

THE EFFECTS OF THE INTEGRATION OF INTERACTIVE TECHNOLOGY,  
SPECIFICALLY THE SMARTBOARD AND CPS CLICKERS, ON STUDENT  
UNDERSTANDING OF SCIENTIFIC PROCESSES

by

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## STATEMENT OF PERMISSION TO USE

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July 2013

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## ABSTRACT

Interactive technology, consisting of a SMARTBoard and CPS clickers, was used in different ways to see the effects on student understanding of scientific processes. Themes in favor of using the technology included that it was fun, modeled the real world, and built confidence. Themes against its use centered on confusion, group dynamics, and pace. Some technology techniques were more successful than others, but overall, it did increase understanding, engagement, and confidence.

## INTRODUCTION AND BACKGROUND

My research is focused on how the use of technology in the classroom will affect student understanding of the process of science in the real world. Traditional teachings can now be altered with the incorporation of technology in the form of interactive whiteboards and classroom response systems. I show that technology can be used in various ways to not only increase student understanding but engagement as well. With data accumulated from various sources, the outcomes were validated and will be shared with teachers across disciplines.

### Observations

The elementary curriculum in Byers 32J district (Byers, Colorado) puts emphasis on reading, writing, and math. Science and social studies are allowed 30 minutes a day, and the teachers have to choose what to teach between the two of them four days a week. Most teachers spend the time equally, two days (one hour total) a week on each discipline. The students enter a balanced curriculum once they attend junior high as seventh graders. This is when I get them in science class, and I have seen so many deficiencies in scientific knowledge, it is scary.

The students in Colorado are tested over many aspects of science in the state test as eighth graders. Topics include life, physical, and earth science as well as scientific processes and experimental examples. Every year I start with a diagnostic test to see where the students are, and every year the results are extremely low. Science is a process, knowledge gained through experimentation, and my students always score the lowest in this area. Not only is it the foundation of science, what people call the scientific method or inquiry, but one fourth of the state test involves the process.

Colorado passed a law that states teachers can be evaluated up to 50% on how their students improve on the state test. So not only is their understanding important for their success in any science class or problem solving situation, it is important for my job as well. This led to my original question of, “How can I improve student understanding of scientific processes?”

Once I started thinking about this question, I realized I have a lot of tools within the classroom that could be used to assist the problem. Our district has received grants in the past two years that supplied the equipment and training for Classroom Performance System (CPS) clickers and software and the SMARTBoard interactive whiteboard. This led me to a second question of, “How can I use technology to improve student understanding of scientific processes?” From here I was able to create the action research project that follows.

### Scientific Processes

It is important to define what is at the heart of the research. Scientists typically follow a guideline as to how to perform research in the real world. Something is observed, questions are asked, the background is researched, a hypothesis is formulated and then tested, data is analyzed and conclusions are made, ending with a communication of what was discovered. Though this is not set in stone, and varies per scientific situation, students need to be aware of, and comfortable with, each process to be successful in any science classroom. Traditionally, students were taught the scientific method as a lecture with experiments and lab reports to follow. Now the push in the educational community is for a classroom based upon inquiry. As the current National

Science Teachers Association (NSTA) Position Statement (2004) says “scientific inquiry reflects how scientists come to understand the natural world and it is at the heart of how students learn” (para. 2). Students are encouraged to pursue scientific knowledge and processes through exploration of real life experiments. As anyone knows with the economy, not all classrooms are funded for the supplies to undertake such elaborate experiments. On the flipside, grants are providing technology in the form of interactive whiteboards, iPads, iPods, and clickers. It is my personal belief that a combination of all tactics will help students be successful in understanding the processes behind scientific investigations.

#### Purpose

The purpose of this study was to show that the recent available technology can be used in ways that will not only engage students, but build their confidence in approaching the scientific processes as defined by the methods and inquiry. It is my job to prepare students for not only state tests, but college entrance exams and possible scientific careers. As the teacher, I benefited from this study on the use of the technological tools as my delivery of content, role as facilitator or instructor, and student impressions shaped how I will teach in the future. The lessons learned from the study can be presented locally and nationally, as techniques in how to use the technology could be applicable across subjects. It should, specifically, provide ways for teachers to help students understand the underlying themes of the scientific method and all the processes associated with research in the real world.

### Research Questions

My primary research question was “How does the integration of interactive technologies, specifically the SMARTBoard and CPS clickers, affect student understanding of scientific processes?”

The following sub-questions were also researched:

1. How will using the technology in different ways affect student understanding and achievement in science?
2. How does the use of interactive technology affect student attitude and engagement towards scientific processes?
3. How will my classroom and teaching be altered with the incorporation of interactive technology?

### Support Team

In order to tackle these questions, I acquired the help of several people to be a part of my support team. I had four constant committed members and two extras for additional support when needed. The first was my husband, Dustin Lawrence. He has been a part of this process from the beginning, and with no formal background in education he brought a fresh outside perspective to the project. An additional benefit was his knowledge of technology. He may not have the training in the specific technology, but his knowledge of general technology workings is superb and his enthusiasm toward the project was high. The second was my classroom observer, science and math teacher Corey Green. He played an important part of the project itself, and his feedback was critical. We are the two combo teachers in the district (both math and science) and we spend a lot of time together and share a lot of experiences.

The third was my critical friend, math teacher Nikki Cox. She has a formal degree in education and therefore brought insight as to classroom workings. She and I also spend a lot of time together as we are currently in another action research project involving a new math program. She was also part of my project, and has provided great feedback to the methods I used throughout the project. The fourth was my SMARTBoard trainer, Emma Richardson. Emma works for the East Central BOCES (Boards of Cooperative Educational Services) as the distance education coordinator and has an extensive background in technology. She was crucial in deciding the ways I put the technology to use, as I ran ideas by her and she gave me ideas as well.

The final two are the high school science teacher (Beth Greenman) and high school English teacher (Kayla DeLong). Ms. Greenman has been teaching for almost 20 years and was a scientist just like me. I used her to judge the difficulty of the activities. She was also my mentor teacher when I got my Alternate Teaching License. Mrs. DeLong agreed to be an editor for the final capstone. Communication consisted of face time, email, and phone conversations. There was no lack of support for the project, of which I was very thankful; however, coming up with ways in how to use the technology was a learning process in itself.

### Technology

Education and technology, two separate yet increasingly intertwined entities, form some of the most important threads to our society. As I think back to how technology was used when I was in grade school in the 1980s, one thought comes to mind: Oregon Trail. It was a great problem solving and history exercise that was the highlight of our

time in the computer lab. Everything else was done with pencil and paper: grade books, lectures, attendance, etc. Fast forward 20 years and now parents can view their student's grade on the internet, presentations are given with animations in programs like PowerPoint, and attendance can be accomplished by each student "popping" a balloon with their name on it on an interactive whiteboard as they come into class. As we continue in this digital age, students now use technology on a regular basis for personal use and can be more knowledgeable than adults. Can we change how we run the classroom to relate more to these students, and perhaps peak their interest? Classroom dynamics are evolving quickly and so must teacher pedagogy.

Obviously technology has been incorporated into the classroom and new tools invented for educational use, but how can these tools be used effectively? Can students truly increase understanding of topics and achievement on state and national exams with the use of technological tools in the classroom? For the past few years, studies have been done worldwide to address such questions. Most of the research has focused on understanding and engagement in the primary classroom and at the college level. Students can touch a whiteboard like the SMARTBoard, making lessons more interesting for the class as a whole. Teachers can use clickers for formative and summative assessment of student knowledge. Educators have also been a part of studies in reference to the workings of the technology. Mostly supportive reports exist, but what it seems to come down to is a matter of how the teacher actually puts the technology to use.

## CONCEPTUAL FRAMEWORK

### Direction For Project

Interactive technology has just recently come to the forefront of education as it has become more financially available for the classroom. How can this technology be used to increase student understanding of educational concepts? Does it positively affect learning? Several research studies have been performed by the companies who make the technology and positive results have been reported. This has been supported by individual research projects as well, with a few studies finding no association.

One main theme that I found very insightful and important is that in order to achieve learning the appropriate pedagogical methods need to be used. As Beatty & Gerace (2009) advised, “Don’t ask what the learning gain from student response system use is; ask what pedagogical approaches a student response system can aid or enable or magnify, and what the learning impacts of those various approaches are” (p.147). The authors are referencing CPS clickers, and also point out how they have been increasing in number in K-12 classrooms the past few years, not just higher education where they were first used. As the CPS eInstruction® IESD White Paper as published in 2010 concludes: 16 studies show greater engagement, 11 studies show increased understanding of complex subject matter, seven studies show increased interest and enjoyment, six studies show heightened discussion and interactivity, five studies show increased awareness of individual levels of comprehension, and four studies show increased teacher insight into student difficulties. Many studies, including one recently from a MSSE graduate (Gillespie, 2011), collectively point out that use of clickers in the proper format should

increase understanding and engagement.

Hoekstra and S. Mollborn (2012) gathered five pedagogical models for clicker use in post-secondary education which include; student feedback to improve teaching and learning, identifying students' assumptions or preconceptions about course material, supporting conceptual application and critical thinking through small- and large-group discussions, fostering social cohesion in the learning community, and collecting data from students to support theory testing, conceptual application, and group discussion. The following five quotes from the paper illustrate the models and echo some of the sentiments expressed by my students.

Clicker data provide immediate feedback useful for formative assessment.

Students can see their own and their peers' responses, and productive group discussions can be held about why the students answered as they did (p.306).

Clickers provide an anonymous and efficient way of collecting data about what students expect and/or what they know (whether correct or incorrect) about the material (p. 308).

First, (clickers) permit each student to have his or her own 'voice' when clicking in. Second, when a clicker question solicits an opinion or past experience (i.e., does not feature a single correct answer), the anonymity of clicker responses encourages honesty. Students can respond however they wish, and when the votes are displayed, the diversity in the group's responses provides an excellent 'jumping off point' for critical thinking (p. 310).

By viewing clicker data overtime, the group develops shared knowledge of its members (e.g., how well others are doing; what peers think). This fosters ties that can bind students more strongly to the learning community. When learning a difficult concept, students may feel relieved to see that others in the class are also struggling (pp.313-14).

Anonymous data about students' beliefs or experiences are perhaps most efficiently gathered through clickers. Students said that they often felt more engaged by data that came from their peers than by data from other sources (p. 316).

In another clicker study by Blasco, Hernandez, Buil, and Sese (2013), they recommended the use of clickers as a tool because it enhanced student learning performance by increasing interactivity with peers and the teacher. "This interactivity, subsequently, promotes individual active participation and collaborative learning, which increases student engagement in the learning process" (p.23). In summary, Kay and LeSage (2009) through a review of the literature themselves compiled the following summary of the benefits of clicker use (Table 1) and the challenges of clicker use (Table 2).

Table 1

*The Benefits Of Using Clickers (Kay & LeSage, 2009, p. 822)*

| <b>Benefit</b>       | <b>Explanation</b>                                                               |
|----------------------|----------------------------------------------------------------------------------|
| Attention            | Students are more focused in class                                               |
| Anonymity            | All students participate anonymously                                             |
| Participation        | Students participate with peers more in class to solve problems                  |
| Engagement           | Students are more engaged in class                                               |
| Interaction          | Students interact more with peers to discuss ideas, “talking science”            |
| Discussion           | Students actively discuss misconceptions to build knowledge                      |
| Contingent Teaching  | Instruction can be modified based on feedback from student                       |
| Learning Performance | Increases as a result of using clickers                                          |
| Quality of Learning  | Better explanations, thinking about important concepts, resolving misconceptions |
| Feedback             | Students and teacher like getting regular feedback on understanding              |
| Formative Assessment | Improves student understanding and quality of teaching                           |
| Compare              | Students compare their responses to class responses                              |

Table 2  
*The Challenges Of Using Clickers (Kay & LeSage, 2009, p. 824)*

| <b>Challenge</b>               | <b>Explanation</b>                                           |
|--------------------------------|--------------------------------------------------------------|
| Clicker Did Not Work           | Remote devices did not function properly                     |
| Responding To Student Feedback | Less experienced teachers cannot adjust to student feedback  |
| Coverage                       | Cover less course content if clicker is used                 |
| Developing Questions           | Time consuming to create good clicker questions              |
| New Method                     | Students find it difficult to shift to a new way of learning |
| Discussion                     | Discussion leads to confusion or wasting time                |
| <b>Challenge</b>               | <b>Explanation</b>                                           |
| Effort                         | Too much effort is required by students when using clickers  |
| Summative Assessment           | Using clickers for tests may not be popular with students    |
| Identifying Students           | Students want to remain anonymous                            |
| Negative Feedback              | Students feel bad when receiving negative feedback           |

There are multiple evidences in support of interactive whiteboards as a learning and engagement tool. Only a few like the one by Albaay and Higgins (2012) had results show no significant relationship between technology and learning. Their results showed that student skills in essay writing climbed for both groups, one using an interactive whiteboard and one not. Most research has been completed overseas as the United States has only been using them the past couple of years. Several findings from the Primary School Whiteboard Expansion project (PSWE) in England included: increases level of student engagement, aids in teaching abstract concepts, enables teachers access to multimedia resources, allows student to demonstrate knowledge, boosts student's self-esteem and teacher's ability to access learning, engages and improves behavior of students with special needs, fosters a sense of community and creates a cooperative

environment, and permits teachers to be more mobile (Becta, 2007).

Though the above is one of many reports that support use of interactive whiteboards, others point out the importance of how it is used. Like Beatty and Gerace, Beauchamp and Parkinson (2005) write that once teachers become familiar with the features of the technology, they need to consider the best ways to create a positive learning environment and promote interactivity. Murcia and Sheffield (2010) suggested seven ways to use interactive whiteboards: engaging and appealing interactive displays, accessing online information, linking in media files, interacting with online activities, constructing a series of interactive activities to develop the scientific story, reviewing learning, and using software tools to increase wait time. In all, the research shows multiple positive gains with the interactive technology, but it will be about how the technology is used that will give a teacher those gains.

### Theory

When considering a project that incorporates technology, I must understand what I want my students to learn and how that will be affected by technology. In the recent years there has been a shift in the definition and practice of the scientific method. Some people are encouraging science educators to incorporate more of a “process” than a 5-step method. As Clyde Herreid says in his article titled “The scientific method ain’t what it used to be” (p. 68), the hypothetico-deductive method of question, hypothesis, experiment, data collection, and conclusion is just too simplistic. This hypothetico-deductive method is limited in that it relies on supporting a hypothesis and not what this means for the overall picture (Haig, 2005). Tang, Coffey, Elby, and Levin (2009) found

that following the simple steps distracted students and teacher from the ongoing, productive inquiry process. The other previous facet of the scientific method was inductive theory, which infers science based on observation and inductive reasoning alone (Haig, 2005). However, we need to make sure we do experimentation to fully understand what we theorize.

In general it looks like we need a more comprehensive theory of method as Haig (2005) created in the abductive theory, utilizing several theories at once such as the aforementioned inductive theories and adding a model theory. Model theory as defined by Develaki (2007) relates theory to model, model to real-world application. We must also incorporate community analysis and feedback (involving the scientific community), and benefits and outcomes of the research (Herreid, 2010). I found this an obvious feature of science as I was a scientist before. It made me think, how can I incorporate all of this into my teachings of the process of science and ultimately this project?

The theory of constructivism can be applied to student understanding of scientific processes. To understand the practice of science, students must figure out what is going on, design and test possibilities, interact with peers, and communicate what they have found out. According to the theory, students learn as they actively construct new knowledge based upon their prior knowledge (Dhindsa & Emran, 2006). Active learning strategies occur through group work, discussion, individual observation and exploration, and interaction with peers, teachers, and technology (Dhindsa & Emran, 2006). Active learning is further defined by Blasco et al. (2013) as practices that engage students in the learning process where students do more than passively listen to a lecture. It involves

talking, listening, writing, reading, and reflecting and can increase exam scores (Blasco et al., 2013).

The authors also point out a method of active learning called collaborative learning which involves the students working together in small groups toward a common goal sharing knowledge and experiences and creating meaning during the process. It has been observed that the effect of active collaborative learning on student performance is further enhanced when it is combined with the use of technology (Blasco et al., 2013). This success coupled to the success of constructivism in combination with technology from the studies by Dhindsa and Emran in 2006 and 2011 gave me hope that I would see positive results with my project. In their study in 2011, they found that an interactive whiteboard technology-rich constructivist learning environment could stimulate active learning, discovery learning, higher-order thinking skills, and would provide more opportunities at equal level in learners' own socio-cultural contexts of living environments. In fact, it was reported as early as 1999 by Santmire, Giraud, and Grookopf that students in a middle school environment who were involved in a social-constructivist approach to education achieved higher gains in standardized test scores than those students who were in the more classroom-based "abstract" instruction.

The social aspect of learning can be characterized by the socio-cultural theory of learning. The theory centers on the physical and semiotic tools of the cultural aspect of human action (Armstrong, Barnes, Sutherland, Curran, Mills & Thompson, 2005). As the authors point out, teachers and students work within a local classroom culture which in itself is influenced by local, national and global factors. The interplay of the physical

tool (an interactive whiteboard or clicker) with a semiotic tool like language will ultimately be controlled by the history of experiences within that classroom culture. For a teacher with an iPad at home, using a touch screen with interactive games off the internet would be no big deal; however, a teacher unfamiliar with such technology may treat the board like the dry-erase boards they used to have. In summary, the use of physical tools is shaped through the social actions of the teacher and students.

The final piece of the theoretical puzzle comes from technology itself. In an article by Schmid (2006), the critical theory of technology was illustrated as a compilation of several aspects associated with my project. The work sheds light on how technology can be integrated into a classroom and relies on the following: the inherent characteristics of technology, the teacher's pedagogical beliefs and activities, students own understandings of the potentials of technology, and negotiations between students and teacher as to how the technology should be exploited. As we have previously seen, several articles have stated the importance of how the teacher uses the technology. Some important aspects of this theory to me were student understanding of technology and negotiations with the students as to how it should be used. I have briefly asked students what they feel about the technology and asked for suggestions as to how to use it, but this article really got me thinking as to making this a permanent part of my action research project.

### Methods

Even though I was confident as to the methods I chose to use for data analysis, it was nice to look at the articles to see what techniques they used that I could employ. I

did find some validation in what measurement tools to use as well as some additional ideas.

In designing activities for practice or test situations of the scientific method, I decided to use computer programs or simulations on the Smartboard. In an unpublished technical report by Chomsky, Honda, O’Neill, and Unger (1985), they used computerized “puzzle-solving” of non-natural phenomena and simulations of natural phenomena to test students on aspects of the scientific method. They had success in student understanding and vocabulary retention with post-quizzes and levels achieved within the games. These kind of results were seen in a similar study by J. Vogel, D. Vogel, J. Bowers, C. Bowers, Muse and Wright (2006) where interactive games and simulations yielded significantly higher cognitive gains and better attitudes toward learning than using traditional teaching methods for instruction. They found statistically that the simulations were beneficial but that the games were boarder line. This was echoed by the results of learning by my students. However, as the realism of the program increased, the amount of knowledge gained also increased (Vogel J. et al., 2006). This is an important concept as comments involving engagement by my students revolved around the “realism” of the activity. The authors also found that individuals outperformed groups, and as a couple of my students preferred to work alone I was not surprised by this finding.

In a study by Chen, Looi, Lin, Shao, and Chan (2012), they used pre- and post-tests with the same questions just in a different order, questionnaires, and student interviews just like I planned to do. They additionally did video recordings; something I ended up doing on the days my classroom observer could not be present. They had

collaborative group work through computers and a special program, which I used during some of the SMARTBoard and clicker activities. In a study with clickers, the author pointed out keeping the type of questions consistent across all forms of treatment or non-treatment groups (Lychock, 2005). The author, who I know and have been trained by on the clickers, points out how she used multiple-choice questions since short answer or essay can be done with the clickers but take a long time. I used multiple choice myself as well as Yes/No agreement questions.

In the study by Dhindsa and Emran, the pre- and post-test each had short answer and essay questions to observe higher-order thinking skills. What I did like about this research is that they had the students summarize what they learned daily, then collaboratively share in a group setting. We put this technique to use during the hands-on lab. With classroom observations, I liked what the researchers used for measurement in a study in Amman, Jordan which included teaching and instructional strategies, student's interactivity, and classroom management (SMART Board Case Study, 2010). They also used student focus groups and surveys. Several studies grouped students into levels of achievement, then analyzed their differences from before and after treatment (Gillespie, 2011; Chen et al., 2012). I think this was very valuable in seeing if technology differently affected students with various learning levels.

In conclusion, most of the studies incorporated the techniques I was already planning to use, with some new ideas for my research. I did appreciate the triangulation table set up by Gillespie (2011) for her capstone, and the article also gave me some ideas for data measurement tools. I specifically liked how she had an article (concept map) to

analyze student understanding, used prompts for classroom observers, checked for concept attainment weeks after instruction, used prompts for her own reflection, and the types of questions she used in every survey or cooperative group grading.

One final article that I felt summed up the credibility of a research project was Schmid (2006) where he concludes you must incorporate prolonged engagement (observing the classes throughout the study), triangulation of data (confirm regularities), and dialogue with other researches (discussing results with critical colleagues and at conferences). Sounds a bit like the new definition of the scientific method itself doesn't it?

#### Additional Helpful Articles

I found several articles that were helpful in finalizing my action research project, but three stood out over the rest. In a study that researched the impacts of information and communication technologies (ICT) in 17 schools across England, several themes stood out above and beyond motivation or learning (Passey, Rogers, Machell, & McHugh, 2004). These findings addressed areas that I had not even thought of yet, that could be impacted by technology in my own research project. The key findings included positive motivational outcomes when engagement/research/writing and editing/presentation of work was used, supported a focus on learning and tackling of learning tasks, and enhancement of subject-specific attainment. It also showed positive effects on motivation when teaching and learning was involved, both boys and girls were motivated equally, and motivation was independent of ethnic background. Socio-economic background was impacted at times because of limited access out of school, and

finally behavior inside school and sometimes outside of school was positively affected (Passey et al., 2004).

In my project I had the students write up a scientific design and present the work for editing on the Smartboard as a group discussion. I could see how socio-economic backgrounds could affect my own study as several of my students do not have technology at home and may be shy to use it or overly motivated to use it. Finally, it would be interesting to look at behavior, inside the classroom and out. I decided to poll parents as to how their child responded to the technology at home. The article provided some interesting things to consider as I put the project in motion.

As part of my investigation into the interactive whiteboard, I gave a questionnaire to my fellow teachers to get their perspective of how effective it is in class and how they use it. Conveniently, a study was just published on teachers' belief and use of interactive whiteboards. The study used a questionnaire on 174 Turkish teachers who teach 6-12<sup>th</sup> grade. It had 26 Likert scale items from strongly disagree to strongly agree, based on the existing themes within the literature (Turel & Johnson, 2012). The article presents several ways of using the board (most I have done already) and benefits of the board as we've seen in previous work listed in this paper. What really surprised me was the finding that most teachers were not able to design a social constructivist environment where students could be involved in active and collaborative learning processes, with a majority of teachers admitting they could not find enough time for their students to use the board (Turel & Johnson, 2012).

Since my project depended somewhat on this learning process and students' use

of the board, this is not what I expected to find. Three key findings that rang true to our district was that to facilitate learning as teachers we need to collaborate, get training, and use it often to improve ourselves. Several of my own colleagues mentioned they didn't use the board as much because they hadn't received enough training. I will have meetings next year to show the potential this technology has. Again, this article involved significant parts of my project and the success of interactive technology in the classroom.

The third and final article by Kennewell and Beauchamp (2007) provided descriptions of ways to use the interactive whiteboard. For just a beginning list, the actions and their meanings have so much potential across all subjects. Ones I specifically employed in this project were "composing, editing, selecting, retrieving, apprehending, focusing, transforming, annotating, repeating, modeling, cumulating, revisiting, undoing, questioning, prompting, and responding" (pp. 232-33). The authors give examples of how the board was used in a primary science classroom and it involved "selecting, focusing, transforming, revisiting, modeling, repeating, apprehending, and comparing" (p. 239). I feel the tables they created in the paper are a great resource for teachers whether they are just beginning or continuing their professional development in interactive technology.

### Conclusion

The literature review revealed many things that helped to mold this research project into what it has become. First, interactive technology has positive effects on learning, understanding, engagement, and motivation. Second, how successful your students are will depend on how one uses the technology. Third, incorporating

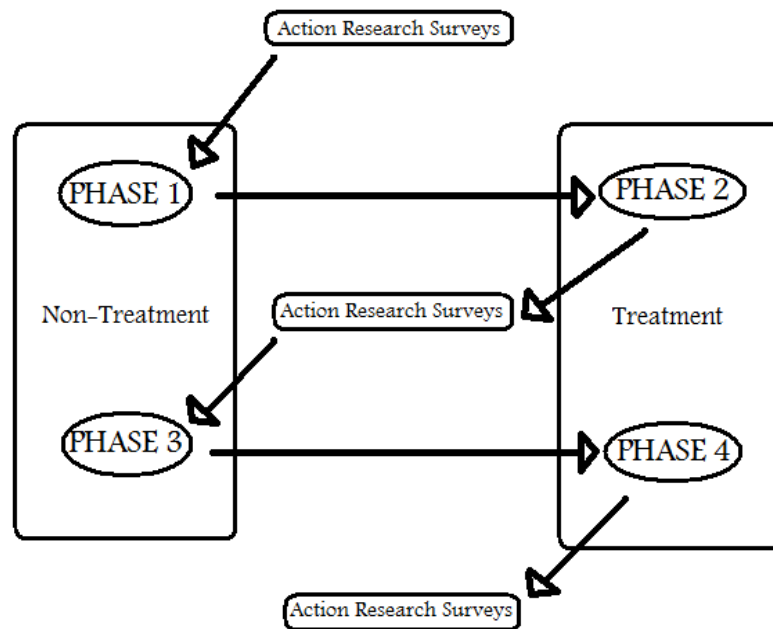
technology will cause a shift in pedagogical methods which should include training, collaboration, and student input. Fourth, the traditional view of the scientific method is too simple; much more should be included when teaching students the process of science. Finally, most of the methods chosen for my data analysis have been used with success in various forms in other studies. As I read the articles, I found myself thinking this project may become more of an inquiry into *how to use* the technology for success than *will using it* give success. I knew I would also have to incorporate all parts of the scientific method or processes. Specifically, in what ways can interactive technology be used to show experimentation as well as be a part of communication in a group setting? I feel my project will give insight to future use of technology in other classrooms. The methodology, or how I used the technology, may have implications for other teachers in all disciplines.

## METHODOLOGY

My action research project occurred during both the first and second semesters of the 2012-2013 school year. Our district, Byers 32J in Byers, Colorado, consists of 213 students in the secondary. 34% of the students are on free and reduced lunch, indicating a lower socioeconomic status for a majority of our students. We have a low minority enrollment compared to other districts nearby of 12%. The class that participated in the project included 20 7<sup>th</sup> graders as part of my 7<sup>th</sup> grade science class. The curriculum is interdisciplinary as it involves life, physical, and earth science units. The particular group I researched had 10 boys and 10 girls, one English Language Learner (ELL), and three with specific learning disabilities (two have reading difficulties and one a visual

disability). Again these students come from the elementary with very little science in their background, especially in the process of science.

A critical part of any science curriculum is student understanding of the process of science. I defined this “process” as the steps of the scientific method as put to practice in inquiry. Students need to understand the process from observation, background research, hypothesis, experimentation, analyzing results, conclusions, and communication. Traditional ways of teaching this includes lecture, worksheet practice, and hands-on experimentation with lab reports. This is what I used for my non-treatment phases. In the past I have seen students struggle with basic memorization, or the requirements of a lab report. Today, students have several technological advances in their daily lives that they not only enjoy but use on a regular basis. With cellphones, iPods, iPads, and computers, students are actively engaged with technology. Only 1/20 students did not have one of the above listed technologies and 35% of them use a computer at least 5 times a week. Classrooms are now getting technology through grants which is often underused. It was this project’s purpose to use the technology, and in different ways, to increase student understanding of scientific processes. This was considered the treatment and involved the use of a SMARTBoard and CPS clickers to engage and teach scientific processes. The project was split into four phases, two non-treatment and two treatment phases which will be described in detail following the figure.



*Figure 1. Phases and flow of the action research project*

#### Phase 1 Non-Treatment

The phase began on Day 1 with the Pre/Post Quiz (Appendix A), and the main action research surveys (Figure 1) called the Technology Survey (Appendix B), the Scientific Processes Confidence Survey (Appendix C), and the Parent Survey (Appendix D) asking about student communication at home in regards to science and technology. I spent 15 minutes the day before describing the phase to my critical friend and she filled out a prompt sheet as to my enthusiasm towards the phase and its potential for success (Appendix E). On Day 2, I lectured to the students about scientific processes with PowerPoint and they were required to take notes. In small groups they were given a worksheet with examples of experiments and asked to identify the steps of the scientific method and experimental design on a graphic organizer (Appendix F). My classroom observer addressed prompts as to student attitude, engagement, and potential for learning

during the activity (Appendix G). An additional practice worksheet was sent home (Appendix H). I answered prompts in my journal and reflected on the process, including my own classroom observations, during and after the activity (Appendix I). On Day 3 a retake of the Pre/Post Quiz was given and student interviews with my focus group were completed at lunch for 15 minutes (Appendix J). The focus group consisted of five students with different demographics. Student A is an “A” student, female, and loves technology. Student B is a “B” student, male, and self-admittedly hates technology. Student C is a “C” student, male, and really likes using the textbook. Student D is my one and only English Language Learner student and is female. Finally, Student E is my visual disability student who is also female.

### Phase 2 Treatment

Day 1 of this phase consisted of the Pre/Post Quiz followed by interactive games on the SMARTBoard from [www.quia.com](http://www.quia.com) (Appendix K). This included hangman, memory, matching, ordering, quizzes, etc. Day 2 involved a simulation of a real world application of infectious disease research from [webadventures.rice.edu](http://webadventures.rice.edu) (Appendix L). Day 3 continued the games from Day 1, with the additional use of the clickers where the class was asked if they agree or disagree with the answer chosen and a discussion of why. Day 4 involved another simulation from the website with the class participation with clickers again. Students were randomly chosen to come to the board throughout all treatments. Day 5 involved a virtual experiment from the textbook software and students filled out a write-up of the experiment (Appendix M). On Day 6 the students took the Pre/Post Quiz, Technology Survey, and Scientific Processes Confidence Survey again.

The process of my journal, critical friend, classroom observer, parent survey, and student focus group interviews was the same as the previous phase. An additional tool administered was exit surveys: short surveys for whole class feedback as class ended for the day (Appendix N).

### Phase 3 Non-Treatment

This second non-treatment phase involved an actual inquiry process. Students designed and carried out an experiment involving plants. They were required to state the problem, summarize background on the topic, write their hypothesis, design the experiment, perform the experiment, and write up a proper lab report. Day 1 of this phase entailed the introduction to the experiments the students would perform after completion of the Pre/Post Quiz. The class is divided into 6 lab benches with 3-4 students a bench. The groups picked from the list of available products and began thinking of the experiment (Appendix O). After picking the topic and deciding upon their scientific question, students were given 20 minutes in the computer lab to perform background research on their products. On Day 2 the groups discussed their findings, decided upon a hypothesis, wrote up their experimental design, and began the experiment. Students were given 9 plants; 3 for controls and 3 each for the experimental groups. On Days 3, 4, and 5, students observed their plants and performed treatments. On Day 6 they created results and conclusions, and then shared verbally with the class. The student lab reports were graded with a rubric (Appendix P). On Day 6 they also completed the Pre/Post Quiz. Again the process of my journal, critical friend, classroom observer, exit surveys, and student focus group interviews was the same.

### Phase 4 Treatment

In Phase 4, the technology was used in several different ways. First pictures were taken of the textbook with the SMART Document Camera and students were placed into groups to discuss what should be highlighted in each paragraph, come up with pictures (found off the internet right there at the board), or decide on written examples to help illustrate the concepts (Appendix Q). Students were numbered and everyone came up to the board at some point in the activity. The next technique put to use was interactive SMARTBoard Lessons about inquiry where students came up to the board to pop balloons, make flow charts, pull tabs, move answers to correct locations, etc. (Appendix R). The third aspect of this phase was the use of the website <http://panpipes.net/edit6200/> which lead students through the process of science with multiple choice questions along the way (Appendix S). Here each step was described followed by multiple choice questions of which the class was asked to click in answers. The answer was then picked and a discussion over right or wrong answers followed. The final piece was editing using the SMART Notebook Tools of actual student work. Students created experiments to do with the elementary students and pictures of their write-ups were taken with the Document Camera (Appendix T). The class then helped each student edit their work by circling, writing, highlighting, and with verbal comments.

### Data Collection Methods

As seen in the previous section, I chose a wide variety of quantitative and qualitative instruments to assess the effects of technology on student understanding of scientific processes (Table 3). The instruments used in this project provided validity to

the results seen in the project, as several yielded data to the same question. Reliability was seen in the tools that I have used in the past (artifacts) and the scores across the tools with small standard deviations. Quantitative methods included the Pre/Post phase quiz and phase related artifacts. Qualitatively I utilized student focus group interviews. Additional methods that bridged both quality and quantity were the technology survey, scientific processes confidence survey, exit surveys, parent survey, classroom observer, critical friend talks, and my journal for field notes. For each of those I provided Likert scale questions with options to explain reasoning. Qualitative data was analyzed for trends; quantitative data was analyzed using an average of scores.

Table 3  
*Data Collection and Research Methods*

| Question                                                                                                                                                         | Data Collection and Research Methods |                         |                   |                                        |                             |                    |               |                    |
|------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------------------------------------|-------------------------|-------------------|----------------------------------------|-----------------------------|--------------------|---------------|--------------------|
|                                                                                                                                                                  | Quantitative                         |                         | Both              |                                        |                             |                    |               | Qualitative        |
|                                                                                                                                                                  | Pre/Post Phase Quiz                  | Phase Related Artifacts | Technology Survey | Scientific Processes Confidence Survey | Teacher Journal/Field Notes | Classroom Observer | Misc. Surveys | Student Interviews |
| <b>How does the integration of interactive technologies, specifically the SMARTBoard and CPS clickers, affect student understanding of scientific processes?</b> |                                      |                         |                   |                                        |                             |                    |               |                    |
|                                                                                                                                                                  | X                                    | X                       | X                 | X                                      | X                           | X                  | X             | X                  |
| <b>How will using the technology in different ways affect student understanding and achievement in science?</b>                                                  |                                      |                         |                   |                                        |                             |                    |               |                    |
|                                                                                                                                                                  | X                                    | X                       | X                 | X                                      | X                           | X                  | X             | X                  |
| <b>How does the use of interactive technology affect student attitude and engagement towards scientific processes?</b>                                           |                                      |                         |                   |                                        |                             |                    |               |                    |
|                                                                                                                                                                  |                                      | X                       | X                 | X                                      | X                           | X                  | X             | X                  |
| <b>How will my classroom and teaching be altered with the incorporation of interactive technology?</b>                                                           |                                      |                         |                   |                                        |                             |                    |               |                    |
|                                                                                                                                                                  | X                                    | X                       | X                 | X                                      | X                           | X                  | X             | X                  |

Triangulation, the combination of several methods to study one aspect of research, is a powerful technique to verify the results one might see in their research.

When more than one data collection instrument provides you with the same overall results, this will increase not only the validity of the research but one's confidence in the trends that might arise. In this study, I acquired several instruments that collectively paint the picture of how interactive technology effects student understanding of and engagement in the scientific processes.

#### Description of Specific Data Instruments

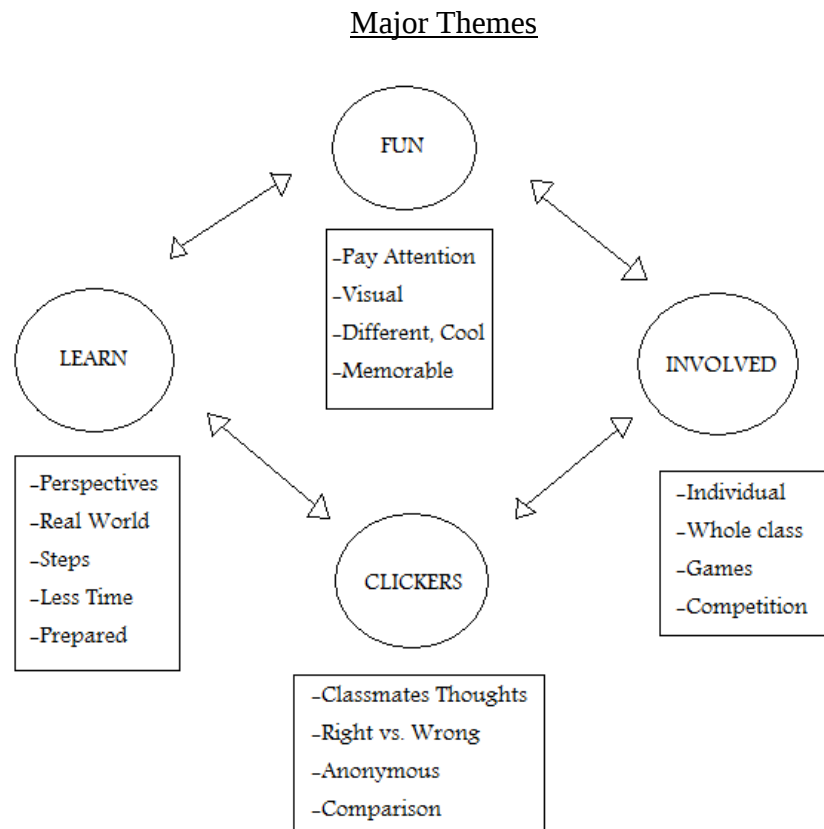
The characteristics of each tool were important for all research questions addressed. The Pre/Post Phase Quiz consisted of 25 multiple choice questions from levels 1 to 4 of Bloom's Taxonomy involving the methods and basics of experimental design (see Appendix A for a summary graph). The phase related artifacts added to the validity and reliability of student understanding of the scientific processes. Scores on the Phase 1 worksheets are low year by year. The CPS clicker questions from Phase 2 involve multiple choice answers addressing experimental design which, again, year by year it is seen that students struggle with this concept. The lab report written in Phase 3 and the experimental write up in Phase 4 was graded with a rubric (Appendix P) that addressed the individual steps of the scientific method and parts of experimental design. Since Phase 4 was new activities, I can only report that in the years past students score at or below 80% in lab write-ups. The technology survey addressing use of technology in the classroom, scientific processes confidence survey looking at student confidence in all aspects of scientific processes, parent survey asking about student communication about science at home, and other phase related exit surveys yielded plenty of data to both understanding and engagement. Student focus group interviews involved asking student

opinions of the treatments or non-treatments used. This gave me insight as to the differences in how I used the technology as well as engagement. The “A”, “B”, and “C” students were chosen at random from last year’s end of year science grades. The disability and ELL students were picked because of their unique characteristics. Daily phase entries from my teacher journal, written examples from my classroom observer, and discussions with my critical friend created a nice triangulation of student engagement and the effects of different uses of the technology. Within the eight different forms of data collection, I utilized previous and current reliability to identity themes and validity was accomplished by using multiple tools to address those themes across the research questions asked. 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 (Appendix U).

### DATA AND ANALYSIS

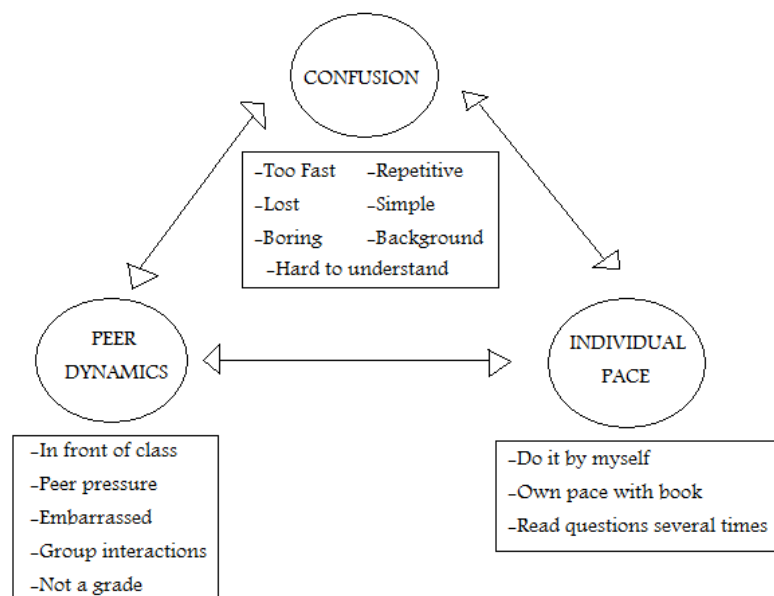
A great amount of data was gathered from all phases of the project. The multiple instruments used supplied information for all four of the research questions. Some overall themes emerged that helped to define and illustrate student impressions of technology, which also correlated to the grades received throughout. First, student understanding did increase over all phases, with the largest gain in understanding using the technology. Secondly, using the technology in different ways showed that some techniques are more successful than others. Third, students found the technology to be fun and interactive. Lastly, several implications can be taken from this study and applied to multiple classrooms. In general, through qualitative and quantitative data, the

majority of students (only 3-5 disagreeing depending on the activity) indicated the interactive technology helped them learn. Overall, the study showed an increase in student understanding, engagement, interaction, and retention of knowledge of scientific processes.



*Figure 2.* Student reasons for using the interactive whiteboard and other technologies.

The main reasons behind students agreeing that the use of the technology helped them learn are illustrated by Figure 2. The technology was fun, different, cool and memorable. With the addition of visual stimulation, it made them pay attention. The students felt they learned more because they got information delivered in steps, which took less time and prepared them for the real world. Through seeing others' perspectives, especially when the clickers were utilized, they used comparison of answers and whether they were right or wrong to build confidence in understanding in an anonymous fashion. Overall, the students were happy to be involved at the individual and whole class levels, with the games and competition driving them to learn.



*Figure 3.* Student reasons for not using the interactive technologies.

The main reasons for students who disagreed that the technology helped them learn are represented in Figure 3. Confusion occurred because of various reasons including pace, repetitive concepts, boring, simple or hard to understand ideas with more

background information needed. Peer dynamics caused fellow students to feel pressured and embarrassed in front of the class or within the group activities. If activities were not for a grade, students were less motivated to participate, especially if they were lost or confused. Overall, the comment was made by a few students that doing things at their own pace with the textbook, or by themselves, was more successful for them because they have to re-read information several times for understanding.

#### Primary Question

*“I think the technology was very interesting! It was engaging and now I finally can understand and memorize the steps of inquiry. I feel very confident about my experiment write ups and am getting science so much better! I feel I learn and remember so much more than just reading and taking notes out of the book!”*

*-Student Quote*

The above student quote from the final survey given after the second treatment (Phase 4) illustrates the overall impressions of my primary research question involving how interactive technology affects student understanding of scientific processes. The interpretations from the quote are that the technology is stimulating and therefore can increase confidence in scientific skills and learning. Both quantitative and qualitative instruments in this study provide data to back this sentiment up. As you will see in Table 4, quantitative data was gathered from a pre/post quiz and phase specific artifacts.

Table 4  
*Quantitative Data of Primary Research Question (N=20)*

| <b>Phase</b>    | <b>Pre Quiz Class Average (%)</b> | <b>Post Quiz Class Average (%)</b> | <b>Class Artifact Average (%)</b> |
|-----------------|-----------------------------------|------------------------------------|-----------------------------------|
| 1 Non-treatment | 44%                               | 56%                                | 62%                               |
| 2 Treatment     | 52%                               | 54%                                | 66%                               |
| 3 Non-treatment | 56%                               | 57%                                | 75%                               |
| 4 Treatment     | 55%                               | 73%                                | 85%                               |

Quantitatively, the scores from the pre/post quiz and the artifacts show an increase in understanding throughout the project. The artifacts involved were the following: Phase 1 had a worksheet with questions about experimental design, Phase 2 was an average of clicker question scores throughout the activities, Phase 3 was a group discussed but individual write-up of a hands-on lab, and Phase 4 was an individual write-up of an experiment to be performed with elementary students. Our district goal is for a proficiency of 80% to indicate understanding, and the quiz scores approached that goal with the artifacts reaching that goal. The level of difficulty per each phase was estimated by a fellow scientist and science teacher. On a scale from 1(Not Difficult) to 5 (Very Difficult) she rated the techniques or artifacts per each phase as follows: Phase 1(3-4), Phase 2 (1-3), Phase 3 (4), and Phase 4 (2-4) (Appendix V). Given that she considered several aspects of each phase moderately difficult (3), I would consider that the differences seen in the scores are from treatment.

When looking at the data in Table 4, there are a couple of surprising data points; a decrease in the score for the knowledge based quiz after the first treatment (Phase 2) and

a large jump in understanding after the final treatment (Phase 4). Though non-treatment Phase 1 saw an increase in understanding by 11%, it was a much larger increase in treatment Phase 4 of 18%. Student scores seemed to hover around 55-56% for both pre- and post- quiz scores through the middle two phases. This indicates retention of some concepts but not all. The qualitative data yielded possible explanations as to why, and I obtained a huge amount of information from whole class surveys, notes in my teacher journal, observations from my classroom observer, and input from my focus group interviews.

Qualitative explanations for the lower scores seen in the first non-treatment and treatment phases centered upon confusion and peer dynamics. A student comment on a survey from non-treatment Phase 1 stated that scientific inquiry was “long and confusing” and this was echoed by the student focus group in that they needed “more practice and time to understand.” Students, through surveys and interviews, still felt the same way in treatment Phase 2. Perhaps the low score seen on the post quiz was due to the fact students were confused more by the games and simulations. When it came to group and class interaction, some students would not participate. As my classroom observer in non-treatment Phase 1 wrote, there were a “couple of distractions in group work” and in my teacher journal I added that some students were “not contributing to group work.” In treatment Phase 2, he observed that activity was higher when performing the virtual experiment, but “figuring out hypothesis activity was low.” Perhaps some of the confusion in the process limited the students’ interaction. I also noted in this phase, “some students not volunteering to come to board, others

embarrassed by peer pressure.” No one likes to be made fun of or look like they don’t know what they’re doing in front of others. Obviously having more confidence in your knowledge would lead to more interaction with the technology. In my opinion, the students did not feel they had a complete understanding of the process at the time and therefore were not as interactive with the technology as they could have been. The academic scores of the first two phases clearly indicate that they had not reached a confident level in their knowledge.

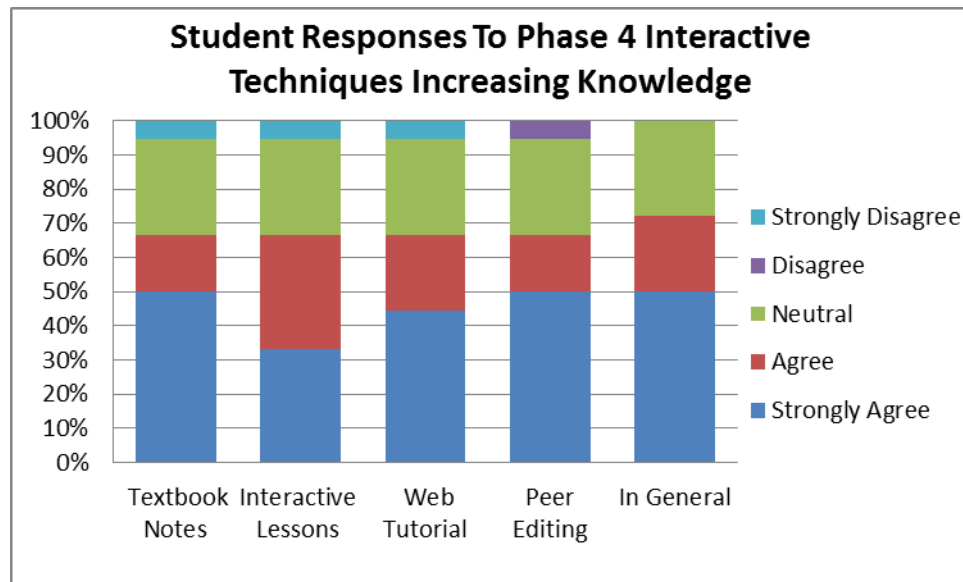
Non-treatment Phase 3 hands-on lab increased engagement, but not overall understanding. Students felt the activity allowed them to perform “by myself,” but were still confused about data and how to communicate results. The interaction in groups was high as illustrated by my journal notes that “difference of opinion spawned discussions” and the classroom observer mentioned that the students “enjoyed thinking about why and what can change.” However, the scores did not reflect the enjoyment in the hands-on activity, but rather weakness in experimental design and interpretation and communication of data.

The four different activities of treatment Phase 4 increased class averages on the surveys and quiz the most out of the entire project. Feedback pointed out that the crucial learning aspects of this phase centered on use of the clickers, interaction with the whiteboard, and seeing and hearing classmate opinions. “Students were excited to come to the board” is what I noted and this was seen by my classroom observer who wrote “students volunteering and confident at board.” When the clickers were used during the tutorial, the classroom observer also stated “participation with clickers and understanding

from discussion of answers high.” Student survey responses about the clickers included “you got to see what the class thought” and “I understood why I got my answer wrong.”

The focus group added that by having the clickers anonymous no one knows if you get an answer wrong. The peer editing “increased my confidence” according to one student on an exit survey and a focus group member responded “I gained confidence in my experiment.” Responses that did not favor these activities included “confusing,” “learn better from the book,” “I like doing it by myself,” and “either way I would learn.”

The students in general were very active learners in this phase. They had to discuss what was most important in the textbook and what could abstractly represent concepts, ways to rearrange flow chart items on the board, or think of ideas for hypothesis, controls or constants. For the most part they appreciated the opinions of their classmates whether by discussing clicker responses or getting feedback on their experimental design. It seems this last treatment phase included activities that were the most successful in increasing understanding of scientific processes. Figure 4 illustrates the percentage of students who strongly agreed to strongly disagreed that the individual techniques, or them in general, in this phase helped them learn scientific processes. Nearly 70% of the students agreed that the individual techniques increased their understanding. None of the students disagreed that the techniques as a whole helped them learn.



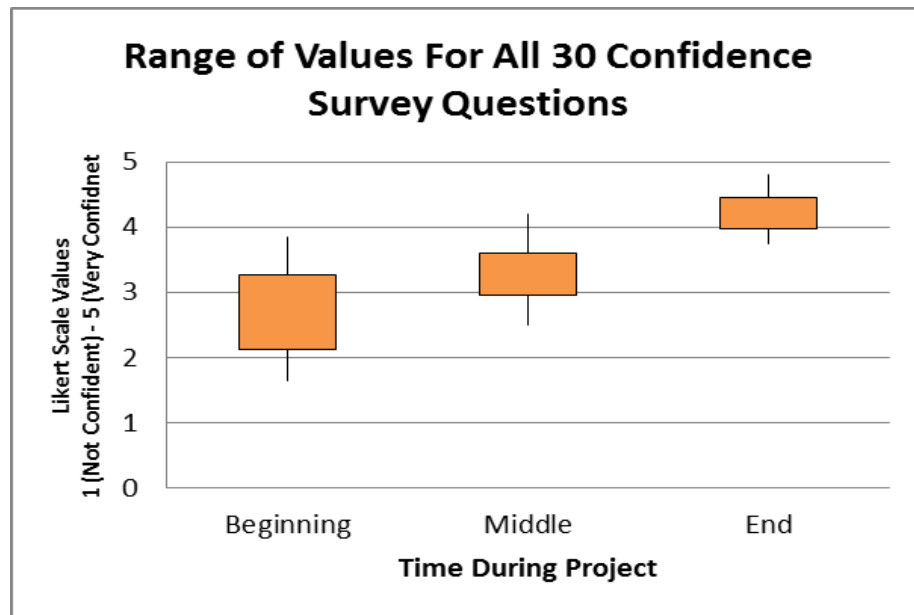
*Figure 4.* Percent of student responses using the agreement scale that the treatment of interactive technology in Phase 4 increased understanding, ( $N=18$ ).

The Scientific Processes Confidence Survey results indicate success of the treatment Phase 4 in the project. The survey itself was given before Phase 1 at the beginning of the project, after Phase 2 or halfway through the project after one round of non-treatment and treatment phases, and after Phase 4 at the end of the project after the second round of non-treatment and treatment phases. Table 5 shows how the class average in confidence (in using the scientific methods and the communication of such knowledge as defined by inquiry) increased. The standard deviation of the student responses is also included which illustrates that the variance in answers decreased as the students proceeded throughout the project, with up to 99% (three standard deviations) having a middle range to high level of confidence in the scientific processes in the end. The class as a whole jumped almost a full point in confidence after the second treatment. The answers themselves became closer to the average than the previous two samples which meant most students felt the same way.

Table 5  
*Average Confidence in Scientific Processes (1 Low – 5 High )(N = 20)*

| Time Of Project | Average Score | Standard Deviation |
|-----------------|---------------|--------------------|
| Beginning       | 2.73          | 0.64               |
| Middle          | 3.27          | 0.43               |
| End             | 4.21          | 0.29               |

This can also be represented with a box-and-whisker plot. As you can see from Figure 5, student responses went from a high range (the whiskers), or distance between the highest score and lowest score, to a much smaller range by the end of the project. A smaller interquartile distance (the box) is observed as well, which indicates that the majority of Likert scale values centered toward the median of the data and had less variance. In general, this means the activities in treatment Phase 4 created a learning environment that not only increased student knowledge but increased their confidence in performing scientific inquiry.



*Figure 5.* The median and range of values for the Likert scale responses from the Scientific Confidence Survey, ( $N=20$ ).

To lend support that the above jump in confidence came from the treatment phases with technology, a few questions from the Technology Survey also yielded feedback that the use of technology increased understanding. As you can see in Figure 6, most of the students agreed by the end of the project that technology increases understanding and academic success. After using the SMARTBoard in different ways, a huge jump in average scores for learning with the board, from the disagree side of below 3 to the agree side of above 4, was seen. The largest increase occurred between the middle and final survey, pointing out that the techniques in treatment Phase 4 once again were helpful to student learning. The students, however, are still torn on the use of clickers to increase learning as seen in the figure. Though so many comments about the clickers suggested they understood things better by using the clickers, for some reason the students on this survey only somewhat agree that the clickers increase understanding.

The only negative comments in reference to clickers were that some students would just enter a choice because they didn't think it was for a grade or didn't understand.

The power of the clickers for the teacher is the quick formative assessment of student understanding. By taking the time to discuss why answers are wrong or right, the teacher is helping students become aware of their own learning. In the end, this particular survey indicated students were influenced by the technology when it came to learning scientific inquiry.

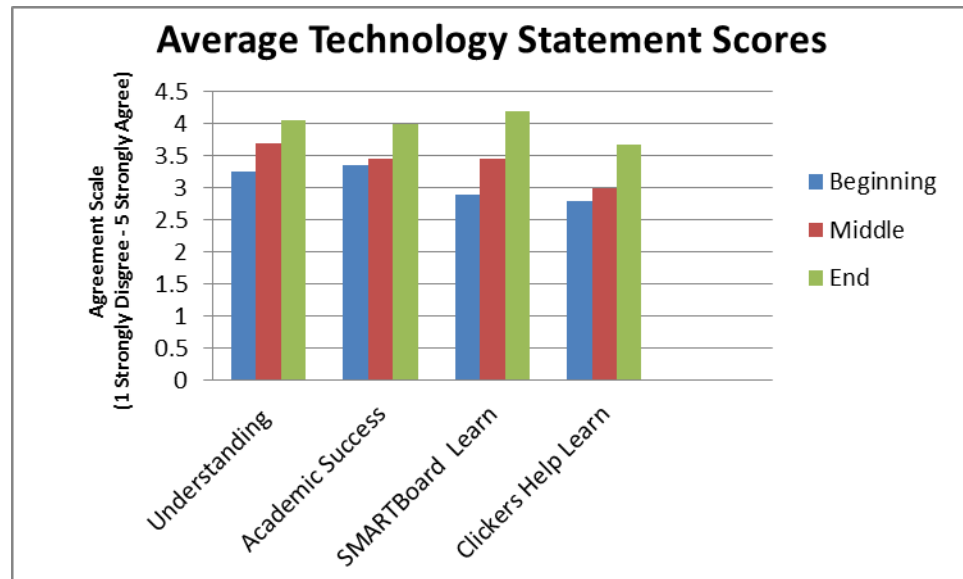


Figure 6. Class averages for statements involving learning from technology over the duration of the project, ( $N=20$ ).

From a class survey given at the end of treatment Phase 4, the students were asked to list the technology based activities that helped them learn the most and gave them confidence. The top five picked items for learning included SMARTBoard games, SMARTBoard and web experiments and simulations, web tutorials, SMARTBoard interactive lessons, and the SMARTBoard textbook notes. The focus group gave explanations as to why these may have been chosen. The games were interesting and fun,

the web experiments and simulations showed you “what could happen in less time” and “prepared you for the real experiment,” the tutorial went “step-by-step,” the lessons were “more understandable,” when highlighting textbook notes “ you knew what was important in paragraphs,” and the pictures were “funny and put things into perspective.”

The top five items for confidence included SMARTBoard games, web experiments, web tutorials, Agree/Disagree clicker questions, and multiple choice clicker questions. I can see why the web experiments and tutorials were picked as confidence building activities. They are very straight forward, with laid out formats following the scientific methods. The games were an interesting choice as student scores did not improve after that treatment in Phase 2. Perhaps they felt they built confidence because of the entertainment factor. The clickers have been shown in other studies to increase confidence for the same reasons as stated above for understanding (Blasco et al., 2013). The anonymous answer allows a student to pick an answer without peer pressure and then hear the explanation for the right or wrong answer. The more the student gets right or understands what is correct, the more confidence is built.

Lastly they were asked to pick the top 5 items from all types of teaching techniques they were exposed to throughout the project. The votes were pretty evenly distributed but SMARTBoard games, virtual labs, lessons, and editing got the most for learning. All of those received many votes for confidence along with SMARTBoard textbook notes, the mini labs, the hands-on lab, and the experiment they created for the elementary. Obviously, from even an engagement point of view, the students felt having an actual experiment to perform was also very important for their learning, which is

behind the heart of inquiry or learning by doing. In conclusion, this final question clearly indicates that technology was important for their success in understanding of scientific processes when compared to normal teaching techniques. Although not every single student would agree with this statement (based upon learning styles), the majority felt they learned better and built more confidence with activities involving technology.

#### First Sub-Question

The first sub question of how using the technology in different ways affect student understanding and achievement in science had very interesting results. In Phase 2 the technology was used in 5 different ways. First the SMARTBoard was used with interactive games including hangman, trivia, ordering, matching, etc. where students were called upon to come to the board and pick an answer. The clickers were then used the next time for the class to click in whether they agreed or disagreed with the student or to get a class consensus of the answer before someone chose an answer. Then a simulation was gone through as a class, followed by another simulation with clickers used in a similar process as above. It ended with a virtual lab where the students were required to write down the whole process as we went through it on the board. Students were called upon to come to the board at different times to pick aspects of the experiment and were able to “see” the results of their choices. In the end they had gone through all steps of the scientific methods.

The SMARTBoard games and simulations got rave reviews by the students as most (85%) (N=20) of them agreed using the technology in this way helped them learn. Through class surveys and the focus group interview, most of this confidence in understanding came from the fact that games were “fun.” Of the nine different games

attempted, one called Rags-to-Riches, a mimic of Who Wants To Be A Millionaire, received the most votes for the type of game that helped them learn the most. Perhaps the temptation of earning money drove the competitive edge behind the interest in this game.

For the two students who did not agree, one was confused and the other made the comment of “I don’t like coming up to the board in front of the whole class.” In my journal, I recorded comments of “peer pressure” which can definitely make students uncomfortable at the board by themselves. The simulation was helpful as a learning tool as students could see the “real world” application. In a class survey asking students if they learned from the simulation, 18/20 agreed that they did because it was “fun” and “went step-by-step.” However, one student remarked “we were going too fast and it got confusing” which is something for me to take into account moving forward. My classroom observer noted that “activity was low when figuring out the hypothesis but high when performing the actual experiment.” Perhaps others were just as confused at that step, and overall with several of the topics, considering the class average on the post-quizz was actually lower than the previous phase (see Table 2). In the end, though the games were fun and the simulations interesting, confusion because of pace or lack of background information left some learners not impressed.

The virtual lab gave the students a lot of confidence in their understanding of the scientific methods. As one student from the focus group said “every step of the virtual process shows you what you’re doing in the scientific methods.” The focus group collectively stated they learned a lot from this process because you could “see what would happen in less time,” know “how to deal with things if they go wrong,” and it

“prepared” them for the hands-on process which yielded a great deal of confidence. In fact they had wished we could have spent more time with the virtual lab because it taught them so much. These sentiments were echoed in the class survey as seeing the steps showed them how the process works.

On the flip side, some students were again confused or “lost” at points and after completion of the hands-on lab the class agreed that they learned more from it than the virtual lab. On an agreement scale of 1 Strongly Disagree to 5 Strongly Agree, the class average was a 4 with reasons including “I got to do it myself” and “it was more exciting.” No one can deny the powerful learning tool of hands-on activities but perhaps having a virtual lab before will not only teach but increase confidence as mentioned by the focus group. Both together could foster a positive learning environment with a focus on critical thinking skills. To illustrate this, here are a couple of quotes; the first from my teaching journal and the second from my classroom observer.

*“They were thinking so much more about the actual experiment using critical thinking skills that they either volunteered information freely or could answer my verbal questions for quick formative assessments with accuracy.”*

#### *Treatment Phase 2 Virtual Lab*

*“All groups were talking, writing, discussing and analyzing. They enjoyed talking about why and what could change, including what could have been changed to help the plants. The teacher walked around and asked questions and the students responded well.”*

#### *Non-Treatment Phase 3 Hands-On Lab*

When asked about how effective the clickers were when used, most of the class agreed that seeing what their classmates thought and having the teacher discuss why answers were wrong or right helped them learn. Examples of this include “gives me ideas to how my answer was right or wrong,” “I understood my answer better,” and “then I know what answer is right.” The interviewees agreed that being anonymous helped build confidence in how they answered.

In Phase 4, the technology was used in several different ways. First, pictures were taken of the textbook with the SMART Document Camera and students were placed into groups to discuss what should be highlighted in each paragraph, come up with pictures (found off the internet right there at the board), or decide on written examples to help illustrate the concepts. Students were numbered and everyone came up to the board at some point in the activity. The next technique put to use was interactive SMARTBoard Lessons about inquiry where students came up to the board to pop balloons, make flow charts, pull tabs, move answers to correct locations, etc. The third aspect of this phase was the use of a website tutorial over the steps of the scientific method. Here each step was described followed by multiple choice questions of which the class was asked to click in answers. The answer was then picked and a discussion over right or wrong answers followed. The final piece was editing using the SMART Notebook Tools of actual student work. Students created experiments to do with the elementary students and pictures of their write-ups were taken with the Document Camera. The class then helped each student edit their work by circling, writing, highlighting, and with verbal comments.

The shocking, but exciting, result from this phase was the huge jump in post-quiz scores. Given the amount of activities undertaken, one would hope the students would increase their knowledge of the scientific processes. However, even after the exciting hands-on lab in Phase 3, I was a bit apprehensive that their scores would ever improve as the class average climbed to just 56% (see Table 2). The quiz itself is made from the current textbook used in class with Blooms taxonomy questions levels 1-4. After analyzing the types of questions missed on the quiz from the first 3 phases I noticed the students struggled with the experimental design style questions dealing with application and analysis, and a few knowledge and comprehension type questions.

In non-treatment Phase 1, the students read the chapter, but did they really retain the information? I had to figure out a way to bridge the textbook with the technology and that is how I came up with SMARTBoard textbook notes. This technique itself took longer than expected and had many implications for not only my immediate teaching style, but for others researching how to teach students to understand textbooks in general.

The textbook notes involved pictures of the chapter paragraphs that were then highlighted by students portraying the most important information, and enhanced by student handwritten examples or internet pictures copy-and-pasted next to the text. Positive comments from both the focus group and the class survey included that the students now knew “what was important in each paragraph,” could “visually see what someone was talking about,” had examples that “put things into perspective,” and were inspired to think about “why they would choose something like that.” For my visually impaired student, she really appreciated the activity as things were bigger and brighter.

For my English Language Learner, the visual examples “really helped me understand.” Students not so convinced stated “if I took notes from the book by myself, I would have gotten it either way” or “I like doing it on my own.” Regardless I couldn’t help myself and gave them the post-quiz after this two week activity and the class average jumped ten percentage points to 66%.

Group interactions were required for the activity and perhaps some of the negative interactions that occurred where members were “not participating and screwing around” or “I was with a bunch of smart people so they ignored me” were not conducive to the learning environment. My classroom observer noticed students off task during picture look up time and he suggested ways for minimizing this as did the focus group. In the end, for the class to climb that much in percentage, I felt it was a unique activity that can be modified to be even more successful in the future. As one of my focus group students said “I think it was actually a smart idea me personally. I was actually into seeing all the funny pictures and when they highlighted things you thought I didn’t think that. You got to put things into perspective and I really enjoyed it.” This is a technique that can be employed by several content areas and modified to each teacher’s personal style.

From my own previous knowledge of students entering the 7<sup>th</sup> grade with a lack of understanding in the scientific processes, and a large piece of that being experimental design, I wanted to find other options for interaction with technology focused on that topic. Since the students were still struggling with that aspect on the post-quiz and how it is so important for success in any science classroom, I was able to find a few options for that part of this final treatment phase. Studies have pointed out the potential of learning

from creating lessons using the interactive SMART Notebook software. I was able to find a few previously made lessons that would accomplish what I needed off the SMART Exchange website.

The particular vocabulary in the lessons centered upon the types of variables, controls, constants, materials, and procedures. The focus group told me the lessons were easier to understand, shorter, interesting, and entertaining for everyone. A student comment from a class survey stated that he believed after the lessons “most of my classmates can have scientific conversations.” Notes in my teacher journal concluded the students “came to the board with confidence and did not need much input from the class as to the correct answer.” These lessons not only address the important aspects of scientific inquiry, they create a more active learning environment where all students can participate, be interested, and be entertained.

Next we went through an online tutorial that provided information and tips as to each step of the scientific method. At the end of each mini-lesson were multiple choice questions that we answered with the clickers. Whatever the class majority chose we went with and then discussed why the answer was correct or not. From my own observation of this activity and that of my classroom observer, the students for the most part were interested, active participators, and learning along the way with comments like “oh now I get it” and “that’s why.” The focus group was split as 3/5 felt it helped, one would get lost and just answer randomly, and the other found it confusing, hard to understand, and boring.

The class survey averaged a 4 on the same agreement scale as listed above that they learned from the website and the clickers. Though one student distinctly did not like the activity, some other comments were “I got confused” and it was “boring to me”. Perhaps this activity was boring to some because it was too easy, too hard, or just not as exciting as coming up to the board to manipulate a scenario. Overall, the students liked the tips and examples, and how seeing the clicker answers “helped me understand why I got it wrong” or “how I compared to the class” without them “knowing it was me who got it wrong.” This specific activity built personal confidence in understanding of the scientific method. Having the clickers involved allows the teacher to monitor individual student understanding and hopefully clear up any misconceptions.

The final activity was editing of student work on the SMARTBoard. Each student created an experimental write-up to perform with elementary students and then the class as a whole was asked to give critique in positive ways. The focus group was very enthusiastic as to how much that activity helped them learn with one exclaiming “it was my favorite thing ever! I am now confident for mine and others experiments. Everyone else paid attention, it was like a competition.” My journal observations stated the students were very involved and wanted to learn or improve their experiment. A comment from the class survey summed it up pretty well, “I understand what I am doing now.” In my personal opinion, this was the most meaningful activity for the students.

In the end the students were able to improve their scores on the post-quiz to 73%, an 18% gain from Phase 3 (see Table 2). A 10% gain was seen just after the textbook notes strategy. This has huge implications for teachers required to teach from and use a

textbook. It gives the students a way to discuss and learn how textbooks are designed, which is very applicable to post-secondary studies. It utilizes creativity and critical thinking to come up with written examples or pictures to illustrate ideas. A teacher could modify this process by having examples to choose from ready to go or predesigned interactive pages. Regardless, most of the textbook users create exams from the textbook software and what better way to prepare the students for the wording on the test? The notes can then be printed off for student copies, especially to fulfill the needs of special education.

The other three activities prepared the students for experimental design. The application and understanding of scientific processes is not only important for in class success, many standards and national exams include questions involving those specific aspects. The increase as a whole from the pre-quiz before Phase 1 was 29%, with the average a 44% to begin with. Two students got perfect scores on the final quiz. Based upon the results from both treatment phases, it looks like the technology can be successful when used in certain ways. The games, simulations, and virtual lab write-up were not enough in themselves to increase student understanding. The SMARTBoard textbook notes and lessons, web tutorial with clickers, and SMARTBoard editing of student work did cause a significant gain in understanding. This indicates that using the technology in different ways will increase knowledge in different ways, perhaps due to different learning styles of students. What if you were to change the order of how you use the above techniques, would success levels also increase?

### Second Sub-Question

The second sub question of how student engagement will be affected can overlap with the learning aspect of the scientific processes. When looking at the data acquired from an exit survey after the games and simulation on the SMARTBoard the majority of students (85%) would agree that using the technology has helped them learn. This would in turn make them have a positive attitude toward the academic requirement of understanding and putting scientific processes to use. As an explanation of why they learned, a comment that represented 25% of their opinions as a whole was, “I think technology has helped because it was fun and interactive.” Several of the data instruments provided insight into how engaging the technology was or wasn’t in the first treatment phase.

The evidence for technology increasing engagement had trends centered around the term “fun” and that you get to “see it” happen. If things are fun, then you tend to be interested. The class average in agreement for the statement that the “SMARTBoard is fun” averaged a 3.9 on the agreement scale of 1(Strongly Disagree) to 5(Strongly Agree) after the mid-project survey. Appealing visual and auditory information will also keep your attention. 25% of students in the exit surveys remarked that using technology, particularly the games, was fun. As I noted in my journal, some games got all students involved where they were standing up and shouting answers to each other. In general it was stated that “games are a kid’s best friend” and they were related to Wii and Xbox games. Though this is great that the kids are engaged, the study by Armstrong et al. (2005) pointed out that teachers and therefore students can lose track of the lesson

objectives in place of entertainment value. This is a valuable point to consider moving forward.

When it came to the simulation, my classroom observer noted that when the actual experiment was performed, the students were very interested in what was going on. This was also mentioned by 3/5 interviewees. The interviews also revealed that visually seeing a “real” world scenario with sound effects made it more “understandable, different, and fun.” While going through the virtual lab, the student who began the year hating technology exclaimed “sweet!” when asked to come to the board. He was also a part of my focus group and time and time again stated he liked the virtual lab and learned a great deal from it. On his exit survey about the virtual lab he also commented that it was fun. As I wrote in my teacher journal, the students were “motivated to see if their hypothesis was correct or not” and paid attention and participated throughout the activity. Another student in my focus group, who is a big fan of the textbook, also commented that he was “very very interested in the virtual lab because it shows you what happens.”

Overall 15 students out of 18 agreed or strongly agreed after doing the non-treatment Phase 3 Hands-on Lab that the virtual lab prepared them, gave them confidence, and they liked doing it before. Most students claimed to be more interested in the hands-on lab, but the virtual lab was still “fun and interesting” and they learned from it. The majority of feelings towards the use of technology at this point were illustrated by this quote, “when technology is in use I tend to pay more attention.” On-the-other-hand, this statement had some conflicting data at this point in the project as we will see next.

Reasons that explain why the games, simulations, and virtual labs might not be engaging include confusion, simplicity, and too hard to understand. As a contradiction to the statement of paying attention, I observed that some students were not participating, and my classroom observer noted that some were not paying attention. The interview students observed classmates in “lala land” with one admitting he wasn’t paying attention the whole time. It was suggested by the interview students that the games were too repetitive or simple causing some students to be “bored.” Again it was mentioned that the simulation had words or concepts that were hard to understand or were confusing. Comments about the virtual lab included having “more background” on the topic and “more time” to go through the lab. In my journal after completion of a virtual lab I wrote “they needed to have a background in the light spectrum to fully understand what we were testing, need to change that next time.”

Another comment that stood out was “getting the wrong answer was embarrassing.” Some students put into a situation where they are uncomfortable will just shut down and this is not the purpose of using the technology. After I observed this, looked at the observer’s responses, and listened to the interview comments, I decided to try the games and simulation again with CPS clickers. When students came to the board to pick answers, order the steps, etc. the class was asked to click in if they agreed or not. This created a less chaotic environment, as I stated in my journal, “a lot quieter and more attention to the activity.” However, when asked if having the clickers helped them stay on task, the class was split. Some reasons shared by my students for not staying on task

included that it “was for fun, not a grade,” “I focus less but it is easier than writing,” “there was still talking,” and “I have to read the question several times.”

This is definitely something to consider moving forward as I can make all the clicker questions count towards their grades and not just the bell-ringer formative assessment style questions that were used during this phase. Confusion was seen across data instruments and the comment “going too fast” may illustrate one of the major reasons for this. Having the information above will lead to several ideas as to how to improve these activities and how my overall teaching will be altered.

Treatment Phase 4 brought a variety of activities that seemed to overall pique the interest of the students. As I wrote in my journal, the group was “very interactive” with some messing around during down time which can be fixed the more I practice the techniques. My classroom observer felt the students were “highly interested” in the activities as well. In Table 6 I list some responses in reference to each type of technique used from an end of treatment survey. The students in favor of using the technology felt these activities were fun, interactive, and made them pay attention. The students against the technology felt pace, confusion, and peer dynamics limited their engagement.

Table 6  
*Class Survey Responses In Favor Or Against Uses Of The SMARTBoard (N=20)*

| Type Of Activity | In Favor Of                                                                         | Against                                                                                  |
|------------------|-------------------------------------------------------------------------------------|------------------------------------------------------------------------------------------|
| Textbook Notes   | “see things I may have missed”<br>“more fun”<br>“made me pay attention”             | “I prefer to take notes from the book by myself”<br>“confused”<br>“too quick”            |
| Lessons          | “fun”<br>“very cool, memorable”<br>“I like coming to the board and sharing answers” | “either way I would have learned”<br>“hard to keep up”<br>“sometimes a little confusing” |
| Web Tutorial     | “I felt more interactive”<br>“all got to interact”<br>“had to pay attention”        | “just wanted to know answer and move on”<br>“pressured to pick fast”<br>“boring to me”   |
| Editing          | “fun and I could be involved”<br>“enjoyed it more”<br>“still nervous yet confident” | “I still have trouble with it”<br>“not totally confident”<br>“a little more confident”   |

There was great feedback as to the above techniques. All but 3 students agreed that taking notes this way increased their confidence in the scientific methods and would like to do it again. I wonder if again group dynamics hindered more than helped the success of the activity. One student wrote “it’s embarrassing when you don’t know what you’re doing” when the group was to make sure everyone was on track before a member was called up. The focus group pointed out that some “people were left out” or that others were “only interested when it was their chance to go up to the board.” The

SMARTBoard interactive lessons were “entertaining and fun for everyone” as my focus group member who is not a fan of technology stated. My ELL student added that she felt “people paid more attention to be able to go up there.” The web tutorial received some similar comments from my focus group as one found it “hard to understand and therefore boring” while having the clickers let them “see what the class thought” and the anonymity kept them from “feeling like a stupid person.” The editing was so positive and rewarding for the students. They kept saying out loud how much that helped them personally with their experiment, they knew what they were missing or needed to change, and gained confidence in themselves.

The class as a whole felt the SMARTBoard games and interactive lessons were the most engaging; however, all but textbook notes and multiple choice clicker questions received many votes. In the survey that asked for their top five interesting teaching styles, the most engaging were the hands-on labs, SMARTBoard games and simulations, CPS clicker questions and having to create their own experiment. This result is not surprising and is illustrated by one student who wrote “I like technology but I like the hands-on labs so I’m at a crossroad of technology and labs.”

From before non-treatment Phase 1 to after the second treatment Phase 4, student opinions have changed as to engagement in the scientific processes. As highlighted by the following figure, agreement in statements has increased over the project with very high scores (4.5) in the fact that the SMARTBoard is fun and interesting.

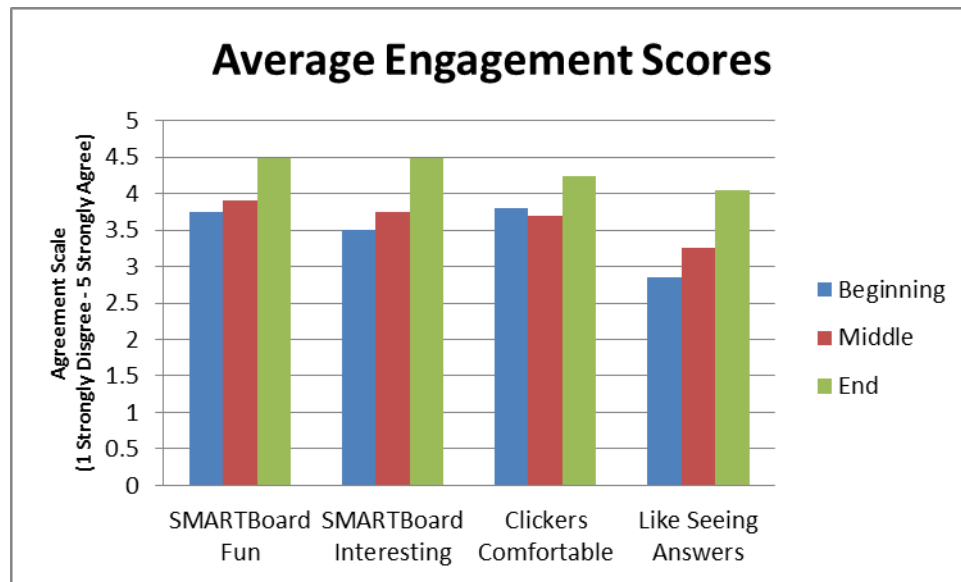


Figure 7. Class averages for statements involving engagement in technology over the duration of the project, (N=20).

In the figure we can see two distinct trends. The increase in average scores climbed the greatest from the Phase 4 treatment or from the survey given in the middle of the project to the end of the project. This correlates with the rest of the data that the majority of students truly were engaged by the techniques used in Phase 4. Secondly, there was a slight decrease in comfort with clickers after the Phase 2 treatment. This drop in confidence was seen in a similar situation in a study by Jones, Antonenko, and Greenwood (2012). They found that student confidence dropped from initial scores indicating that students were less confident at that point in the course or that they recalibrated their confidence to a more appropriate level as research shows that today's learners are very self-confident. Their research showed clicker instruction provided the students more self-awareness of their understanding of concepts and they rated themselves accordingly. Perhaps this is why my students did not feel as comfortable using the clickers at the middle point, their confidence in their knowledge or abilities was

not at the point they initially thought it was. Altogether, the technology based techniques were very engaging for most students with pace, confusion, and peer dynamics the only negative aspects.

### Third Sub-Question

The final question of how my classroom and teaching will be altered with both types of interactive technology has already gained so much feedback from the data. From talking with my critical friend, looking at the survey suggestions, hearing input from the focus group, and revisiting notes from my teacher journal, I have a lot of ideas moving forward. For example, the students will need more background knowledge on the simulations or virtual experiments. I will also need to put forth the expectations of each activity to maintain better classroom management. With comments like “it’s confusing when too many people are talking to you at once” from a focus group member to one from an exit survey that stated “too much pressure with everyone yelling out their opinions at you,” it comes down to how the class acts during the activity. Being in front of your peers, especially during the middle school years brings about a lot of fears and the classroom needs to have a ‘safe’ feel to it. One student commented “I don’t like writing at the board because of my spelling” while others were “embarrassed”. Having the proper expectations set forth (including classroom behavior) and detailed roles for each group member will likely increase the success for a positive learning environment for all.

Finally, better student accountability for their work or answers with clickers will need to be a common practice. Perhaps a printout of their percentage from the day’s questions will show them that I am monitoring and it will affect their class performance.

Another suggestion from clicker studies at the college level would be to use partner or group communication where students would click in an answer then discuss with others. After the active collaboration of learning, students could change their answer and class discussion could follow.

From overall impressions, to small detailed changes, it all points back again to how the technology itself is used and how I can optimize that for student understanding. The games and simulations were fun, but a lot more learning occurred during the fourth and final phase (a decrease versus an 18% increase on the pre/post quiz). Though some activities worked well for some like the visual appeal for the students with a disability or language barrier, not all were convinced the technology was for them. "I feel I learned better without technology. Because if I read it I remember more of it. And it makes it a lot easier when its right in front of you and you can go at your own pace." A few students believe the book is better and complained that some of the activities went at too fast a pace. I recognize that not all of us learn in the same ways and do believe a combination of all styles will increase the chance for success in the classroom. However, based upon this study, I do believe using the technology enhanced student understanding and interest in the scientific processes. It would be a matter of how to proceed with the techniques, in what order and in what ways would they be most successful?

#### INTERPRETATION AND CONCLUSION

This action research project was designed to show that technology can be used to increase student understanding of concepts. Is it limited to the discipline of science? No. As a two-core teacher myself of science and math, I have already used the technology in

both classes. I can “see” how what I have done in science class with the technological tools at my disposal can be transitioned to math class and vice versa. With students becoming more and more exposed to technology, and tools becoming more and more available to a classroom, who wouldn’t want to relate to the students and together dive into a learning environment that is engaging and successful for all?

This study was not the first, and will not be the last to look into how technology can be used in a classroom. The purpose of this particular project was to look at how the interactive whiteboard and classroom response system can be used separately and together to increase student understanding of scientific processes. Much data was gathered from various tools that not only supported the use of technology, but suggested ways to improve its use for those students not convinced it works for them. As we all know, not everyone learns in the same manner and therefore we cannot limit ourselves as teachers to teaching one style. The question then becomes, how can we use technology to benefit all types of learners?

The research questions in this project gained much insight as to how interactive technology can affect student understanding of the scientific processes. The primary question of what effect the interactive technology will have on understanding benefited from a longitudinal research design to minimize differences in data and to optimize reasons for changes. Use of the technology increased student understanding of scientific processes as the class average on the pre/post quiz climbed from 44% to 73%, with 18% of that gain coming from the second treatment phase. As for the sub-question involving engagement, at a minimum 75% of the students felt the technology increased their

interest in the scientific processes because it was “fun” and “interesting.” This percentage varied depending on the technique that was used.

Confidence increased over the project from the slightly low confidence average of 2.73 out of 5 to 4.21 indicating a solid confidence in their knowledge. The sub-question addressing whether using the technology in different ways would affect understanding showed that Phase 4 technology techniques had the highest jump in understanding, engagement, and confidence. The main support in qualitative data suggested that through the use of the technology which was “memorable”, the individual or class could get involved and would learn by seeing other perspectives and discussing clicker question answers. The technology laid the information out in a step-by-step format and fostered a collaborative active learning environment.

At times the activity caused confusion, went at too fast of a pace, or was not a positive learning environment due to peer pressure at the board or inappropriate group interactions. These are many of the things to consider as I alter my teaching as suggested by my third sub-question. In conclusion, using the technology with seventh grade science students increased engagement and understanding in scientific processes.

#### Implications To My Teaching

My teaching and classroom will be greatly altered by the findings in this project. The students have given great feedback as to how they want and like the technology to be used, and pointed out areas of strengths and weaknesses as to confusion, practice, and classroom management. Overall, students want to use the technology and like that it presents the information in “different ways.” 18/20 students felt they should be spending

more time at the SMARTBoard. The research so far implies that students need to have a complete background, expectations, and accountability as the technology is used.

Expectations set forth by the teacher must be maintained and students need to remain focused upon the objectives.

Accountability will only enrich student discussions in class if every clicker question is counted towards their grades and a form of “think-pair-share” could be used. It could also be established with paper in hand where students who are confused can write down why and where, and students who want to mess around will see the reflection in their class grade. Having an exit slip like “muddiest point” would give students more control over their own learning and understanding of personal weaknesses. It will also give the teacher an understanding of any deficiencies or confusion that still needs to be addressed daily before a huge summative exam three weeks later.

I personally felt the most rewarding aspect of this project was the feedback from the students and how grateful they were that someone cared about their input. As one student said to me, “I like that you care what I think, even if you don’t end up using it.” Having been trained to teach at the college level, I was used to giving out feedback surveys and have done so once a year at the secondary level, just not as much as these students were asked. I feel this is a critical aspect to making your classroom the best you can for all students. As the study by Boscardin and Penuel (2012) points out, “it is essential that we identify potential students that would be negatively affected by the use of interactive technology so that we can accommodate these individuals” (p. 826). This has caused me to ask, how can we accommodate those that struggle with time?

As one student pointed out, “it’s really hard to keep up.” In order to meet this student’s needs, I have a few ideas to help them keep pace with the class. Perhaps a print out of the slides or activity will keep them more on track. What about those students who like to work on their own with the textbook? “I like taking notes by myself from the book.” Should we differentiate the lesson in that those students can move to the back of the room and work on a separate assignment? My concern with this is that the students may be distracted by the interactive environment that is incorporating the technology. Perhaps one could require textbook reading and notes as a homework requirement, leaving class time for the interactive technology activities. This mimics a “flipped classroom” where students are required to watch lectures from home and perform hands-on activities in class the next day.

Finally, the peer dynamics were quite controversial during the project. The collaborative constructivist learning environment requires communication between students. “My group members did not include me that much, when I try to speak to them they wouldn't listen to me.” This study was not about this aspect of learning but it turned out to be a very important issue for engagement during some of the activities. Therefore I, as well as others, will have to research group roles and classroom management techniques to best suit this type of learning environment. The immediate teacher and students are not the only ones to benefit from the data in this report and there is much value in it for others.

## VALUE

This research will provide several ideas and options for teachers to use in their own classrooms. Teachers from every level and discipline can intertwine interactive games and or simulations in their daily lessons to peak student interest and engagement. The social constructivist environment with SMARTBoard Notebook Lessons and clickers questions can challenge students. Teachers who are required to use textbooks may now add a creative spin on traditional lectures based on the book. Not only will it be presented to my colleagues and I will offer professional development, the administrators will see the recently acquired technology finally being put to use. Community members and parents will see the value of technology for their students.

The parent survey revealed that most students began the year talking about science and technology about a couple of times a month and ended the year a couple of times a week. The survey also revealed that interest, knowledge, and enthusiasm in science and technology rose from a mid-low level to high-mid level. With it being incorporated into the real world more and more, perhaps they will support their students at home with computers and the district with donations for more technology.

Other classroom researchers can test my ideas out and see if they too get the same results. They could also build upon my research and create even more ways to use the technology. Eventually themes may surface where one use of the technology works for one type of student while another works for a different type of student. As Kennewell and Beauchamp (2012) summarize, there are several different ways to use the interactive whiteboards and it would be interesting to research if they would affect different learning

styles. These include composing, editing, selecting, comparing, retrieving, apprehending, focusing, transforming, role playing, collating, sharing, annotating, repeating, modeling, cumulating, revisiting, undoing, questioning, prompting, and responding. This could lend itself to differentiation of instruction in the classroom and can be generalized and shared among all in the profession. We've seen something like this already in the online school environment; some students flourish where others do better in the public or private domain. In the end, most kids love to interact with games, and touch and handle things. Most classrooms would benefit as mine has in the engagement factor of technology; it would be the understanding of concepts that would need more focus.

#### Future

This study has multiple questions and areas of focus that could be looked into moving forward. One could just look into specific SMARTBoard applications, CPS applications, or combinations of the two. By doing this you could research specific types of students or other demographics including gender, cultures or ethnicities, grade levels, content areas, class sizes, or learning environments in general. In this study the girls scored higher overall on the pre- and post- quiz, but boys made the largest gain in knowledge (Appendix W). In a study by Dhindsa (2011), they found that by using an interactive whiteboard in a constructivist learning environment they minimized gender differences in chemistry. Teachers could have students create their own experiments as presentations just by using the technology. Teachers would not have to focus just on the scientific processes, perhaps one of the national or state required standards.

In my opinion, the next step of this particular research project would be to look at the order in which the uses of the technology could be optimized for student understanding. Should one start out with student led textbook annotation with the SMART document camera, followed by a SMART Notebook interactive lesson, then ordering and other games, simulations and virtual experiments to end with CPS clicker questions throughout? In essence, how would the order of technology techniques affect student understanding?

Moving forward, I know I would also like to try clicker case studies. In a large national research project influenced by the movement of teaching science as inquiry, 22 authors in 2011 from several universities created case studies using the clickers as a tool for engagement and discussion. It has been reported case-based teaching led to students' abilities to engage in critical thinking, make connections across multiple content areas, view an issue from multiple perspectives, develop deeper understanding of concepts, and become more engaged in the class (Lundeberg et.al., 2011). In fact the students taught with case studies out performed students taught with lecture in their ability to analyze data, a critical part of scientific inquiry. My question is, would this be applicable at the secondary level and would it help build student understanding of scientific processes?

The ideas for future research are important but a foundation is needed for ultimate success. Education for teachers themselves is essential for success of the interactive technology in the classroom. Lee, Feldman, and Beatty (2012) tabulated several factors that can negatively affect teachers. These include hardware and software, operating the technology, time and curriculum pressure, question development, integration of the

technology into the curriculum, classroom discussion, students themselves, practicing formative assessment, contextual factors, and overall ways of being a teacher. Knowing these in advance and creating a positive professional development plan in each district should help alleviate any stress moving forward.

In fact, pre-service teachers should be trained in such tools as stated by Blue and Tirotta (2011) in this quote. “As university faculty model technology use, pre-service teachers gain the opportunity to explore and use new applications and experiment with ideas about how they can integrate technology into classroom instruction for school-age learners” (p.37). Regardless, Serow and Callingham (2011) have created roles for the teacher to take when creating lessons (Table 7) and the stages teachers may have to progress through to optimize its use and their success in the profession (Table 8).

Table 7

*Teacher Roles When Using Interactive Technology (Serow & Callingham, 2011, p.163)*

| Role        | Description                                                               |
|-------------|---------------------------------------------------------------------------|
| Consultant  | providing information, internet searching, exploring simulations          |
| Organizer   | providing tight structure but unpredictable results for activities, games |
| Facilitator | providing a looser structure for focusing on construction activities      |
| Repository  | enabling student ideas to be recorded for later                           |

Table 8  
*Stages Of Teacher Growth (Serow & Callingham, 2011, p.164)*

| Stage                       | Description                                                                                                                                           |
|-----------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------|
| Black/Whiteboard Substitute | the teacher continues to function in a similar teaching style                                                                                         |
| Apprentice User             | characterized by use of a wider range of existing computer skills in a teaching context, although lessons still proceed in a largely linear direction |
| Initiate User               | awareness of the potential of the interactive technology to change and enhance practice                                                               |
| Advanced User               | teacher is now in a phase of exploration where new features are added to existing lessons, students are engaged as active participants                |
| Synergistic User            | the growing equality of teacher and pupil, focus is on opportunities to create new learning scenarios                                                 |

To sum this up, Dhindsa (2011) points out that simply introducing new technologies will not bring about fundamental change in the traditional patterns of whole class teaching, and what needs to happen is for teachers to consider what type of pedagogical practices best supports the learning. This study has shown that, through a variety of techniques, increase in understanding, engagement, and confidence in the scientific processes is possible through the use of interactive technology. In my immediate future is reordering of the techniques and continued use of the technology. I will expand the techniques into other classes, such as my sophomore biology. I want to strongly suggest that if you have the possibility of getting the technology, try changing your pedagogy to include it and find the best ways to support student success.

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## APPENDICES

APPENDIX A

PRE/POST QUIZ

Name: \_\_\_\_\_ Class: \_\_\_\_\_ Date: \_\_\_\_\_

ID: A

**SM QUIZ****Multiple Choice***Identify the choice that best completes the statement or answers the question.*

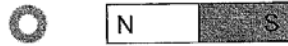
- \_\_\_\_\_ 1. What should a scientist do first if a hypothesis is NOT supported?
  - a. more repetition
  - b. more testing
  - c. gather more info
  - d. modify and revise the hypothesis
- \_\_\_\_\_ 2. Which of the following is a way that scientists communicate their results to others?
  - a. speak at a conference
  - b. write scientific articles
  - c. exchange information on the Internet
  - d. all of the above
- \_\_\_\_\_ 3. A research hypothesis includes the original hypothesis, a method of testing it, and a(n) \_\_\_\_\_ that supports the hypothesis.
  - a. analysis
  - b. prediction
  - c. observation
  - d. conclusion
- \_\_\_\_\_ 4. Scientists analyze results by using which tool(s) to help recognize patterns?
  - a. graphing and tables
  - b. models and calculations
  - c. speaking at conferences
  - d. a and b only
- \_\_\_\_\_ 5. Which is NOT a result of scientific inquiry?
  - a. adding more branches of science
  - b. possible explanations for questions
  - c. technology
  - d. new materials
- \_\_\_\_\_ 6. An explanation of observations of events based on knowledge gained from many observations and investigations is which of the following?
  - a. scientific law
  - b. scientific truth
  - c. scientific theory
  - d. scientific experiment
- \_\_\_\_\_ 7. Which of the following describes a pattern or an event in nature that is always true?
  - a. scientific theory
  - b. scientific law
  - c. scientific experiment
  - d. scientific truth
- \_\_\_\_\_ 8. Which involves studying a small amount of something in order to learn about the larger whole?
  - a. bias
  - b. skepticism
  - c. sampling
  - d. none of these
- \_\_\_\_\_ 9. When you are skeptical of scientific issues in the media, what are you doing?
  - a. using critical thinking to question information presented
  - b. accepting the information as truthful
  - c. dismissing the information as false
  - d. using your bias to form opinions
- \_\_\_\_\_ 10. When using living animals in scientific research, which of the following is especially important?
  - a. precision
  - b. bias
  - c. ethics
  - d. constants



Name: \_\_\_\_\_

ID: A

19. Jason wants to compare the magnetic force exerted by two different magnets. Jason hypothesizes that the bar magnet will have greater magnetic force than the disk magnet. He bases his hypothesis on the shape and size of each magnet. Which would **not** be a valid way to test the hypothesis?



- count the paper clips that will attract over each magnet's total surface at one time
  - measure the separation distance at which a paper clip will be attracted to each magnet
  - count the number of unattached paper clips that form a chain attracted to each magnet
  - use water displacement to determine the volume of each magnet
20. Lidia collected the data shown here during an experiment in which she used the same amount of force to put each marble in motion. Based upon the information shown in the chart, which **best** describes the purpose of Lidia's experiment?

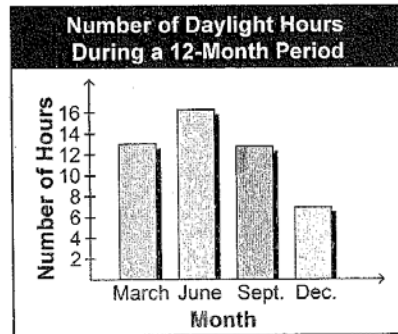
| Experimental Data |                 |                 |                 |
|-------------------|-----------------|-----------------|-----------------|
|                   | Mass One        | Mass Two        | Mass Three      |
| Trial 1           | 3.2 centimeters | 2.6 centimeters | 2.8 centimeters |
| Trial 2           | 3.3 centimeters | 2.5 centimeters | 2.9 centimeters |
| Trial 3           | 3.5 centimeters | 2.3 centimeters | 2.9 centimeters |
| Average           | 3.3 centimeters | 2.5 centimeters | 2.9 centimeters |

- to determine the effect of mass on the distance a marble will move across a flat surface
- to determine the effect of mass on how much time a marble will travel before stopping
- to determine the effect of mass on the speed of a marble rolling across a flat surface
- to determine the effect of mass on the direction of a marble rolling across a flat surface

Name: \_\_\_\_\_

ID: A

21. Lucita studies the graph below, which shows the number of hours of daylight throughout the year where she lives. Which statement **best** describes how these variables are related?



- Daylight hours decrease from December to June, and increase from June to December.
  - The number of daylight hours depends upon the time of year.
  - The number of daylight hours is not affected by the time of year.
  - The time of year depends upon the number of daylight hours.
22. A biologist is working on a major research project comparing the effects of three over-the-counter medications for the common cold. She keeps a detailed journal of her research, which is divided into the categories shown below.

| The Effects of<br>Three Medications on<br>Various Cold Symptoms |  |
|-----------------------------------------------------------------|--|
| Body aches                                                      |  |
| Congestion                                                      |  |
| Cough                                                           |  |
| Fever                                                           |  |
| Headache                                                        |  |

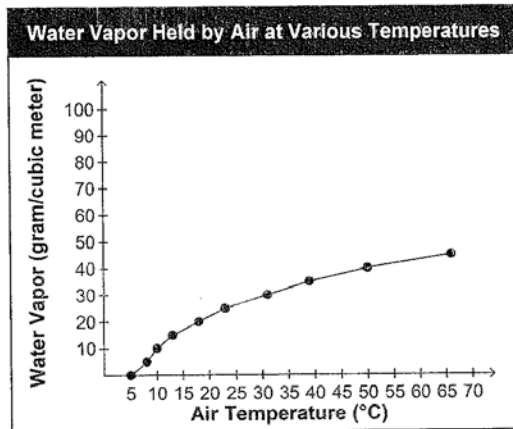
Which statement about the records of the experiment is **true**?

- Detailed records will not show that the experiment had errors.
  - Detailed records will not assist other scientists in replicating the study.
  - Detailed records will assist other scientists in validating the study's findings.
  - Detailed records will not demonstrate the ethical nature of the study.
23. The World Wide Web is an extremely useful tool for scientists involved in any type of research. Which does **not** describe why a researcher would utilize the Internet in his work?
- Scientists can quickly and easily search for experiments related to their own research.
  - Researchers can easily communicate with other scientists in their fields.
  - Researchers can quickly report findings, making them available to other scientists.
  - Researchers can use the Internet to keep their studies from being replicated.

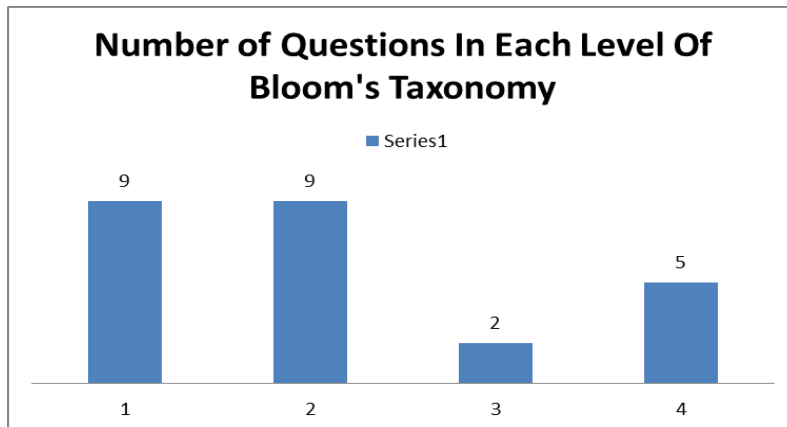
Name: \_\_\_\_\_

ID: A

24. Using an array of computer hardware and software allows scientists and researchers to make progress in their fields with greater speed and accuracy than could have ever been achieved without technological tools. Which task listed below, however, is **least** likely to be made easier for researchers through the use of computer technology?
- making a judgment about whether or not a researcher's methodology is ethical
  - collecting and sorting large amounts of data quickly
  - analyzing large amounts of data quickly for any existing patterns or trends
  - sharing ideas with and requesting feedback from other scientists in distance locations
25. The graph shows data collected in an experiment comparing the amount of water vapor ( $H_2O$ ), in grams per cubic meter, which was held by air at various temperatures. One important step in a scientific method is to analyze collected data. Which is an accurate analysis of the data shown?



- Warm air cannot hold as much water vapor as cool air.
- As air temperature increases, it can hold more water vapor.
- There is no relationship between air temperature and amount of water vapor it can hold.
- Air at  $10^{\circ}\text{C}$  can hold more water vapor than air at  $50^{\circ}\text{C}$ .



|           |               |             |          |
|-----------|---------------|-------------|----------|
| Level 1   | Level 2       | Level 3     | Level 4  |
| Knowledge | Understanding | Application | Analysis |

APPENDIX B

TECHNOLOGY SURVEY

## **Technology Survey**

*Participation is voluntary, and you can choose to not answer any question that you do not want to answer, and you can stop at anytime. Your participation or non-participation will not affect your grade or class standing.*

1. How often do you use a computer? **(Enter number for times per week)**

2. Do you have a computer, iPad, iPod, or cell phone? **(A for yes, B for no)**

**For Questions 3-22 use the following scale.**

**Strongly Disagree (1) Disagree (2) Undecided (3) Agree (4) Strongly Agree (5)**

3. Technology is important in our society.

4. Technology is important for education.

5. Technology will increase my understanding of concepts.

6. Technology will increase my academic success in the classroom.

7. My teachers use technology to its potential.

8. I wish more of my teachers used technology in the classroom.

9. I am comfortable with using computers.

10. I am comfortable with using touch screens.

11. I am comfortable with using the Smartboard.

12. Using the Smartboard is fun.

13. Using the Smartboard is interesting.

14. I think students should spend more time at the Smartboard.

15. I think more educational games should be played using the Smartboard.

16. I feel I learn more when the Smartboard is used.

17. I am comfortable with using clickers.

18. I like that my answers are anonymous with the clickers.

19. The clickers give me confidence in answering questions.

20. I like to see what and how others answer questions.

21. Seeing class responses helps me understand what I may have gotten wrong.

22. I feel I learn more when clickers are used.

23. Suggest ways the Smartboard can be used in the classroom.

24. Suggest ways the CPS Clickers can be used in the classroom.

25. General suggestions for using technology in the classroom.

APPENDIX C

SCIENTIFIC PROCESSES CONFIDENCE SURVEY

### Scientific Processes Confidence Survey

*Participation is voluntary, and you can choose to not answer any question that you do not want to answer, and you can stop at anytime. Your participation or non-participation will not affect your grade or class standing.*

**On a scale of Not Confident (1) to Very Confident (5) rate yourself on the following statements.**

1. I can list the basic 5 steps of the scientific method.
2. I can explain what each step means.
3. I can think of a real world problem.
4. I can do research to find information on that problem.
5. I can write an explanation as to why that problem occurs, a hypothesis.
6. I can design an experiment.
7. I know the difference between control groups and experimental groups.
8. I know the difference between constants and variables.
9. I know the difference between independent and dependent variables.
10. You should always have at least 3 tests or repeat the experiment 3 times.
11. A hypothesis is supported or rejected, rather than proven true or false.
12. I can create data tables, graphs, and figures to represent data.
13. I know what I have to do next if the hypothesis was rejected.
14. I know what I have to do next if the hypothesis was supported.
15. I can write up my research in the correct format.
16. I can display my research on a poster board.
17. I can explain my research to others.
18. I can ask others questions about their research.
19. I can critique my classmates' research.
20. My knowledge of scientific processes will bring me academic success.

**Use this excerpt to answer Questions 21-30.**

*Patrick believes that fish that eat food exposed to microwaves will become smarter and would be able to swim through a maze faster. He decides to perform an experiment by placing fish food in a microwave for 20 seconds. He has the fish swim through a maze and records the time it takes for each one to make it to the end. He feeds the special food to 10 fish and gives regular food to 10 others. After 1 week, he has the fish swim through the maze again and records the times for each.*

21. I could identify a problem or observation that started Patrick thinking about this.
22. I can identify Patrick's hypothesis.
23. I can identify the independent variable.
24. I can identify the dependent variable.
25. I could list two or more controls needed for the experiment.
26. I could list the control group.
27. I could list the experimental group.
28. I could create a graph of the data.
29. I could make a conclusion relating to the hypothesis if data was provided.
30. I could think of ways to improve or change the experiment.

\* Students will be asked to provide answers to questions 21-30 after Phase 4.

APPENDIX D

PARENT SURVEY

## **Parent Survey**

*Participation is voluntary, and you can choose to not answer any question that you do not want to answer. Your participation or non-participation will not affect your child's grade or class standing. All effort on your part is very much appreciated, Thank You, Ms. Coulter.*

1. How often does your student talk about science?

EVERDAY      COUPLE TIMES A WEEK      COUPLE TIMES A MONTH      NEVER

2. How often does your student talk about technology?

EVERDAY      COUPLE TIMES A WEEK      COUPLE TIMES A MONTH      NEVER

3. How often does your student talk about technology in the classroom?

EVERDAY      COUPLE TIMES A WEEK      COUPLE TIMES A MONTH      NEVER

4. My student's INTEREST in science is

HIGH      MID      LOW

5. My student's KNOWLEDGE in science is

HIGH      MID      LOW

6. My student's ENTHUSIASM towards science in the past was

HIGH      MID      LOW

7. My student's ENTHUSIASM towards science this year is

HIGH      MID      LOW

8. My student's KNOWLEDGE of/in using technology is

HIGH      MID      LOW

9. My student's INTEREST of/in using technology is

HIGH      MID      LOW

10. My student's ENTHUSIASM of/in using technology is

HIGH      MID      LOW

APPENDIX E

CRITICAL FRIEND PROMPTS

**Date** \_\_\_\_\_ **Time** \_\_\_\_\_

**Nature of the lesson or title of the lesson.**

**Critical Friend Prompts**

**Rate the following from 1 (LOW) to 5 (HIGH) state examples.**

1. Teacher's attitude toward class activity

1      2      3      4      5

2. Teacher's engagement toward class activity

1      2      3      4      5

3. Teacher's motivation toward class activity

1      2      3      4      5

4. Class activities described increase understanding

1      2      3      4      5

5. Class activities described increase engagement

1      2      3      4      5

6. Class activities described increase student/student interaction

1      2      3      4      5

7. Class activities described increase student/teacher interaction

1      2      3      4      5

8. Class activities described increase retention of knowledge

1      2      3      4      5

9. Class activities described increase critical thinking skills

1      2      3      4      5

10. Class activities described increase desire to learn

1      2      3      4      5

11. Class activities described increase confidence in scientific processes

1      2      3      4      5

APPENDIX F

GROUP GRAPHIC ORGANIZER

## Practice Identifying Parts of the Scientific Method

**Directions:** The following are experimental scenarios. Read the experiments and then identify the components of the scientific method by completing the graphic organizer provided.

### Experimental Scenario #1

A student investigated whether ants dig more tunnels in the light or in the dark. She thought that ants used the filtered light that penetrated the upper layers of earth and would dig more tunnels during the daytime. Ten ant colonies were set up in commercial ant farms with the same number and type of ants per ant farm. The same amount of food was given to each colony, and the colonies were in the same temperature. Five of the colonies were exposed to normal room light and five were covered with black construction paper so they did not receive light. Every other day for three weeks the length of the tunnels was measured in millimeter using a string and a ruler. Averages for the light and dark groups for each measured were then computed. The averages are listed in the following chart.

Length of Tunnels (mm) Constructed by Ants in Different Light Conditions

|                                                                                     | Day | Light | Dark |
|-------------------------------------------------------------------------------------|-----|-------|------|
|                                                                                     | 1   | 5     | 7    |
|                                                                                     | 3   | 10    | 15   |
|    | 5   | 20    | 25   |
|                                                                                     | 7   | 26    | 32   |
|                                                                                     | 9   | 32    | 47   |
|                                                                                     | 11  | 50    | 62   |
|                                                                                     | 13  | 61    | 93   |
|  | 15  | 66    | 110  |
|                                                                                     | 17  | 90    | 115  |
|                                                                                     | 19  | 95    | 120  |
|                                                                                     | 21  | 103   | 136  |

### Experimental Scenario #2

A student investigated the effect of radiation on the germination of bean seeds. He thought that exposure to radiation would limit the seeds ability to germinate (grow) much like ultra-violet light causing skin cancer. Three hundred seeds were soaked in distilled water for one hour. They were then divided into three groups. One group was placed in a microwave oven on high for three seconds. Another group was microwaved on high for six seconds. The last group was not microwaved. The seeds were then planted in three separate flats and given the same amount of water. The seeds were then planted in three separate flats and given the same amount of water. The flats were placed in a location with a constant temperature of approximately 27 degrees Celsius. Each day for two weeks the number of seeds that germinated each group was recorded.

Total Number of Bean Seeds Germinated after Microwave Radiation

| <u>Three Seconds of Radiation</u> | <u>Six Seconds of Radiation</u> | <u>No Radiation</u> |
|-----------------------------------|---------------------------------|---------------------|
| 54                                | 26                              | 88                  |

### Experimental Scenario #3

A student investigated the effect of aged-grass compost (fertilizer made from decaying plant material) on the growth of bean plants. She thought that the compost would provide extra nutrients and make plants grow faster. Thirty bean seeds were divided into three groups and planted in different flats (boxes). All seeds germinated after 12 days and were allowed to grow for five days. The flats were each given the same amount of water and the same amount of light. Flat A was then fertilized with 3-month old compost; Flat B was given 6-month old compost; and Flat C was given no compost. At the end of 14 days the height of each plant was measured in centimeters.

### Final Heights of Bean Plants

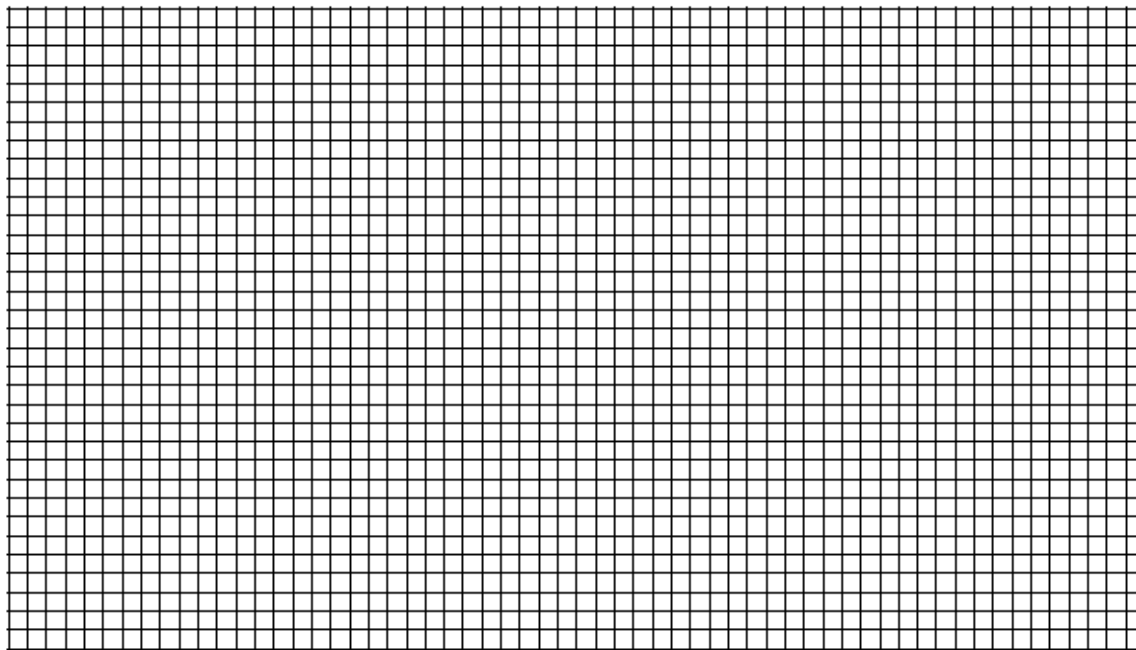
| <u>3-month old<br/>Compost</u> | <u>6-month old<br/>Compost</u> | <u>No Compost</u> |
|--------------------------------|--------------------------------|-------------------|
| 7.6                            | 10.1                           | 6.5               |
| 5.4                            | 9.5                            | 7.2               |
| 8.2                            | 12.1                           | 8.4               |
| 9.3                            | 13.0                           | 11.0              |
| 8.2                            | 8.5                            | 6.9               |
| 6.9                            | 13.1                           | 6.8               |
| 7.3                            | 12.4                           | 6.3               |
| 9.4                            | 11.6                           | 10.7              |
| 10.2                           | 14.8                           | 9.9               |
| 12.0                           | 10.8                           | 10.6              |



## Analysis of Experimental Scenarios – Graphic Organizer –

[illegible]

**Results/Data (Graph):**



**Conclusions:**

APPENDIX G

CLASSROOM OBSERVER PROMPTS

**Date** \_\_\_\_\_ **Time** \_\_\_\_\_

**Nature of the lesson or title of the lesson.**

**Classroom Observer Prompts**

**Rate the following from 1 (LOW) to 5 (HIGH) and state examples. List specific students involved.**

1. Student attitude toward lesson.

1      2      3      4      5

2. Student desire to learn.

1      2      3      4      5

3. Students were engaged with material.

1      2      3      4      5

4. Student were aware of their own learning.

1      2      3      4      5

5. The activity empowered students to learn.

1      2      3      4      5

6. Student/teacher interaction was positive.

1      2      3      4      5

7. Classroom atmosphere was conducive to learning.

1   2      3      4      5

8. Activity involved varying cognitive levels.

1      2      3      4      5

9. Students were stimulated by activity.

1      2      3      4      5

10. Students had confidence in activity.

1      2      3      4      5

11. Students cooperated/interacted with each other.

1      2      3      4      5

12. Retention of lecture was applied to activity.

1      2      3      4      5

13. Student grasp of scientific processes.

1      2      3      4      5

APPENDIX H

PRACTICE WORKSHEET

## Scientific Method Controls and Variables – Part 1

Worksheet created by T. Trimpe 2003 <http://sciencespot.net/>

Name \_\_\_\_\_

**SpongeBob and his Bikini Bottom pals have been busy doing a little research. Read the description for each experiment and answer the questions.**

### 1 - Patty Power

Mr. Krabbs wants to make Bikini Bottoms a nicer place to live. He has created a new sauce that he thinks will reduce the production of body gas associated with eating crabby patties from the Krusty Krab. He recruits 100 customers with a history of gas problems. He has 50 of them (Group A) eat crabby patties with the new sauce. The other 50 (Group B) eat crabby patties with sauce that looks just like new sauce but is really just mixture of mayonnaise and food coloring. Both groups were told that they were getting the sauce that would reduce gas production. Two hours after eating the crabby patties, 30 customers in group A reported having fewer gas problems and 8 customers in group B reported having fewer gas problems.

Which people are in the control group?

What is the independent variable?

What is the dependent variable?

What should Mr. Krabs' conclusion be?

Why do you think 8 people in group B reported feeling better?

### 2 – Slimotosis

Sponge Bob notices that his pal Gary is suffering from slimotosis, which occurs when the shell develops a nasty slime and gives off a horrible odor. His friend Patrick tells him that rubbing seaweed on the shell is the perfect cure, while Sandy says that drinking Dr. Kelp will be a better cure. Sponge Bob decides to test this cure by rubbing Gary with seaweed for 1 week and having him drink Dr. Kelp. After a week of treatment, the slime is gone and Gary's shell smells better.

What was the initial observation?

What is the independent variable?

What is the dependent variable?

What should Sponge Bob's conclusion be?

### 3 – Marshmallow Muscles

Larry was told that a certain muscle cream was the newest best thing on the market and claims to double a person's muscle power when used as part of a muscle-building workout. Interested in this product, he buys the special muscle cream and recruits Patrick and SpongeBob to help him with an experiment. Larry develops a special marshmallow weight-lifting program for Patrick and SpongeBob. He meets with them once every day

for a period of 2 weeks and keeps track of their results. Before each session Patrick's arms and back are lathered in the muscle cream, while Sponge Bob's arms and back are lathered with the regular lotion.

| Time          | Patrick | SpongeBob |
|---------------|---------|-----------|
| InitialAmount | 18      | 5         |
| After 1week   | 24      | 9         |
| After 2 weeks | 33      | 17        |

Which person is in the control group?

What is the independent variable?

What is the dependent variable?

What should Larry's conclusion be?

#### 4 – Microwave Miracle

Patrick believes that fish that eat food exposed to microwaves will become smarter and would be able to swim through a maze faster. He decides to perform an experiment by placing fish food in a microwave for 20 seconds. He has the fish swim through a maze and records the time it takes for each one to make it to the end. He feeds the special food to 10 fish and gives regular food to 10 others. After 1 week, he has the fish swim through the maze again and records the times for each.

*Special Food Group*  
(Time in minutes/seconds)

| Fish | Before | After |
|------|--------|-------|
| 1    | 1:06   | 1:00  |
| 2    | 1:54   | 1:20  |
| 3    | 2:04   | 1:57  |
| 4    | 2:15   | 2:20  |
| 5    | 1:27   | 1:20  |
| 6    | 1:45   | 1:40  |
| 7    | 1:00   | 1:15  |
| 8    | 1:28   | 1:26  |
| 9    | 1:09   | 1:00  |
| 10   | 2:00   | 1:43  |

*Regular Food Group*  
(Time in minutes/seconds)

| Fish | Before | After |
|------|--------|-------|
| 1    | 1:09   | 1:08  |
| 2    | 1:45   | 1:30  |
| 3    | 2:00   | 2:05  |
| 4    | 1:30   | 1:23  |
| 5    | 1:28   | 1:24  |
| 6    | 2:09   | 2:00  |
| 7    | 1:25   | 1:19  |
| 8    | 1:00   | 1:15  |
| 9    | 2:04   | 1:57  |
| 10   | 1:34   | 1:30  |

What was Patrick's hypothesis?

Which fish are in the control group?

What is the independent variable?

What is the dependent variable?

Look at the results in the charts. What should Patrick's conclusion be?

APPENDIX I

TEACHER JOURNAL PROMPTS

Journal Prompts

On a scale of LOW 1 to HIGH 5, today's activities:

- Encourage learning
- Engage students
- Empower student to learn
- Positive interaction
- Motivate students
- Increase understanding
- Increase student/student and student/teacher interactions

I feel:

- Excited
- Prepared
- Motivated

Describe the activity, list students who react in different ways or other specifics that help describe the situation. Redo prompts after the activity and explain.

Finally, how can this be improved, what did I learn about myself?

APPENDIX J

STUDENT INTERVIEW QUESTIONS PER PHASE

**Phase 1 –**

1. How do you feel about the scientific method?
2. How do you feel about using it in class, as in a lab?
3. Do you understand it?
4. How do you feel about technology?
5. How do you feel about using technology in class?
6. How do you want to use technology in class?
7. What are your thoughts on the SMARTBoard?
8. What are your thoughts on the clickers?
9. What did you like/not like about the lecture and worksheet practice over the Scientific Method?

**Phase 2 –**

1. What did you like/not like about the games on the SMARTBoard?
  - a. Did you learn from it?
  - b. Why?
2. What did you like/not like about the simulation on the SMARTBoard?
  - a. Did you learn from it?
  - b. Why?

**Phase 3 –**

1. We did a virtual lab over plants before we did the hands-on lab over plants. Did you guys like seeing a virtual lab on plants before doing a hands-on lab with plants?
  - a. So did you like having a virtual lab before a hands-on lab?
  - b. Why?

2. Do you guys think overall you're interested in the virtual labs? Why?
3. So as far as the virtual lab goes, how do you feel your understanding of the scientific processes is?
4. How interested in the hands-on lab were you guys and why?
  - a. Do you feel your classmates were more focused with the SMARTBoard virtual lab than the hands-on lab?
5. How confident are you now in the whole scientific processes?
  - a. How confident would you be if I told you to start your science fair project tonight?

#### **Phase 4 – Part 1**

1. I want to first ask you if you feel taking notes from the book that way versus the way we done it before with our summary sentences helped to learn the information better or worse or no difference?
  - a. Did having examples from other groups on the board help?
  - b. As far as highlighting is concerned, do you feel that helps you as far as the important information goes?
  - c. Was getting pictures beneficial?
  - d. How can we make this better?
2. How did you guys talk as a group before you came up to the board? Did the group interaction help this time?
  - a. Why do you think they are acting like that?
3. Now that you have been through some SMARTBoard use, do you feel more confidence in using it?
  - a. Did it help that your classmates talked to you from their bench on how to maneuver through the process as you were at the board?
  - b. Was this a successful learning activity for the whole class?

**Phase 4 – Part 2**

1. What did you think about the virtual this time?
2. What did you guys think about the SMARTBoard interactive lessons?
  - a. Was the class into it?
  - b. How did you feel working in the groups?
3. What did you guys think about that website on the tutorial of the scientific method and processes?
  - a. How did you like using the clickers with the website?
4. How did you like editing each other's work?
  - a. Ways to improve?
5. Do you think the technology works for you and your understanding of scientific methods and processes?
6. Which technique to learn the scientific method the best?

APPENDIX K

QUIA.COM GAMES

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Picture Perfect: Reveal the entire picture hidden underneath the squares.

### Steps in the Scientific Method

Put these steps in order from first to last so that they describe the scientific method.

Tools: Copy this to my account, E-mail to a friend, Print other activities, Start over, Help

Directions: Uncover the hidden picture by putting the terms in order. Enter the numbers 1 through 6 in the fields provided.

|                                                              |                                                    |                          |
|--------------------------------------------------------------|----------------------------------------------------|--------------------------|
| <input type="checkbox"/> Develop a hypothesis                | Gather data by making observations or measurements | <input type="checkbox"/> |
| <input type="checkbox"/> Interpret the data                  | Conduct a controlled experiment                    | <input type="checkbox"/> |
| <input type="checkbox"/> Pose or state a scientific question | Draw a conclusion                                  | <input type="checkbox"/> |

Attempts available: ★

Check answers

2 out of 15

Hint: test hypothesis

Guess the answer

A B C D E F G H I J K L M

What step of the scientific method would include making an educated guess?

A Experiment

B Gather information

C Record and analyze data

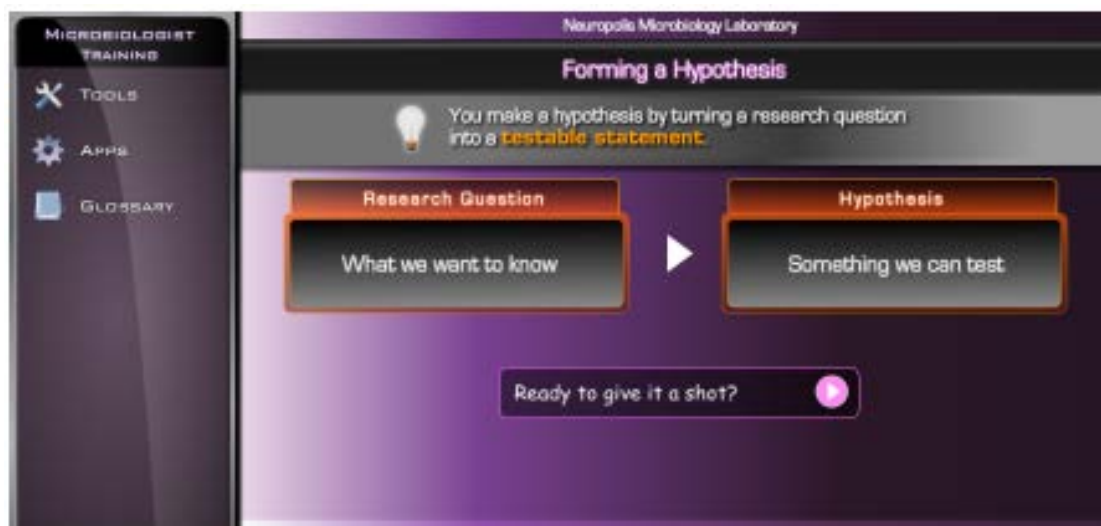
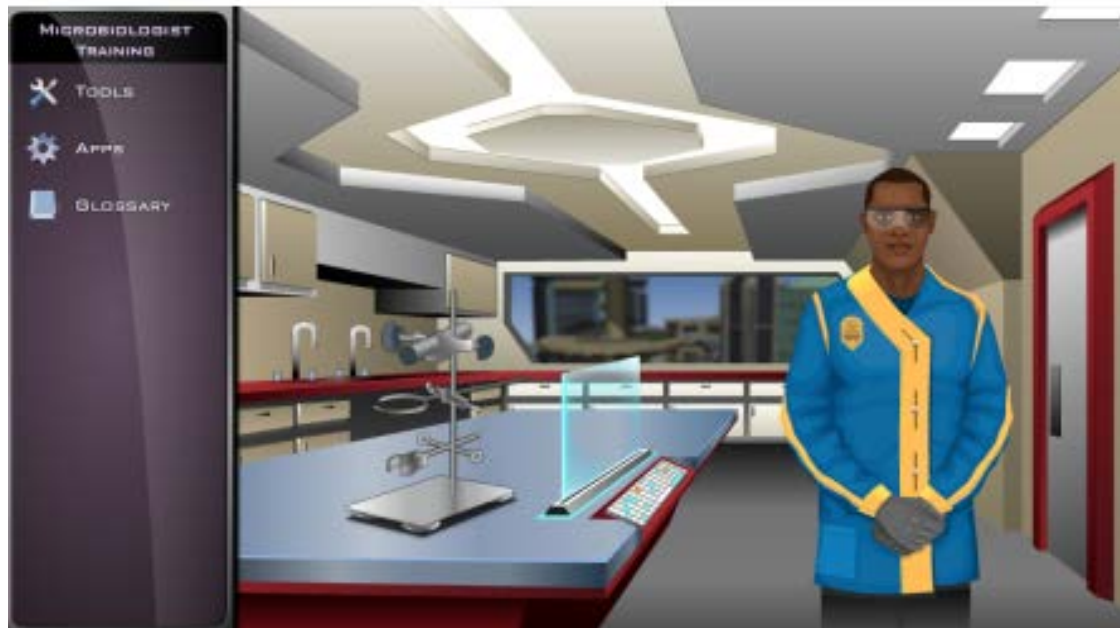
D Form a hypothesis

\$ 1,000,000  
\$ 500,000  
\$ 250,000  
\$ 128,000  
\$ 64,000  
\$ 32,000  
\$ 16,000  
\$ 8,000  
\$ 4,000  
\$ 2,000  
\$ 1,000  
\$ 500

Hint Hint Hint

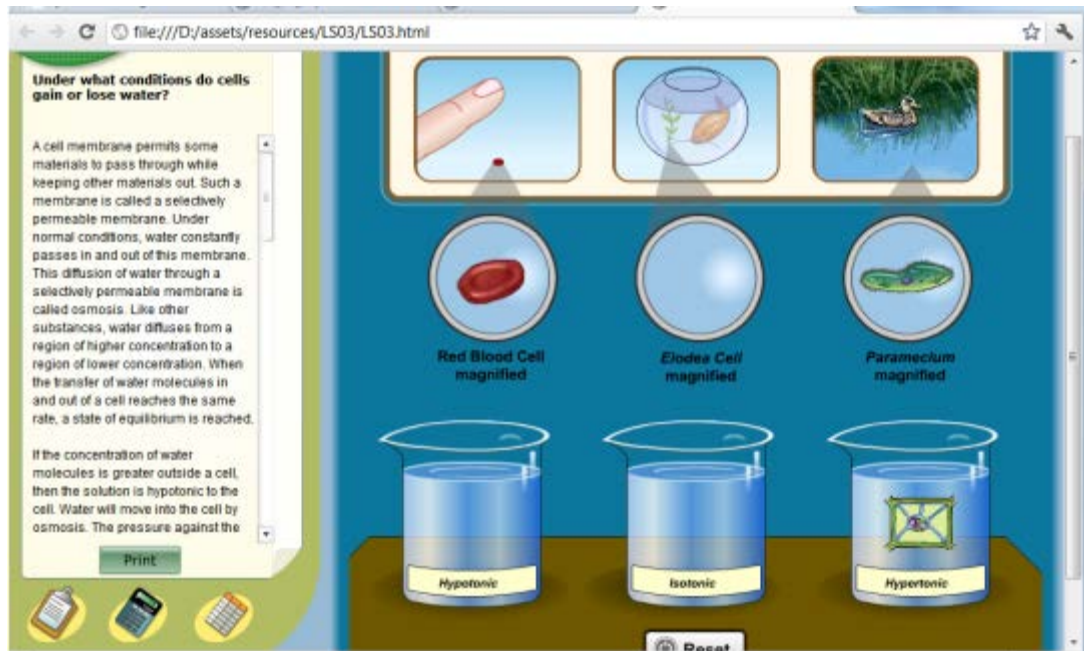
APPENDIX L

WEBADVENTURES SIMULATIONS



APPENDIX M

TEXTBOOK VIRTUAL EXPERIMENTS



Virtual Lab Report  
Name \_\_\_\_\_

### **The Loss or Gain of Water Across a Cell Membrane**

Question –

Background –

Diffusion

Osmosis

Hypothesis –

*If the concentration of water molecules is greater on the outside of the cell, then the water molecules will move \_\_\_\_\_ the cell causing the cell to \_\_\_\_\_.*

*If the concentration of water molecules is less on the outside of the cell, then the water molecules will move \_\_\_\_\_ the cell causing the cell to \_\_\_\_\_.*

Experimental Design –

Controls-

Constants-

Independent Variable-

Dependent Variable-

Procedures-

Data –

| Molecules  | Red Blood Cell Water Movement | Red Blood Cell Appearance | Elodea Cell Water Movement | Elodea Cell Appearance | Paramecium Cell Water Movement | Paramecium Cell Appearance |
|------------|-------------------------------|---------------------------|----------------------------|------------------------|--------------------------------|----------------------------|
| Hypotonic  |                               |                           |                            |                        |                                |                            |
| Isotonic   |                               |                           |                            |                        |                                |                            |
| Hypertonic |                               |                           |                            |                        |                                |                            |

### Results –

What is a hypotonic solution? What did it do to the cells?

What is an isotonic solution? What did it do to the cells?

What is a hypertonic solution? What did it do to the cells?

### Conclusions –

Summary of data-

Hypothesis Supported or Rejected-

Future Research-

APPENDIX N

PHASE RELATED EXIT SURVEYS

**SMARTBoard Games Exit Survey**

*Participation is voluntary, and you can choose to not answer any question that you do not want to answer, and you can stop at anytime. Your participation or non-participation will not affect your grade or class standing.*

Do you feel the SMARTBoard games helped you to understand the scientific method?  
Why or why not?

Which type of game helped the most?

|          |                 |                  |             |
|----------|-----------------|------------------|-------------|
| ORDERING | HIP HOP EXAMPLE | HANGMAN          | RAGS-2-     |
| RICHES   | JEOPARDY        | CONCEPT MAP QUIZ | FLASH CARDS |
| MATCHING | MEMORY          |                  |             |

Do you feel more comfortable with using the scientific methods now that you have used this technology?

YES NO

Do you feel using the technology in this was truly helped you learn?

YES NO

**SMARTBoard Experiment Simulation Exit Survey**

*Participation is voluntary, and you can choose to not answer any question that you do not want to answer, and you can stop at anytime. Your participation or non-participation will not affect your grade or class standing.*

Do you feel doing a simulation of an experiment on the SMARTBoard helped you understand scientific processes? Why or Why not?

Do you feel more confident in performing your own experiment? Why or why not?

Do you feel the use of technology in the classroom has helped you to learn? Why or why not?

### **SMARTBoard Games and Clickers Survey**

*Participation is voluntary, and you can choose to not answer any question that you do not want to answer, and you can stop at anytime. Your participation or non-participation will not affect your grade or class standing.*

**Use this scale to answer the questions and please explain your answers.**

**1 = low                      3 = mid                      5 = high**

1. How engaged (interested) did you feel with the games?
2. Did you feel motivated to learn?
3. Do you feel having the clickers help you stay on task?
4. Did you like being able to see what your classmates thought?
5. Did it help you learn by seeing what the class answers were?
6. Did it help you that your teacher discussed why answers were right and wrong?
7. Do you feel having the clickers helped keep your classmates on task and interested?
8. Any other suggestions for the use of technology?

### **Virtual Lab vs. Hands-On Lab Survey**

*Participation is voluntary, and you can choose to not answer any question that you do not want to answer, and you can stop at anytime. Your participation or non-participation will not affect your grade or class standing.*

Using the agreement scale, answer the following statement. Please explain your choice, be specific.

**Strongly Disagree (1)      Disagree (2)      Undecided (3)      Agree (4)      Strongly Agree (5)**

1. The virtual lab involving plant research prepared me for the hands-on lab with our groups.  
1            2            3            4            5
2. I was more confident in performing the group experiment because of the virtual lab.  
1            2            3            4            5
3. I was interested in the virtual lab on the SMARTBoard.  
1            2            3            4            5
4. I like doing virtual labs before hands-on labs.  
1            2            3            4            5
5. The hands-on lab was interesting.  
1            2            3            4            5
6. I was more interested in the hands-on lab.  
1            2            3            4            5
7. I learned more about scientific processes from the hands-on lab than the virtual lab.  
1            2            3            4            5

**Mini Labs VS. Virtual Lab Survey**

Rate your answers according to the scale and *explain*.

**1=Strongly Disagree    2= Disagree    3=Neutral    4=Agree    5=Strongly Agree**

1. The mini labs helped me understand the scientific method.
2. The virtual lab helped me understand the scientific method.
3. Seeing the experiment on the SMARTBoard helped me understand the scientific method.
4. I was interested in the mini lab experiment.
5. I was interested in the virtual lab experiment.
6. I learned more from the mini labs than the virtual experiment.
7. I was more interested in the mini labs than the virtual experiment.
8. I think the mini labs will make me more successful than the virtual experiment when doing my own experiments in the future.
9. Having write-ups for the lab report help me understand the scientific method.
10. Any other comments, such as what did you like about today's activity and what did you not like?

**SMARTBoard Book Notes Exit Survey**

Rate the following with the scale of 1 (Strongly Disagree) to 5 (Strongly Agree). Please provide specific reasons for the number chosen.

1. Using the SMARTBoard to take notes helped me learn.
2. Using the SMARTBoard to take notes from the book helped me learn.
3. Using the SMARTBoard to take notes from the book helped me learn how to read a textbook and pull out important information.
4. Using the SMARTBoard to take notes from the book helped me learn more than reading and taking notes from the book by myself.
5. I am more confident in my knowledge of scientific inquiry after doing SMARTBoard book notes.
6. I would like to take notes like this more often.
7. I believe coming to the SMARTBoard to write examples, get pictures or highlight helped me learn.
8. I believe seeing what other groups think is important, examples they gave, or pictures they chose helped me learn.
9. I think having to discuss as a group helped me learn.
10. I think having to discuss as a group before chosen to go up to the board gave me confidence in using the board.

11. The class help at the board gave me confidence in using the board.
  12. After the activity I am more confident in using the board.
  13. This is a successful learning tool for me.
  14. This is a successful learning tool for the class.
- 

15. Which use of the board did you like the best?
16. What about the activity did you like?
17. What about the activity did you not like?

#### **SMARTBoard Activities and Clickers Survey Phase 4**

*Participation is voluntary, and you can choose to not answer any question that you do not want to answer. Your participation or non-participation will not affect your grade or class standing.*

**Using the scale, please rate the following statements and give examples or explanations for your choice.**

**Strongly Disagree (1) Disagree (2) Undecided (3) Agree (4) Strongly Agree (5)**

***When considering the website that allowed you to pick the parts of the experiment involving flower type and soil...***

1. I liked coming up to the board to pick options for an experiment.
2. I think activities like that help me understand the scientific methods.
3. I would like to do more experiments at the board.

***When considering the SMART Notebook Lessons involving popping balloons, moving tabs, fill-in-the-blanks, flow charts, etc...***

4. I felt these interactive lessons at the board helped me understand scientific inquiry.
5. I felt these interactive lessons at the board helped the class understand scientific inquiry.
6. Having discussions as a group before coming to the board gave me confidence in using the board.
7. Having the group discussions during activities helps me learn.
8. Having the group discussions during activities gives me confidence in my own understanding.
9. Doing the interactive lessons at the SMARTBoard gave me confidence in using the scientific methods.
10. Using the SMARTBoard in interactive ways gave me more confidence in, and understanding of, the process of science (rather than regular lecture, reading the textbook, or performing a classroom experiment.)

***When going through the scientific methods step-by-step on the website with clickers...***

11. I felt I learned from the website.
12. It helped to see what the class thought was the answer.
13. It helped that the teacher went through an explanation of why other answers were not correct.
14. Having questions to practice for each step helped me learn.
15. I liked using the clickers as a learning tool.
16. Having the clickers involved helped me build confidence because my answers were anonymous.
17. The clickers kept me involved.
18. The clickers kept the class involved.
19. The clickers helped the class learn as a whole.

***When looking at and editing students' work with the SMARTBoard...***

20. I learned even more about the process of science.
21. I felt it helped me personally.
22. I feel the class learned as a whole from the activity.
23. I understand my experiment better.
24. I have more confidence in setting up my experiment.
25. This gave me confidence in using scientific inquiry.

**Please rate the following technology based activities from MOST TO LEAST under each statement.**

- |                                    |                                      |
|------------------------------------|--------------------------------------|
| 1. SMARTBoard Games                | 2. SMARTBoard experiment simulations |
| 3. Clickers w/ Activities on board | 4. Website Experiments               |
| 5. Website Tutorials               | 6. SMARTBoard Book Notes             |
| 7. SMARTBoard Interactive Lessons  | 8. SMARTBoard Student Work Editing   |
| 9. Clickers Agree/Disagree         | 10. Clickers Multiple Choice         |

A. HELPED ME **LEARN** THE PROCESS OF SCIENTIFIC INQUIRY

B. KEPT ME **INTERESTED** IN LEARNING THE PROCESS

C. GAVE ME **CONFIDENCE** IN USING OR DOING THE SCIENTIFIC METHODS

**ANSWER THE FOLLOWING STATEMENTS USING THE FOLLOWING OPTIONS**

- |                              |                            |                       |
|------------------------------|----------------------------|-----------------------|
| a. Regular Lecture and Notes | b. Practice Worksheets     | c. SMARTBoard Games   |
| d. SMARTBoard Simulations    | e. SMARTBoard Virtual Labs | f. Mini Labs          |
|                              |                            | g. Hands-On Lab       |
| h. CPS Clicker Questions     | i. SMARTBoard Book Notes   | j. SMARTBoard Lessons |
| k. SMARTBoard Editing        | l. Creating Own Experiment |                       |

1. Pick 5 of the options that truly helped you **LEARN** the process of scientific inquiry.
2. Pick 5 of the options that were the most **ENGAGING** (interesting, fun).
3. Pick 5 of the options that gave you the most **CONFIDENCE** in using scientific inquiry.

***\*Do you feel that using the technology (instead of just lecture, notes, practice worksheets, hands-on labs) to learn about the scientific methods actually helped you learn or not? Please explain using the back of this paper.***

APPENDIX 0

PLANT INQUIRY LAB

### Plant Experiment

As a group decide which experiment you would like to perform from below:

1. Coke vs. Red PowerAde
2. Ibuprofen vs. Acetaminophen
3. 1tsp Sugar vs. 5tsp Sugar
4. 1tsp salt vs. 5tsp salt
5. Soap Detergent vs. Laundry Detergent
6. Powder Insecticide vs. Spray Insecticide

Complete the following in order in your Journals.

1. Come up with a scientific question about those products in relation to your live plants.
2. Spend 20 minutes in the computer lab researching your products, write down specifics you feel are important , share with your group members.
3. Write a hypothesis, share with your group members.
4. List the materials needed for the experiment.
5. Decide as a group the procedure for your experiment. List the Independent Variable, Dependent Variable, Control Group, Experimental Groups, and Constants.
6. Create a Data Table to record observations.
7. Write the Results from your data in complete sentences, describe what you observed.
8. Conclusion
  - a. Was the hypothesis supported or rejected?
  - b. Summary of the results in relation to the hypothesis (describe why).
  - c. How could the experiment be improved?
  - d. How would you move forward, future experiments?

APPENDIX P

LAB REPORT RUBRIC

|                    | <b>1</b>                                               | <b>2</b>                                                           | <b>3</b>                                                                        | <b>4</b>                                                                          |
|--------------------|--------------------------------------------------------|--------------------------------------------------------------------|---------------------------------------------------------------------------------|-----------------------------------------------------------------------------------|
| <b>QUESTION</b>    | Student does not state question to be investigated     | Student's question is mostly unclear                               | Student's question is somewhat clear                                            | Student's question is clear                                                       |
| <b>BACKGROUND</b>  | Student does not write background information          | Student writes 1-2 sentences of background information             | Student writes a good amount of background                                      | Student writes a good amount of background with scientific terminology            |
| <b>HYPOTHESIS</b>  | Student does not write a hypothesis                    | Student writes a hypothesis that does not tie into experiment      | Student writes a hypothesis that vaguely ties into experiment                   | Student writes a hypothesis that involves the proper if/then statement            |
| <b>MATERIALS</b>   | Student does not list materials                        | Student lists a few of the materials needed                        | Student lists almost all materials needed                                       | Student lists all the materials needed                                            |
| <b>PROCEDURE</b>   | Student does not list the steps                        | Steps are listed but confusing and could not be repeated           | Steps are listed and mostly accurate, experiment could be repeated with support | Steps are accurate, experiment could be repeated by another researcher            |
| <b>DATA TABLE</b>  | Student does not create a table or gather observations | Student attempts the data table, but observations are incomplete   | Student has data table, observations are mostly complete and understandable     | Student data table is complete and understandable                                 |
| <b>RESULTS</b>     | Student does not summarize results                     | Results are incomplete, no mention of experiment specifics         | Results are mostly complete, experiment specifics mentioned                     | Results are complete, experiment specifics are listed and tied back to hypothesis |
| <b>CONCLUSIONS</b> | Student does not write a conclusion                    | Student writes a conclusion that contains 1-2 of required elements | Student writes a conclusion that contains 3 of the required elements            | Student writes a conclusion that contains all the required elements               |
| <b>TOTAL SCORE</b> |                                                        |                                                                    |                                                                                 |                                                                                   |

APPENDIX Q

SMARTBoard NOTES

The study of chemistry and physics is physical science. Physical scientists study the interactions of matter and energy. This chemist is preparing electrolytic solutions. Physical scientists ask questions such as

- How do substances react and form new substances?
- Why does a liquid change to a solid?
- How are force and motion related?

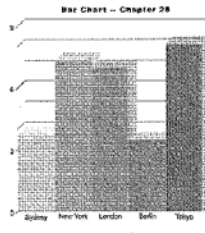
Jan 9-8:31 AM

After you state a hypothesis, you might make a prediction to help you test your hypothesis. A prediction is a statement of what will happen next in a sequence of events. For instance, based on your hypotheses, you might predict that if some plants receive more water, sunlight, or fertilizer, then they will grow taller and more quickly.

 $I = 0.041 \text{ A}$

**Analyze Results**  
As you are testing your hypothesis, you are probably collecting data about the plants' rates of growth and how much fertilizer each plant receives. Initially, it might be difficult to recognize patterns and relationships in data. Your next step might be to organize and analyze your data.

You can create graphs, classify information, or make models and calculations. Once data are organized, you more easily can study the data and draw conclusions. Other methods of testing a hypothesis and analyzing results are shown in Figure 2.



collection → organization → analyze → conclude  
graphs  
classify  
models  
calculations

Jan 9-8:49 AM

**1 Sampling**  
A method of data collection that involves studying small amounts of a population to make inferences about the whole population.

**2 Blind Study**  
A procedure that can reduce bias in a study. The investigator, subjects or both do not know which group they are in. Personal bias cannot affect the investigation if participants do not know what they are testing.

**3 Repetition**  
If you get different results when you repeat an experiment, then there is a problem. Repetition probably means flawed, imperfect or inconsistent data. Repetition can reduce bias.

*ms. c. interview*  
*ms. c. like benches, not desks*  
*Have someone blindfolded and have 3 cups of different milk soy fat free, 1%*  
*you go to classes over and over.*

Jan 9-9:02 AM

APPENDIX R

SMART EXCHANGE

**Science Fair Steps - drag to put in order**

Step 1: ☐ Gather information

Step 2: ☐ Write a hypothesis

Step 3: ☐ Test hypothesis with an experiment

Step 4: ☐ Create and practice presentation

Step 5: ☐ Write a conclusion

Step 6: ☐ Write a question

Step 7: ☐ Analyze data

**Read the scenario below. Identify the independent, dependent and control variable/variables. Discuss and check your answers by pulling the tab.**

Alissa tested an electromagnetic system she made. She wrapped a wire around a battery and a nail. Different sized nails were used and the number of paper clips the electromagnet picked up was measured by how many paper clips were picked up.

**Control Variable:** \_\_\_\_\_

**Independent Variable:** \_\_\_\_\_

**Dependent Variable:** \_\_\_\_\_

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**Science Fair - Scientific Method**

Downloads: 732 | Recommend this resource: 0

Writing a science fair question.

File Type: SMART Notebook lesson  
Subject: Science  
Grade: Grade 1, Grade 2, Grade 3, Grade 4, Grade 5  
Date submitted: August 2, 2012

Search terms: enrichment, scientific method, BVSD, science fair  
Submitted by: Mrs. Eckstein

Download: 5.13 MB | Open in SMART Notebook Express

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**Create your research question**

What effect will \_\_\_\_\_ have on \_\_\_\_\_?

Independent Variable: \_\_\_\_\_  
Dependent Variable: \_\_\_\_\_

**SCIENTIFIC METHOD - click on the "?" to reveal**

1. ?
2. ?
3. ?
4. ?
5. ?
6. ?

**Pick and describe a variable below then pop the balloon to check your answer.**

Independent Variable: \_\_\_\_\_

Dependent Variable: \_\_\_\_\_

Control Variable: \_\_\_\_\_

APPENDIX S

PANPIPES.NET

[Directions](#)  
[Purpose](#)  
[Objectives](#)  
[Review of Steps](#)  
[Introduction](#)  
[Steps](#)  
[Quizzes](#)  
[Help](#)  
[Glossary](#)  
[Simulation](#)

## THE SCIENTIFIC METHOD

---

### STEP 1: Choosing a Problem or Question

Tip #3:  
Your question must include both a manipulated and a responding variable.

A manipulated (or independent) variable (or MV for short) is something that you intentionally change in your experiment.

A responding (or dependent) variable (or RV for short) is something that changes as a result of what you intentionally changed.

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## THE SCIENTIFIC METHOD

---

How are rainbows formed?

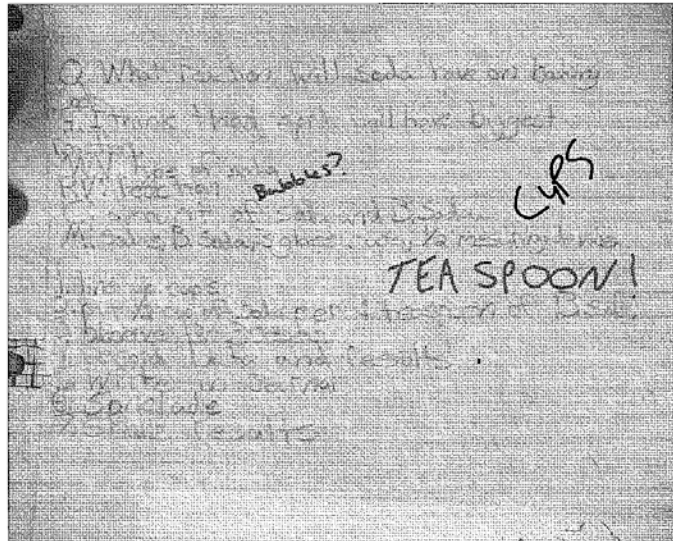
- ☐ No Manipulated or Responding Variable
- ☐ Difficult to get materials
- ☐ Unsafe question
- ☐ Good question

APPENDIX T

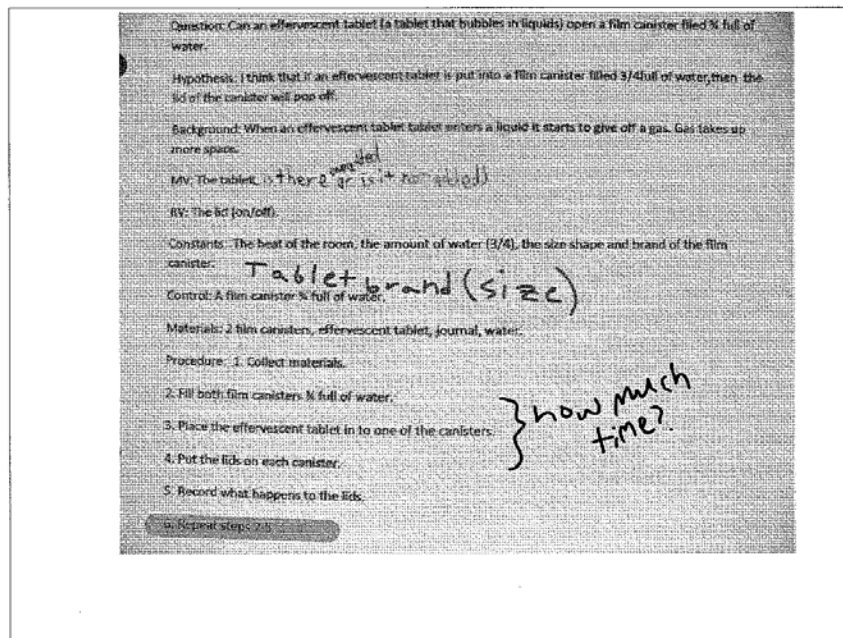
STUDENT LEAD EXPERIMENTAL DESIGN

example of editing.notebook

April 29, 2013



Apr 29-12:58 PM



Apr 29-1:21 PM

APPENDIX U

INSTITUTIONAL REVIEW BOARD APPROVAL



**INSTITUTIONAL REVIEW BOARD**  
**For the Protection of Human Subjects**  
**FWA 00000165**

960 Technology Blvd. Room 127  
 c/o Immunology & Infectious Diseases  
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 Bozeman, MT 59718  
 Telephone: 406-994-6783  
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*Chair:* Mark Quinn  
 406-994-5721  
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*Administrator:*  
 Cheryl Johnson  
 406-994-6783  
 cherylj@montana.edu

**MEMORANDUM**  
 .....

**TO:** Brooklynn Coulter and Walt Woolbaugh  
**FROM:** Mark Quinn, Chair *Mark Quinn*  
**DATE:** August 20, 2012  
**RE:** "The Effects of Interactive Technology on Student Understanding of Scientific Processes"  
 [BC082012-EX]

The above research, described in your submission of August 17, 2012, is exempt from the requirement of review by the Institutional Review Board in accordance with the Code of Federal regulations, Part 46, section 101. The specific paragraph which applies to your research is:

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

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

### Participation Consent Form

The study, "The Effects of Interactive Technology on Student Understanding and Use of Scientific Processes", will fulfill the requirements of the Masters of Science in Science Education at Montana State University. The study has approval from Byers Jr/Sr High School. The purpose of this study is to see how the use of interactive technology, such as the SMARTBoard and CPS Clickers, will affect student understanding, engagement, interaction, and retention of scientific processes.

Your child will be involved in four phases involving the scientific method and presentation of information. Pre- and post-tests, surveys, and interviews will take place. There are no foreseeable risks to the students involved. The student may be removed from the study at any time. Specific information about individual students will be kept *strictly confidential* and will be obtainable if desired. The results that are published publically **will not** reference any individual students since the study will only analyze relationships among groups of data.

The purpose of this form is to allow your student to participate in the study and to allow the researcher, Ms. Brooklyne Coulter, to analyze the outcomes of the study. Consent by guardian and student is strictly voluntary without penalty. If you have any concerns or questions, please contact the researcher at 303-822-5292 ext. 1174.

\_\_\_\_\_  
(Student Name)

\_\_\_\_\_  
(Student Signature)

\_\_\_\_\_  
(Guardian Name)

\_\_\_\_\_  
(Guardian Signature)

\_\_\_\_\_  
(Date)

APPROVED  
MSU IRB  
08/20/2012  
Date approved

APPENDIX V

PHASE LEVEL OF DIFFICULTIES

**Rate the following on their overall difficulty to understand the process of science. Please explain why you chose the answer you did. (Perhaps one of the activities included in the phase was harder than others.)**

**1 – Not difficult at all .....5 – Very Difficult**

- a. *In class group work with graphic organizer*—3 moderately difficult, but it seems like this would take less time than some of the other projects
- b. *Sponge Bob Scenarios*—4 moderately difficult, but also driven in a particular order. I would give this a 3 if given in chunks (1 scenario/class period) rather than as one large worksheet.
- c. *SMARTBoard games*—1 but more time consuming depending on the number of games done
- d. *SMARTBoard simulation*—3 moderately difficult, less so if done by class as a whole
- e. *Virtual Lab and graphic organizer*—I'm not sure what the actual lab is in terms of difficulty, but the write-up sheet seems to direct students in a fairly orderly way, so it's probably a 3 again
- f. *Hands-on lab and write-up*—4—Was there enough time to actually perform an experiment and get good results? Were 2 variables (2 different substances) actually tested (9 plants, 3 as control, 3 each for experimental groups)?
- g. *Textbook notes on the SMARTBoard*—3 when done as a group activity
- h. *SMARTNotebook Lectures*—3 moderately difficult, group work makes this less of a task
- i. *Scientific Methods Website and clickers*—2-3 difficulty, requires some amount of reading and/or prior knowledge
- j. *Experiment write-up and class editing*—3-4 lengthy process, moderately difficult

*Also do you feel the SM Quiz is representative of skills and knowledge needed?*

I would rather see more of the scenario-type questions (#19-25) rather than the general knowledge/definition questions (and therefore I think you should cut down the questions pre #19), but this does seem to be a valid pre/post test for the scientific method.

APPENDIX W

GENDER RESULTS

| Gender | Phase 1 | Phase 4 | Gain |
|--------|---------|---------|------|
| Boys   | 9.7     | 17.8    | 8.1  |
| Girls  | 12.3    | 19.1    | 6.8  |