COLLABORATION FACILITATED THROUGH TECHNOLOGY: PART OF A

COMPREHENSIVE INQUIRY-BASED TEACHNING AND LEARNING STRATEGY

by

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ABSTRACT

As our school embraces technology integration, identifying effective methods of reinforcing and enriching inquiry-based instruction through technology has become a focus. My study compared the academic and motivational impacts of technology-based collaboration to traditional face-to-face collaboration. Emphasis was placed on determining if collaborating through technology distracted students or if it facilitated cognitive growth in terms of improved critical thinking and problem solving.

Within the context of thematic units, students were given instruction on conducting cooperative activities and allowed to practice. Prior to collaborative interventions, the treatment group was allowed to become familiar with various types of technology through play, exploration and simple practical assignments. Eventually, the treatment group shifted from face-to-face collaboration to technology-facilitated collaboration. Simultaneously, the non-treatment group practice face-to-face collaboration.

Academic performance and content literacy were measured through summative assessments, project plans and practical applications. Additional data concerning student motivation, engagement, problem-solving proficiency, and critical thinking skills were collected through surveys, interviews, teacher video journals and student journals.

The results indicate that technology-based collaborative activities did little to improve the academic performance of low-range students. Low-range performers, however, benefited technically and socially from their peer-to-peer interactions. Mid-range and high-range academic performers benefited significantly from the technology interventions. The data also suggest that while student motivation to communicate through technology diminished over time, critical-thinking and problem-solving skills greatly improved as the study progressed.

INTRODUCTION AND BACKGROUND

Change comes slowly here in Eureka MT, but when the community decides that change is necessary, it happens literally overnight. I teach Life and Physical Science at Eureka Middle School. Eureka is located in northwest Montana. The primary industry is logging. With the closing of the two large lumber mills in town, however, small, service-oriented business and tourism are emerging as primary industries. Additionally, as the logging industry disappears here in Eureka, and families are displaced, the student population is changing in diversity and number. The entire school typically has an enrollment of approximately 100 7th and 8th graders, with an ethnic diversity of less than 5%. Diversity in this study generally refers to academic abilities across a wide spectrum.

In light of economic and social pressures, the way we look at education in the Eureka public school district is changing. Paradigms are shifting and the faculty is eagerly seeking techniques and strategies that will lead to meaningful educational opportunities and experiences for both teachers and students. A significant portion of that change involves technology upgrades on a very large scale. As we tackle the best way to effectively implement sound practices, rooted in good research, two significant questions concerning technology use emerge:

1. How much political risk can we as a school afford to take by allowing various technology-based personal communications devices into the school, considering the potential for inappropriate use?

2. How can such devices effectively and seamlessly be incorporated within inquiry based teaching and learning as described by the National Science Education

Standards (NSES, 2000)? One specific area of interest concerns finding practical

applications that use the technology to foster inquiry.

<u>Focus Question</u>

Collaboration is a significant strategy for successful inquiry-based teaching and

learning. As part of a comprehensive inquiry-based curriculum, will technology-

facilitated collaborative practices improve critical thinking and problem solving skills, or

will technology distract students from the content? Specifically, can various technology

applications within a classroom result in improved student motivation and content

literacy? I am also interested in knowing how technology-facilitated collaboration will

impact the social-support and scaffold present in group dynamics as students shift from

face-to-face collaboration to indirect contact through technology-facilitated collaboration.

CONCEPTUAL FRAMEWORK

Spend some time perusing educational and scientific journals and you will

quickly become aware of an effort that seeks to discover and improve how students learn

and how educators teach science. In the United States, this movement began in the early

1900s when John Dewey challenged how science was taught. He suggested that science

should be taught as a process and not a discipline of memorizing facts and data (NIH,

2010). Today educators and scientists have developed an inquiry-based instructional

strategy inspired by progressive educators and scientists. Scientific inquiry is a process of

investigation and reporting. Likewise, inquiry in education is a strategy that incorporates

activities that facilitate the construction of knowledge around scientific ideas. This process mimics what scientists do to investigate scientific questions, thus teaching students how scientists go about the investigation of the natural world, albeit at a different level of sophistication (NIH, 2010). According to the National Research Council's (NRC's) National Science Education Standards (NSES, 1996):

> Inquiry is a multifaceted activity that involves making observations; posing questions; examining books and other sources of information to see what is already known; planning investigations; reviewing what is already known in light of experimental evidence; using tools to gather, analyze and interpret data; proposing answers, explanations and predictions; and communicating the results. Inquiry requires identification of assumptions, use of critical and logical thinking and consideration of alternative explanations (p. 23).

<div align="center">Constructing Knowledge Through Inquiry</div>

The NSES (1996) clearly imply a full spectrum approach to investigating natural phenomena through inquiry where students actively engage in the processes of scientific investigation. A common misconception that science educators have is that inquiry learning is exclusively a hands-on approach (Morrow, 2000). Hands-on activities are an important element of inquiry learning, but inquiry learning also includes a foundation of learning science concepts and procedures to include formulating and testing hypotheses, collecting data, analyzing data and communicating the results (CIRES, 2009). Organized in Table 1 are five essential features of inquiry teaching and learning as outlined by the NRC (2000). These essential elements of inquiry facilitate scientific discovery and allow

for meaningful scientific exploration. As students learn the process of inquiry, their level

of sophistication grows and their procedural and science-specific skills improve (NIH,

2010). There is strong evidence to support the academic belief that scientific knowledge

develops through the inquiry process (Bell, Urhahne, Schanze, & Ploetzner, 2010).

Table 1
NSES five essential elements of inquiry teaching and learning

Essential Elements*
1. Learners are engaged by scientifically oriented questions.
2. Learners give priority to evidence, which allows them to develop and evaluate explanations that address scientifically oriented questions.
3. Learners formulate explanations from evidence to address scientifically oriented questions.
4. Learners evaluate their explanations in light of alternative explanations, particularly those reflecting scientific understanding.
5. Learners communicate and justify their proposed explanations.

*Summarized from NSES (2000)

By placing students in a situation where they are equipped to solve a given

problem, and by providing those students with a teacher to guide them through the

inquiry process, researchers theorize that learners will become skilled at applying

scientific concepts and methods to various problems (Looi, Chen, Ng, 2010). As students

progress through scientific inquiry, working through authentic problems or situations,

they become engaged, excited and proficient at constructing knowledge (Lee et al.,

2010).

Collaborative Inquiry

In his book, *The World is Open*, Dr. Curtis J. Bonk (2009), observes that Web technologies have expanded human capacity to remotely team and collaborate on sophisticated issues (Bonk, 2009). Teamwork and remote collaboration are skills paramount in our modern society, and implementing those strategies has been a topic of discussion for the last decade. In 1996, researchers performed a study in coordination with Kids as Global Scientists [KGS] to understand the learning potential available when students conducted face-to-face and technology-facilitated collaboration over the internet (Songer, 1996). Songer (1996) observed that as students collaborated face-to-face and worked through scientific problems related to weather, they became more adept at technology-facilitated collaboration through the internet with peers in different countries.

As students gain experience and confidence through the inquiry process, and when they learn how to effectively collaborate, they become capable of transferring or using that knowledge when new situations or problems are presented (Bell et al. 2010). Researchers suggest that collaborative efforts are often inherent components of inquiry teaching and learning (Sun et al., 2010; Nussbaum et al., 2009; Kong & Li, 2009; Tolentino et al., 2009; Urhahne et al., 2010; Lakkala, Lallimo & Hakkarainen, 2005). These studies also indicate that through collaborative efforts, knowledge construction and student motivation are positively impacted.

Collaborative efforts are effective, in part, because knowledge emerges as communities pool their collective experiences and collaborate on finding solutions to particular issues or problems (Bell et al. 2010; Sun et al., 2010). It is through social

interactions that multiple beneficial properties of collaboration emerge to generate a rich, dynamic learning environment. For example, students that form collaborative circles benefit cognitively because no two people perceive any experience exactly the same way. The differences in perception and thought produce cognitive conflicts, which force the participants to negotiate their own understanding (Ching & Kafai, 2008). The result is knowledge construction. Within the framework of a guided activity, that process would be useful and authentic to both teacher and student. Students that engage in guided and structured collaborative activities benefit from mutually supportive zones of proximal development.

Dr. Heather Coffey (2008) writes, "The zone of proximal development [ZPD] is the gap between what a learner has already mastered (the actual level of development) and what he or she can achieve when provided with educational support (potential development)" (p. 1). The mechanism or strategy developed by the teacher to close that gap between what a student knows and the potential of what he or she could know is called scaffolding. How we choose to assist students in bridging their previous knowledge with current scientific phenomena is important. Coordinating a strategy that takes advantage of ZPD leads students towards deeper and richer investigation (Looi, Chen & Ng, 2010; McCafferty, 2002).

Possible Challenges

Introducing technology as a tool in developing the scaffold architecture represents a challenge. Initially, there will be significant exploration with any device. In time, however, the novelty becomes less a focus and students begin to construct knowledge

(Tolentino et al., 2009). Grouping students together randomly and expecting high achievement in a collaborative assignment is not the best use of the technology-facilitated collaborative strategy either. Ultimately, the tasks should guide the selection of the grouping. Additionally, personalities and capabilities should be considered when developing the group in order to really leverage the benefits of collaboration (Nussbaum et al., 2009). The crux of success in collaboration then becomes a design requirement, and not necessarily dependent on whether the collaboration is face-to-face or facilitated through technology. Guiding students through the task is the teacher's opportunity to provide a rich inquiry-driven collaborative environment.

Stakeholders

Parents-students, schools-teachers, contribute to the overall health of any inquiry-based, technology-facilitated collaborative program (Kong & Li, 2009). When any one group resists the effort, the entire program is jeopardized. Conversely, when all the participants cooperate, the collaborative environment flourishes. For example, parents generally agree that information technology, or the use of technology applications, has a positive impact on learning outcomes, especially now in the digital world (Kong & Li, 2009). Parent perception is that student access to technology at home provides another means for their student to interact with the technology-rich outside world. Extending information technology into the home appears to be a natural extension of the school collaborative effort. Parents do, however, worry about managing student access to include digital-citizen aspects, and ensuring they, the parent, are sufficiently technologically literate to assist their students in technology-facilitated collaborative

efforts (Kong & Li, 2009). Moving into the school environment, additional concerns manifest.

<u>Culture</u>

School and community cultural beliefs and practices could limit wide-scale participation in developing models of technology-facilitated collaboration because implementing new techniques could include real or perceived risks. Developing new strategies and exploring new instructional models requires a time commitment on behalf of the school in general and teachers in particular. According to Lakkala, Lallimo and Hakkarainen (2005), secondary teachers focus on end-of-level assessment to the extent that experimentation and development of new techniques of instruction, regardless of the technology flavor, are resisted. There is a sense of being overburdened with another task. Specific administrative coordination must be arranged to ensure technology assistance and logistical support are in place. Without such support, any given experiment or innovation would necessarily be pushed to the side of more pressing or directed activities. The whole goal of implementing any innovation is to improve the educational environment and knowledge output for any given student group. The attitudes of the parents affect the students; the attitudes and policies of the administration provide either momentum or obstacles for the teachers' research. One particular study illustrated the power of using existing student biographical and assessment data to build educational support structures around students requiring differentiated instruction (Wayman, & Stringfield, 2006). The effort requires face-to-face and technology-facilitated collaboration on the part of teachers, administrators and parents. It was a simple

demonstration illustrating the positive potential of communities and schools working together to orchestrate a positive change on behalf of students.

<div align="center">Possible Benefits</div>

Inquiry-driven instructional models that utilize technology-facilitated collaboration exploit the understanding that facilitating collaboration through technology provides learners a unique forum not readily available to traditional collaborative efforts (Ching & Kafai, 2008; Walls et al., 2010). In other words, technology-based collaborative environments promote knowledge-building within the context of authentic activities that employ tools, activities and communication modes that reflect modern technology uses. In fact, using the technology to solve actual scientific questions validates key components or purposes of the inquiry process (Kong & Li, 2009; Lee et al., 2010; Looi, Chen & Ng, 2010; Nussbaum et al., 2009; Urhahne et al., 2010). The more complex the inquiry, the greater the knowledge construct (Bell et al., 2010). Consider the educational dynamic established when a student collects data with various computer probes, inputs that data into an on-line or hand-held digital storage devices, manages and manipulates that data, analyzes that data and reports those results to a group of peers. When aligned with a guided inquiry structure, these types of activities can provide a powerful mechanism for technology-facilitated collaboration and knowledge construction. As an example, students performing a mixed-reality activity (meaning some aspects were technology-facilitated and other aspects were face-to-face) were confronted with a complex series of problems requiring them to manipulate a variety of resources. The students were able to employ a wide range of virtual and real-world strategies,

including technology-facilitated collaboration, to work through the problem set

(Tolentino et al., 2009). Most significant is the realization that through collaborative

efforts, students were able to build on to previously discovered truths and knowledge to

solve a very complex set of problems.

Given a perfect world, teachers will be empowered, equipped and trained to

implement effective inquiry-based, technology-facilitated collaborative activities. It is

imperative to carefully construct and then direct collaborative activities if desired

outcomes are to be achieved. The focus need not depend solely on what tools are used,

but also how those tools are implemented, as part of a comprehensive inquiry-based

teaching and learning strategy. Inquiry is not a linear, locked-stepped or rigid process. It

requires a methodical, yet open-ended approach to learning (Reiff, Harwood &

Phillipson, 2002). As the teacher, I need to guide the learners through the process by

carefully constructing appropriate scaffolds that help students connect what they know

with what they are learning. Technology is another tool I can use to assist students in

constructing knowledge by harnessing the power of technology-facilitated collaboration

to both motivate students and to virtually extend proximal zones of development.

METHODOLOGY

Design

My study aimed to assess how technology could be used to enrich collaborative activities as part of a larger inquiry-based teaching strategy. I wanted to know if technology-facilitated collaborative practices improved critical thinking and problem-solving skills, or if the technology simply distracted students from the content. I also wanted to gauge how using technology as a mode of collaboration affected student motivation and content literacy. Within the context of a thematic unit, my action research compared face-to-face collaboration with technology-facilitated collaboration. The thematic unit allowed me to assess the viability and effectiveness of technology-based collaborative efforts and face-to-face collaborative efforts within an authentic construct. The thematic units incorporated NSES' (2000) essential elements of inquiry teaching and learning.

The collaborative nature of the study's embedded activities required careful consideration of how students were cooperatively organized and grouped. In order to leverage the maximum benefit of the collaborative efforts, effective grouping was essential (Nussbaum et al., 2009). Additionally, building student collaborative skills and teaching them how to use the various technologies prompted me to carefully consider how I would implement the specific collaborative interventions. I was concerned with scaffolding the assignments leading up to the study to level the knowledge playing field for all students, as well as facilitating the widest participation for all academic levels. To those purposes, I phased in each component of my project's collaborative focus.

Finally, the research methodology for this project received an exemption by Montana

State University's Institutional Review Board, and compliance for working with human

subjects was maintained.

<div align="center">Participants</div>

The two participating classes of the study were selected because they represent

the most complete academic crossection within our 8th grade. The goal of the selection

process was to ensure that the data collected captured efforts and attitudes from a truly

representative crossection of our student body. Additionally, I wanted to conduct this

study with approximately the same number of students in each class to measure my own

effort and proficiency in moving students through the various forms of collaboration.

Each class consisted of approximately 22 students with a wide range of academic and

social abilities.

Table 2
Demographics and Academic placement by class

Class period	Females	Males	High math/reading placement	Low math/reading placement	Grade level math and reading
3rd period	11	10	6	5	10
6th period	10	13	4	6	13

<div align="center">Phase 1: Teach Face-to-Face Collaboration</div>

During this phase, the thematic unit on trebuchets was not yet introduced.

Essential elements of cooperative learning and collaboration were introduced, however,

through a paper-tower team-building activity (Appendix A) and a lever mini-lab

(Appendix B). Within the context of these activities, I was able to teach students to

effectively work in groups. The focus here was less on the content and more on the

ability of students to negotiate solutions as a group.

Small groups were organized by academic ability, and by my assessment of who

could work with whom without undue duress. Students were then assigned a work

station. At the work station were three color-coded cards. The color-coded cards

represented the cooperative roles within the group. The roles were: Blue—motivator,

Red—engineer, Green—resource manager/recorder. Once students were at the lab

stations and in their groups of three, I introduced the definitions of each of the color-

coded cards. I asked the students to review the definitions with each other and choose

among themselves their roles.

Armed with their roles, I explained the rules of the paper-tower team building

activity. As students worked on their activity, I collected observations on their work in

my teacher journal (Appendix C), specifically looking for active engagement by all

students within their roles. Following the activity, students were asked to complete a

post-activity survey (Appendix D). Moving from small group to large group discussion,

we, as a class, outlined the significant factors of the collaborative activity, focusing on

improving the working dynamic for future projects. My comments were recorded in my

journal and students made their comments in their journals focusing their thoughts with a

reflection prompt (Appendix E). Additionally, video recordings of student collaborative

interactions and class discussions were made and analyzed to identify motivational

trends, and active student engagement within their roles. Those observations were recorded in my teacher journal.

Phase 1 culminated with students participating in the lever mini-lab. As students progressed through the lab, I made observations in my journal, again focusing on group dynamics. Following the lab, I asked students to complete a post-activity survey (Appendix F). We, as a class, moved from small groups to a large group and discussed positive and negative aspects of the lab. My observations and comments regarding the activity were recorded in my journal and students made their comments in their reflection journals. Both the team-building activity and the mini-lab allowed students time to practice investigating scientific questions and report their findings collaboratively prior to moving into phase 2.

Following the class discussions, I gave the students a summative quiz (Appendix G). I used the quiz results to baseline academic performance for both the treatment class and the non-treatment class.

Phase 2: Using Various Technologies

This phase was a play-and-learn phase. Students in the treatment group were introduced to and allowed to work with a variety of applications such as Google Apps, Gmail video and voice chat, PhotoStory (Microsoft), and blog applications (Blogger). Students in the treatment class began using these applications to communicate ideas collaboratively. Students in the non-treatment class practiced collaborating face-to-face.

Using the data from the previous mini-lab, students in the treatment class learned to input, sort and manage data using Google applications. As students became proficient

at basic spreadsheet and document applications, they were introduced to the collaborative nature of Google applications. Simultaneously, in their World Geography class, students learned to build webpages as a means of posting work into their on-line portfolios. Piggy-backing onto that knowledge, students began using the web-building skills to generate a collaborative group page embedded in the science home page. As students became familiar with the technology process, new science content was added.

Using the same color-code role, students participated in a torque mini-lab (Appendix H). Following data collection in the lab, the treatment-class students organized and reported their data via their webpage, managing their data collaboratively, using Google applications within their sites. My observations concerning technical problems, student attitudes and assignment completion were recorded in my journal. Students were asked to submit a post-activity survey (Appendix I) and record their thoughts in their reflection journals.

I scheduled two computer labs, one upstairs and one downstairs, to ensure face-to-face discussion between individuals in the same group did not occur. Additionally, I wanted to ensure that the treatment class and the non-treatment class had the same amount of structured collaborative time.

During phase 2, the non-treatment class collaborated in the classroom and in the library, covering the same material. Their data collecting, organizing and reporting, however, was conducted by hand or using technology in a stand-alone capacity. As with the treatment class, my observations were recorded in my journal. Students were asked to submit a post-activity survey (Appendix J) and record their phase 2 thoughts in their

reflection journals (Appendix K). Video recordings of student collaboration for both the face-to-face class and the non-treatment class were made and analyzed to identify peer interactions, technical mastery and student engagement within their roles. Both the treatment class and the non-treatment class were given a summative quiz to determine the level of content literacy across all groups and modes of collaboration (Appendix L).

In addition to the post activity surveys and summative quiz, six students, three from each group, were selected for an interview (Appendix M). Selection was random. I had students place their blue, red and green cards into three containers. I picked one representative from each group to interview. My focus was to look more closely at post-activity responses regarding student perceptions of collaboration and motivation.

Phase 3: Putting it Together

Comfortable with the mechanics of collaborating, students were assigned the task of designing, building and testing a trebuchet (Appendix N). Groups from the treatment class brainstormed ideas, designed their models and otherwise communicated their ideas on-line, using their webpages as discussion forums. The non-treatment class had access to the computer lab for research purposes, but those groups did their brainstorming and designing in the classroom. Both classes were encouraged to openly share ideas with the whole group. Observations concerning whole-group collaboration were recorded in my journal. Student products and web-based collaboration was captured from their webpage discussion and planning entries and analyzed for content literacy and student engagement. I was specifically concerned with analyzing engagement within the roles they were assigned, student motivation, and how they helped each other learn content and

technical skills. Following the research and design phase, both the treatment class and the non-treatment class were asked to submit a post-activity survey and record their thoughts in their reflection journals. Again, I collected observations and recorded them in my journal.

Phase 3 activity was not limited to school, but highly encouraged to facilitate my observations. Students kept daily journals of their progress and collaborative effort. I took notes and recorded student collaboration in my journal. Finally, video recordings of student interaction and collaboration were made and analyzed to identify motivational trends and active student engagement within their roles. Following the building and testing phase, I asked students from the treatment and non-treatment classes to complete a post project survey (Appendices O & P). I also selected six students, using the same selection technique previously mentioned, to interview. The final set of data collected was a summative assessment covering the major content elements of the project and mini-labs (Appendix Q).

Qualitative and quantitative data collected through the variety of collection tools is used to inform claims concerning how collaboration facilitated through technology impacts learning and motivation. Table 3 summarizes those sources of data and provides an outline of how data regarding the focus questions were triangulated.

Table 3

Data Triangulation Matrix

Focus questions	Source 1	Source 2	Source 3
Primary Question:			
1. How does technology-facilitated collaboration compare to face-to-face collaboration with respect to improving critical thinking and problem solving skills?	Instructor notes	Student journals/web page analysis	Summative assessments
Secondary Questions:			
2. Can using various technology applications within a classroom foster student engagement and minimize distractions?	Instructor notes/Video Recording	Surveys/Student Journals	Summative Assessments
3. How will technology-facilitated collaboration impact the social-support and scaffold present in group dynamics as students shift from face-to-face collaboration to indirect contact through technology-facilitated collaboration?	Instructor notes/Video Recording	Student Journals/web page analysis	Student surveys and interviews

DATA AND ANALYSIS

Over the span of approximately eight weeks and encompassing four thematic activities, data from the treatment and non-treatment groups were compared to determine the impact of technology-based collaboration on student learning and motivation. During each of the thematic activities, qualitative and quantitative data were triangulated in order to answer my questions.

Calibrating qualitative and quantitative data for the purpose of comparison was difficult.   Comparing summative data between the two distinct groups required me to level assessment scores using baseline data. For example, on the initial assessment, non-treatment, low-range students scored 9.49% lower, on average, than treatment low-range students. For each of the subsequent assessments, and for comparison purposes, I added 9.49% to the average score of the non-treatment, low-range group. I used the same leveling technique for mid-range and high-range student assessment comparisons. Table 4 contains the baseline score differences for the treatment and non-treatment groups.

Over time, data from each activity clearly indicates change in student motivation and academic performance.

Table 4
Baseline Score Ratio, Treatment Group to Non-Treatment Group, (N=41)

Target Group	Levers Quiz (baseline)
Low-Range	9.49%
Mid-Range	16.82%
High-Range	3.16%

Performance

Incorporating technology as part of a comprehensive inquiry approach did not necessarily improve content-specific knowledge for low-range academic achieving students. Figure 1 shows the average, unadjusted, scores for each assessment in the study.
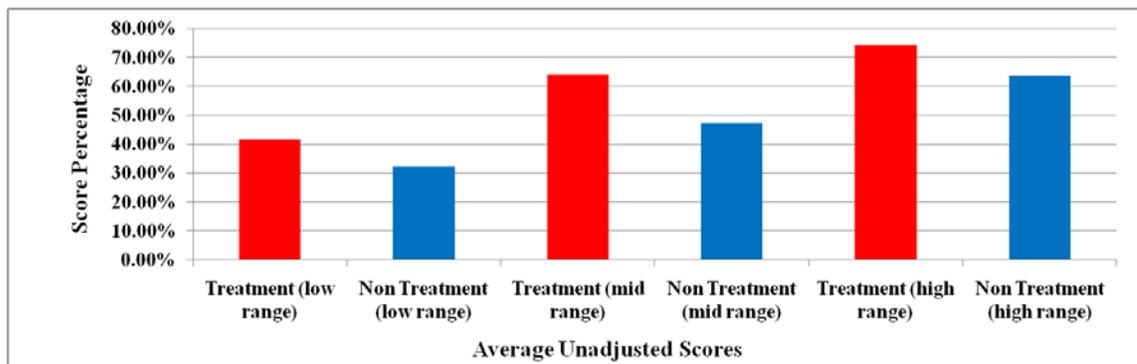

Figure 1. Average unadjusted quiz scores by academic performance group, (*N*=40).

Essentially, over the duration of the study period, academic performance for low-range students, regardless of the intervention, only slightly improved. Conversely, as interventions were implemented there was initially a sharp divergence in assessment scores between mid-range treatment and mid-range non-treatment students. Likewise, with the implementation of technology, as a means of collaborating, there was a significant divergence in academic performance between the high-range treatment and high-range non-treatment students. T-tests performed for each of the assessments indicated an extreme statistical significance for the torque test; having a p-value of approximately 0.0005. Interestingly, technology interventions were first assessed through the torque test; indicating that the interventions led to the punctuated differences in assessment scores. Figure 2 shows assessment score comparisons between treatment

and non-treatment mid-and high-range performers. Both the treatment mid-range and

treatment high-range groups outperformed their non-treatment counterparts, on the
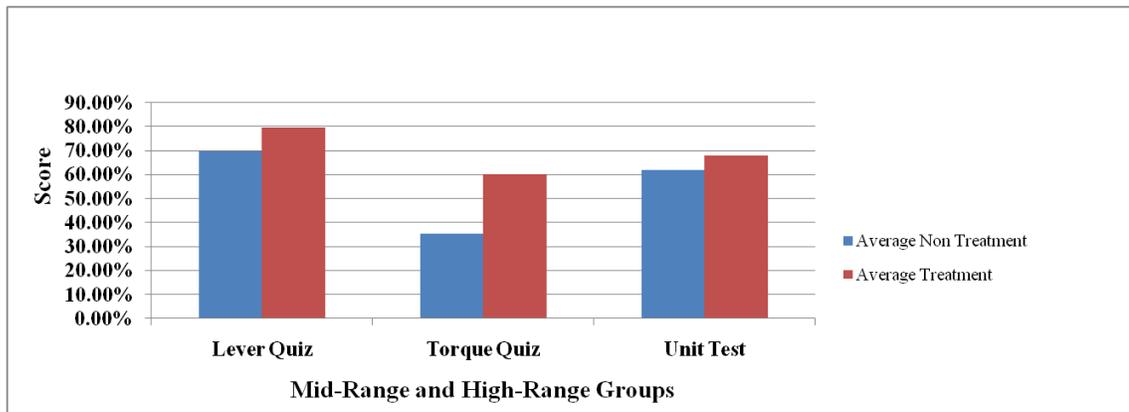
assessments.

Figure 2. treatment and non-treatment mid-and high-range comparison, (*N*=30).
Note. Levers Quiz: p>.05, Torque Quiz: p<.05, Unit Test: p>.05

As the study culminated, academic performance for the mid-range treatment and

high-range treatment groups leveled off, while the academic performance of non-

treatment mid-range and high-range students improved. When assessment scores were

adjusted to reflect the baseline assessment scores, another trend emerged. It appeared that

the early academic gains made by the treatment students were eventually matched by

non-treatment students. The adjusted scores, shown in Figure 3, suggested that

technology interventions allowed students to quickly master some aspects of the content.

Over time, however, the academic advantage that technology afforded was not

necessarily superior to traditional face-to-face collaborative interventions.
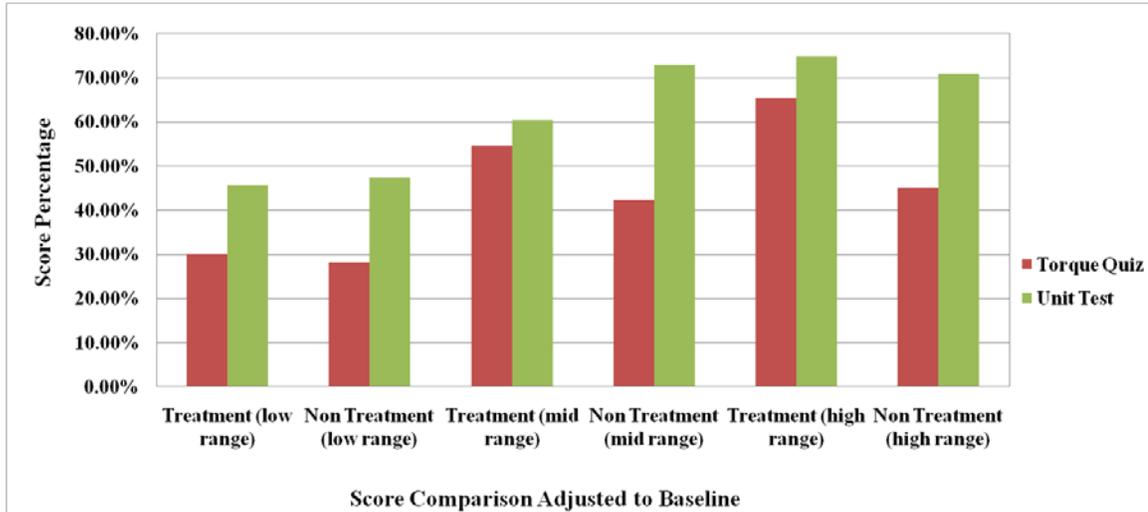
Figure 3. Assessment score comparisons adjusted to baseline, (*N*=40).

Never the less, whether referring to the adjusted scores in Figure 3 or the raw scores from Figure 1, those treatment students who are historically high-range achievers outpaced and outscored every other group. It is my opinion that the performance distinctions occurred because students had access to a wider scope of knowledge made available through technology and had the personal disposition to leverage that global knowledge to their advantage.

Additional evidence is found in the actual project test results. For example, four of the top five crane designs were from the treatment class. Figure 4 summarizes the top 10 throwing trebuchets. In both projects, treatment groups designed and built more superior models than non-treatment groups. Moreover, each of the top four groups for the crane project, and the top five groups in the trebuchet project had, one of the five identified historically high-range academic achievers. High-range academic achievers elevated the performance level of their groups and directly benefited themselves academically, as evident by their improved scores and efficient projects.
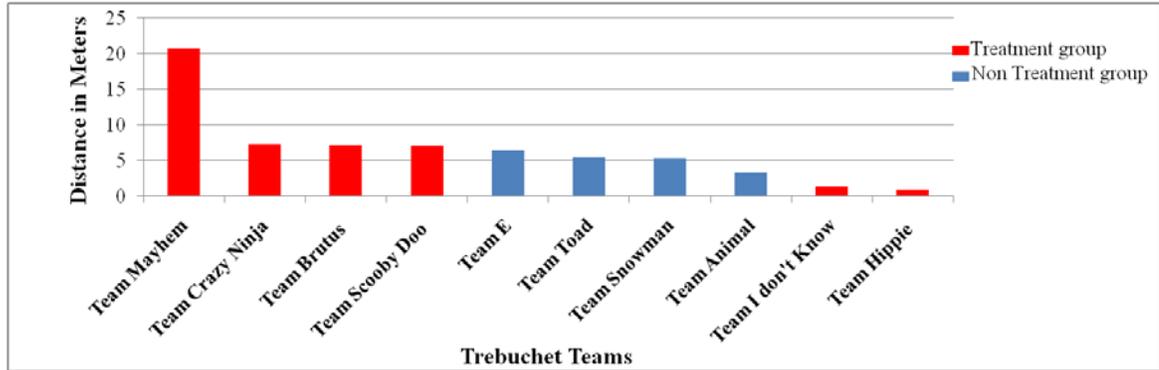
Figure 4. Top 10 combined treatment and non-treatment trebuchet results.

<u>Scaffolds to Success</u>

Inevitably, technology-facilitated collaboration impacts the social-support present in group dynamics as students shift from face-to-face collaboration, to indirect contact through technology-facilitated collaboration. Addressing student social and technology-use needs was challenging.

I expected that scaffolding techniques for using technology to cooperate and collaborate would be a critical task for me if I expected successful participation from all academic achievement ranges. Scaffolding in the context of this study means interventions such as peer tutoring, teacher-led discussions and modeling, recording online examples and any activity that manipulates a student's zone of proximal development (ZPD) involving other teachers, facilitators or competent students.

While it is clear from the summative assessments that academic performance for low-range performers was, at best, marginally improved, low-range students benefited from their association with their peers and improved their skill to some level. One particular low-range student stated, "Working in a group helps me learn new stuff." When probed to ascertain the ease of using the technology, she stated, "We used it

[computers and the web] to talk about what we were going to do for the day." She acknowledged that she only participated in technology-facilitated coordination during school and only when prompted by me or a peer in her group. This student's partner, a mid-range achiever, then stated in her partner's defense, "She is not able to help with the project, so she is working on the [web-based] design." Encouraged to become part of the effort, low-range students benefited socially and, to some measure, technically.

On average, there was no measurable improvement to written reports, homework completion, out-of-school research participation or immediate academic achievement for students who are historically low academic achievers. This is the first time in my experience, however, that every person completed at least the cooperative project aspects of all sub-units involved in this study, including daily journals, team designs, team projects and model test-day activities. Triangulating all these data indicates that students involved with others in a cooperative activity, regardless the mode of collaboration, benefited at least socially, and definitely technically.

<u>Motivation and Engagement</u>

Academic performance is affected by attitude. Prior to the technology intervention, while cooperative groups were being introduced, students were surveyed and both the treatment and non-treatment groups felt that they were able to learn more in a group than by working alone. Following each of the activities, students were again queried on their belief that working in groups improved their learning. Student response scores are recorded in Table 4. Over time, students in the treatment group felt that group

work was less beneficial to their learning. Non-treatment students, however, consistently

reported feeling like group work was beneficial to their learning.

Table 5

Survey results referencing student perceptions to learning and group work, (N=42)

Target Group	Paper Towers	Levers	Torque	Trebuchet
Non-Treatment	4.06	3.35	3.48	4.29
Treatment	4.10	4.33	2.33	2.86

Note. 5 = Strongly Agree, 4 = Agree, 3 = Indifferent, 2 = Disagree, 1 = Strongly Disagree

Additionally, extracting all the survey responses dealing with the enjoyment of

doing hands-on activities, learning in groups, participating in groups and solving

problems in groups, provided additional insight into how student attitudes were linked to

academic performance. Each of those questions queried student attitudes regarding group

work. Therefore, the surveys provided an effective method of gauging how students

valued working in groups. Figure 3 provides a snapshot of declining treatment-group

attitudes as a function of time. The non-treatment group maintained a generally positive

attitude towards group activities, indicating that the mode of collaboration is culprit in

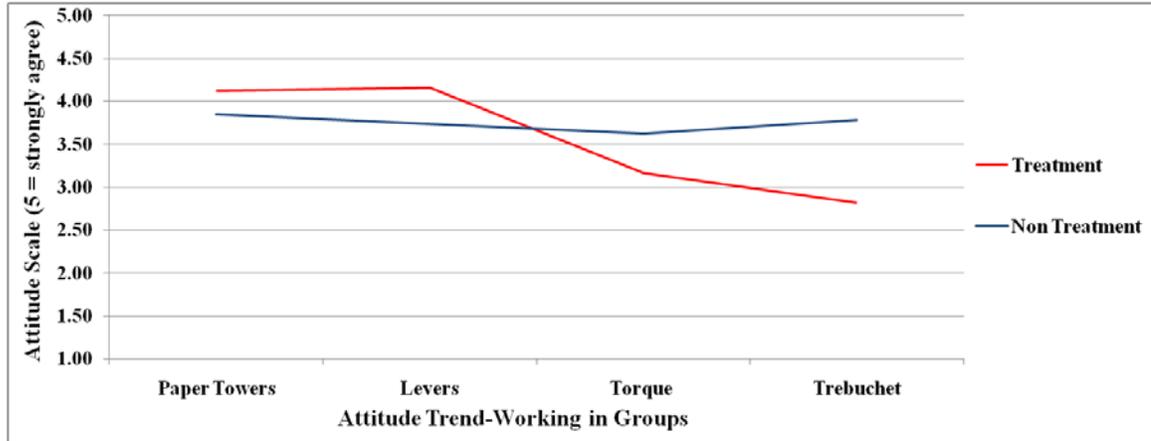diminishing motivation and engagement, rather than the group work itself.

Figure 5. Average student responses to selected survey questions concerning working in groups, (*N*=42).
Note. 5 = Strongly Agree, 4 = Agree, 3 = Indifferent, 2 = Disagree, 1 = Strongly Disagree

Triangulating this data with teacher video-journal data provides additional

supporting evidence for these claims. Excerpts from four specific teacher video-journal

entries follow a low- to mid-range treatment group through the process of designing and

building the trebuchet (Montoya, 2011a). These students were not able to complete any

technology-based activities without extensive assistance. They marginally completed

group logs and blogs. As a mid-project intervention strategy, school-sponsored tutor time

was offered and denied. Peer tutoring and peer shadowing was also declined by the

particular treatment team. In the end, parent involvement was required to get the students

involved in the project. The group did build a good trebuchet, as seen in Figure 6, but

articulating its design features was difficult for them. They knew how to build one, but

they could not explain how the components determined the efficiency of the machine.

Some of the problem may not have been ability, but rather the inability to operate in the

digital environment in preparation of the hands-on tasks.

Figure 6. Trebuchet model

Technology Burden

There is a point when the technology over-burden or the ability to learn and simultaneously use technology presents its own dilemma. It is important to state that all of the low-range academic performers in the treatment group had access to the technology at school and at home. It is also important to acknowledge that access to technology and familiarity with technology are not the same thing.

Without enough unevaluated practice and play, using technology was stressful to students, and technology over-burden created an adverse effect on student motivation. In my video log, I recorded building frustration within the treatment students as they struggle with managing technology tasks (Montoya, 2011b). Additionally, written comments in open-ended survey questions corroborate the frustrated sentiment. One student wrote in the trebuchet survey remarks section, "Well it's easier to do drawings and stuff and [be] more organized with it when your [sic] on the computer, but the

teammates have to be willing to go on the computer also and sometimes people in your team aren't use [sic] to doing that stuff and don't like figuring how to do them [sic] themselves." These data indicate that the lack of technical ability and technology overburden contributed to diminished student attitude and motivation.

From my perspective, the activities provided low-range academic performing students with opportunities for success separate and distinct from using technology. For low-range treatment students, however, the strategy of using technology to tap into their motivation and effect positive academic change was not realized. High-range academic achieving students, on the other hand, excelled when challenged with the task of collaborating through technology. For them, collaborating through technology proved to be academically beneficial.

Balancing Play and Work

Regardless the methods of collaboration, encouraging play and exploration as a cooperative strategy within the collaborative effort is as important to successful participation and learning as are teaching etiquette and appropriate behavior. It was clear during the study that failure to participate individually affected the entire cooperative goal. Recorded in a teacher video-journal students acknowledged that their failure to plan and perform individually led to the team failing to meet minimum project time-lines. Likewise, when individuals did not perform their roles the group struggled to complete the tasks. Group failure can be attributed to individual and group procrastination (Montoya, 2011c). Procrastination then resulted in the group's inability to generate a clear team objective. In one student interview, the student acknowledges momentary

lapses in productivity stating, "we got distracted." When prompted to explain his feelings about working in a group, however, the student indicated that once the team was able to get together and get focused, productivity increased; because as a group, "getting the help you need, you get a lot done faster [than working alone]." I also observed who performed their roles as instructed, and who in turn, produced well-functioning models. My notes indicate that both treatment and non-treatment students who engaged in their cooperative roles completed their assignments on time and to at least the minimum standard to the benefit of the group project (Montoya, 2011d).

Division of Work

Qualifying the importance of cooperative assignments within a cooperative activity, I asked students at the beginning of the study, and as interventions were initiated, to report their feelings in a survey. Generally, as recorded in Table 5, students in the treatment and non-treatment groups agreed that when individuals in the group were assigned a task, learning was facilitated. One student commented in an anonymous survey, "when you can split up the work, and you didn't have to do everything by yourself, that takes a lot of stress off of you."

Table 6
Survey Responses Referencing Student Answers when Asked if Learning Increases when Individuals are Given Specific Jobs, (N=40)

Target Group	Treatment	Non-Treatment
Girls	4.1	3.7
Boys	3.1	4.1
Average	3.6	3.9

Note. 5 = Strongly Agree, 4 = Agree, 3 = Indifferent, 2 = Disagree, 1 = Strongly Disagree

My students were taught to work cooperatively and then were assessed on their performance. It was evident from survey data, teacher observation and student interviews that the students themselves realized that the individual effort directly affected the performance level of the group. Students were also cognizant that during this study the potential benefit of team activities was juxtaposed with the liability of inactive partners. That inactivity manifested in a variety of ways and for a variety of reasons.

Critical-Thinking and Problem-Solving

Treatment students progressively perceived problem solving to be a more difficult process when they were required to communicate via technology. Initially, treatment students and non-treatment students felt that working in a group facilitated or eased solving problems. Figure 7 shows that attitudes of those exclusively performing face-to-face collaboration remained relatively consistent throughout all four surveys concerning problem-solving within the group. Treatment group scores, however, significantly changed once the technology interventions were introduced. After implementing the technology interventions, treatment students, on average, slightly disagreed that working in groups made problem-solving easier.
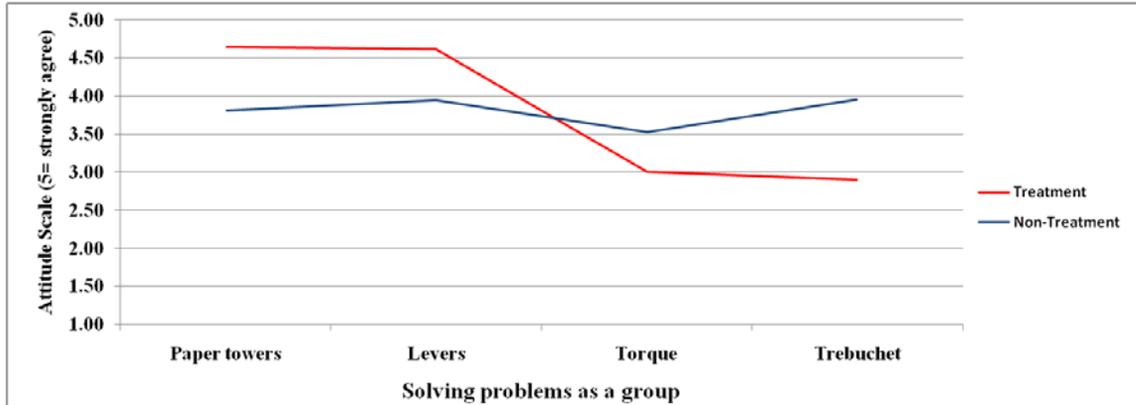
Figure 7. Average student responses to a survey question asking if solving problems is easier in a group, (*N*=40).
Note. 5 = Strongly Agree, 4 = Agree, 3 = Indifferent, 2 = Disagree, 1 = Strongly Disagree

Yet, at the same time, students developed higher-order thinking skills and problem-solving abilities when they were required to operate in an unfamiliar situation. Essentially, when students lacked the basic skills required to collaborate through technology, they initially complained and then learned to circumvent the issue and accomplish the task. One particular video journal records a mid-range student attempting to asynchronously communicate, through technology, with a low-range, usually absent, teammate. After a brain storming session with me and another student, the target student developed a strategy to ensure her asynchronous communication attempt would be successful. She walked me through various methods that she would use to coordinate the group assignment. Those proposed tactics included attempting to Google chat after school, making a telephone call to remind the partner to check her Google documents, posting a web announcement to the team homepage and sending a Google calendar event invitation.

Communication challenges also provided good opportunities for high-range students to enhance their leadership skills among their peers. In an interview with a high-

range, very grade-minded student, the student states, "It's sometimes difficult to get your ideas across when you are trying to type it out and you are trying to find the right words so your team gets it." She continued, "when you are in a position of leadership, you want to know what's going on so you can help others out. So you got to call each other and make sure they are updating your blog or webpage so you can get the assignment completed."

Captured in another video-journal entry, students discuss the difficulties of translating their plans and drawings to their Google documents. They come up with two strategies to overcome the hurdle. The first was to scan their drawing into their Google documents, and the other was to use an on-line drawing tool to reproduce their draft design.

On another occasion, a student discusses the difficulty of sharing ideas among the group due to extracurricular activities and absenteeism. The team solution was quite inspiring. The team learned how to take video with their i-pods and then post those video journals to their webpage. For that group, it became a continuity tool and an engaging way to record and share their progress with absent partners.

It is clear from all the mutually supporting data that a recurring theme arises within the distinct collaborative groups. The data indicates that collaborating exclusively through technology pushed students to be inventive and creative, at times solving problems through asynchronous communication, and at other times simply tipping each other to group needs by making a telephone call or other synchronous method of communication. The treatment students identified the significant challenge in

collaborating through technology, but they also learned to adapt and invent strategies that got them through or around problems. Unlike the treatment students, however, non-treatment students did not face technology-based communication obstacles as their collaboration was all face-to-face. Hence, the lack of fluctuating attitude concerning problem solving throughout the study is observed. Additionally, for me, facilitating technology-based communication and collaboration presented its own challenges.

Managing Distractions

Using technology in the classroom had the potential to distract students from the content, and caused me to consider the balance between teacher-control and student-exploration and play. Identifying how to integrate technology to reinforce inquiry activities was a challenging task. It required me to introduce cooperative strategies through a medium that could present liability concerns for me and the district. There is a balance between encouraging play and exploration, and teaching etiquette and appropriate behavior.

Student webpages, web-based journals and paper journals provided me with a window to study student engagement and distraction levels. In their web-based communications and hand written journals, I noticed play, but it was appropriate and inquisitive. Students appeared to understand their digital responsibility and they appeared to operate within the established behavioral protocol. For example, one student stated in a web-based journal, "Today I hit Seth because he hit me in the hand with a ruler. Even [sic] though it did not hurt and we were kidding around." To which a third partner responds, "lol, you guys, we did alot [sic]. [J]ust waiting for our tower to dry [sic] attach

the arm, [sic] then we are DONE!!! Guys heads up, I am coming at lunch to work on this, you guys should com[e] in to [sic]." The discussion demonstrates that while distractions occur, they are typical of children. Additionally, the distraction is temporary and, without any prompt, the students resolved the play and continued on with productive communication.

On another occasion and within another group, students were communicating via their blog. An interesting discussion ensues where technical difficulties using the computer are shared between two partners. A third partner joins the conversation and requests assistance in the design of a trebuchet. One partner states, "You do it like this... a line.... and another line... and some mathematical crap.... it's easy...." To which the requesting partner states, "lol quit messing around." Following the exchange, the peers organize the work and begin an appropriate dialog.

Again, once educated and trusted, students rise to the occasion. This does not suggest that they will not diverge from their task, but it indicates that their ability to self-regulate is reinforced and nurtured by education. I did not use fear tactics, so I cannot speak to its efficiency in regards to managing adolescent behavior. From the pre-project experience dealing with cyber bullying, however, I would speculate that education encourages good behavior, while fear tactics encourage rebellion.

INTERPRETATION AND CONCLUSION

Data collected during this study enabled me to determine the impact of technology-based collaboration on my students' critical thinking and problem-solving skills. I was also able to gain insight in how technology-facilitated collaboration affected student motivation and content literacy. Finally, the study provided me with a unique vantage point from where I observed social impacts to learning as students transitioned from face-to-face collaboration to technology-facilitated collaboration.

The data indicated that technology-based collaborative activities did little to improve the academic performance of low-range students, as measured in summative assessments. As I implemented technology interventions I noticed immediate patterns in the data. Statistical t-test indicated that the trends were not coincidental and I was compelled to ask myself, what the factors were that caused the low-range students to remain consistently unaffected. The impacts I did notice were because of social, peer-to-peer interactions. It became very evident that academic performance for those students was intimately tied, at some level, to some aspect of their social interactions. I can only speculate that the pressure of performing in a group caused low-range students to participate and engage only when prompted externally. What is the chemistry of self-motivation that leads to success? What factors contribute to successful academic performance? Each of these questions would require significant study and are far beyond my expertise. What is clear is that low-range academic performers benefited socially and, to some measure technically, from their association with mid-range and high-range academic performers.

What is not clear is how the interactions fully impacted mid-range and high-range students. Did they not reach their potential because of the limitations in their groups? Perhaps the limitations in their groups motivated them to excel where they would otherwise have been complacent. In order to ascertain motivational impact to those higher achieving groups, the surveys would have to identify the individuals and be sorted by performance levels. In the short term, it would be useful to continue the study, arranging students into ability groups versus randomly-selected groups. Perhaps grouping high range-achievers would result in significant content mastery for those groups. Additionally, a longitudinal study would be useful to track these students by a set of skill-based standards, in addition to academic performance, to investigate the correlation between leadership roles and academic-knowledge generation. Without a limit or restriction, it would be interesting to explore how far an advanced student could reach.

The data indicates that mid-range and high-range students academically benefited from the challenges presented in using technology as a means of collaborating. Not only did their assessment scores indicate improved content literacy over the non-treatment students, but the technical challenges they faced facilitated significant critical-thinking and problem-solving growth. It is true that attitudes concerning using technology as a mode of collaborating degraded through the study. It is equally true that students who faced communication challenges, invented solutions to inter-team communication challenges. The ability to critically solve a complex, unrehearsed problem indicated significant cognitive growth. Successful collaborators used technology to access a very

large and universal knowledge base. The true impacts of their growth will be observable in time as they continue to engage difficult problems.

My students did not necessarily enjoy the challenges that communicating through technology presented; that may be an artifact of the current institutional mind-set. If grades had always been based on creative problem-solving versus low-level knowledge comprehension assessments, like the typical summative assessments I have traditionally assigned, I think the attitude surveys would not have reflected negatively. I believe that as the paradigm shifts to skill-focused, standards-based assessments, student expectations and attitudes will also evolve.

In practical terms, this study illuminated a few very valuable tactics that will facilitate incorporating technology as a mode of collaboration. Technology-based collaborative efforts should be prefaced by activities that introduce necessary technology-use skills in order to alleviate the burden a student feels when trying to negotiate new content with new methods of communicating and reporting. For the educator, establishing clear boundaries allows the students to explore the technology in a safe environment. There will be an initial infatuation with the new device; within a structured context, the tool eventually becomes an integrated part of the classroom. My study found that structured play prior to the actual technology intervention mitigated distractions during the actual assignments. Allowing students to practice and play within an established protocol reinforces good citizenship and appropriate behavior. It was very evident that education and mentoring established a healthy, playful atmosphere. Prior to

the study, I notice that threatening a student with punishment inspired rebellion, where education inspired trust and respect.

Ultimately, using technology as a means of collaborating provides students with an enormous resource for developing sophisticated problem-solving and critical-thinking skills. It allows the educator another mode of extending and making more comprehensive the inquiry process. Technology integration, however, especially introducing cooperative collaboration activities opens an opportunity for those who are less motivated, less skilled or less resourced to fall short of the designed curricular goals. Strategically, providing technology education as early as possible is a recommendation that could alleviate technology-burden and its associated fears. When was the pencil technology introduced to the education system? Was there an apprehension among parents and educators when students transitioned from slate and chisel to portable, easily hidden, potentially lethal recording devices?

VALUE

Conducting this research project has made very clear to me the importance of developing precise and measurable objectives as one implements new technology within the scope of inquiry-based instruction. There are too many variables that affect student learning; blindly applying an untested concept or strategy leads to ambiguous results. My project forced me to refine my objectives and expectations often. I had to reflect daily on what I was doing and what I expected. As the data presented trends in student performance, my decisions to alter my approach became informed and not simply intuitive, as had traditionally been the case.

Interestingly, as I focused my attention on student performance and achievement, the content material became transparent and student needs moved to the forefront of my teaching strategy. That is to say, the content simply became the construct on which my teaching facilitated student learning. Technology then became merely one of many instructional tools that helped me organize, moderate, facilitate, and streamline student learning through inquiry. It allowed students to explore study and assimilate as much as they chose from a global knowledge-base.

For those students who traditionally struggle academically, the process was painful. It required deliberate, time-intensive planning, mentoring and supervising over and above typical classroom instruction and management. If such an endeavor is to be academically successful, not considering all the other factors affecting student performance, then educators will need to spend significant time preparing instructional and social scaffolds for lower-range students to maximize the potential for any

measurable academic gain. Differentiating to meet the needs of learning- and emotionally- disabled would require teachers to focus full-time attention on a very small group of two or three students. For mainstream students, time invested early in a student's academic life, including access to and casual use of the technology, would disperse the technology burden over time. Regardless of the student population, providing unlimited knowledge at a student's disposal exponentially increases learning opportunities. It also creates an exponential increase in wonderful teaching moments. In fact, teachers will be inundated with email, blog and face-to-face requests for assistance.

A persistent concern that I have is the divergence between low-range academic performers and other students. With each successful intervention, it seems that the academic, social and technical differences between low-range performers and other students increase. As we move into an even more technology-dependent age, what strategies will help us encourage, motivate and mentor low-range academic performers? I plan to continue performing action research, in part to answer this question, and in part to ensure I maintain reflective practices that facilitate my own learning. Some of the challenges to incorporating new strategies are personal philosophy or fear, but many are systemic.

Challenges to implementing technology as a meaningful collaborative mode, including technical infrastructure and training concerns; social impacts, such as liability concerns; hard-to-monitor peer interactions; and cultural impacts, because new innovation, usually challenge institutional paradigms. The benefits, however, are personally and educationally rich. Students will develop dynamic problem-solving skills

and learn to appropriately interact with others. Their work will be public, and accountability will take on a personal flavor. Their growth will include academic improvement in the content and technology area, but the real benefit will be in their cognitive growth. This study clearly demonstrated students collectively solving unique problems on a daily basis. Those performing collaboration through technology had even more technical challenges to overcome. The learning process led to great growth among the active participants, including myself.

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APPENDICES

APPENDIX A

PAPER TOWER ACTIVITY*

Appendix A
Paper Tower Activity

THE PAPER TOWER
3 Students per team and one tower per team.

SKILLS AND ENGINEERING CONCEPTS DEVELOPED:
Involves designing and constructing a free standing tower from a single sheet of 8 inch by 11 inch paper. Involves creative design, analysis of structural concepts, construction skills (with paper), and concepts of stability.

INTRODUCTION
If you look up the definition of a tower, you will find the following: "An exceptionally tall building or part of a building or an exceptionally tall structure used for some functional purpose." In the past, towers were usually used to house bells (bell towers), for observation (watch towers), or for signaling (light houses). Perhaps the earliest record of a tower comes from the Bible, where the story of the Tower of Babel is told. Other notable towers include the Tower of Pisa and the Eiffel Tower, two completely different types of towers. Today there are many more types of towers that are used for a wide variety of functions. A few examples are transmission line towers, radar towers, radio and TV broadcasting antenna towers, and towers for suspension bridges.

OBJECTIVE
The objective of this project is for students to design and build the tallest free standing tower using only one sheet of 8 inch by 11 inch paper and masking tape. The tower may **NOT** be taped to the floor.

PROJECT DESCRIPTION
The challenge of this project is to design the tower to make optimum use of the single sheet of paper in order to achieve the greatest tower height. The design of the base will also be challenging, as the tower must be free standing.

CONSTRUCTION
Each team should be given **one** 8 inch by 11 inch paper, a pair of scissors, and 3 feet of masking tape. The tape is to be used only to fasten the pieces of paper together, and may not be used to provide extra height. Each team will have 15 minutes to plan and design their tower, and 30 minutes to execute their design.

PROJECT CONSTRAINTS
The towers constructed must:
• Be constructed from a single sheet of 8 inch by 11 inch paper.
• Be free standing for at least 5 seconds (cannot be taped to the floor).

SUPPLIES REQUIRED

- One sheet per team
- Masking tape (three feet per team maximum)
- Ruler
- Scissors (one pair for each team).

COMPETITION
• Each tower will be required to free stand for a period of at least 5 seconds.
• The height of each tower that meets the first requirement will be measured, and the tallest tower will win.
• Each team will be given three chances to have their tower free stand for 5 seconds.

*Based on the Math Engineering and Science Achievement (MESA) activity, "Paper Tower

APPENDIX B

LEVER MINI-LAB

Lever Mini Lab

I. **Objective:** *(As a group, identify what levers are and how they multiply force. Explain how this lab will help you better understand the properties of leverage)*

II. **Materials and Equations:** *As a group brain storm all the equations necessary that explain leverage and any other quantity that you may run across in this lab)*

III. Procedures:
    A. Calculate 1st class lever arm lengths for output forces listed in table 1.
    B. Calculate input or output force required to lift various masses using 1st class levers for table 1.
    C. Measure the input force and output force for calculated lever arm lengths derived in Procedure A and B.
    D. Record any discrepancies in table B.
    E. Graph mechanical advantages.
    F. Analyze the data and write a conclusion.

IV. Results:
    A. Table 1.

| Side 1 Mass (g)	Side 1 Length (cm)	Side 2 Mass (g)	Side 2 Length (cm)	Mechanical Advantage
20		20		
20	60		40	
20	80		20	
50		20	71	
50	50	50	50	
50	66.7		33.3	
50	75		25	
100		100		
100	60		40	
100	20		80	
100		20		

    B. Table 2.

    A. Table 1 (discrepancies)

| Side 1 mass Calculated: Measured	Side 1 length Calculated: Measured	Side 2 mass Calculated: Measured	Side 2 length Calculated: Measured

IV. Analysis questions:

1. A man exerts 20N on a 200N rock and lifts it using a class 1 lever. If the rock to fulcrum distance is 1m, how long is the lever arm from the fulcrum to the man?
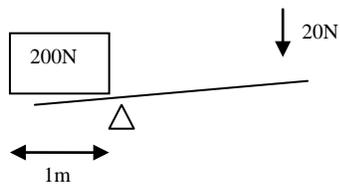
2. A boy has to lift a 20kg stump with lever. If he sets the fulcrum 1m from the stump and leans on the lever arm that is 5m long how much weight (force) does he have to exert to move the stump?
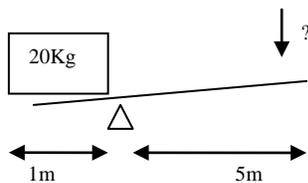
3. A class 1 lever has a total length of 10ft with the fulcrum 2 ft from one end. If a 110 lb girl stands on the long end, how heavy a person could she lift?
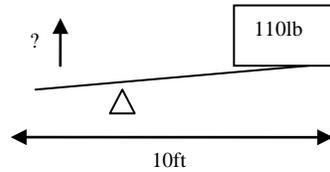
4. What is the equation for mechanical advantage?

5. If output force is 10N and input force is 2N what is the mechanical advantage?

6. What is the weight of 300g and 400 g?

7. Draw a schematic for all 3 types of levers.

V. Conclusion: *(Attach the conclusion to another sheet)*

APPENDIX C

TEACHER JOURNAL/VIDEO OBSERVATION PROMPTS

Teacher Journal/Video observation prompts

Prompt 1: Were the group instructions clearly understood by the students?
Prompt 2: Did each group function within the scope of their instructions and group roles?
Prompt 3: Was knowledge within the group evenly distributed? (Did any groups flounder because of academic/social/intellectual deficits within the group?)

Map: (group organization and room use):

Observations:

APPENDIX D

PAPER TOWER POST ACTIVITY SURVEY

Paper Tower Post Activity Survey

Please complete the survey honestly. The purpose of this survey is to hear your thoughts concerning the paper tower activity. This is not a test; it is anonymous and does not affect your grade.

Are you male or female?

Use the following scale: 1 (strongly disagree), 2 (disagree), 3 (indifferent), 4 (agree), and 5 (strongly agree).

1. I like hands-on activities in science.	1 2 3 4 5
2. Working in groups motivates me to work hard.	1 2 3 4 5
Explain your answer.	
3. I participate more when I work in groups than when I work alone.	1 2 3 4 5
4. When I work in groups I am comfortable speaking my mind.	1 2 3 4 5
5. I do all the work when I work in a group.	1 2 3 4 5
Explain your answer.	
6. I learn more when I work with others.	1 2 3 4 5
7. When everybody in the group is assigned a job, I learn more.	1 2 3 4 5
Explain your answer.	
8. I like to lead or be in charge when I work in a group.	1 2 3 4 5
9. Solving problems is easier when I work in a group.	1 2 3 4 5

APPENDIX E

PHASE 1 STUDENT REFLECTION POMPT, PAPER TOWER AND LEVER MINI-LAB

Phase 1 Student Reflection Prompt, Paper tower and lever mini-lab

1. What was the objective of the activity (Paper tower or lever mini-lab)
2. What was your responsibility to the group?
3. What did you learn about working in a group to build the tower/complete the lever mini-lab?
4. Do you think you could have built the tower/completed the lever lab more easily without being in a group?
5. Is there anything else you would like to say about this project?

APPENDIX F

LEVER MINI-LAB POST ACTIVITY SURVEY

Lever mini-lab Post Activity Survey

Please complete the survey honestly. The purpose of this survey is to hear your thoughts concerning the lever mini-lab activity. This is not a test; it is anonymous and does not affect your grade.

Are you male or female?

Use the following scale: 1 (strongly disagree), 2 (disagree), 3 (indifferent), 4 (agree), and 5 (strongly agree).

1. I like hands-on activities in science.   1 2 3 4 5
2. Working on real projects motivates me to learn more about science.   1 2 3 4 5
3. Working in groups is enjoyable.   1 2 3 4 5
Explain your answer.
4. I learn more when I work in groups.
5. I participate more when I work in groups than when I work alone.   1 2 3 4 5
6. When I work in groups I am comfortable speaking my mind.   1 2 3 4 5
7. When I am in a group, I end up doing all the work.   1 2 3 4 5
Explain your answer.
8. When everybody in the group is assigned a job, I learn more.   1 2 3 4 5
Explain your answer.
9. I like to lead or be in charge when I work in a group.   1 2 3 4 5
10. Solving problems is easier when I work in a group.   1 2 3 4 5

APPENDIX G

LEVERS QUIZ

Levers Quiz

1. Complete the table (determine how much mass it will take to balance the scale or determine the arm length necessary to balance the mass).

Side 1 Mass (g)	Side 1 Length (cm)	Side 2 Mass (g)	Side 2 Length (cm)	Mechanical Advantage
100		100		
45	60		40	
50	80		20	
30		20	70	

2. A person exerts 50N on a 400N rock and lifts it using a class 1 lever. If the rock to fulcrum distance is 1m, how long is the lever arm from the fulcrum to the man?
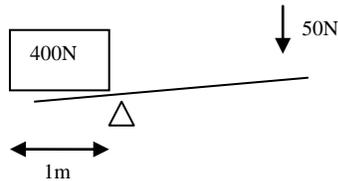
3. A boy has to lift a 15Kg stump with lever. If he sets the fulcrum 1m from the stump and leans on the lever arm that is 5m long how much weight (force) does he have to exert to move the stump?
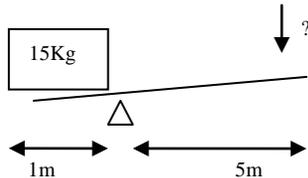
4. A class 1 lever has a total length of 10ft with the fulcrum 2 ft from one end. If a 110 lb girl stands on the long end, how heavy a person could she lift?
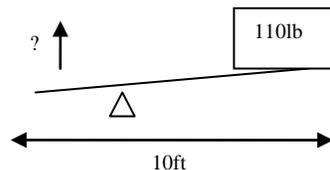
5. What is the equation for mechanical advantage?

6. If output force is 10N and input force is 2N what is the mechanical advantage?

7. What is the weight of 400g and 40 g?

8. Draw a schematic for all 3 types of levers.

APPENDIX H

TORQUE MINI-LAB

Torque Mini-Lab

I. Objective: *(As a group, identify what torque is and how this lab will help you better understand the properties of torque)*

II. Materials and Equations: *(As a group brain storm all the equations necessary that explain torque and any other quantity that you may run across in this lab)*

III. Procedures:
A. Draw and then design a free-standing spaghetti crane (that means it has to stand on its own). As you draw the crane include a table that shows how much torque is at each centimeter on the crane arm.
B. Build the crane with 100g or less of spaghetti, Elmer's glue and string.
C. Place a 100g mass on the crane arm and verify its ability to hold the mass without breaking or tipping over. If it holds the mass, increase the mass until the crane snaps of you reach 1000g mass on the arm.
D. OPTIONAL: Attach pulleys a motor, a wining screw and a battery pack to automatically lift the mass with the flick of a switch.
E. Post your lift mass and the data from the other cranes in the table below.
F. Make observations of the other cranes in your reflection journal.
G. Graph and analyze your data using your objective to guide what you graph.
H. Write a conclusion. Please use the writing rubric your English teacher gave you.

IV. Results:
C. Table 1.

name	Crane lift mass (g)	Arm length (cm)	Torque

IV. Analysis questions:
A. Find the Weight of a rock with mass = 110 g.

B. What does Work, Torque and Energy have in common? What makes them different?
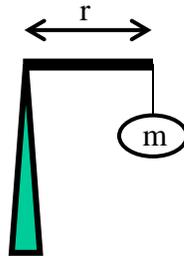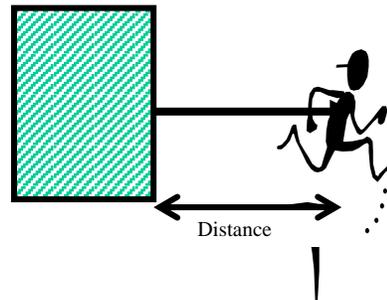
C. Find the Torque on this system:

mass = 30 kg
r = 5 m
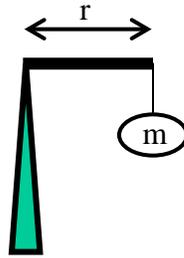
D. Find the Torque on this system:

mass = 12 Dg
r = 2 dm

E. Find the work:
    Distance is 20Hm
    mass is 3 Hg

Distance

V. Conclusion: *(Attach the conclusion to another sheet)*

APPENDIX I

TREATMENT: GOOGLE APPLICATION LEVER PRACTICE WRITE-UP AND
TORQUE MINI-LAB POST ACTIVITY SURVEY

Treatment: Google Application Lever Practice Write-Up and Torque Mini-Lab Post Activity Survey

Please complete the survey honestly. The purpose of this survey is to hear your thoughts concerning the playing with Google docs (Practice lever write-up) and the torque mini-lab activity. This is not a test; it is anonymous and does not affect your grade.

Are you male or female?

Use the following scale: 1 (strongly disagree), 2 (disagree), 3 (indifferent), 4 (agree), and 5 (strongly agree).

1. Hands-on activities help me learn science better.   1 2 3 4 5
2. Hands-on activities make science more enjoyable.   1 2 3 4 5
Explain your answer.
3. Using technology (the computer, my cell phone etc) to work   1 2 3 4 5
with others in my group is enjoyable. Explain your answer
4. I learn more when I work in groups on-line than when I   1 2 3 4 5
work in groups in the classroom.
5. I participate more when I work in groups on-line than when I work alone. 1 2 3 4 5
6. When I work in groups on-line I am more comfortable.   1 2 3 4 5
speaking my mind than when I work in a group in the classroom.
7. Making graphs and managing the data is easier on-line than by hand.   1 2 3 4 5
8. Solving problems is easier when I work with a group on-line.   1 2 3 4 5
9. I worked with my group outside of class using my cell phone or computer. 1 2 3 45
Explain why you did that.

<u>APPENDIX J</u>

NON-TREATMENT: LEVER PRACTICE WRITE-UP AND TORQUE MINI-LAB
POST ACTIVITY SURVEY

Non-Treatment: Lever Practice Write-Up and Torque Mini-Lab Post Activity Survey

Please complete the survey honestly. The purpose of this survey is to hear your thoughts concerning the playing with Google docs to complete the lever mini-lab activity and to hear your thoughts concerning your group work on the torque mini-lab. This is not a test; it is anonymous and does not affect your grade.

Are you male or female?

Use the following scale: 1 (strongly disagree), 2 (disagree), 3 (indifferent), 4 (agree), and 5 (strongly agree).

1. Hands-on activities help me learn science better.   1 2 3 4 5
2. Hands-on activities make science more enjoyable.   1 2 3 4 5
Explain your answer
3. I liked when my group worked with other groups.   1 2 3 4 5
Explain your answer.
4. I learn more when I work in a group.   1 2 3 4 5
5. I participate more when I work in groups than when I work alone.   1 2 3 4 5
6. I am comfortable speaking my mind in a small group compared   1 2 3 4 5
to speaking my mind in front of the whole class.
7. Making graphs and managing the data is easier on Google Docs   1 2 3 4 5
than making a graph by hand.
8. I think I would rather work with a group on-line compared   1 2 3 4 5
to working with a group in the class. Explain your answer.
9. Solving problems is easier when I work with a compared   1 2 3 4 5
to when I work alone.
10. I worked with my group outside of class. Explain why   1 2 3 4 5
you chose to do that.

APPENDIX K

PHASE 2 & 3 TREATMENT AND NON-TREATMENT STUDENT REFLECTION
PROMPT

Phase 2 and 3 Treatment and Non-Treatment Student Reflection Prompt

What was the objective of the activity?

What was your responsibility to the group?

(Treatment) What did you learn about working in a group and using technology to communicate?

(Non-Treatment) What did you learn about working in a group and sharing ideas face-to-face?

Do you think you could have completed easily without being in a group?

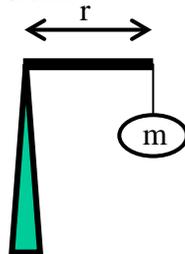Is there anything else you would like to say about this project?

<u>APPENDIX L</u>

LEVERS AND TORQUE QUIZ

Levers and Torque

1. Find the Weight of a rock with mass = 250dg.
    a. 2.5 Kg   b. 25 N   c. .025 Kg   d. .025 N   e. .25 N

2. Find the Weight of a rock with mass = 1000 cg:
    a. .1 kg m/ s^2 b. 1 Nm   c. .01 Kg   d. .010 Kg   e. .none of the above
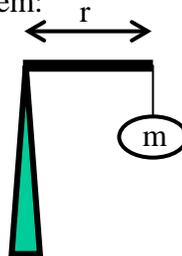
3. Find the Torque on this system:
    a. 100 N
    b. 1000 Nm
    c. 10 Kg/m
    d. 100 Nm
    e. 10 Kgm/s^2

    r
    mass = 2 kg
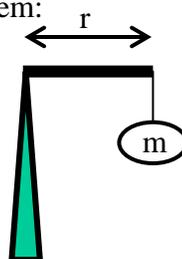   r = 50 dm

    m

4. Find the Torque on this system:
    a. 71.2 N
    b. 7.12 Nm
    c. .712 Kg/m
    d. 712 Nm
    e. 7120 Kgm/s^2

    r
    mass = 3.56 Dg
    r = 2 Dm

    m

5. Find the Torque on this system:
    a. 100 N
    b. 1 Nm
    c. 10 Kg/m
    d. 10 Nm
    e. 1 Kgm/s^2

    r
    mass = 1Kg
    r = 1 m

    m

6. Match these *(There may be more than one correct answer for each)*:
    Torque _____   a. m/a   d. F x g   g. F x d   j. d/t^2
    Weight _____   b. F x d/t   e. d/t   h. F   k. F/s
    Energy _____   c. Kg m/s   f. F x r   i. r x t   l. Kg
    Velocity _____
    Acceleration _____
    (m is mass, d is distance, t is time, F is force, r is radius, a is acceleration, g is gravity)

8. Match these:

1st class lever _____   a. Load between the fulcrum and output force
2nd class lever_____   b. Fulcrum between input and output forces
3rd class lever _____   c. Input force between fulcrum and load
                                  d. Output force between input force and fulcrum
                                  f. Load between fulcrum and input force

9. A woman exerts 10N on a 100N rock and lifts it using a class 1 lever. If the rock to fulcrum distance is 1m, how long is the lever arm from the fulcrum to the man?
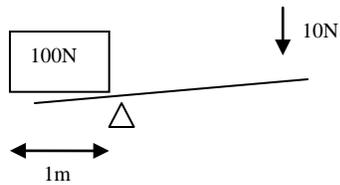
10. A student has to lift a 200kg stump with lever. If he sets the fulcrum 2m from the stump and leans on the lever arm that is 5m long how much weight (force) does he have to exert to move the stump?
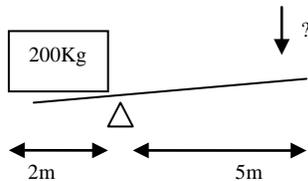
<u>APPENDIX M</u>

STUDENT INTERVIEW

Student Interview

Please answer the interview questions honestly. The purpose of this interview is to hear your thoughts concerning Google docs (lever mini-lab) and your group work with the torque mini-lab lab. This is not a test, and your answers do not affect your grade.

1. What was your job title in the group?
2. What were your responsibilities to the group?
3. Explain how working in the group motivated you or did not motivate you to learn the science concepts?
4. (Technology) Was it hard using technology to plan your project? Explain your answer.
5. (Technology) What was the most difficult part of using technology to communicate your ideas to your group?
6. Did your group work with other groups or share ideas with other groups? (Follow up: why did you or why did you not?)
7. What is the hardest part about working with other people?
8. What was the best part about working with other people?
9. Did you like working with a group on these projects?
10. Did you study for the quiz as a group?

APPENDIX N

TREBUCHET PROJECT

Trebuchet Project

I. Objective: *(As a group, identify the important science concepts that can be demonstrated by the trebuchet and then write an objective. Hint: What are some of the science topics we have already discussed in class this year?)*

II. Materials and Equations: *[As a group brain storm all the equations necessary to explain all of the topics in your objective. Hint: velocity = distance/time, Ideal range: Range = 2 x counter-mass height x (counter-mass/throwing mass)].*

III. Procedures:
- I. Research and design a mini-scale trebuchet. Make a sketch and a scale drawing (one per person, even though you are working in a group).
- J. Build a trebuchet using as many the simple machines as necessary. The overall throwing arm length (not including the sling) can be a maximum of 60cm.
- K. Calculate the ideal range and annotate it on the class data sheet.
- L. Using your trebuchet, throw a 50 g mass.
- M. Measure the actual distance and annotate that range on the class data sheet.
- N. Graph and Analyze the data. At least compare the designs of the trebuchets to the distances thrown, and compare the ideal throw distances to the actual throw distances.
- O. Write a conclusion (follow the writing rubric provided to you by your English teacher).

IV. Results:
- A. Table 1: Trebuchet ideal ranges and measured ranges (Review your objective and develop a chart that will record the important data).
- B. Analysis questions:
  1. Which simple machines can be demonstrated by the trebuchet?
  2. Which other concepts are demonstrated by the trebuchet?
  3. What are some issues with the ideal range equation?
  4. What are some characteristics of the trebuchet that affected throwing distance?

V. Conclusion: *(Please use the writing rubric provided to you by your English teacher)*

<u>APPENDIX O</u>

TREATMENT: TREBUCHET PROJECT SURVEY

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Treatment: Trebuchet Project Survey

Please complete the survey honestly. The purpose of this survey is to hear your thoughts concerning the trebuchet project. This is not a test; it is anonymous and does not affect your grade.
Are you male or female?

Use the following scale: 1 (strongly disagree), 2 (disagree), 3 (indifferent), 4 (agree), and 5 (strongly agree).

1. Making the trebuchet made science interesting.   1 2 3 4 5
2. Using the computer to communicate my ideas to the others in my   1 2 3 4 5
group is enjoyable. Explain your answer.
3. Using technology to work with my group made learning easier   1 2 3 4 5
Explain your answer.
4. Solving problems is easier when I work with a group on-line.   1 2 3 4 5
5. I participate more when I work in groups on-line than when I work alone. 1 2 3 4 5
6. I used my cell phone to communicate with others in my group.   1 2 3 4 5
7. Hands-on activities make science more enjoyable.   1 2 3 4 5
Explain your answer.
8. When I work in groups on-line I am more comfortable   1 2 3 4 5
speaking my mind than when I work in a group in the classroom.
9. Making graphs and managing the data is easier on-line than by hand.   1 2 3 4 5
10. It is easier to turn in data and conclusions on-line compared to in person. 1 2 3 4 5

APPENDIX P

NON-TREATMENT: TREBUCHET PROJECT SURVEY

Non-Treatment: Trebuchet Project Survey

Please complete the survey honestly. The purpose of this survey is to hear your thoughts concerning the trebuchet project. This is not a test; it is anonymous and does not affect your grade.

Are you male or female?

Use the following scale: 1 (strongly disagree), 2 (disagree), 3 (indifferent), 4 (agree), and 5 (strongly agree).

1. Making the trebuchet as a group I learned more science than   1 2 3 4 5
working alone.
2. Solving problems is easier when I work with a group.   1 2 3 4 5
3. I participate more when I work in groups on-line than   1 2 3 4 5
when I work alone.
4. I called others or met with them outside of class to work on the project. 1 2 3 4 5
5. Hands-on activities make science more enjoyable.   1 2 3 4 5
Explain your answer.
6. When I work in groups I am more comfortable speaking my mind   1 2 3 4 5
than when I am with the whole class.
7. Making graphs and managing the data is easier on-line than by hand.   1 2 3 4 5
8. It is easier to turn in data and conclusions on-line compared to in person. 1 2 3 4 5
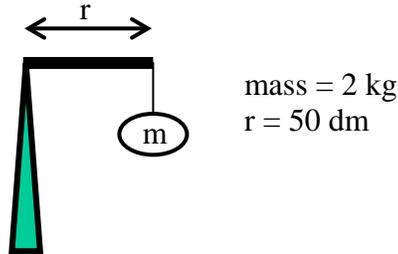
APPENDIX Q

UNIT TEST

Unit Test

1. Find the Weight of a rock with mass = 250dg.
        a. 2.5 Kg   b. 25 N   c. .025 Kg   d. .025 N   e. .25 N

2. Find the Weight of a rock with mass = 1000 cg:

        a. .1 kg m/ s^2 b. 1 Nm   c. .01 Kg   d. .010 Kg   e. .none of the
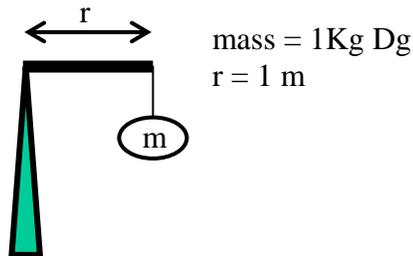   above

3. Find the Torque on this system:

        a. 100 N   mass = 2 kg
   b. 1000 Nm   r = 50 dm
        c. 10 Kg/m
        d. 100 Nm
        e. 10 Kgm/s^2

4. Find the Torque on this system:
        a. 100 N   mass = 1Kg Dg
        b. 1 Nm   r = 1 m
        c. 10 Kg/m
        d. 10 Nm
        e. 1 Kgm/s^2

5. A _____ class lever places the load between the fulcrum and output force.

6. A _____ class lever places the fulcrum between input and output forces.

7. A _____ class lever places input force between fulcrum and load.

8. Which lever places the output force between input force and fulcrum?

9. Which lever places the load between fulcrum and input force?

10. A rifle shoots a bullet. The bullet flies through the air and hits the ground. Trace and name the energy conversions from shot to bullet stopping.

11. A rabbit runs from 0 m/s to 10 m/s in 5 s. What is his acceleration?

12. A man exerts 10N on a 100N rock and lifts it using a class 1 lever. If the rock to fulcrum distance is 1m, how long is the lever arm from the fulcrum to the man?
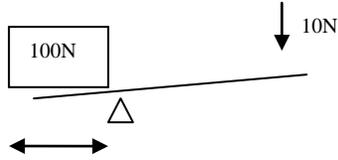
13. A mass 20 Hg hangs 2000dm above the ground. Find the Potential energy.

14. Fill in the table.

Time	Distance	Velocity
1.3 hours	6.3 miles	
20 sec	120 m	
10 sec	120 m	
20 min	60 ft	

15. A student has to lift a 50kg stump with lever. If he sets the fulcrum 2m from the stump and leans on the lever arm that is 5m long how much weight (force) does he have to exert to move the stump?

16. A class 1 lever has a total length of 20ft with the fulcrum 4 ft from one end. If a 120 lb girl stands on the long end, how heavy a person could she lift?

17. A mass 20 Hg flies 10m/sec for 100 m and hits a wall. What is the Kinetic energy released.

18. A 0.2-kg hockey puck moving at 50 m/s is caught by a 100-kg goalie at rest. With what velocity does the goalie slide on the ice after catching the puck?
19. Define the differences between kinetic and potential energy.

20. Define friction.

21. What is the law of energy conservation?