizmos, not in the workbook. Cause I don't like workbooks.

Mr. Shields: Ok. Student Number Two

Student Number Two: I like science because you make it have a fun atmosphere. Like last year was out of the book, out of the book and you try to mix up different activities.

Mr. Shields: Ok. Anybody else want to jump in? Student Number Five.

Student Number Five: I like to come to science sometimes because, uh, a lot of the time, uh, we'll do activities and have fun.

Student Number Nine: Hey, stop.

Student Number Five: But then sometimes I don't like it because we just work from the book and then we have to read in the book too.

Mr. Shields: Ok. Uh, Student Number Seven.

Student Number Seven: Um, there are some days I don't like to come and that is more like when we are working in our workbook, but I like to do stuff that is more like hands on. (Unintelligible.)

Mr. Shields: Ok.

Student Number Six: I like to do science whenever we, um, do stuff like we did with the Van Der Graff Generator.

Mr. Shields: Ok.

Student Number Six: And stuff like on the computer. So.

Mr. Shields: Alright. Anybody else? Student Number Four, you came in and missed at the beginning. On most days do you enjoy coming to science class? Why or why not?

Student Number Four: Sorry, um.

Student Number Nine: Don't say, like, homework. Yeah.

Student Number Four: Most days I enjoy coming, but, um, I like them better when we do hands on stuff.

Mr. Shields: Ok.

Student Number Four: Like the Van Der Graff Generator and labs. Like last year was really fun because we did a lot of labs.

Mr. Shields: Ok.

Student Number Nine: That was very short.

Student Number One: I love to, working in the lab.

Mr. Shields: Alright. Student Number Nine, Student Number Eight anything to add from you guys?

Student Number Eight: Same thing

Mr. Shields: Same thing? Student Number Nine.

Student Number Nine: Um, I really don't like the workbooks

Mr. Shields: Ok.

Student Number Nine: But when we get on the computer and stuff to do like fun things like Gizmos and stuff

Mr. Shields: Ok.

Student Number Nine: It's fun and we learn more stuff.

Mr. Shields: Ok, Alright. Ok, so did the, did the West Point Bridge Designer Activity, did that change your opinion? Did you look forward to doing that activity?

Several Respondents: Yes

Student Number Four: I was absent

Mr. Shields: Any particular reason why? Ok, Student Number Four you were absent; so, everybody else, um, why did you like it?

Student Number Ten: Because you got to like, like the thing we are doing now, like making it out of paper and everything is hands on and I think it is going to be really fun.

Student Number One: I think that it was fun.

Mr. Shields: So, sorry, not the part we are doing today, we will talk about that next week, but the part we did the last three days. Did you like that part on the computer?

Student Number One: Yes, because you have to design your own, you have to design your own bridge. [7]

Student Number Nine: You have to watch it fall. [7]

Student Number One: You can have an idea like if you want to grow up and be a designer or something like that.

Mr. Shields: Ok.

Student Number One: You can build your own bridge.

Mr. Shields: Ok.

Student Number One: That is what you do.

Mr. Shields: Anybody else? Student Number Five?

Student Number Five: I like going to the computer lab because then, uh, because (laughs) because instead of doing things out of the workbook and like for the bridge design in the lab, uh, it is like a little bit harder and it made you think more. [10]

Mr. Shields: Ok.

Student Number One: Mr. Shields?

Mr. Shields: Yep.

Student Number One: Um, you just called her by her name?

Mr. Shields: What's that?

Student Number One: You just called by her name, you just said.

Mr. Shields: No, uh, I am going to type out everything we say; so.

Student Number One: Ok

Mr. Shields: In there it will be like Student One, Student Two.

Student Number One: Ok, so doesn't matter then!

Mr. Shields: Alright, anybody else, anything to add there? (Pause). So, a little bit different. On a daily basis do you try as hard as you can in science? Do you put forth your best effort?

Student Number One: I try to do my best because like I don't live here, well I do, but I wasn't born here and I try to learn more and try to learn to do my best to get the best grade so I can go to like college and that stuff.

Mr. Shields: Ok.

Student Number Ten: I do sometimes, but like it just depends on my attitude. But, I know my attitude shouldn't change if I try hard enough or not, but it usually does. So some days, depending on what my attitude is, is when I try.

Mr. Shields: Ok. Student Number Seven.

Student Number Seven: Um, I try to do my best and it just like, what Student Number Ten says, it just depends on what mood I am in.

Mr. Shields: Ok. Student Number Five?

Student Number Five: Uh, just like Student Number Seven and Student Number Ten said, it depends on the kind of mood I am in, but then like if I am in a really really happy mood then I will actually try. But, if I am in a really bad mood then I will just be like you know, I don't want to do this I am kind of mad.

Mr. Shields: Ok.

Student Number One: I always try my best, like it makes me happy when I have a great, good grade. Because if I have an F, like I can, it makes me sad.

Mr. Shields: Ok.

Student Number One: It makes my family [sad].

Mr. Shields: Anybody have anything to add to what Student Number One and Student Number Ten and Student Number Five have said?

Mr. Shields: Student Number Nine

Student Number Nine: Um.

Mr. Shields: You try your hardest?

Student Number Nine: Well, sometimes, but when I am in like a bad mood I don't feel like talking to anybody and then I get frustrated and I just start working and then the more I work it feels like I am doing better.

Mr. Shields: Ok. Student Number Six.

Student Number Six: Ok, what was the question again?

Mr. Shields: Do you try your hardest in science?

Student Number Six: Sometimes, it depends on my mood really.

Mr. Shields: Ok. Student Number Two.

Student Number Two: I try my hardest because this is one of my favorite subjects in school, so I want to forth most of my effort in to it.

Mr. Shields: Ok. Student Number Eight

Student Number Eight: Half the time.

Mr. Shields: Half the time? Ok, why?

Student Number Eight: Sometimes I just don't want to work.

Mr. Shields: Ok. Any particular reason you do not want to work?

Student Number Eight: No.

Mr. Shields: You just don't want to work?

Student Number Eight: I just don't want to work.

Mr. Shields: Ok. Student Number Four.

Student Number Four: My mood, like most everyone here.

Mr. Shields: Ok. Um, so what did you like most about the bridge building activity? We can just go around the room, I guess, and everyone can say one thing. We'll start off with Student Number Five.

Student Number Five: You did not have to be in this classroom and you went to the computer lab and kind of just like, not in a mean way though, but you kind of got to get out of this area. [3]

Mr. Shields: Ok.

Student Number Five: And then got to click and stuff.

Mr. Shields: Alright, Student Number Ten.

Student Number Ten: Like, you like got to go to the computer lab and were able to like try it [building the bridge] like a million times and if you failed then just redo it. [3,7,4]

Mr. Shields: Ok. Student Number Two.

Student Number Two: You still had your guidelines but you could make what you wanted with, but you still had the guidelines. [5]

Mr. Shields: Ok. Student Number One.

Student Number One: Like, so like it was fun cause you make your imagination blow up and try and do like a pretty bridge and try to figure out how to make it and it doesn't matter if you fail you try it again. [4]

Mr. Shields: Ok.

Student Number One: That is why.

Mr. Shields: Student Number Seven.

Student Number Seven: It was different. [10]

Mr. Shields: How was it different?

Student Number Seven: Cause like it's, it was like a new activity we were doing.

Mr. Shields: Ok. So what did you guys like the least about it? Student Number Five.

Student Number Five: Uh, you, uh, if you didn't make it then the bridge would fall and that would kind of made me mad. [6]

Mr. Shields: Ok. Student Number Ten.

Student Number Ten: That there was like an amount like when you first started that you could only spend like this much money but then like you like raised it but in the beginning I did not really like it. [6]

Mr. Shields: You didn't like having the amount of money to work with?

Student Number Ten: Yeah

Student Number One: Yeah [6]

Student Number Ten: I like spending more money on things.

Mr. Shields: Alright. Student Number Nine.

Student Number Nine: You had to have a certain amount of parts. Like not, yeah a certain amount of parts. [6]

Mr. Shields: Ok. Student Number Seven.

Student Number Seven: What was the question again, sorry, I forgot.

Mr. Shields: What did you like least about it?

Student Number Seven: Oh, that I had to start over so many times, because I couldn't figure it out. [4]

Mr. Shields: Ok. Um, kind of already covered that one, so I will skip that one. So, was there anything. What was the part that made you the most interested or least interested? I think we have pretty much covered that, anything to add? [Pause]

Mr. Shields: Ok, you guys talked a lot about that.

Several students: Yeah.

Mr. Shields: Ok, so what could I have improved on to make the West Point to make it better for you guys? So, if I were to start teaching it next year again, what I could I do to make it better? Student Number Four.

Student Number Four: Raise their amount of money.

Mr. Shields: So, raise the amount of money from the very beginning? Ok.

Student Number Four: Um-hum

Mr. Shields: Ok, um, Student Number Seven.

Student Number Seven: Have more, um, like characters. So, like instead of 55 members raise it a little more.

Mr. Shields: Ok, Student Number Five.

Student Number Five: Uh, you could have to have to go up with the money, like Student Number Seven said with the characters.

Mr. Shields: Ok, Student Number Two, did you have your hand up? Nope. Student Number Ten.

Student Number Ten: Um, I think that you should like not like make them use like you could use like the steel thing and then you could use the um hollow. I wish that you didn't have use like both of them cause I didn't.

Mr. Shields: So, you liked just having the hollow or the solid, not both?

Student Number Ten: Cause yeah.

Mr. Shields: Student Number Two, you shook your head and agreed with that? [confirms] Student Number Nine.

Student Number Nine: Um, like instead of like 160 x 160 make it bigger.

Mr. Shields: Ok. Student Number One.

Student Number One: I think they should make like their own bridge how they want to build it and it doesn't matter the money and then when you get there to check the grade (the money) you should like tell them it was fine and not try to make them feel sad because you crossed the money line.

Mr. Shields: Alright. Student Number Six.

Student Number Six: Um, like lower, lower and higher the depth of the bridge.

Mr. Shields: Ok.

Student Number Six: With itself.

Mr. Shields: Ok, um, almost done. Just a couple more questions. Um, uh. Obviously you guys were talking to your neighbors when you were working, and I really didn't care about that, uh but did you find you were asking them questions about the project. Were you saying like, you know, how do I add a joint or how do I, how do I add a type of material? Or were you socializing with them and just talking with them about what is going to be happening at lunch or what is going on. Again, feel free to answer. Student Number Ten.

Student Number Ten: Um, well (laughs). To my (my cousin) I was talking about random things.

Mr. Shields: Ok.

Student Number Ten: and, uh, yeah and when I was talking to someone else. I asked someone, I forget who it was. I asked someone that was sitting behind me a question about like the bridge and everything. But most of the time I was technically talking about different things.

Mr. Shields: Ok. Student Number One.

Student Number One: Well, I like when peopled asked me questions about bridges because I like helping people and sometimes I would talk to them about other stuff, like how is your day or like that stuff and he won't answer me and then when has got a question about the bridge I will answer him because I love answering questions.

Mr. Shields: Ok. Student Number Five.

Student Number Five: Um, I was kind of like talking to (another student) about things and then uh, and then like at the very end I kind of asked for help on the bridge because I didn't really get it, like on the fifth time I tried.

Mr. Shields: Ok.

Student Number Five: So I was like, ok (another student) I need kind of help here.

Mr. Shields: Alright Student Number Seven.

Student Number Seven: Sometimes I asked for help and sometimes I just talked about random things.

Mr. Shields: Ok: How many of you, just raise your hand, asked more questions about how to build the bridge than about socializing? Ok, so three of you.

Student Number One: Four

Mr. Shields: Four of you

Student Number One: Five, cause she was absent

Mr. Shields: Five of you.

Student Number Four: I was absent.

Mr. Shields: So then five of you asked more questions than socializing. Ok

Several Students: Yes

Mr. Shields: Are you half and half Student Number Six? (Confirms.)

Student Number One: Yeah, half and half

Mr. Shields: Ok, um one last one. What, so did you like the, uh, fact that it was on the computer. So, basically, do you like computer activities or do you like hands on activities and why do you like that one? Student Number Ten.

Student Number Ten: Um, I liked how it was on the computer, but, um, I would have liked it if it was hands on cause I am more of a hands on person cause I like working with like my hands because it helps me learn better I think.

Mr. Shields: Ok. Student Number Five.

Student Number Five: Oh, I like the hands on one because that is how I learn with doing stuff with my hands and touching around and stuff.

Mr. Shields: Ok

Student Number Five: It was like with the static hair thing.

Mr. Shields: Yeah

Student Number Five: That was amazing.

Student Number Ten: I loved that.

Mr. Shields: Uh, Student Number Seven.

Student Number Seven: I liked it because it was on the computer. [3]

Mr. Shields: Student Number One

Student Number One: Student Number Four go.

Student Number Four: Well, I am a more of a hands on person but building a bridge, like an actual bridge, would have been really hard. [3]

Mr. Shields: Ok

Student Number Four: And so I liked it on the computer.

Mr. Shields: Ok.

Student Number Four: This time.

Student Number One: I like it like computer enhanced because you can get an idea to make it on the computer if it works. And then go kind of like another like play with a model or something that is like building a bridge. [3]

Mr. Shields: Student Number Nine

Student Number Nine: I like it when it is on the computer because I am like on the computer sometimes and I know how to work a computer. [3]

Mr. Shields: Ok.

Student Number Nine: Not like anybody else does.

Mr. Shields: Student Number Four

Student Number Four: If we had done it as building and actual bridge it would have been really hard because every time you tested it and it failed you would have to restart all over and that would have taken forever. [4]

Student Number Nine: like you did.

Mr. Shields: Ok, Student Number Eight, Student Number Six, Student Number Two anything to add to that?

Student Number Two: I agree with Student Number Four.

Mr. Shields: You agree with Student Number Four, ok.

Student Number Six: I like the computer better; I am just a computer guy. [3]

Mr. Shields: Alright. Nothing to add Student Number Eight.

Student Number Eight: No

Mr. Shields: Alright, one last thing, we've only got a couple of minutes left anyway. So, everybody go around, we can start with Student Number Two and go around everybody tell me one thing you learned about engineering while you were building the bridge.

Student Number Four: That triangles were good at holding weight.

Mr. Shields: Ok

Student Number Six: Same thing really.

Mr. Shields: Ok, let's do this. You can't say the same thing as the person before you, how is that?

Student Number One: Yeah

Student Number Six: Um, I don't know.

Mr. Shields: How about this, does anybody have anything they learned other than triangles are strong?

Student Number One: Me, me.

Student Number Nine: Um, I don't know if this counts as a strong shape but the little thing that holds the bridge up.

Student Number Ten: Like the cable part?

Student Number Nine: I don't know what that's called?

Student Number One: The cable.

Mr. Shields: The cable, or the buttress, or the abutment, or.

Student Number Nine: It is the thing that holds it up from the river.

Mr. Shields: The pier. Ok. Student Number Five.

Student Number Five: Ah, I kind of figured out that the arches were not really that steady because I tried it and it fell to pieces.

Mr. Shields: Ok.

Student Number One: Student Number Seven or Me?

Mr. Shields: Student Number Seven did you have your hand up. Ok, Student Number One.

Student Number One: I like, like engineering, like how you engineered your bridge if you don't like really understand what you are doing then it can be difficult to make in real life.

Mr. Shields: Ok.

Student Number One: It could come down and kill a lot of people.

Mr. Shields: Ok. Anybody learn anything about engineering? (Laughter)

Student Number Six: I want to say (bell rings) something about, um, once I talked about random things or asked about the bridge.

Mr. Shields: Thanks you guys very much, very much. Have a good afternoon.

END OF INTERVIEW