EXAMINING THE IMPACT OF STUDENT-GENERATED SCREENCASTS ON MIDDLE SCHOOL SCIENCE STUDENTS' INTERACTIVE MODELING BEHAVIORS, INQUIRY LEARNING, AND CONCEPTUAL DEVELOPMENT

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ABSTRACT

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Analysis of the results from this study indicate that student activities involving screencast production can serve as scaffolds to enhance inquiry behavior, heighten explanation development, and encourage the connection of conceptual ideas developed by eighth grade science students engaged in interactive computer modeling. The screencast recordings enabled students to simultaneously combine their narrative explanations with a visual record of their computer modeling activity. Students (n=210) generated numerous screencasts and written explanations while participating in an online exploration focusing on global climate change and the greenhouse effect. The quasi-experimental design used in this study prompted student groups in four classrooms to screencast their final explanations concerning their modeling activity, while groups in the four control classrooms used a text entry tool to provide their explanations. Results indicated that student groups constructing screencast explanations spent 72% more time with the model (t=7.13, p<.001, d=2.23) and spoke an average of 131 words compared to the 44 written by control classroom groups (*t*=3.15, *p*=.002, *d*=0.99). Screencast groups were 42% more likely to mention inquiry behavior linked to specific values obtained from the model derived from two combined measures for on-task behavior (*t*=2.89, *p*=.003, *d*=0.90). The inclusion of causality within the explanations was examined as a measure of knowledge integration. The implemented research design assured that the composition of fully integrated student responses was reliant upon internalization, a cognitive attribute of autonomous learning. Only one text entry group (*n*=22) provided a discussion supported with at least one scientifically normative idea regarding causality, compared to five screencast explanation groups (*n*=21). This study also suggests that middle school science students who screencast explanations spend significantly more on-task time investigating computational models compared to those writing their explanations. Implications, limitations, and suggestions for further research are discussed in the presentation that follows.

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Chapter One – Introduction

Introduction to the Issue

The term “Net-Generation” was coined for children growing up in environments heavily influenced by the internet, instant messaging, interactive simulations, and seemingly endless access to information (Tapscott, 1998). These digital exposures play a significant role in how students approach, absorb, process, and apply information, yet teaching methods, content delivery, and assessment in K-12 education have remained relatively steadfast for decades (DeGennaro, 2008). Strong evidence indicates that these exposures can actually modify neural pathways in students who stay *connected* much of the time (Small, 2008). Advancements and the proliferation of communicative technologies are changing the way this generation processes information, yet our educational systems are seemingly unresponsive to this reality. Classroom instruction is still largely dominated by lecture, and the ability to recall factual information serves as our primary instrument for measuring academic progress (Harris & Rooks, 2010; Windschitl, 1999).

Standardized measures of academic achievement indicate that students in the United States are steadily declining compared to other nations (National Research Council, 2010). This decline is greatest in areas involving science and math (Lynch, Kuipers, Pyke, & Szesze, 2005; National Research Council, 2012; Toulmin, Groome, & National Governors' Association, 2007). In a five year follow-up to a science, technology, and global awareness report entitled *Rising Above the Gathering Storm* (National Academy of Sciences, 2005; National Research Council, 2010), a United States House of Representatives science committee announced that its greatest concern out of all of its alarming findings was the current state of K-12 education. The report indicates that the United States, when compared to other industrialized economies, approaches the bottom of the list for numerous Science, Technology, Engineering and Math (STEM) educational indicators, in spite of the fact that the United States invests more money per student on K-12 education than any other nation. This same committee revealed that American citizens earn less than one third of the total engineering PhD's awarded by United States universities. As the subtitle of the revised report indicates, the hurricane is *Rapidly Approaching Category 5* and disciplines related to STEM education are forecasted to receive the brunt of the damage. The response of the United States educational system to this imminent storm remains to be seen.

Extensive science education reform guidelines that promote an inquiry approach are, and have been, readily available from national, state, and local agencies. For example, the Committee on Science Learning (Duschl, Schweingruber, Shouse, & National Research Council, 2007) reports that "students learn science by actively engaging in the practice of science, including conducting investigations; sharing ideas with peers; specialized ways of talking and writing; mechanical, mathematical, and computer-based modeling; and development of representations of phenomena" (p. 251). Classroom evidence supporting these recommendations is often sparse or completely absent (Windschitl, 2006). In addition, science curricular guidelines tend to expand in depth and content with each revision, yet the amount of time devoted to K-12 science education in the United States has actually decreased in recent years (Marshall, Horton, Igo, & Switzer, 2009; McMurrer, Kober, & Centre on Education Policy (U.S.), 2007). Science educators today are tasked with teaching more material in less time with fewer resources. Add to that demand more pressure from an environment steeped in high-stakes testing, and what surfaces in the classroom is often far from *scientific* (Gyllenpalm, Wickman, & Holmgren, 2010; Longo, 2010). Consequently, practices such as laboratory activities, narrative essays, computer modeling, discussion forums, and student presentations are often overlooked or no longer viewed as essential for teaching science.

When investigations or lab activities are conducted in the school setting, teachers often treat these as special events or rewards, not as vital components of the core curriculum (Rudolph, 2003; Windschitl, Thompson, & Braaten, 2008a). Lessons developed with this mindset often reflect more of a cookbook approach to science investigations rather than an authentic, inquiry-based activity (Ketelhut & Nelson, 2010; Linn, Bell, & Hsi, 1998). While there are wonderful exceptions in place at many schools, all too frequently school science is seen as a boring series of ritualized tasks overloaded with foreign terminology and delivered at an ever accelerating pace. Missing all too often are expressions of wonder, intrigue, and curiosity – measures of success that cannot be documented on a bubble sheet.

This dissertation study adapted technologies collectively known as screencasting to serve as an alternative assessment for middle school science students actively engaged with computer models. Screencasts capture video of activity that appears on a computer display and simultaneously records the computer operator’s voice. Study participants were asked to explain certain events displayed in the model, encouraged to keep the model running, and use the visual information it provided to assist with their discussion. The rationale behind using screencasts in this manner was to provide a means of formative assessment that could be easily generated, quickly reviewed and revised by the student, and easily evaluated by the instructor.

The idea to use screencasts in this fashion originated from observations that the proliferation of high-stakes testing and the associated emphasis on easy to score multiple choice assessment items has affected the extent and manner in which science curriculum is taught (Linn & Eylon, 2011; Passmore, Stewart, & Cartier, 2009; Slotta & Linn, 2009). Multiple choice tests and similar questioning formats primarily assess memorization and recall - the lowest level of learning engagement (Bloom, 1956). The ability to recognize glossary definitions or recant factual fragments inadequately measures the underlying scientific concepts associated with any given lesson (Clark & Linn, 2003; Liu, Hee-Sun, Hofstetter, & Linn, 2008). Educators are often placed in a precarious situation where allocating additional time and resources to support inquiry learning and higher order thinking has little or no effect on student performance as measured by multiple choice assessments (Clark & Linn, 2003; Özkan, Tekkaya, & Geban, 2004). High-stakes tests are typically designed to span entire course curriculums, complicating matters even further as curricular guidelines in science tend to be expanding while instructional time diminishes. These influences result in instructional designs and classroom practices that reward memorization and recall at the expense of higher order thinking, problem solving, and creativity.

The National Research Council (1996) suggests that students should be brought to the point where scientific principles and practices learned in school are applied to settings that reach far beyond school boundaries. It has been suggested that the best way to reach this point is through the classroom engagement of inquiry learning (van Joolingen, de Jong, & Dimitrakopoulou, 2007). Linn, Clark, and Slotta (2003) described inquiry as “engaging students in the intentional process of diagnosing problems, critiquing experiments, distinguishing alternatives, planning investigations, revising views, researching conjectures, searching for information, constructing models, debating with peers, communicating to diverse audiences, and forming coherent arguments" (p. 518). This form of pedagogy encourages students to orient themselves to the issues at hand, make observations, formulate hypotheses, experiment, construct and manipulate models, develop theories, form explanations, and evaluate and refine their endeavors (National Research Council, 2000). Inquiry learning has been demonstrated as effective across boundaries associated with gender, socioeconomic status and ethnicity (Lynch et al., 2005). Inquiry learning, when properly implemented, is very fluid, full of original questions, gets children out of their seats, and stimulates their senses.

Given current discussions over national educational policies and demands for high-stakes testing, the associated use of multiple choice questions will not likely be relinquished any time soon. Subsequently, there is a definite need to further develop efficient and consistent assessment instruments that challenge students beyond memorization and recall (Pellegrino, Chudowsky, & Glaser, 2001). Yeh (2001) suggests that the easiest way to improve education may be to create assessments which place greater emphasis on critical thinking and explanation and rely less on trivial material that prompts memorization and recall. Classroom practices that involve inquiry, critical thinking, problem solving, and other investigative activities provide far better records of accomplishment but are more difficult to implement and process, especially on a large scale basis (Alberts, 2009).

A study involving middle school science students engaged in inquiry learning practices showed that students were very reluctant to offer written explanations regarding the scientific investigations they were involved with (Ruiz-Primo, Li, Tsai, & Schneider, 2010). Most of the student responses in this study either provided no data to support their claims or they just let the data stand as evidence on its own with no reasoning provided. While the students may have been full participants in the inquiry process, their means of assessment provided little or no confirmation of their activity. Newcombe et al. (2009) propose that “assessment should mandate the sorts of activities that characterize a science literate individual” (p. 546) – a challenge not easily accomplished with a multiple choice bubble sheet. If middle school students have not developed the skills to properly write about their inquiry activities and other traditional forms of assessment do not adequately identify their strengths and weaknesses, then the development and implementation of alternative forms of assessment in this area are warranted. Assessment tools aligned with inquiry learning activities must be capable of measuring complex, multi-faceted thoughts that vary widely from student to student, class to class, and region to region. These instruments need to be void of potential distracters such as the capacity to translate thinking into writing, the ability to recall intricate details, or interpret terminology not associated with the student’s everyday language (Ahmed & Pollitt, 2010). The assessments should be formative in nature, providing feedback from the actual activity while serving as indicators for cognitive development, achievement level, and overall progress.

Assessments that elicit student explanations overcome many of the fallacies embodied in multiple choice questions (Hee-Sun, Liu, & Linn, 2011; Liu, Lee, & Linn, 2011). Explanation is an inherent component of science that encompasses synthesis, evaluation, and argumentation (Driver & Newton, 2000; Sandoval & Millwood, 2005). Explanation is also thought to be an innate quality available to all humans without prejudice (Barthes & Duisit, 1975; Bruner, 2003). The act of explaining causes organization, clarification, and restructuring of thoughts which can reveal knowledge gaps or discrepancies, and may ultimately lead to the recognition that additional actions are warranted (de Vries, Lund, & Baker, 2002).

The effective use of computer modeling engages students with authentic inquiry practices and may assist in explanation development as well (Passmore et al., 2009; Zacharia, 2007). Computer modeling permits the elicit testing of student developed scientific theories that may not be accessible through other means (van Joolingen et al., 2007). Models can also free up considerable amounts of time, eliminate labor intensive processes and decrease distractions, thus allowing students and teachers the ability to focus more on the goals and objectives directly associated with the learning task (Hennessy et al., 2007; Osborne & Hennessy, 2003). Models can improve the overall quality of information by performing complex calculations and automatically depicting data as charts and graphs, thus increasing opportunities for more salient student behavior (Fund, 2007). In addition, students prefer the type of interactivity provided by models, simulations, and other forms of multimedia (Armstrong & Georgas, 2006; Oud, 2009; Sharp et al., 2005; Sims, 2003).

Computer modeling and interactive simulations encourage students to make observations, form hypotheses, conduct experiments, analyze data, reach conclusions, and readdress challenges (de Jong, 2006). Models and modeling behavior enable visual outlets for complex phenomenon, permit the testing and reformulating of various theories, and provide students the opportunity to externalize their thinking (Hogan & Thomas, 2001; Jonassen, Strobel, & Gottdenker, 2005). Various forms of scaffolding can be embedded in models to assist students with specific tasks, and at the same time, establish why specific procedures are important (Hmelo-Silver, 2006). A study conducted by Schwarz and White (2005) demonstrated that middle school students' understanding of curriculum improved when they were encouraged to provide design and evaluation input on the computer models they were working with.

Hmelo-Silver and Azevedo (2006) recognized that computer models and simulations assist student understanding of complex systems in science, but also acknowledged that most teachers are not properly prepared to guide students in the use of these tools. Professional development designed to assist teachers in the use of computer based modeling emphasizes close alignment with the curriculum, establishment of clear and realistic expectations and providing ample opportunities for student expression (Pallant & Tinker, 2004; Slotta & Linn, 2009; Varma, Husic, & Linn, 2008). Novice teachers and those new to inquiry learning tend to approach computer modeling as a simple means for proving a hypothesis and often fail to recognize its value in supporting investigations and stimulating idea development (Windschitl, Thompson, & Braaten, 2008b). Teachers often presume that their students learn more during inquiry activity with computer models than analysis of their assessment items can support (Varma et al., 2008).

Reitsma (2010) suggests that formulating explanations which describe a modeling activity are necessary to the express the causal relationships generated by the model. He claims that the output format that models provide can describe *what* took place, but some form of narrative is required to explain *why* it happened. Lemke (1990) points out that learning is directly associated with talking, not just listening, and suggests that encouraging students to *talk science* is the best way to instill them with the language of science. Oral responses from students immersed in interactive computer-based activities appear to provide better clarification of their ideas than written expression (Ahmed & Pollitt, 2010). The act of talking helped these students bring clarity to their ideas, elicited more relevant information, improved the ease in which their final answers were written, and enhanced the overall quality of their work.

Hsu and Thomas (2002) suggest that simulations and models have the capacity to record input and output activity in detail, thus allowing the manipulators the opportunity to further develop their reflective thinking skills. Self-analysis of these recordings might improve the quality of the student revisions to the model and also their ability to generate valid predictions for future activities. Most computers that run science models and simulations have the capacity to record screen activity along with an optional voice recording track – a practice referred to as screencasting (Oud, 2009; Slebodnik & Riehle, 2009). Screencasting software is readily available, simple to operate, and the videos that are created can be easily redone, edited, stored or hosted (Sparks, 2010). Screencasts are relatively new to the field of education, and the vast majority of those that exist serve as online tutorials for tasks that are procedural in nature (Peterson, 2007). It has been suggested that math instruction might benefit by having students generate screencasts for problems they attempt to solve (Fahlberg-Stojanovska, Fahlberg, & King, 2008). The recordings could then be evaluated by the instructor for areas of weakness in a far more efficient manner than what current assessments allow. My intention is to take this suggestion one step further and encourage students to self-evaluate their computer modeling screencasts, revise their hypotheses as needed, and rerecord until they are comfortable with a final product to be submitted for evaluation.

This dissertation study investigated whether the act of screencasting would function as a scaffold and provide students with a mechanism to improve their explanations, enhance the quality of inquiry behaviors performed within the model, and assist in connecting the concepts being modeled with existing ideas. Screencasting has a number of inherent features that may assist students in attaining these goals. A video created from screencasting is immediately available for review and can be easily discarded and remade as many times as deemed necessary by the student's own self-evaluation. Every remake involves another full set of model manipulations accompanied by a narrative explanation. Some remakes may allow students to test new ideas by making modifications to the model while others may be initiated to simply correct for a mispronounced word, or a stumble within a series of events. Students assume ownership for their work as they conduct these revisions and will hopefully continue until they are satisfied with their efforts and release a final cut.

Educational leaders among the science disciplines are continually challenged to develop practical and efficient ways to increase student participation with the curriculum being taught. Screencast technology applied to interactive computer modeling should engage students in *doing* science and *talking* science as well. As an assessment instrument, these recorded discussions will provide teachers and researchers with a highly descriptive account of the students' modeling behavior along with their reasoning. These screencast recordings could also benefit educational leadership as they should help identify areas of weakness, missing links, misconceptions and other learning deterrents not easily expressed through other assessment means.

Controversy

Inquiry based learning is widely embraced by constructivists and touted for its similarity to science activities conducted at research institutions and within industry. Close examination of actual practices conducted by scientists in the field reveal little commonality regarding approaches to the nature of science and the scientific method (Schwartz &

Lederman, 2008; Windschitl et al., 2008a). Some argue that students are better served with a fact-based approach to teaching science and claim that a firm foundation of facts better prepares students for behaviors involving hypotheses, exploration, experimentation, and synthesis (Mahoney & Knowles, 2010). Many in this group are comfortable with the current status quo of high-stakes testing and embrace the broad, shallow curriculum currently adopted by most K-12 educational systems. Arguments are made that as long as overall test scores continue to increase, and individual gains can be measured within students over the span of any given year or course, then the students must be benefiting from the pedagogy. Yet, we continue to slip in the global arena in many educational areas and on certain norm-referenced tests like those used for college admissions (Martin, Mullis, Foy, & Olson, 2008; National Academy of Sciences, 2005). Another unintended negative attribute for high-stakes testing is that while the assessments may have been designed to identify students who are struggling to learn and/or those that may have fallen far behind, accountability pressures applied to teachers, schools and districts often result in a system that excludes these very same children the program was designed to help (Darling-Hammond & Rustique-Forrester, 2005; Linn, 2008).

Assessments used to measure a fact based approach to learning science often take the form of multiple choice and true/false questions and many teachers are reluctant to let go of the convenience, efficiency, and affordability that these evaluation formats provide (Alberts, 2009; Clark & Linn, 2003). Multiple choice and true/false tests can be completed by students in a relatively short period of time and graded efficiently with minimal effort required from the classroom teacher. In some cases, these tests can provide students with immediate feedback - a practice not often achieved with questions that prompt students to explain their reasoning or provide support for their answers. Students also react favorably to bubble sheet questions for a number of reasons. First of all, bubble sheet entries take a lot less effort to answer in most cases and the mere action of answering, even if just a guess, represents participation at some level. For the clueless student, having a 50% chance of getting a true/false question correct, or knowing how to better the odds by eliminating distracters within multiple choice items, provides an unrealistic assessment of understanding compared to a blind attempt at an essay item (Ruiz-Primo et al., 2010). Administrators at state and district levels responsible for implementing and evaluating high-stakes tests are not likely to let go of the multiple choice format either. There is little room for subjectivity with multiple choice items; various forms of the same assessment can be readily generated and the results can be easily tallied, distributed, and analyzed.

A fair amount of controversy also exists regarding the design and implementation of computer modeling activities (Baker, Walonoski, et al., 2008; Baker, D'Mello, Rodrigo, & Graesser, 2010; Buckley et al., 2004; Slotta & Linn, 2009; van Joolingen et al., 2007). Some researchers feel that computer models used in education provide an unrealistic, overly simplified view of the scientific phenomena they represent in nature. According to this mindset, student modeling activities provide a disservice to the authentic and complex systems they represent. Limited access to computers, inadequate bandwidth or networking capabilities, lack of technical and instructional support, and other issues regarding technology also support arguments against computer modeling activities. With some model designs, students can learn from the operational mechanics of the model and employ behaviors known as *gaming the system*. These students are able to figure out how to get the model to reveal solutions without having to thoroughly explore the embedded concepts.

Modeling activity also presents numerous challenges when attempting to measure the effectiveness of the model. The amount of time students are engaged with the activity does not necessarily correlate to learning (Buckley et al., 2004). Students may follow all the procedures in a model, but often need assistance in one form or another to internalize the material and give meaning to the activity (Linn, 1996; Windschitl, 2006). This assistance often takes the form of scaffolding, and a fair amount of debate exists regarding the level to which this type of help should be made available in computer modeling activities (Azevedo, Cromley, & Seibert, 2004; Davis, 2000; Linn & Eylon, 2011; Puntambekar & Hübscher, 2005; Quintana et al., 2004). Some contend that scaffold assistance should be available to all students whenever it is needed. Others believe it should be withdrawn over time in an effort to coax students into being more responsible for their own learning. Scaffolding that is capable of reacting to the individual learner and only providing assistance as warranted is yet another vision held by certain researchers. Others recognize scaffolding simply as an overused educational buzzword that no longer serves its original purpose. For purposes involved with this proposed study, it was assumed that properly designed and well executed scaffolding can assist students in a wide variety of ways without having to *pull* them through the activity. Scaffolding can also provide an added benefit of freeing up instructional time for teachers thus allowing greater opportunities for student assistance.

Problem Statement

Instruction needs to incorporate new methods for content delivery, however, advances in technology have left pedagogy far behind (Hess, 2009; Mishra, Koehler, & Kereluik, 2009). Computer models, simulations, and scientific probeware can assist learners of all ages by helping them develop clarity and understanding for many complex topics in science, yet, the classroom integration and availability of instructional technology tools are often overshadowed by a drive to deliver content in preparation for high-stakes testing.

Numerous studies have indicated serious concerns for evaluation and feedback in science instruction (Ahmed & Pollitt, 2010; Baker, Barstack, et al., 2008; Pellegrino et al., 2001). Middle-school students are reluctant to engage in learning about complex systems in science but react favorably to well designed, complex computer models and their associated scaffolding (Azevedo et al., 2004; Hogan & Thomas, 2001). It has also been demonstrated that middle-school students can follow procedures to interface and control computer models but struggle when making conclusions based on their interactions with the model (Krajcik et al., 1998; Palincsar, Anderson, & David, 1993).

A climatology unit involving Earth's greenhouse effect was selected for the curricular area investigated in this study for a number of reasons. Students often possess various mental models that are flawed regarding the atmosphere's role as an insulator retaining heat radiated by the earth's surface (Gautier, Deutsch, & Rebich, 2006). Energy transfers involved in the greenhouse effect and particularly the association between radiation and matter are also known to challenge student comprehension (Besson, De Ambrosis, & Mascheretti, 2010). Students often mistakenly confuse components of the greenhouse effect with those involved in ozone layer depletion (Gautier et al., 2006; Kerr & Walz, 2007). While extremely persistent and very resilient to change, these misconceptions, when corrected, boldly enhance student learning of key concepts (Özkan et al., 2004). Linn et al. (2003) refer to these conceptual challenges as pivotal cases and suggests that they challenge students to employ inquiry skills to examine prior ideas and misconceptions, integrate their newly acquired knowledge to reorganize their thoughts with lived experiences. Also, climatology represents a complex system in science that is well suited for computer modeling, plus activities related to global climate change seem to increase student motivation as they are intrigued by the both the familiarity of the concept and the perceived uncertainties that exist amongst scientific, social, and political communities (Edelson, Gordin, & Pea, 1999).

This dissertation study is closely aligned with the Knowledge Integration framework developed by Marcia Linn at University of California, Berkeley, and the community of researchers, teachers and students involved with the Web-based Inquiry Science Environment (WISE) program (Clark & Linn, 2003; Linn, 2000; Linn et al., 1998; Linn & Eylon, 2011; Liu et al., 2008; Slotta & Linn, 2009; Varma et al., 2008). One of the overarching goals of the program is to promote and assist students with lifelong learning. WISE encourages in depth exploration of topics, which is often contrasted by the fast paced content delivery methods typically associated with high-stakes test preparation. This highly constructivist approach has students interact with online computer activities containing various forms of embedded assessments, interactive models, and rich visualizations of content that is closely aligned to curricular standards. The technology completes many of the task-oriented procedures involved with sorting, calculating, graphing, etc., thus allowing students to focus more attention on inquiry skills and conceptual understanding. Teachers also benefit from the technology by being able to allocate more resources interacting with students while spending less time managing their learning products.

The content deployed for this study was based upon the North Carolina Essential Standards for middle school science instruction. The curricular attention concentrated on energy transformations involved with the greenhouse effect and introduced various issues related to global climate change.

The purpose of this dissertation research study was to investigate the functionality of student-created screencasts designed as a scaffolding device to enhance inquiry behaviors among middle school science students engaged in interactive computer modeling activities. An initial assumption was that study participants would develop a deeper understanding of complex concepts related to the transfer of energy associated with global climate change. Data was analyzed to identify if any associations existed between the use of screencasting and inquiry behaviors performed while students are engaged with the interactive computer models.

Research Questions

The following research questions pertain to middle school science students engaged in inquiry-based computer modeling activities related to energy transformation, feedback mechanisms, and global climate change.

Question 1: Do students that utilize a screencasting tool to provide explanations spend more time with computer models compared to students that use a text entry tool for explaining modeling events?

Question 2: Does the act of screencasting result in explanations that contain a greater number of words when compared to explanations created using a traditional text entry tool?

Question 3: Do students that screencast explanations remain on-task to a greater extent compared to students that enter explanations with a text entry tool?

Question 4: Compared to text entry explanations, do screencasts demonstrate higher levels of knowledge integration based on the number of relevant observations containing scientifically normative ideas?

Methodology

This dissertation study took a quantitative approach that employed a quasi-experimental design. Randomization techniques were used to assign the treatment among participating classrooms, the formation of challenge scenario groupings within each class, and the distribution of various challenge scenarios to the student groups in each class. All conditions that could be controlled, with the exception of the treatment itself, were kept the same for all students participating in the study. Challenge groups in the control classrooms were instructed to write their explanations using a text entry tool, while those in the experimental classrooms were asked to screencast their explanations. Data logs were then analyzed to determine the amount of time each groups spent with the model, the number of words contained in their explanations, and the extent to which directions were followed. Explanations were analyzed further to establish a knowledge integration value which measured the relevance of student observations based on the concepts portrayed in the model and extent to scientifically normative ideas were used to support findings.

Significance of Issue

Student manipulation of screencast devices embedded within computer modeling activities is a unique proposal among the known body of educational research. Screencasting has the potential to enhance science inquiry learning activities and increase student knowledge acquisition for complex topics. The practice is potentially significant for teachers as the screencast recordings should provide a highly descriptive account of the student’s modeling behavior and associated thought processes. The screencast videos will help instructors identify areas of weakness or faulty connections not easily exposed through written explanation.

The act of screencasting is intended to function as a scaffold mechanism prompting students to explain and rationalize modeling activity of complex subject matter in science. Complex systems, like those associated with the greenhouse effect, involve a relatively large number of sequential steps which are often cyclical in nature. Student retention for these complex concepts often benefit through repetition. Unfortunately, repetition often leads to boredom and loss of interest for the concepts being taught. It was hoped that the application of screencasting to generate explanations for events being modeled would allow for meaningful repetitions and do a better job at preserving student interest and motivation.

An extensive amount of research exists regarding the design and use of interactive models in science education. An even greater body of literature addresses scaffolding employed to assist learners with their investigations, yet certain gaps in both areas of research remain. Hogan and Thomas (2001) observed that students often approach interactive models as having only one correct answer even though the models were designed to encourage inquiry learning through exploratory behavior. To a large extent, these students did not realize they could use the model to test and analyze various ideas and they paid very little attention to the output data generated from their activity. Exposing students to a variety of model types and complexities is recommended as a possible way of overcoming this challenge. Again, there is very little research regarding student awareness of model output and how those perceptions affect subsequent revisions to the model. Designing scaffolding prompts that motivate students who assume little responsibility for their own learning and are difficult to reach through conventional means, represents another research challenge (Davis, 2003; Edelson et al., 1999; Linn, 1996).

Thomson et al. (2009) recognize the struggle many students have when assembling evidence or output information to generate explanations for scientific events. These authors claim that because science curriculum is generally presented in a narrow context, the struggles demonstrated by students are often due to lack of experience with complex tasks and big ideas. Students also face challenges when they confront a large number of variables or are provided numerous pathways to follow. This issue is compounded further when output data reflects this same level of variation. While models by definition represent simplifications for real phenomenon in nature, models associated with intricate concepts, like global climate change and the geosciences, can still seem quite complex (Gautier et al., 2006; Reitsma, 2010; Windschitl et al., 2008a). Thorough analysis for the explanations students generate from activities involving complex models is generally lacking as most research attention has either focused on the design of the model or the retention of key concepts portrayed by the model.

Though the technology to enable screencasts has been available for decades, as of 2007, screencasts had only been discussed in research literature twice and both of those articles involved library science (Peterson, 2007). Generally speaking, screencasts are created as training tools for activities that are sequential in nature and may require a fair amount of repetition to master. Screencasts have become very popular in recent years and are now widespread on the internet. Academic use of online tutorials is still somewhat limited with library sciences serving as the prime exception. Many public and academic libraries now offer banks of online tutorials that assist with research, record retrieval, and other task-oriented behaviors. The recent surge in these electronic resources can be attributed to the demands of the end user, overall reduction in library staffing, availability of screen capture software and the ease with which videos can now be created, stored, and retrieved online (Brumfield, 2008; Slebodnik & Riehle, 2009).

The amount of literature on screencasting has increased significantly in recent years, even to the extent that you can now find published articles that misconstrue the original intent of the design (Bailin & Peña, 2007). Practically all of this available literature examines the use of screencasts as a means of content delivery for information that is generally sequential in nature and/or requires a certain level of technological know-how on behalf of the end user. Although other disciplines have started using screencasts for tutorial purposes in recent years (Evans, 2011; Falconer, deGrazia, Medlin, & Holmberg, 2009), the application of screencasts as a student centric tool for self-assessment in an inquiry learning environment is lacking among the body of literature examined for this study. The development of assessment instruments that provide accurate portrayals of student understanding while simultaneously assisting learners with their conceptual development of complex systems in science is definitely warranted. This study examines whether applying screencasting as a means of student assessment and expression may help fill this apparent void.

Definition of Terms

Constructivism: a knowledge theory that suggests learning is accomplished through interactions constructed between ones' ideas and lived experiences. The role of educators under this theory is to support learners as they attempt to make sense of the world that surrounds them.

Knowledge Integration: a mental perspective that recognizes that learners possess numerous, often conflicting ideas for the same concepts in science. Meaningful and sustainable understanding for new ideas is realized through the elicitation, sorting and linking of existing ideas with new ones.

Scaffold: appropriate support devices that selectively assist learners in constructing meaning by extending the range of what would normally be obtainable without such assistance.

Screencast: a digital recording of computer display activity, typically accompanied by a narrative audio track which details the computer event being captured.

Organization of Study

The content in the remainder of this paper explores screencasting as an alternative assessment instrument designed to enhance and measure inquiry science learning skills performed during computer modeling activities. Chapter two reviews science education literature related to learning theory, conceptual development, scaffolding and other assistive strategies, and discusses how they relate to interactive model development, inquiry learning, and student expression. The methodology, research design, and means for implementation are discussed in Chapter three. Results gathered from the research study are presented in Chapter four and the final chapter provides and a detailed analysis of this data, establishes limitations regarding the scope and of this study, and discusses the need and potential pathway for further research.

Chapter Two – Literature Review

Introduction

Chapter two provides a broad overview of literature pertaining to science education, instructional technology, inquiry based learning, computer modeling and numerous assistive techniques designed to improve conceptual development. Additional information is provided to help define the theory of knowledge integration as the conceptual framework used in this study. The final section of this chapter presents a review of literature related to student comprehension for complex systems in science, examines various forms expression used to measure gains in this area, and analyzes assistive technologies as potential learning scaffolds.

Classical Literature

The scientific method is often touted for its straight forward, orderly, and somewhat universal approach. In practice however, the scientific method is rarely followed by field scientists and is especially absent in science classrooms (Windschitl et al., 2008a). Many science educators teach the principles of the scientific method and espouse to follow such judicious methodology, but what usually starts and finishes each day in a science classroom is far from the ideals proposed in this method over a century ago. Hennessy et al. (2007) suggest that students can improve their scientific reasoning abilities by using a variety of technology tools such as models, simulations, animations, and data logging instruments. These authors’ ideal view of a teacher assumes a facilitator role that assists students by “selecting appropriate resources, sequencing and structuring learning activities, adapting to particular learners' needs, and guiding students' experimentation, generation of hypotheses and predictions, and critical reflection upon outcomes" (p. 149).

Developing confidence with inquiry learning activities requires a foundation of relevant facts that can be connected to new findings (Bransford, 2000). Meaningful inquiry practices need to also tap into ideas that children bring with them to the classroom. Those who are unable to confront their existing ideas often fail to understand new concepts or may remember them only for a test and then quickly revert back to their misconceptions. Linn et al. (1998) suggest that

> instruction should support students as they contrast, integrate, and differentiate their ideas. All student ideas, whether they are intuitions, observations, or scientific principles, should enter into this process. Only if students consider all their ideas can they reliably and consistently develop the robust models that will serve them well as lifelong learners. (p. 8)

Simply engaging students in active learning events does not necessarily guarantee clearer reasoning or improved knowledge acquisition (Linn, 1996; Windschitl, 2006). Discovery activities, open-ended investigations or certain self-paced lessons have the potential to leave many students behind. Students may be able to follow all of the procedures and reach an endpoint but assistance in various forms is often needed to internalize the concepts and give meaning to the activity. De Jong (2006) claims that the most effective science classroom learning environments integrate inquiry activities and direct instruction to reinforce, rather than isolate the activities. Yet, these two modes of instruction are often treated as separate entities, which are frequently labeled *lab* and *lecture*.

Science standards that call for inquiry practice as a primary mode of content delivery but rely solely on assessments that measure recall add to the perceived incongruity between lab and lecture (Liu et al., 2008; Newcombe et al., 2009). Instructors, under pressure imposed by high-stakes assessments, often feel the need to *teach to the test* (Longo, 2010). These teachers frequently abandon inquiry practices, or never initiate them, in an effort to capitalize more time for the delivery of factual information residing in a very broad and shallow curriculum (Clark & Linn, 2003; Linn, 2000; Linn, Lewis, Tsuchida, & Songer, 2000; McMurrer et al., 2007). Consequently, classroom discussions are typically limited to teacher delivery of content in the form of lectures, notes, handouts, worksheets and other forms which allot very limited opportunities for student input. Rop (2002) adds support to this claim by demonstrating that even within so called *discussion-centered* classes, the most fundamental of scientific practices, questioning, is often shunned. His study involved high school chemistry classes where teachers asked *sixty* times more questions than their students. On the rare occasions when students in this study asked questions, most were informational, procedural, off-task, or trivial in nature.

Students who achieve success in classroom environments where student-to-teacher interactions are limited are able to recreate the teacher's logic, connections and reasoning at time of assessment (Windschitl, 2006). Those students that have not fully developed these skills must rely on 'the brute force of memory' to perform well (p. 352). Teacher initiated questions directed to a classroom of students can leave the false impression that students understand more than they actually do. Questions posed in this fashion are often answered correctly, but usually by one or two male individuals that typically offer answers on a regular basis (Varma et al., 2008; Wellesley College Center for Research on Women & American

Association of University Women Educational Foundation, 1992). Taking all of these issues into consideration, it is difficult to expect students to develop a scientific voice when they are simply not given opportunities to practice using that voice in the classroom (Lemke, 1990).

Scientists in the field allow models to provide a voice for their research findings and interpretations, and according to Passmore, Stewart and Cartier (2009), science students should do the same. They claim that

> all scientific disciplines are guided in their inquiries by models that scientists use to construct explanations for data to further explore nature. The development, use, assessment, and revision of models and related explanations play a central role in scientific inquiry and should be prominent feature of students' science education. (p. 395)

Building and modifying interactive computer models encourages scientific thinking and causes students to reflect on their own mental representations, but these benefits are only realized if the subjects have some understanding for the nature and purpose of the model in use (Gobert & Pallant, 2004; Sins, Savelsbergh, van Joolingen, & van Hout-Wolters, 2009). Jonassen et al. (2005) add that output products generated by student modeling activity can serve to assess intellectual growth. These authors include a note of caution by suggesting that most technology-based models provide few, if any, variable manipulations which subsequently inhibit inquiry learning and conceptual change. Similar findings were reflected in pre-service teachers, most of whom lacked a general understanding for scientific modeling (Windschitl et al., 2008b). With more exposure and experience, their epistemological views developed over time as did their ability to construct and effectively use models as authentic science inquiry tools. Schwarz and White (2005) recommend exposing students to a wide variety of different models and simulations as another strategy for improving learning associated with interactive modeling.

The use of interactive student models inherits certain risks as well. Attention must be directed toward the models' design, implementation, and support. A study involving high school science students identified numerous difficulties encountered during modeling activities (Sins, Savelsbergh, & van Joolingen, 2005). These students struggled with the selection and proper use of variables in the model, had difficulty with feedback mechanisms, and failed to apply prior knowledge to the concepts being modeled. The authors suggest implementing a holistic, top-down approach to modeling where expert models are presented for student review prior to the actual model engagement. When to use models and interactive animations over static graphics also demands attention as motion and flow can cause visual confusion with certain concepts (Betrancourt, 2005).

A study involving secondary science students engaged in a WISE activity revealed that those less familiar with computers actually gained more knowledge compared to their familiar counterparts (Wecker, Kohnle, & Fischer, 2007). The researchers suggest that this may be due to the observation that the more familiar students spent more time browsing through the activity and less time examining its content. Some students involved with computer activities often engage in behaviors commonly referred to as *gaming the system* (Baker, Walonoski, et al., 2008; van Joolingen et al., 2007). The challenge for students involved with gaming behaviors is to complete the activity as quickly as possible with the least amount of effort. Thus, it is not surprising that students with greater exposure to computer technologies would attempt to cheat the system. Embedding numerous support systems designed to break gaming behaviors increases student involvement within the unit and improves the quality of their inquiry activity.

Boredom is another detrimental attribute that can lead to gaming behaviors, and according to R. Baker et al. (2010) it is especially persistent and difficult to modify. These authors place boredom above frustration in terms of risk and suggest that the best solution to avoid problems is to simply not let students get bored in the first place. Designing components that pique student curiosity, offer a sense of challenge, and include content that is both interesting relevant to the students can reduce the risk of gaming. Visualizations have potential to illustrate concepts where words fail and they can captivate students' attention. If not designed and implemented properly though, visualizations can confuse, frustrate and even cause abandonment (Edelson et al., 1999; Krajcik et al., 1998; Linn, 2003; White & Frederiksen, 1998).

Linn (1996) suggests that properly designed scaffolds can progress students toward a goal of independent learning. She classifies learners into three categories - autonomous, active, and passive. Autonomous learners take initiative to seek additional information, critique their own understanding for newly acquired concepts, and apply what they have learned to new situations confronted outside of the classroom. Active learners are easily engaged, follow procedures well, and generally perform assigned tasks adequately but rarely internalize what they are learning. Active learners often rely on others to initiate and steer them through complex lessons. Passive learners hope to simply absorb material conveyed in the classroom, put forth the least amount of effort, and are the most difficult to motivate and engage. Interestingly enough, most teaching styles tend to cater to this last classification of students as lectures, videos, PowerPoint presentations, etc. encourage passivity among learners. Instructors will often require that students take notes, prompt them to ask questions or may issue frequent, even daily assessments in an effort to make them more active with their learning, but the methods for content delivery rarely change.

Consequently, many students approach interactive computer models as a series of distinct steps, which if followed correctly, will lead to a single correct solution. In the absence of prompts for deeper exploration and/or calls to integrate existing ideas, active learners may complete an activity without ever analyzing the model's output or revising input criteria for subsequent testing (Hogan & Thomas, 2001; Reid, Zhang, & Chen, 2003). Properly designed and implemented scaffolds can help students reflect upon what they are learning, integrate new knowledge with existing ideas, and invoke strategies of their own creation to assimilate difficult concepts confronted in the future. While teacher input is viewed by some as the ultimate scaffold to direct and assist students, instructor access to all individuals working on self-paced computer activities is extremely limited (Hmelo-Silver, Duncan, & Chinn, 2007). Therefore, properly designed scaffolding devices embedded within modeling activities serve as critical components for intellectual development. Discovery activities alone simply do not provide students with adequate support (Hmelo-Silver, 2006). On the other hand, care has to be taken to ensure that the scaffolding does not simply hurry students along in a step-by-step fashion with little or no reasoning taking place. Davis (2003) classifies these type of procedural scaffolds as *direct* prompts and reserves the term *generic* to describe prompts that elicit reflection behaviors among students.

In an effort to bring uniformity and consensus to a widely diversified field in education, Quintana et al. (2004) published a theoretical framework for designing scaffolding tools used with science inquiry software. Their framework emphasizes the need for design tools that connect prior knowledge and experiences to current learning objectives. Making student thinking more visible and allowing for multiple means of interaction with the software can also benefit students. Effective designs should provide guidance in the form of leading questions, hints, and exemplars. Meticulous tasks such as mathematical calculations and graphing data are automatically handled by the software allowing students greater opportunity to focus on lesson objectives. Students should be prompted at numerous points throughout an activity to reflect upon and share their findings. Establishing boundaries or limitations for student exploration, constraining the number of available functions or variables, and assisting learners with the sequential aspects of inquiry activities enable less complex and more manageable components. According to these authors, scaffolds provide assistance based upon three types of need. *Sense making* scaffolds provide the learner with support for basic operations involved with testing hypothesis and interpreting data. Scaffolds can also assist with process management by helping students make strategic decisions regarding inquiry activities. Scaffolds designed properly for online inquiry units and the interactive computer models that may be contained within should support all three of these needs without taking away student control of the activity.

A number of researchers feel that scaffolding has become generalized to the extent that many of the original tenets proposed by Vygotsky, Woods, Bruner and others have been largely abandoned (Hmelo-Silver & Azevedo, 2006; McNeill, Lizotte, Krajcik, & Marx, 2006; Puntambekar & Hübscher, 2005). One of the original principles frequently missing in today’s instruments is *fading* - a practice that gently pulls the assistance away as the learner becomes more comfortable with the task. Scaffolding tools also need to provide ongoing diagnostics and adjust the level of support based on individual requirements. Azevedo et al.

(2004) demonstrated that adaptive scaffolding is more effective than the using fixed scaffolds or none at all. Davis (2003) contends that the major challenge remaining with scaffolding is to design prompts that work with students who have little or no autonomy towards their own learning. Similar to the earlier discussion of the passive learner (Linn, 1996), Davis's suggestion is based upon findings that show that less autonomous learners expect their teacher to identify their weaknesses rather than using self-identification methods.

In a similar fashion, Ahmed and Pollitt (2010) propose using a *support model* to distinguish how much help students require to succeed, rather than measuring how often, or what it takes to see them fail. Even students that know the answers to certain challenges often struggle in finding ways to adequately express themselves. According to these authors, students need a sense of comfort in knowing that their ideas, regardless of their validity, are welcomed by both the instructor and their peers. Encouraging students to work with a partner may help reduce some of this apprehension as well.

Driver and Newton (2000) contend that argumentation plays a vital role in both science and science education and condemn educational practices that hinder student opportunities for this type of expression. Yeh and She (2010) showed that online argumentation, when combined with conceptual change theories, improve students' scientific knowledge. They also acknowledge that students generally lack opportunity to engage in argumentation both inside and outside the classroom. Jonassen and Kim (2010) claim that "argumentation is the means by which we rationally resolve questions, issues, and disputes and solve problems. Embedding and fostering argumentative activities in learning environments promotes productive ways of thinking, conceptual change and problem solving" (p. 439). They suggest that requiring students to memorize large amounts of factual information is one of the steepest obstacles opposing argumentation. In other words, it is hard to argue when there is no room for disagreement.

Argumentation has been described as the process used by scientists to assess the validity of explanations generated as a result of modeling activity (Passmore et al., 2009). Students often struggle when trying to connect existing evidence to support their arguments (Bell & Linn, 2000; Driver, 1995; McNeill et al., 2006; Sandoval & Millwood, 2005). These students may revert to long held personal beliefs which are often flawed, they may focus only on a small segment of available evidence, or they may offer no support at all. Much of the current research regarding the logical use of argumentation in science draws upon Toulmin's work which recommends four components for proper argument development - data, claim, warrant and backing (Seethaler & Linn, 2004; Toulmin, 1958). The parameters suggested here for argumentation are also congruent with inquiry learning, experimentation, explanation development, and the general practice known as the scientific method. While distinctions and nuances exist among all of these labeled behaviors, as a collection, their commonality far exceeds their variation. Developing techniques that students can use to effectively communicate their own involvement with these behaviors represents the general purpose of this proposed research and will hopefully lead to better understanding of complex concepts that students confront in science.

Conceptual Framework for the Study

Knowledge integration can be defined as

> a dynamic process where students connect their conceptual ideas, link ideas to explain phenomena, add more experiences from the world to their mix of

> ideas and, restructure ideas with a more coherent view. (Bell & Linn, 2000, p. 797)

Knowledge integration is based on decades of research conducted by Marcia Linn and her research associates at the University of California, Berkeley, combined with numerous national and international research institutions including, but not limited to, the University of Toronto, the Concord Consortium, Tufts University, the Technion: Israel Institute of Technology, Vanderbilt University, and Educational Testing Services. The framework emanated from Linn's work with Piaget in Geneva, Switzerland, as she began to question finite boundaries separating the various stages of his cognitive development theory (Linn, 2006). She quickly realized that children hold numerous, conflicting beliefs for the same scientific phenomena. This leads to intellectual confusion when these same concepts are confronted in the classroom. The WISE consortium designs online activities for a wide range of science topics in an effort to better develop the metacognitive skills required to sort, analyze, modify, and accommodate the vast array of students' scientific ideas.

Knowledge integration recognizes that many students and adults have the misconception that science, with the exception of discovery, is relatively static and void of controversy (Driver, 1995). Accordingly, when thoughts in the classroom conflict with previously held ideas, students often fail to modify their original conceptual understanding. They may either abandon the new concept, or maintain two separate theories for the same phenomenon – one for school and one for everywhere else (Linn, 2000). For new ideas to fully develop, learners need to connect existing interpretations with new ones (Bransford, 2000; Varma et al., 2008). Knowledge integration obtains support through four basic tenets:

make science accessible; promote autonomous learning, help students learn from others, and make thinking visible (Linn & Eylon, 2011).

Providing access to content and activities which are relevant to students helps establish meaningful connections, increases retention, and facilitates the use of lifelong inquiry practices such as critical thinking, problem solving, synthesis, and experimentation (Slotta & Linn, 2009). For effective learning models to persist over time, students need to confront all of their ideas, preconceptions, and intuitions head-on in order to be aware of internal conflicts that may exist (Linn et al., 1998). The knowledge integration framework invites students to share all of these ideas in a learning environment that values misconceptions as learning opportunities, not wrong answers.

Supporting autonomous learning is a second tenet of knowledge integration and requires more than just active engagement in the learning process. Newly acquired concepts will only be retained over time if students are able to internalize them in some way. Student behaviors that involve self-reflection, sorting, argumentation, experimentation, or even a simple prompt to explain their reasoning, increase retention and assist with the development of lifelong learning skills (Davis, 2003). Learners may fully participate in hands-on or inquiry activities, follow directions, form a hypothesis, answer questions, manipulate data, draw conclusions, etc. but in order for their activity to promote autonomous learning, they must internalize the event in some way. Knowledge integration promotes the development and application of various forms of prompts and scaffolding to assist students within activities and help them become more autonomous with their learning. This approach is a rather dramatic shift when compared to common science education models which stress content delivery and factual memorization.

Providing social supports through collaboration and peer exchange is a third highly valued tenet of knowledge integration. Vygotsky, Cole, John-Steiner, and Scribner (1978) advocated that children learn best in a social context interacting with peers who share similar interests. Accordingly, design principles that emphasize knowledge integration promote collaboration through student groupings, peer review, mock debates, and demonstrations. Properly designed activities also encourage some individual input in an effort to discourage passivity among group members (Linn, 1996). The advent of social networking and interactive Web 2.0 tools provides tremendous opportunities for further collaboration among students, teachers and experts in the field (Slotta & Linn, 2009).

The fourth tenet of knowledge integration strives to make ideas visible and recognizes the use of visual aids to simplify understanding of intricate concepts and complex systems. Linn (2003) defines visuals as “any representation of a scientific phenomena in two dimensions, three dimensions, or with an animation” (p. 743). A well designed flowchart, simulation, video, or even a simple image can make all the difference for concepts that are not very intuitive and steeped with strange terminology. Care has to be taken to ensure that visuals do not oversimplify the concepts they represent or confuse the learner by adding unfamiliar variables (Chiu, 2010).

Knowledge integration also promotes the use of visuals as manipulative tools for expression of student ideas. It is important that students have the ability to translate their thoughts into a visible format that can be critically analyzed, modified, and redeveloped to express growth in the learning process. Students make thinking visible when they conduct activities that prompt them to write out answers, draw a diagram, complete equations, label an image, or graph data. These products benefit the learner by providing a visual representation of their thoughts and supply teachers with a quality record of their aptitude regarding the subject matter. Interactive models and visualizations are especially helpful in making student thinking visible (Casperson & Linn, 2006; White & Frederiksen, 1998). The model's visual output is based upon the input variables selected by the student. Many of the interactive modeling activities used in WISE provide small windows that mirror the data output in the form of charts and graphs as the model is running. Interactive models such as these allow the learner to investigate history by literally sliding back the time to pinpoint conditions when favorable trends started to take shape or possibly identify what caused the system to *crash* to levels well below the baseline. The students can test their ideas quickly, view them in a format that has some entertainment value, and gain a sense of challenge with the activity (Slotta & Linn, 2009).

Results gained from the modeling activity can be shared with peers to reveal multiple setup scenarios capable of producing similar results. Model designs that effectively incorporate these types of features reduce the risk of boredom and the associated detrimental effect on learning and behavior (Baker et al., 2010). Motivation is also heightened when the concepts being modeled are familiar to the students or topical in some way. The more students know about the nature of the model and modeling behavior, the more they gain from working directly with the models and the better prepared they are for those encountered in the future (Gobert & Pallant, 2004; Schwarz & White, 2005).

Student use of screencasting also fits well with the foundation underlying knowledge integration. Screencasting permits students to capture their modeling activity and associated explanations, quickly review and analyze their results, and then modify their research design to incorporate as many new ideas as needed. The screencasts that students generate while engaged with an interactive computer model represents a multi-media depiction of their own ideas. Subsequent analysis, reflection, and possible modifications made to the model will further increase the likelihood that behaviors and knowledge gained from the activity will be internalized. Student created screencast productions resemble short video clips and can be easily shared in a social context through websites such as YouTube and Facebook. The screencasts can also be made readily available to other members of the class through the network infrastructure supporting the overall project.

The learning environment for the interactive computer activity established an atmosphere that welcomed *all* student ideas, and not just those deemed appropriate for the discussion at hand. If ideas that are off-task or irrelevant to the topic surface, they are rewarded at a higher level compared to those that provide no ideas at all. If students learn by making connections, then they have to summon up at least two thoughts or there is nothing to connect to. Fear of providing a wrong answer simply does not meld well with the highly constructivist foundation that knowledge integration theory upholds.

The data gathering mechanisms used in this study included design components to accommodate the four basic tenets of knowledge integration. The video component of the screencast aligns directly with the tenet for making student thinking visual. Students often create repetitive manipulations with interactive models and under normal conditions; their previous activity disappears as soon as the model is reset. However, a screencast recording for the same modeling event results in a tangible object that can be viewed repeatedly and analyzed thoroughly. The visual aspect of the model stimulates the initial explanation and the subsequent analysis of the screencast will hopefully catalyze further investigation and ultimately promote autonomous learning.

The particular session where data was collected for this study had students working collaboratively in groups of three or four. This design component supports the knowledge integration tenet that learning is heightened when it takes place in a social context. Grouping students for the final session increased the likelihood that alternative points of view might be discussed. Confronting a wider array of ideas through group interaction makes divergent thinking more accessible and increases the relevance for the content being presented.

Research Literature

Windschitl, Thompson, and Braaten (2008a) take a critical view of the scientific method and its treatment within education circles. These authors contend that the scientific method has little merit in science and actually undermines children’s conceptual knowledge and scientific disciplinary practices as it prompts followers to make predictions rather than test ideas. While this variation may initially seem subtle, the act of predicting assumes there is a known, finite result which leaves little room for discovery. Accordingly, most investigative or lab activities conducted by students follow a distinct, finite series of steps which, when followed correctly, lead to one, predefined outcome. School science practices may be disguised with jargon and a regiment that attempts to qualify them as authentic, but they are far from scientific. Alternative theories, divergent pathways, and supported argumentation are generally not encouraged on *lab days*. Following procedures and completing assigned tasks on time takes precedence over curiosity, intrigue and wonder. While structure is warranted in all learning environments, investigations conducted in school settings need to allow for the free expression of student ideas and provide opportunities to explore beyond the confines of an instructional set.

According to Windschitl et al. (2008a), emphasis on scientific method should be replaced with model-based inquiry, which they define as “a system of activity and discourse that engages learners more deeply with content and embodies five epistemic characteristics of scientific knowledge: that ideas represented in the form of models are testable, revisable, explanatory, conjectural, and generative” (p. 941). Each student researcher determines the appropriateness of the model by comparing their outcomes to phenomena in nature. The authors also contend that models are used universally within all sciences and that their association with the operator/scientist naturally encourages explanation development.

Many middle school students need assistance in developing explanations, especially when trying to describe complex subject matter (McNeill et al., 2006). These students also have difficulty determining what information counts as evidence and what qualifies as theory (Kuhn, 2010; Sadler, 2004; Sandoval & Millwood, 2005). Students typically do not provide sufficient evidence to support their claims and they often place their own beliefs ahead of inferences supported by data (Hogan & Maglienti, 2001). McNeill et al. (2006), relying heavily on the work of Toulmin (1958), recommend simplifying explanation development into three components: a claim, evidence, and reasoning. The claim attempts to answer a question, which is supported or refuted by the evidence and justified through reasoning. This line of thought suggests that scientific theories are not events of discovery, rather, they exist as constructed explanations to rationalize occurrences in nature (Sandoval & Millwood, 2005). The fate of this theory therefore hinges upon the effectiveness of the argument and the persuasive capabilities of the narrator.

Before students can be expected to argue effectively or create meaningful oral narrations, they need opportunities to develop their explanations and these behaviors are simply not very common in science classrooms (Driver & Newton, 2000; Yeh & She, 2010). Effectively prompting students involved with interactive modeling activities may represent one way to increase the frequency and overall quality of explanatory behaviors (Slotta & Linn, 2009). Nearly a decade ago, Hsu and Thomas (2002) recommended that interactive computer models contain the ability to record student actions. The intent for this suggestion was to provide instructors with the capability of viewing these recordings, identifying specific areas that warranted additional assistance, and modifying their lesson prior to the next session. Technology has advanced to the point where recordings of actual computer activity as it appears on the monitor can be simultaneously combined with an optional voice track narrated by the student/operator. The resulting video, known as a *screencast*, is available for immediate playback using the same software that recorded the activity. Screencasts are also referred to as online tutorials and some articles use these terms interchangeably. The same hardware and software components required for screencast production are also used for the creation of online tutorials.

Students involved with producing screencasts have the opportunity to review their own recordings, enhance their metacognition skills, develop better conceptual understanding for the events being modeled, and improve their rationale *before* submitting a final product for approval. It is hoped that after viewing their modeling activities and listening to their explanations, students will analyze their results independently, modify their existing hypothesis, and rerun the model with the new variables and/or reasoning in place. If students choose to re-record their activity due to a mispronounced word or awkward stutter in their presentation, these additional recordings may help reinforce understanding for the complex concepts being modeled.

Screencasts are gaining attention by researchers in other disciplines. Peterson (2007) was one of the first to examine screencasts as a receptive tool for learning. In this study, a series of screencasts assisted library science students with cataloging and classifying material using the Dewey Decimal System. The author points out that prior research regarding screencasts has been limited to library science and most of the current studies still reside within that field (Ergood, Padron, & Rebar, 2012; Gravett & Gill, 2010; Stagg & Kimmins, 2012). Almost exclusively, existing studies evaluate screencasts for their tutorial potential with information being passed asynchronously from teacher to student.

A well-conceived and fairly extensive list of guidelines has been published on creating screencasts for tutorial purposes (Oud, 2009). Suggestions are offered to help minimize distractions, tap into pre-existing knowledge, and increase critical thinking among students. The author stresses the importance of knowing your audience and designing tutorials based upon their existing conceptual knowledge and prior experience. Learners with greater conceptual understanding and/or experience would be able to select specific sections of the tutorial based upon individual needs. For instance, designing screencasts to meet the needs of students with little prior knowledge might include numerous worked examples, thorough explanations, and multiple opportunities for practice with unlimited access to support. Those with a better conceptual understanding coming into the activity could jump to the specific section that they required assistance with, thereby reducing the risk of boredom and frustration.

Perhaps, the most decisive item in Oud’s study simply asks if text or graphics could serve the learner just as well as a screencast could. This is an important point as it has been demonstrated that screencasts can create distractions and cause considerable frustration for the learner (Palaigeorgiou & Despotakis, 2010). Many of the computer science students involved in their study used the screencast to *write* instructional lists by repeatedly pausing and playing the video at various points. These students could not keep up with the pace of content delivery in the tutorial screencast and found it too frustrating to switch back and forth between the actual computer application and the screencast tutorial. The perspective of both of these studies places the instructor as the media producer with an audience of student participants. From a constructivist vantage point, reversing these roles to allow students to generate their own screencasts for self-assessment and instructor review would appear to be a natural extension and would require only minor modifications to Oud's (2009) guidelines, thus improving the cognitive value of the tool.

Prompting students to *orally* explain their activity by means of screencasting may prove beneficial as research by Ahmed and Pollitt (2010) revealed that many earth science students struggle to adequately convey known ideas through written expression. Students in this study often failed to write the correct answers to certain questions even though previous discussions revealed that they clearly understood the concepts. It is also interesting to note that writing came easier to the students in this study who were prompted to talk about their ideas first, compared to those that were just asked to write their explanations. Enabling the production of student created screencasts to encourage the use of spoken language might alleviate some of the written expression challenges observed with this age group and result in better understanding for the concepts being explored.

Narrative explanations can serve as a rich expression of a model's output and convey far more information than graphs or other statistical formats can provide (Reitsma, 2010). These explanations express knowledge by giving meaning to the data and revealing causal relations contained within the model. Narrative production also helps define curricular boundaries and maintains order for highly sequential events like those often associated with interactive computer activities (Hazel, 2008). Modeling activities that involve environmental and geosciences can benefit tremendously by narrative development given the inherently complex nature of both disciplines (Reitsma, 2010).

If students generate screencasts, the explanations they provide should be prompted by their observations and manipulations as the model is running. Written explanations for the modeling activity could require pausing the model at various intervals to allow time for entering text. Certain text tools appear as floating windows which permit writing while the desktop activity appears uninterrupted. More than likely though, students charged with writing their explanations would run the model in its entirety and then generate their explanation after the model has run its course. These students have to rely on recall to generate their answer as the model no longer serves as a scaffold that prods their explanation along. If the act of screencasting causes middle school students to increases the number of times they rerun the model, or changes the frequency and type of manipulations they perform with it, their inquiry skills and overall understanding for the concepts being modeled might show improvement.

A thorough review of the existing literature indicates that the implementation and use of student generated screencasts to portray and explain interactive computer modeling has the potential to enhance conceptual knowledge and improve inquiry skills for the complex series of events being modeled. This dissertation research represents the first known study to examine the use of student-generated screencasts to assist in explanation development and improve inquiry behaviors associated with interactive computer modeling. While there is a lack of published research to directly support the claim made at the top of this paragraph, results obtained from this study lend support to the idea that middle school science students obtain numerous benefits by screencasting their explanations as compared to creating them with a text entry tool. The remaining chapters in this paper discuss the research design and methodology implemented to guide students through the four-session activity, present the results obtained through their participation, analyze those findings in a context to promote conceptual development and autonomous learning and establish criteria for further investigation.

Chapter Three - Methodology

Methodological Approach

Science students exhibit a great deal of diversity in their approach and interaction with computer models (Hsu & Thomas, 2002; Quintana et al., 2004; Reitsma, 2010; Slotta & Linn, 2009). Some explore the models as they would a video game by seeking a winning conclusion that expends the least amount of effort over the shortest possible time period. Other students may follow procedures and manipulate the model as intended, only to misinterpret or fail to use the results from the activity to support their reasoning. Still others manipulate the models by changing multiple variables at one time and are therefore unable to determine with any level of certainty the probable cause of the modeling outcomes. Students across all of these categories may appear to be actively engaged and excited to work with the technology, but gain little or no intellectual benefits from their explorations. Instructional designs need to support high levels of student interest and motivation without hindering the inquiry attributes associated with the model. The methodology and research design developed for this study examined the effectiveness of student generated screencasts on both inquiry behaviors associated with interactive computer models and conceptual understanding for the curriculum being explored.

The inquiry unit used in this study investigated the atmosphere’s role in helping earth maintain relatively stable temperatures and explored possible scenarios that influence climatic stability. The online computer learning unit designed and created for this study used a learning platform developed by the Technology Enhanced Learning in Science (TELS) research group under the direction and leadership of Marcia Linn at the University of California, Berkeley (Linn & Eylon, 2011; Slotta & Linn, 2009). TELS was established in 2003 by the National Science Association and serves as a national Center for Teaching and Learning. TELS research and other associated programs managed under the same direction are developed on and delivered through an online internet portal known as WISE (Web-based Inquiry Science Environment). See Appendix A for more details regarding the WISE environment and student activity within.

The particular interactive model used to gather data for this research is an extension of Uri Wilensky's NetLogo product (Tisue & Wilensky, 2004) which has been modified and implemented into various units within the WISE community. Researchers at the Concord Consortium, an educational technology research and development organization located in Concord, Massachusetts, are long-standing TELS research partners and have been influential in the design and implementation for many of the online components intended for use with this research (Buckley et al., 2004; Pallant & Tinker, 2004). Numerous national and international university research partners, program alumni associated with the private sector, plus participating classroom teachers all contribute to the educational learning community established by WISE. The findings from this research will hopefully add to this longstanding and continuously evolving body of knowledge. The remainder of this chapter discusses the research design and specific methodology employed in this study and further elaborates upon the intellectual influences and contributions established through these research partnerships.

Research Questions

The following research questions pertain to middle school science students engaged in inquiry-based computer modeling activities related to energy transformation, feedback mechanisms, and global climate change.

Question 1: Do students that utilize a screencasting tool to provide explanations spend more time with computer models compared to students that use a text entry tool for explaining modeling events?

Question 2: Does the act of screencasting result in explanations that contain a larger number of words compared to explanations that are typed using a text entry tool?

Question 3: Do students that screencast explanations remain on-task to a greater extent when compared to students that enter explanations with a text entry tool?

Question 4: Compared to text entry explanations, do screencasts demonstrate higher levels of knowledge integration based on the number of relevant observations containing scientifically normative ideas?

Research Design

Accurately measuring the effects that screencasts may or may not have on student inquiry behaviors required a research design that was closely aligned with the curriculum, provided meaningful feedback to all parties involved, and did not interfere with the overall learning objectives established for the project. The design also needed to maintain enough complexity to encourage the full exploration and testing of student ideas conducted throughout the unit. Care had to be taken to ensure that there was enough variation among the control and test groups to warrant conclusive findings, but not so much deviation that one group suffered due to the treatment or lack thereof.

The means by which students explained and supported their findings from the challenge scenario served as the independent variable in this study. *t*-tests were used to determine if significant relationships exist among the control and experimental groups for total time spent with the model, number of words provided, on-task behavior, and the degree which explanations contained normative ideas. It was hypothesized that positive relationships of a significant nature would exist among the experimental group and these four dependent variables.

The treatment was randomly distributed among 12 eighth grade science classrooms located at one middle school by pulling class section numbers from a hat until 50% of the participating class sections were assigned. The remaining classrooms served as the control group for this project. All students worked independently for the first three sessions of the project where the bulk of the content and background information was delivered through a multi-media format that included text passages, video segments, interactive computer models, simulations and a wide range of various assessment instruments. Students were prompted to provide written explanations for certain modeling activities by using a text entry tool. Other steps that involved computer models instructed the students to create screencast recordings to document their activity with the model. The screencast tool recorded the model activity displayed on the computer monitor and was accompanied by the student's voice explaining the activity in narrative form. All students had numerous opportunities during the first three days of activity to create explanations using both types of tools.

The students were randomly assigned to various challenge scenario groups prior to the final session. Group sizes consisted of three or four students and the various group scenarios (red, green, and blue) were equally distributed among all the classes. The model created for this final session provided more output features than those the students encountered during the first three activity days. The nature of the content being conveyed through the model was also more complex compared to earlier versions. This final modeling session was poised as a *challenge* to the students, and they were instructed to apply what they had learned thus far to setup conditions needed to achieve desired results. In order to meet the challenge, groups had to devise a way to operate the model in a fashion that met the goal presented to them. Participants then had to formulate an explanation that supported their reasoning either through screencasting or text entry depending upon their assigned treatment group.

Additional steps were taken to ensure that internal validity remained as high as possible within these various scenarios. Student groups were tasked with maintaining or restoring specific levels of atmospheric carbon dioxide, surface ice coverage, or ocean surface temperatures within the model for an extended period of time. The three modeling scenarios differed only with regard to the expected outcomes students were asked to maintain. The actual model, along with all of the default and start settings were exactly the same for all three challenge scenarios. Starting points for the model, prescribed lengths of runtime intervals, and the variable manipulation options were also the same for each scenario type. Appendix B contains a detailed listing of the three sets of background information provided to students for this activity.

Presenting a variety of challenge scenarios was necessary to reduce the amount of cross-over that could have occurred with upwards of nine separate groups working within the same computer lab setting. Multiple scenarios also enabled a social setting where like and unlike groups could compare and contrast their findings and recommendations. Scenario groupings in the control classrooms were prompted to submit their discussions in written form, while those in the experimental groups were asked to create screencasts for the same task. Specific instructions are provided in Table 1. Note that the two areas in italics represent the *only variation* among control and experimental groupings. With the exception of challenge scenario assignments, all other conditions were exactly the same for all participants throughout the entire four session inquiry unit.

Table 1

Student Instructions for Challenge Scenario Step

Preliminary instructions provided to *all groups* prior to accessing the challenge model (appeared above the model in a series of floating windows)	To successfully complete this challenge, your team must work together to use the model effectively and efficiently. You do not want to make final recommendations regarding CO_2 level reductions without having adequate data to back up your proposal. Pay close attention to all features of the model as you use it for your predictions. Accurately record the input data and results for each attempt with the model as you will be asked to present your findings once your team has obtained a possible solution. Click "Next" for additional instructions. • Turn the "Show-only-10%" switch to the "On" position. • Remember that the speed-slider is available if you need to change the rate at which the model runs. • Keep the "Human-emission" slider set to 0% for the first 20 year run. • You may only adjust this slider for the twenty year run beginning on 2032. • Make lots of observations and take accurate notes for each attempt your team performs. • Once you have found a solution, proceed to the "Part C" for instructions on how to report your findings.

Control group instructions (appeared in a floating, resizable window above model)	*In the space provided below*, explain how your team used the model to complete your challenge. • Please mention prior attempts that you made with the model and briefly summarize those results. • Use the tools and data output provided by the model to defend your team's CO_2 emission reduction recommendation. You may want to RUN the model and describe in detail the events that take place within the model. All members of the team are expected to contribute here in one form or the other.
Experimental group instructions (appeared in a floating, resizable window above model)	*Create a screencast to* explain how your team used the model to complete your challenge. • Please mention prior attempts that you made with the model and briefly summarize those results. • Use the tools and data output provided by the model to defend your team's CO_2 emission reduction recommendation. You may want to RUN the model and describe in detail the events that take place within the model. All members of the team are expected to contribute here in one form or the other.

The experimental treatment with the challenge model occurred near the end of the project. All students by that point had interacted independently with a wide variety of models which gained in complexity with each introduction. Students interactions with these models included such activities as monitoring temperature fluctuations on the moon, focusing in on solar energy transformations at earth’s surface, erupting volcanos to change atmospheric greenhouse gas concentrations, observing oceans absorb large amounts of carbon dioxide from the air, and analyzing fresh snow, sea ice, and melting glaciers to determine which surface absorbs the most solar energy. Various screenshots of some of the models implemented during the first three project sessions are displayed in Appendix C. Students were familiarized with both methods of explanation as they created two independent screencasts and provided numerous text entries during the three sessions leading up to the challenge scenario.

The tool used to provide final instructions and accept text entry was designed as a resizable, floating window that appeared above the model itself. This allowed student groups to work on their written explanations while observing and maintaining full functionality with the model – a feature often missing from similar assessments of interactive computer models. Specific instructions regarding the challenge model appeared at the top of this text entry box which encouraged screencasting students to also keep that window open while they were actively engaged with the model. The flexibility of this pop-up window helped maintain high levels of internal validity by ensuring full and uninterrupted functionality of the model for all student groups as they progressed from making observations to generating their explanations and recommendations. Similar to the setup for written explanations, the act of screencasting did not restrict any functionality with the model.

The instructional prompts for both groups asked students to make final recommendations regarding how much human emissions would have to be lowered to meet the challenge. They were also instructed to include specific data and results obtained from the model to support their findings. The number of student groups that provided these specific recommendations was recorded as a measure of on-task behavior. In other words, did they do what they were asked as evidenced through their presented findings and recommendations?

The design of this study relied heavily on the knowledge integration construct which supports a great deal more than the learner's ability and willingness to follow procedure.

Knowledge integration was recently defined by Lee and Liu (2010) as “students’ knowledge and ability to elicit and connect scientifically normative and relevant ideas in explaining a scientific phenomenon or justifying their claim in a scientific problem” (p. 669). Knowledge integration theory suggests that students gain understanding for scientific concepts by assimilating existing ideas with newly confronted ones in a process that compares and contrasts, links some and abandons others (Linn, 2006). According to this theory, the retention of new concepts is dependent upon the links, connections and assimilations that learners establish.

Knowledge integration development is often evidenced through the explanations that learners formulate, specifically the extent to which they include and properly connect scientifically normative ideas to the concepts they are attempting to give meaning to. The degree to which students were comfortable sharing their ideas regarding the challenge scenario was one of the first design features incorporated into this study. Understanding that 100% participation from all members or groups within any classroom setting is not always realized, a t-test was performed to be determined if a significant difference existed between the experimental and control classrooms for the number of groups failing to turn in a response.

Properly assigning the degree of accuracy and the extent to which ideas were presented by each challenge group was another important design component of the study. Internal conflicts often exist between newly acquired ideas and very persistent, non-normative or underdeveloped ones. It is often extremely difficult to replace or modify these long held ideas, but it is even more of an obstacle if the ideas are never exposed by the learner. Consequently, design implementations that value knowledge integration methodologies strive to create learning atmospheres that encourage learners to present *all* relevant ideas, despite their measure of accuracy. After the screencast narratives were transcribed into text, a knowledge integration rubric was used to assign a scale score to each group that provided feedback on their modeling activity. The rubric discerned how well explanations aligned with what was being asked of each group and awarded additional points based upon the number of normative ideas provided to support those explanations. The knowledge integration rubric is discussed in greater detail in Chapter Four and displayed there in Table 6. Knowledge integration scores obtained by screencast and text entry groups were compared using a t-test and an appropriate measure of effect size.

It is imperative when designing computer inquiry units that students are provided with ample opportunities to explore and become fully engaged with the entire range of instructional constructs. When employing the use of interactive computer models within the activity, additional support is often needed to encourage the proper use of inquiry skills. As mentioned in previous sections of this paper, students will often try to *game the system* in a number of different ways if they find the conceptual challenge presented by the model to be overly simplistic or too advanced. Given this awareness, a great deal of care and deliberation accompanied the design for each of the numerous models created for the learning activity.

This study sought to determine if the means by which students described their interactions with the model, through screencasting or writing, had any influence on the inquiry skills used with the model. Screencast explanations were later transcribed into text and both types were copied to a word processor and spreadsheet for further analysis. A word count was conducted for both forms of explanation. An analysis was conducted measure how well student groups remained on-task based on their reported findings. A second analysis determined the extent to which student explanations included normative ideas relevant to the concepts presented in the activity. Specific details and thorough discussions regarding these measures are presented in later sections of this chapter and in Chapter Four.

The total amount of time spent working with and discussing the model activity was recorded for each group participating in the study. A *t*-test was used to determine if any significant differences existed among the experimental and control groups regarding time spent with the model. A Cohen's *d* was used to measure the effect size for any resulting variation among the two groups. The average length for both types of explanatory formats was determined by conducting word counts. A comparison between experimental and control groups was then examined using the same type of statistical analysis mentioned above.

The number of variable manipulations and data output displays tends to increase as interactive computer models become more complex. Subsequently, the chances for distraction and off-task behavior tend to increases as well. The challenge model introduced features, manipulations and data displays that were more complex than what students experienced with earlier models. As shown previously in Table 1, all student groups received very specific instructions on how to interact with the model and what types of information to include in support of their findings. Explanations were analyzed to determine if group responses included a discussion about their activity with the model and if they presented a specific recommendation about the level of reduction in greenhouse gas emissions required to meet the challenge presented to them. A series of independent t-tests and measures of effect size were performed for these two variables. A frequency analysis was also conducted to analyze trends among groups that displayed both on-task behaviors, only one such behavior, or none at all.

In summary, the research design and methodology employed in this study assumed somewhat of a backdoor approach to learning by suggesting that if students are given a better mechanism for formulating explanations, their knowledge integration for complex concepts in science should improve accordingly. The study represented an initial step to determine if screencasting technology applied to modeling activity can assist student explanation development, knowledge integration, on-task behavior, and inquiry skills refinement to a greater extent than writing can.

Design Rationale

The research design and methodology implemented in this study were influenced to a large extent by the researcher’s sustained involvement with the WISE/TELS research community. The learning units developed for WISE projects are *not* intended for distance learning applications and rely heavily on the leadership, stability, and instructional guidance provided by the classroom teacher (Linn & Eylon, 2011; Slotta & Linn, 2009; Urhahne, Schanze, Bell, Mansfield, & Holmes, 2010). WISE acknowledges the role of the classroom teacher as an essential and vital contributor to student learning - conditions not always observed in other computer-enhanced classroom scenarios for fear that active teacher participation might interfere with and influence certain research objectives. WISE research encourages this direct involvement while maintaining high levels of validity and reliability due to a number of design factors. For example, many of the research questions investigated in WISE are quite discrete and are often embedded in areas that may not seem obvious. The overall complexity of these units and the interactive nature of the design keep participants engaged with content that is closely aligned with curriculum. See Appendix D for a more detailed account of the teacher's direct experience within the WISE/TELS learning environment.

WISE online computer units are designed to facilitate the integration of existing ideas with new concepts revealed through the inquiry activities. For many students, this new information may appear overly complex, counter-intuitive, or even contradictory when compared to their existing conceptual understanding. Knowledge integration suggests that much of this anxiety can be reduced by supporting learning in a social context (Linn & Hsi, 2000). Students are consequently encouraged to work in small groups when engaged with WISE activities. Individual students still maintain their own identity within the project as each student has a unique login, complete many of the assessments independently, and can be assigned different investigative roles at various points in the unit. In the unit designed for this study, students worked independently during the initial sessions, and were randomly assigned into groups to complete the final component of the unit.

The greenhouse effect and global climate change were selected as curricular themes for this study based on middle school curriculum alignment, prominence in current discussions, and because they have been well established as difficult concepts for students to effectively process (Gautier et al., 2006; Özkan et al., 2004). After completing introductory activities designed to acquaint the participants with the online environment, students received background information regarding the science involved with the unit. Students were prompted to make predictions, share ideas, and revise their responses at numerous points throughout the inquiry unit. Helping determine through manipulation what will appear next in a computer model can help with motivation, exploration, and conceptual understanding, but care has to be taken to ensure that interactions do not overwhelm students or prompt them to begin gaming the system (Baker, Walonoski, et al., 2008; Betrancourt, 2005).

Material presented in WISE units is age appropriate and relevant to the students' experience. For instance, when describing the greenhouse effect, discussing a car in a parking lot on a sunny day with the windows up would be more familiar to most middle school students than an actual greenhouse analogy. Also, if the consequences of increasing stream temperatures were being presented, students located in the Pacific Northwest might study salmon populations, whereas trout would be more relevant to participants conducting the activity in the mountains of North Carolina. Students are not totally reliant on the examples provided for them though, as they are prompted to examine their own ideas, establish connections, and share their experiences and thoughts with others. The research design developed for this study paid close attention to all of these details in an effort to increase the likelihood that students would internalize what they were learning during the activity and then accurately call upon their findings well beyond middle school.

Role of the Researcher

In addition to the design and analysis components described in detail in other sections of this paper, I assumed additional responsibilities associated with project management, implementation and professional development for this project. I have been in direct association with the WISE group of researchers and have actively participated with many of the inquiry units dating back to 2004. I have served as a consultant on numerous projects and contributed valuable information through direct communications at conferences, retreats, workshops and indirectly through webinars and other forms of electronic communication. In the district where this research was conducted, I have served in a leadership role for more than a dozen middle and high school science teachers involved with WISE/TELS. In that capacity, I acted as a liaison between the various research institutions involved with the project, district and school administrators, and classroom teachers. I also provided technical support to setup and maintain the software at the local level and held numerous professional development sessions for participating teachers. I served as a model for new teachers in the program and would actually run the initial project with their students from start to finish. The teacher's role during that first run was to observe and assist with the activity as I modeled its implementation. Teachers then assumed more of a leadership role with subsequent unit runs with the lead teacher providing assistance as needed.

I viewed myself in a similar role with the research methodology conducted with this study. The participants were eighth grade students and teachers at a school that I currently serve at as an instructional technology facilitator. While it is understood that my close working relationship with these teachers and students does not help the validity and reliability of the research, my association should benefit other study objectives by providing greater opportunities to reveal shortcomings and design flaws in this initial research. Serving as a professional liaison among researchers, students and their teachers on numerous occasions has bettered my understanding of the established research and greatly assisted the design for this study. I feel confident that my experience over the years as a lead teacher combined with my technical prowess for the hardware, software and network infrastructure associated with my current position as an instructional technology facilitator enhanced the research design, methodology and overall learning experience for all participating groups associated with the project. It is hoped that this study will result in findings that meet established research guidelines while allowing for a hearty analysis of the overall design instrument to ensure that subsequent research may be performed with even higher levels of proficiency.

Ethical Issues

Prior to implementation, the experimental design, treatment activity and data collection techniques for this study satisfied rigorous standards established by the university's internal review board and a similar committee that oversees research activities at the district level. The Institutional Review Board (IRB) at Appalachian State University granted this study an exemption from further review on the basis that the research fell under normal educational practices and settings. A letter of agreement was generated and signed by the principal. Participating teachers also provided their written consent to partake in the study with the understanding that the research provided minimal risk to both teachers and students. A letter containing information about the nature of the research study, a detail regarding student participation, and information pertaining to confidentiality was sent home with each eighth grade student. This letter provided parents and guardians with an option to select an alternative assignment for their child, one that would not be included within the scope of this research. The research process and the nature of the study were discussed with the students and they were also provided with the option to participate with an alternative assignment. No parents, guardians or students exercised that option and written assent was obtained from each student prior to their active participation in the study. Students were also given the option of opting out at any time during the study, though they all chose to remain active participants. Anonymity could not be guaranteed due to the investigator's professional relationship at the school being studied, although strict confidentiality was maintained throughout.

Data Sources and Collection

Students encountered numerous assessment pieces throughout their activity with the inquiry unit. These were designed for reflection and to check for understanding of key curricular concepts. These items appear in many different forms and require a variety of response types which included the use of text entry tools, screencast productions, short answer responses, match sequencing and challenge questions. All of the student responses were available to teachers and researchers for review at any point during the unit and archived after completion. Teachers were encouraged to review and make comments to these assessment items on a daily basis, but specific data obtained from these steps are not included in the general research scope of this study.

WISE logs various types of information from student interactions and these log files can be customized to provide datum pertaining to specific research questions. Data log files were electronically captured during the challenge scenario modeling section of this unit. The total amount of time spent with the challenge model as students prepared for and reported on their findings was recorded by the WISE server. The student's written explanations were saved to the WISE server while screencast explanations were hosted on the local network at the middle school. Written and screencast explanations that students generate during all sessions were archived and may be examined further in subsequent studies.

Participants

The global climate change project was conducted with eighth grade science students at a middle school in the western portion of North Carolina. The ethnic makeup of the school is predominantly Caucasian (65%) with Hispanics representing 21% of the population, African Americans at 7%, Asians at 4%, and multi-racial students representing 4%. The percentage of students receiving free and reduced lunch is approximately 55% at the school level and 50% across the district.

All eighth grade students participated in the study although the last four of the twelve classes were unable to complete the unit due to activities and celebrations that accompanied the last week of school. Consequently, data analyzed in this study came from eight classes with an equal distribution of four control and experimental classroom groups. Eighth grade was selected for this study because of the curricular alignment with the North Carolina Standard Course of Study and the North Carolina Essential Standards.

Data Coding

The rubric used to measure the extent to which student groups added their own ideas to their findings was adapted from one used by Lee and Liu (2010) for a large scale study conducted with middle school students and their ability to assimilate complex energy concepts. The knowledge integration construct measures more than what students know or do not know with regard to specific concepts - it includes the students' ability to *elicit* their ideas and *connect* them in meaningful ways. This rubric has six levels which range from 'Irrelevant response' at the low end of the scale to 'Integrated response' at the top. A complete description of this rubric, its coding application, and obtained results are presented in Chapter Four.

Data Analysis

Students in control group classrooms reported their challenge procedures, findings and rationale in written form using the onboard text entry tool, while the experimental groups submitted their explanations using the screencasting method. Both groups received the same direction and were offered the same assistance with the one exception being the specific instructions for the two tools. Data logging for the challenge model activity kept track of the amount of time each group spent with the challenge model. The narratives generated by screencasting were later transcribed into text to enable comparisons regarding word counts and on-task behavior. Both forms of explanation were archived and are available for possible examination that extends beyond the realm of this study.

Data were analyzed to determine if significant differences existed between the type of tool used to record challenge scenario explanations and the extent to which students apply inquiry practices while engaged with interactive computer models (see Appendix B for an overview of the interactive model proposed for this study). A series of independent *t*-tests accompanied with a Cohen's *d* measure for effect size was conducted for each of the four dependent variables involved with the inquiry activity.

Trustworthiness

It is acknowledged that significant threats to internal and external validity exist in the proposed research design for this study. Even without any conscious effort, my presence as both a researcher and employee serving the teachers and students represented in this study inevitably had some influence on the results. Measures were taken to ensure that my role within the district and at that particular school had a minimal effect on student outcomes and subsequent analysis of the collected data. The activity's design and the nature of its implementation had students receiving the bulk of their content and specific instructions through the scripted computer activity - not from their teacher or the facilitator/researcher. In addition, all results that were captured on both network servers were assigned a group identification number to ensure that no student names were associated with the data. It is also understood that while the sample size was more than adequate for the analysis proposed, sampling within a single district and only at one school is less than ideal. Nonetheless, the knowledge and experience gained through the direct exposure and narrow scope of this study should prove invaluable when expanding the research to a larger context.

Given that these inherent threats exist, there are still ways to limit their influence. The use of random assignment and distribution helped maintain high levels of internal validity. Randomization techniques were employed when assigning the treatment to various classrooms, for the formation of student challenge groups, and in assigning the various scenarios to those groups. In addition, student assignments for science classes used in this research were populated by a computer program that gives high priority to balancing class loads while accommodating other student scheduling commitments. While these classroom assignments are not purely random, they are not influenced by gender, achievement level, age, or attributes indicative of ability grouping.

The research design and methodology employed in this study sought to achieve a balance where participants were able to explore and examine content through an online computer activity that utilized a wide variety of media formats and assessment instruments. A great deal of care was taken to ensure that students not only developed conceptually through their experience with the activity, but that their newly gained knowledge and understanding regarding global climate change could be called upon long after the fourth session had finished. The findings presented in the next chapter as well as the discussion that follows in Chapter Five examines the effectiveness of these overarching goals and presents potential modifications that may serve to improve this line of research in the future.

Chapter Four - Findings

Introduction

This dissertation study explored screencasting as an alternative means of expression compared to written assessments among middle school science students engaged in computer modeling activities. The investigation specifically examined if prompting students to screencast their findings and discussions affected the amount of time spent with the model, the overall length of explanation provided and the extent to which specific instructions were followed. The resulting screencast and written explanations were examined for differences regarding the amount and accuracy of ideas offered to support their modeling activity.

The curricular design for the online learning unit involved a thorough examination of scientific processes associated with the greenhouse effect and climate change. Students were actively engaged for three one-hour sessions working independently with media formats that included video content, text entries, descriptive images, simulations, and interactive computer models. Students worked with a wide variety of interactive models during the first three one-hour sessions and created numerous screencasts and written explanations based on their modeling activity. Student group participation during the fourth and final session involved running the model for a simulated 20 year period and observing the resulting changes to the amount of sea ice coverage, ocean surface temperature, or atmospheric temperature. Groups then manipulated the model with the goal of determining the optimal human-emission levels of greenhouse gases needed to return conditions to their original levels within the next 20 year span. Screencast and text entry groups were instructed to explain how they used the model to complete the challenge and to provide specific data to support their findings. This chapter describes the participants involved with this study and presents the data and results collected from their activity.

Participants

The participants involved with this study included eighth grade science students at an economically and ethnically diverse public school located in the foothills of North Carolina. The original design called for participation of all eighth grade students taught by three teachers, each of whom had four classes averaging 26 students per class. Due to unforeseen scheduling conflicts in the last week of school, four of the classes taught by one teacher had insufficient time to finish the activity. Therefore, results discussed in this were obtained from students ($n = 210$) in eight classrooms taught by two teachers. Challenge scenario groups in four classes were instructed to screencast their explanations ($n = 25$) while groups in the control classrooms ($n = 29$) wrote their explanations.

Attendance and participation was high throughout the four session activity with daily absences averaging less than 3% of the sampling population. A randomized list of students was generated for each class prior to the challenge activity and was used to assign groups of three to four students just prior to the start of the fourth session. Those not in attendance for the challenge activity ($n = 11$) were not assigned to a challenge scenario group and their place was filled by the next available student on the randomized class list. All students that began the challenge scenario were present for the entire session.

Additional components beyond those being analyzed in this study were added to the final session in an effort to keep groups that finished early engaged throughout the entire class period. While most groups did not complete the entire session, activity logs indicated that all groups (*n* = 54) participated with the specific step where the treatment was applied. A number of groups (*n* = 11) did not submit either type of explanation. This lack of participation was evenly distributed among the control and experimental groups (*p* = .23) which indicates that the treatment had no influence on their willingness or ability to submit an explanation. Subsequently, the time spent with the challenge model recorded for these particular groups is not included with the results section below.

Results

This section presents results related to inquiry behaviors associated with interactive computer models, the degree to which these behaviors were on-task, and the level of support as measured through the explanations created is also presented. Data obtained by groups that were screencasting their explanations were compared to those prompted to write their responses. The results from this study were collected and analyzed using a number of different techniques which are presented individually in the following discussion.

Results regarding the amount of time each group spent with the interactive modeling step were collected from data logging files recorded on and later retrieved from the WISE server that hosted the activity. The research design developed for this study had the various sets of instructions, the text entry tool, and the screencast program appear as floating, resizable pop-up windows that appeared above the interactive challenge model. The amount of time recorded for each group included actual time engaged with the model, all time spent reading directions, and the amount of time spent formulating written or screencast explanations. Individual time components could not be identified as both the experimental and control groups were encouraged to run the model while forming their explanations.

Table 2 displays *t*-test results for the average amount of time groups spent on the modeling step. Screencasting groups spent an average of 615 seconds more time on the model step which represented a 72% increase compared to groups using the text entry method for explanation development. The *p*-value of <.001 and Cohen's *d* of 2.23 confirmed that the treatment was significant and had a large effect on those screencasting their explanations.

Table 2

Summary of Analysis for Time Spent on Modeling Step between Screencast and Text Entry Groups

	Screencast Groups (*n*= 21)		Text Entry Groups (*n* = 22)					
Characteristic	*M*	*SD*	*M*	*SD*	*df*	*t*	*p*	*d*
Time spent with model (seconds)	1464	351	849	96.0	41	7.13	***<.001	^{ttt}2.23

Note. *p < .05, **p < .01, ***p < .001. Cohen's (1992) suggestion that effect size of ^{t} = 0.2 is small, ^{tt} = 0.5 is medium, and ^{ttt} = 0.8 is large.

Additional data was collected and analyzed as quality indicators for student interactions with the challenge model and for the products of learning associated with their activity. The first component for this criterion measured the amount of words student groups used when forming their explanations. Screencast narrations were transcribed using a word processing program and word counts were then conducted for the explanations provided by all groups. The results displayed in Table 3 indicate that screencast groups demonstrated a 200% increase for the number of words provided in their explanations compared to those using the text entry method. A *t*-value of 3.15 combined with a *p*-value of .002 and large effect size (*d*=0.99) indicated that factors associated with screencasting caused these student groups to provide explanations that contained a far greater number of words compared to those entering text explanations.

Table 3

Summary of Analysis for Number of Words in Explanation between Screencast and Text Entry Groups

	Screencast Groups (*n*= 21)		Text Entry Groups (*n* = 22)					
Characteristic	*M*	*SD*	*M*	*SD*	*df*	*t*	*p*	*d*
Number of words in explanation	131.0	128.2	43.6	21.4	41	3.15	**.002	^{ttt}0.99

Note. **p* < .05, ***p* < .01, ****p* < .001. Cohen's (1992) suggestion that effect size of ^{t} = 0.2 is small, ^{tt} = 0.5 is medium, and ^{ttt} = 0.8 is large.

The research design for this study established two measurable components to determine if the student generated explanations contained the type of on-task information that was asked of the student groups. The instructions embedded within the challenge step specifically asked students to mention how they used the model to complete their challenge activity. A value of '1' was awarded to groups that mentioned the model in their explanation and a value of '0' was assigned to those that did not. Student groups were also instructed to report the specific reduction levels of CO_2 emission needed to meet the challenge scenario. The other measure of on-task behavior examined if groups recommended specific CO_2 reduction levels in their explanations. The same '1' and '0' scoring method used to establish a quantitative value for analysis.

The results from both of these inquiries are presented in Table 4. Student groups that were screencasting their explanations scored significantly higher for both measures of on-task behavior compared to those that used the text entry method. 86% of the screencasting groups included some reference to the interactive computer model in their explanations verses 64% of those writing their explanations. The statistical analysis indicates that the treatment had a medium effect size (*d*=0.52) on the likelihood that instructions about including the model in their discussion were followed. A large effect size (*d*=0.87) was established regarding the inclusion of specific emission level recommendations within group responses. For this measure, 62% of the screencasting groups included such a recommendation verses 23% for those groups using the text entry method.

Table 4

Summary of Analysis for On-task behaviors between Screencast and Text Entry Groups

	Screencast Groups (*n*= 21)		Text Entry Groups (*n* = 22)					
Characteristic	*M*	*SD*	*M*	*SD*	*df*	*t*	*p*	*d*
On-task: Model discussed	0.86	0.36	0.64	0.49	41	1.67	*.05	^{tt}0.52
On-task: Made recommendation	0.62	0.50	0.23	0.43	41	2.77	**.004	^{ttt}0.87

Note. **p* < .05, ***p* < .01, ****p* < .001. Cohen's (1992) suggestion that effect size of ^{t} = 0.2 is small, ^{tt} = 0.5 is medium, and ^{ttt} = 0.8 is large.

Individual groups were also examined for the number of favorable on-task attributes that were provided in group explanations. Each group's explanation was analyzed and received a label based upon their inclusion of *both task* behaviors, *one task* behavior, or *no task* behaviors present. These data are presented in Figure 1. Results indicate that screencast groups were more than four times as likely to include both on-task behaviors in their explanations when compared to text entry groups.

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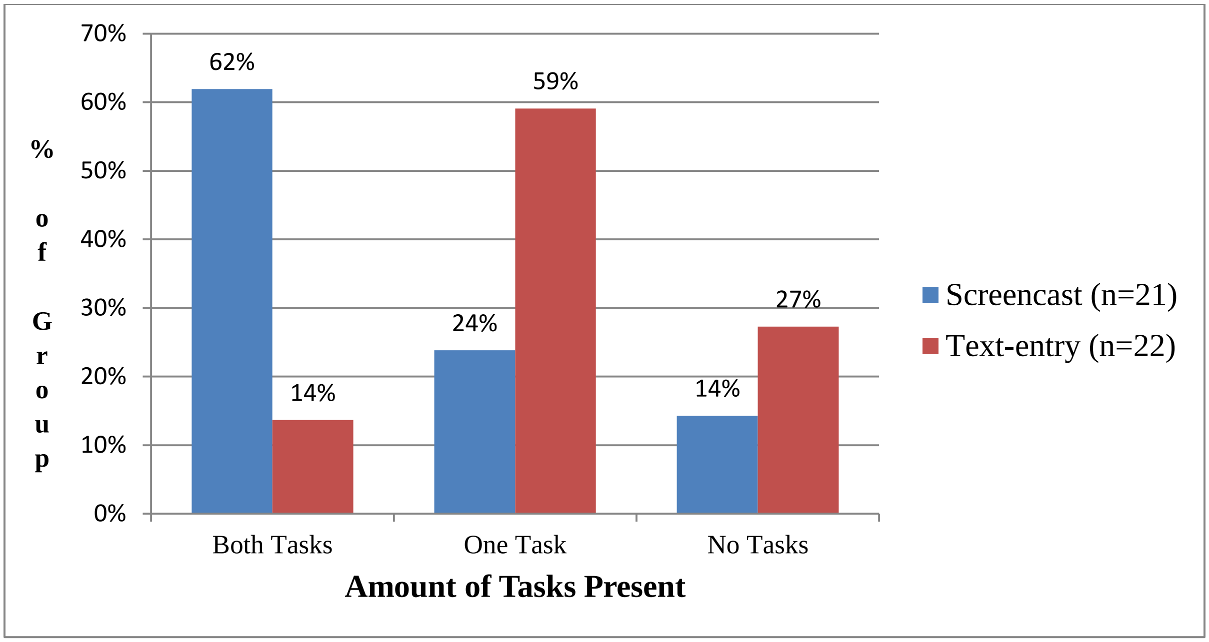

Figure 1. Percent of screencast and text entry groups exhibiting on-task behaviors.

A Knowledge Integration (KI) component was also examined to determine if students were able to apply both what they had learned during the activity along with prior knowledge when explaining their activity with the model. KI recognizes that students bring a lot of pre-existing ideas to the classroom and rather than simply abandon those that are incorrect or underdeveloped, learners are encouraged to bring forth all of their ideas and modify and/or build upon the ideas they possess. To promote autonomous learning, KI encourages learners to expose all of their ideas, especially those that may conflict with the concepts being presented as that is necessary to ensure that misconceptions do not surface long after the lesson is complete. Consequently, the KI rubric displayed in Table 5 awards points based upon the inclusion of relevant observations and the extent of scientifically normative *and* non-normative ideas that were provided in support of their findings.

Table 5

Knowledge Integration Scoring Rubric

Irrelevant response	1	Challenge response was irrelevant to the context presented by the activity.
Incomplete response	2	(a) Challenge response included relevant observations but presented no solution. *Or* (b) Challenge response presented a solution, but did not include relevant observations.
Partially connected response	3	(a) Challenge response presented a solution that was connected to relevant observations, but integrated no conceptual support. *Or* (b) Challenge response included relevant observations and integrated conceptual support containing at least one scientifically non-normative idea, but presented no solution.
Connected response	4	Challenge response presented a solution that was connected to relevant observations, and integrated conceptual support containing one scientifically normative idea.
Integrated response	5	Challenge response presented a solution that was connected to relevant observations, and integrated conceptual support containing multiple scientifically normative ideas.

It is important to note that students were instructed to *explain* their activity with the model, but were not directly prompted to include ideas as to *why* or *how* the events occurred as they did – information offered in this regard was voluntary and rewarded at a higher level based on the rubric. Table 6 displays the results derived for the KI component of this study.

Table 6

Analysis of Knowledge Integration Scores between Screencast and Text Entry Groups

	Screencast Groups (*n*= 21)		Text Entry Groups (*n* = 22)					
Characteristic	*M*	*SD*	*M*	*SD*	*df*	*t*	*p*	*d*
Number of words in explanation	3.10	1.22	2.14	0.83	41	3.02	**.002	^{ttt}0.94

Note. **p* < .05, ***p* < .01, ****p* < .001. Cohen’s (1992) suggestion that effect size of ^{t} = 0.2 is small, ^{tt} = 0.5 is medium, and ^{ttt} = 0.8 is large.

Challenge scenario groups that screencasted their explanations obtained higher KI scores (*M* = 3.10) than those using the text entry method for explanation (*M* = 2.14). Cohen's effect size value (*d* = 0.94) suggested a high practical significance. These results indicate an average KI increase for screencast explanations of nearly one entire level on a five point scale. The average increase as related to the rubric, suggests that screencast students were much more likely to offer explanations with support compared to the text entry groups. These findings are further clarified by the frequency distribution displayed in Figure 2.

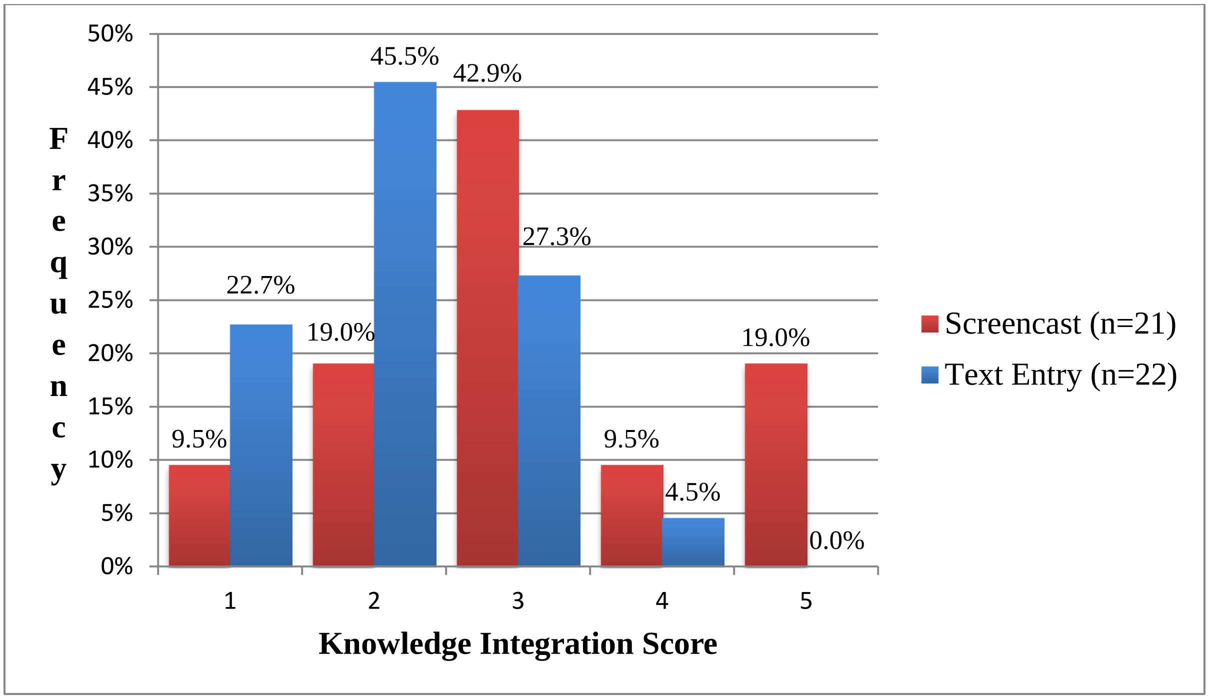

Figure 2. Knowledge integration frequency distribution chart.

The results from the KI frequency distribution data indicate that 68% of text entry groups scored at or below level 2. Explanations in this range provided no solution and/or contained irrelevant observations. In comparison, only 29% of the screencasting group explanations scored in that range. A similar gap between groups was observed at the opposite end of KI scale with less than 5% of the text entry groups scoring at or above level 4 compared to 29% of those that were screencasting their explanations. Explanations that qualified for these scores contained solutions with relevant observations based on the model which were supported with one or more scientifically normative ideas. Explanations scoring in this upper range indicated both a clear understanding for the concepts being modeled and displayed the groups willingness to provide support beyond what was being asked of them.

The measure analysis presented in this study supports the various components outlined by the research question. Compared to text entry groups, those that screencasted their explanations spent significantly more time with the model and provided explanations that contained more information that was closely aligned with the stated objectives for the activity. Screencasting groups also displayed more of the KI attributes that promote autonomous learning reflected in their willingness to offer ideas related to causality compared to those that were writing their explanations. Chapter 5 analyzes these findings in greater detail, describes limitations regarding the scope of the study, and discusses the implications of using these results to help refine possibilities for further research applications regarding screencasting as a means of alternative assessment and expression among middle school science students.

Chapter Five – Analysis

Introduction

Chapter five provides a discussion intended to analyze the results obtained through this investigation of screencasting as a means of student expression and assessment. Associations with research findings and intellectual contributions provided by those that helped develop the conceptual framework, study design, methodology and practical implementation will also be discussed as they relate to the findings of the investigation. Analysis of the results will address limitations that confine the scope and generalizability of this study and the potential implications the findings may have on student learning. This chapter culminates with a final discussion regarding the direction and extent to which this research will be conducted in the future.

Analysis

Groups that screencasted their explanations spent more time manipulating the model, composed explanations that contained more words, improved on-task behaviors, discussed observations which were more relevant to the modeling activity, and contained a higher number of scientifically normative ideas. Significant differences among all conditions outlined by the research questions were observed in this study. Each component is discussed separately below.

The largest effect size (d = 2.23) and the most significant difference (p = <.001) among all of the outcomes measured in this study involved the average amount of time challenge groups spent with the interactive model. Groups that screencasted their explanations spent 72% more time with the model compared to those that were writing their explanations. These results need to be viewed in context with the other components analyzed in this study as Buckley et al. (2004) indicated, time spent modeling does not necessarily equate to learning. Nonetheless, given the positive results for other attributes analyzed in this study, the additional engagement demonstrated by the screencast groups appears to represent time well spent.

A portion of this additional time spent with the model is reflected by the average number of words included with screencast explanations (131.0 words) compared those composed using the text entry tool (43.6 words). What specifically motivated screencast groups to provide explanations that were nearly three times longer than those written by the control groups is beyond the scope of this study, although the implications for such results and practical application for these findings warrant discussion. Providing explanations through spoken language is suggested to be an innate human characteristic (Barthes & Duisit, 1975) and one that logically encompasses a much larger population compared to those competent with writing. The willingness to speak overshadowed the reluctance to write especially among certain screencasting groups that assumed a role best described as a *television meteorologist.* These particular narrators seemed to want to attract attention from a viewing audience by supplying introductions like *As you can clearly see in the model…*, or *So now you see the temperature is changing….* Ahmed and Pollitt (2010) suggested that *talking* about science in this way helps bring clarity to student ideas and improves the relevance of information they provide. The knowledge integration component analyzed in this study supports these authors' findings as screencasting groups were far more likely to offer solutions with greater relevance to the model. Screencasting groups also included many more ideas that were scientifically normative.

Similar to findings from Reitsma (2010) and Lemke (1990), the screencast explanations lend support to the theory that narratives can help provide clarity to a model's outcome and result in activity that is better aligned with learning. The narrative represents only one aspect of a screencast recording – the video track provides an additional scaffolding mechanism not examined by the research community until now. The visual context that is recorded along with the soundtrack allows students to review and analyze not only their explanations, but the specific actions they conducted with the model as they talked their way through the activity. Researchers have shown that the combination of dynamic visualizations and engaged behaviors associated with interactive models improves inquiry learning, heightens productivity, and increases retention of complex concepts in science (Chiu, 2010; Linn, Hee-Sun, Tinker, Husic, & Chiu, 2006; Williams, Linn, & Hollowell, 2008). It is important to note that the frequency at which groups reviewed their screencasts or replaced them with new takes could not be captured directly given limitations of the data logs deployed by WISE. These limitations will be detailed in a later section, but given that screencast groups spent an average of 24 minutes and 24 seconds on the interactive model step, a span which was more than ten minutes longer than time spent by control groups, it is certainly conceivable that some of this time may have been spent employing these types of critical behaviors. Designing methodologies and enhancing existing technologies to enable the collection and analysis for this type of data is also discussed in greater detail in a subsequent section of this chapter.

Screencasting groups also remained on-task to a much higher degree than the text entry groups. Providing ways to improve this behavior is especially important with computer modeling as students can easily succumb to boredom (Baker et al., 2010), or be enticed to *game the system* (Baker, Walonoski, et al., 2008; van Joolingen et al., 2007). Faced with screencasting their explanations, 62% of the responders in the experimental group offered recommendations pertaining to model settings as they were directed to, versus only 23% of the text entry groups. Less of a separation existed between the two groups regarding the inclusion of examples derived from the model as 86% of the screencast groups followed these directions compared to 64% of the writers.

The frequency distribution analysis regarding the number instructed tasks that were present in group explanations provided an even clearer distinction among the experimental and control groups. 62% of the screencast explanations displayed both tasks verses only 14% of the written explanations. Results from this same analysis showed that text entry groups were almost twice as likely to exclude both tasks from their explanations when compared to the screencasting groups. The findings indicate that screencasting groups paid closer attention to the instructional tasks they were directed to perform.

Though the sustainability of screencasting as an effective means of student expression and assessment cannot be concluded without further research, the results obtained by this study support Slotta and Linn's (2009) suggestion that certain types of prompts can serve as scaffolds to improve the quality student explanations. The knowledge integration component results indicate that screencasting represents the type of scaffold that increases autonomy among learners – a particularly challenging pedagogical task as revealed earlier by Davis (2003). The average KI scores between experimental and control groups attained almost an entire step increase on a five point scale. Close examination of the individual KI score distributions among the experimental and control groups revealed that only one challenge group from the control classrooms (4.5%) obtained a KI score of 4 or higher, verses five of the screencasting groups (23.8%). The threshold score of four on the KI rubric is especially important as it indicates that these explanations were supported with at least one scientifically normative idea. The ideas that students provided in these explanations were not prompted by instructions or similar attributes associated with the challenge step. In addition, content from the three previous sessions was not available on the final day of activity. The ideas supporting these robust explanations were therefore either present in the students' minds before the first session began, originated from knowledge gained during the activity, or were deduced as a result of some form of critical thinking. Although less than one quarter of the screencasting groups relied on internalization to offer support for their solutions, this still represented a five-fold increase over those that were asked to provide written responses. Elevating students to the point where they begin to construct meaning from the multitude of pieces gathered over the course of their young lives and moving them in ways that foster the development of lifelong learning skills represents shared goals among many of the authors contributing intellectually to this study and these same goals will be used to help direct this research further.

Limitations

The quantitative methodology used for this study reveals no information as to student motivation nor does it address *why* or *how* screencasting effected explanations. Care must also be taken to not generalize the findings beyond the limited scope of this study – middle school science students engaged in online modeling activities. It should also be noted that the researcher served as an instructional technology facilitator at the school where the study was conducted. Any subsequent studies would benefit from a wider array of schools, including those where the researcher has no direct employment ties.

Results from this study should not be generalized to include distance learning communities. While the students were engaged in online science activities during this research, the routine delivery of content, periodic assessments, and general classroom communication are not computer assisted to the extent that they are with distance learning opportunities. It is also important to note that while computer lab activities for these students do take place throughout the year, this study represented the first time they had ever been asked to create screencasts. Even though all students had created two screencasts in the earlier sessions leading up to the challenge model, screencasting was still relatively new to them and an effect for novelty may have some influence on the results. The extent to which a novelty effect may serve as a limitation is difficult to determine without the implementation of some form of longitudinal study.

Revisiting the Conceptual Framework

The design for the four session activity was largely influenced by knowledge integration and attributes of this framework were evident throughout. The conceptual design where students worked independently for the first three sessions and were then randomly assigned to groups for the challenge scenario was a difficult decision to make. Original plans were to have students working in groups throughout the entire unit, but a logistical barrier was realized as all students needed to have experience creating screencasts, writing explanations, and manipulating models prior to the start of the challenge scenario session. While students were working independently for the first three sessions, they were not working in isolation. All students were encouraged to seek assistance as needed from available members among the entire learning community, not just their teacher and/or facilitator.

Students controlled and manipulated modeling activity directly and this repeated reinforcement of inquiry behaviors was designed to increase personal relevance. The participants were not just watching conceptual animations or simulations; they were testing their ideas by setting up initial conditions within the model, running them for a specified amount of time, analyzing their results, and modifying the models if additional tests were warranted. Though not validated through the quantitative methodology used in this design, the act of creating screencasts may have also instilled a greater sense of pride among students as hearing their voice and watching their recorded actions appeared to captivate the students' interest to a much greater extent than their writing did.

The products of learning displayed through the screencast explanations were certainly more visual than the text entries. Most of the students seemed to gain a sense of pleasure by simply *watching* and *listening* to their recorded products of learning right after creating them. Some students would choose to redo them, and while they may have viewed their initial efforts as being flawed, the behaviors associated with *getting it right* involved inquiry skills that science educators strive so hard to instill in their students. While there were no qualitative or quantitative measures employed in this study to properly examine these parameters, it was quite obvious that behaviors similar to those mentioned above were not present when students were asked to type their explanations about their activity with the model.

Implications

The results from this study indicate that compared to writing, screencasting improves the quality of middle school science students' expression pertaining to complex modeling activity in an online learning environment. For teachers and other instructional professionals, the implications of screencasting as a means of student expression are noteworthy as it is difficult to fully assess student understanding in science through the application of commonly implemented assessment tools involving multiple-choice, true/false, and similarly designed items (Bloom, 1956; Clark & Linn, 2003; Özkan et al., 2004; Passmore et al., 2009). Results gained from this study appear to indicate that the act of writing about inquiry behaviors involved with modeling activity hinders student expression. Compared to those charged with writing their explanations, screencasters demonstrated a 200% increase in the average number of words provided, spent 72% more time engaged with the model, and were far more likely to be on-task during the activity. Screencasting also appeared to be a much more precise instrument at identifying both understanding and misconceptions involved with modeling activity as the screencast groups were five times more likely to internalize and offer possible ideas regarding the causality for what was being observed in the model.

Implementing screencasting for student assessment and expression on a large scale basis appears to be fairly obtainable for a number of reasons. First, if students are already engaged with inquiry modeling in an online environment, then they have access to most of the technology infrastructure required to enable screencasting. The free screencasting program used for this study, Jing, allowed screencast recordings to be stored on individual machines, local or wide area networks, or on a limited cloud network made available by the manufacture. The screencast service is not platform specific and the recordings play back through a number of different browsers. The only additional equipment that might need to be provided by the school would be a headset with a built-in microphone and these are readily available for less than ten dollars per unit. Additionally, screencasting does not require extensive training for the students or much in the way of professional development for teachers. In this study, students watched a three minute online tutorial prior to their first screencast and had very few problems mastering the process in the next project step. Finally, because the screencasting service used in this study originates as a free download, it can be easily installed and made readily available in computer labs, classrooms and in homes with internet connectivity.

The research community might also benefit from screencast recordings created by online modeling participants as the recordings may help identify specific student interactions with the model, especially when such information may not be readily available through data logging or similar reporting formats. Enabling screencasts to capture verbal and tactile activity associated with computer modeling could also free up valuable resources as traditional data logging often resides on the same server delivering the online content for the activity. A number of the premium screencast programs can capture two simultaneous video streams; one of the desktop activity as was the case in this study, and a second recording from a web cam traditionally mounted near the monitor or display device. This camera would then provide a recording in which facial expressions could be analyzed as indicators for attentiveness, confusion, surprise, boredom, and intrigue to name a few.

Further Research

All indicators gathered from this study showed that student created screencast production significantly affected the modeling and explanatory behaviors performed by middle school science students’ interactions with the model. A cautious approach to these results is warranted as this study represents the first of its kind, as peer reviewed studies on the student use of screencasts in science education do not appear to be part of the research base. Additional studies will broaden the sampling base beyond the confines of this first project and hopefully begin to examine longitudinal effects that may or may not occur with similar treatments.

One particular limitation of this study involved the data logging capabilities of the host server. Data could be recorded for the amount of time spent with any particular step, but there was no capacity to collect the type or frequency of actual manipulations conducted while students were engaged with the model on that particular step. Analysis of the screencast recordings would expose some of these actions as you could *watch* what the students were doing with the model, but that technique is not available for those groups asked to write their explanations. Development teams at the University of California, Berkeley and the Concord Consortium are working to improve data collection features for interactive models embedded within WISE and subsequent enhancements should allow for close examination of specific inquiry behaviors and performance standards.

This dissertation study was also confined by the fact that only one component of a roughly four-hour learning activity was actually analyzed in this study. Utilizing the results obtained by this study and keeping much of the same instructional content intact, an additional study is being planned to directly compare screencast explanations to written ones among individual student authors and the entire group of participants. This study would examine several instances currently found in the three one-hour sessions where students are asked to explain their modeling activities. Individual classes that participate in this study would not be randomly assigned as experimental or control classrooms as was this case in the first study, but would be labeled with one of two colors. As the activity unfolds students in *Red* classes would screencast their explanations for the first model, while those in the *Blue* groups would provide explanations through text entry. At the next modeling step the roles would reverse and this repeating pattern would continue through the end of the third session. The direct comparison of screencast and written explanations for four or possibly six modeling steps would strengthen validity and might help increase the generalizability of the research. This design would also provide a significant amount data for each individual participant, thus enabling additional analysis on more of an intrinsic level. It might then be possible to start examining specific attributes such as gender, ethnicity, motivation, prior knowledge, and/or grade point average to determine if any of these characteristics influence the quality of student generated screencast explanations.

Adding a second treatment group, one that records narrative explanations through a simple audio recording device without capturing video of the desktop activity, represents another potential study. This design would help isolate the audio from the video track in a screencast and could provide insight towards the influence that the video component has in a screencast recording. If it is found that a simple audio recording can accomplish similar results to that of a screencast, then the familiarity and availability of audio recording devices might hasten the implementation on a wide scale basis for a more effective alternative to written expression.

At some point in the future, I would like to enable teachers to use screencasting techniques to provide feedback to assessment items submitted by their students. Teachers are increasingly pressed for time and seemingly find comfort in assessment items that require little time on their part for grading, yet it is well established that these quick turn-around items often do not offer the level of formative feedback required to truly assist student learning. In addition, many of the items that even traditional classroom teachers are now grading appear in digital formats of one kind or another – just like students that are involved in computer modeling, teachers that rely on computer technologies to view and assess student work already have the essential tools required to screencast. It would be meaningful to uncover if instructors' response to screencasting tools as a means of providing formative assessment paralleled those obtained by the students engaged in this study. Would screencasting teachers spend more time with their evaluations, include descriptions that contained more information, and provide feedback more closely aligned with the needs of the learner compared to those that use traditional methods for grading?

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Appendix A

Student experience with typical TELS/WISE interactive learning module

The overall structure of a typical unit activity is shown in Figure A1. Students engaged with these learning activities receive online curricular content through embedded video segments, visualizations, reading passages, simulations, interactive models, and guided explorations that involve hyperlinks to various internet resources and other forms of embedded content. Inquiry maps guide students through activities which are divided into various sections and subsections. Students are prompted throughout the activity to create, review, take notes, and modify their reflections through an onboard electronic journal.

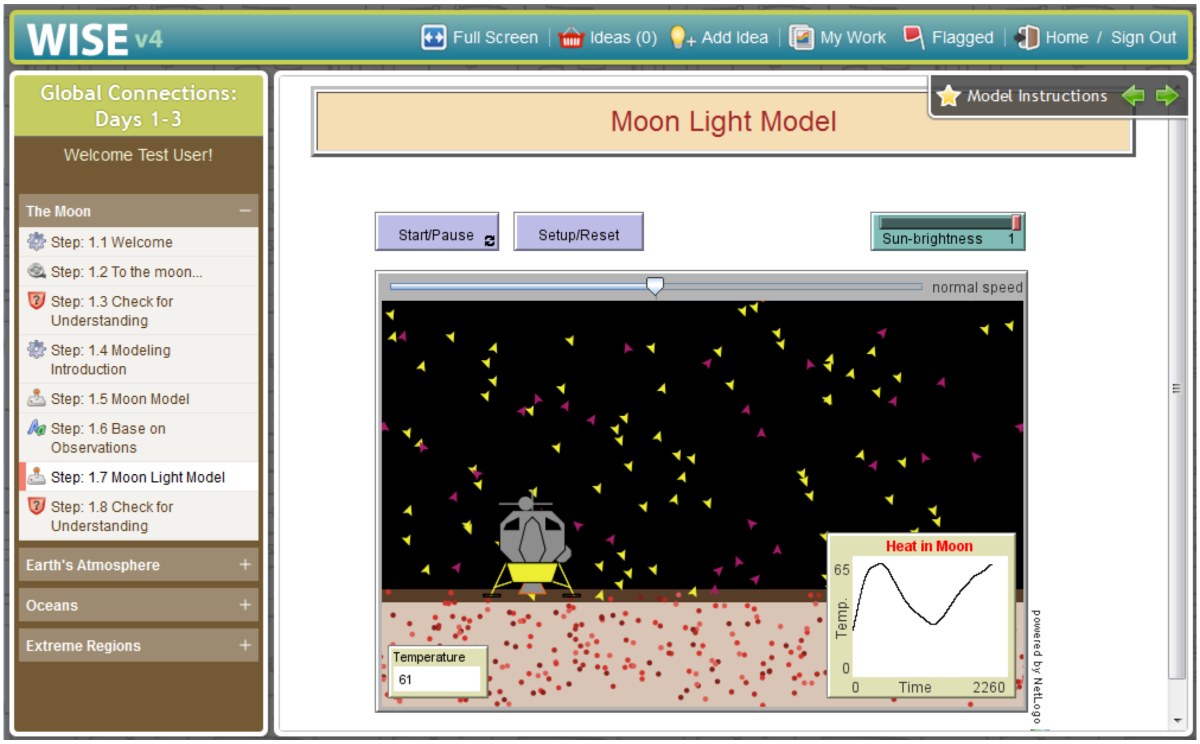
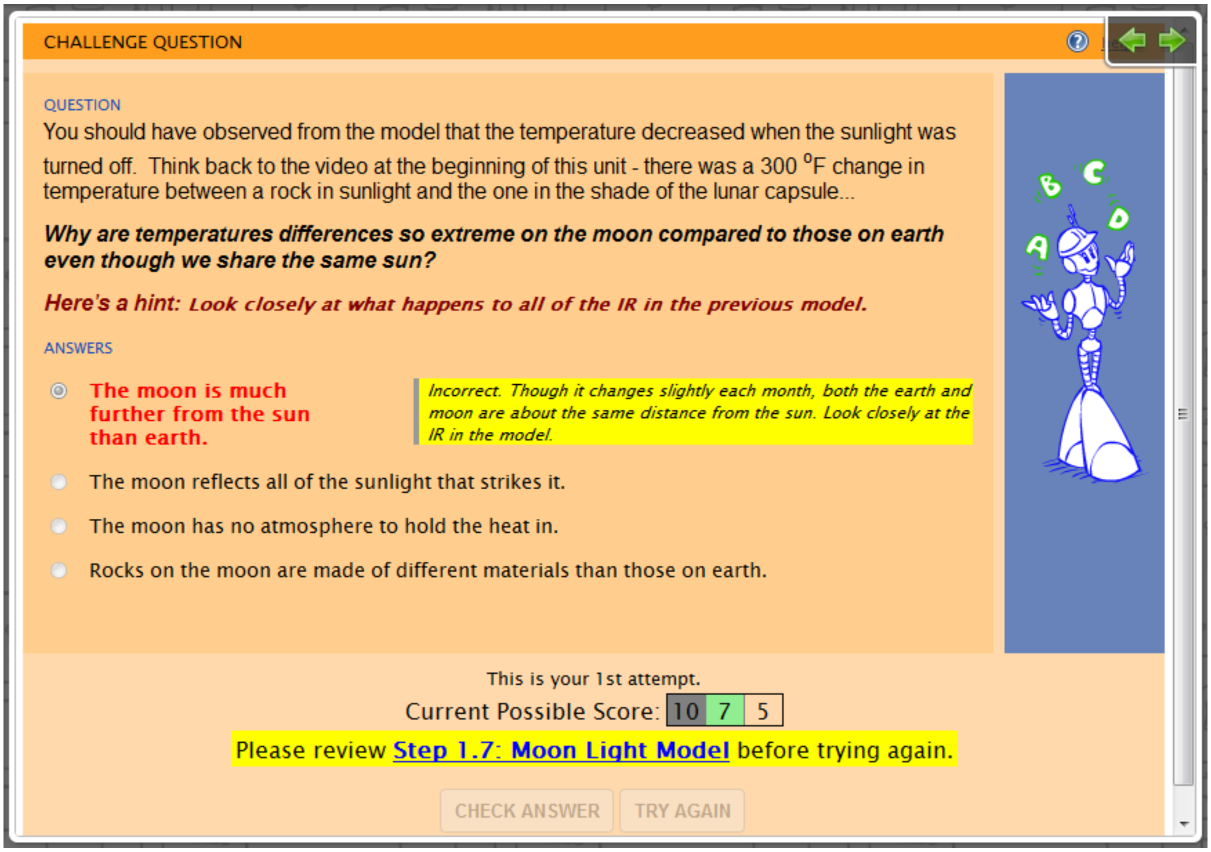


Figure A1. TELS/WISE interactive computer model screenshot. Screenshot overview of typical activity step in TELS module showing navigation bar to the left, animation window to the right, and user tools at the top.

Controls can be activated to prevent students from skipping over material within a section or proceeding to new sections before demonstrating mastery for previous concepts. Application of these controls is fairly restricted as student navigation is designed to be flexible. Hints and other forms of scaffolded assistance are available to students on demand.

The software itself provides students with additional means of formative assessment. In some instances, mastery of a particular step or key concept must be demonstrated before the program will allow students to proceed to the next step. Many of the specific questions that appear in the unit take the form of challenge questions (see Figure A2) where incorrect answers redirect student inquiry to specific steps where they are able to review related concepts and revise their answers. Students involved with challenge questions earn a higher number of points when they answer correctly on their first attempt. Consequently, most will actively collaborate with their partner(s) and share ideas before submitting that first answer.



You should have observed from the model that the temperature decreased when the sunlight was turned off. Think back to the video at the beginning of this unit - there was a 300 °F change in temperature between a rock in sunlight and the one in the shade of the lunar capsule...

Why are temperatures differences so extreme on the moon compared to those on earth even though we share the same sun?

Here's a hint: ***Look closely at what happens to all of the IR in the previous model.***

- ● **The moon is much further from the sun than earth.** — *Incorrect. Though it changes slightly each month, both the earth and moon are about the same distance from the sun. Look closely at the IR in the model.*
- ○ The moon reflects all of the sunlight that strikes it.
- ○ The moon has no atmosphere to hold the heat in.
- ○ Rocks on the moon are made of different materials than those on earth.

This is your 1st attempt.

Current Possible Score: 10 7 5

Please review **Step 1.7: Moon Light Model** before trying again.

Figure A2. Typical challenge question format and style. Challenge question displaying feedback for incorrect answer. Note the prompt to return to the model, specific link for the review step, and current score earned for the question.

Appendix B

Challenge scenario student information sets

Red groups	Members of the Red Team are especially concerned with retreating glaciers and disappearing sea ice. As large amounts of both types of ice melt, valuable sources of freshwater are lost, wildlife is threatened, and sea levels around the world begin to rise. Team Red clearly understands that rising air and ocean temperatures is the primary cause for most of the melting. Your team also realizes that there is currently not enough clean energy sources to meet the demands of a growing worldwide population. Your challenge is to use the model to determine how much human emissions of CO2 need to be reduced by to ensure that the Earth still has about 28% Ice coverage in the year 2052. If you are within a percentage point or two, up or down, that's acceptable, but you want to make sure that your final recommendation does not result in any gains or losses above or below 26 to 30% ice coverage. Specific instructions for running the model are provided on the next page. Good Luck!
Green groups	Green team members develop state of the art technologies that utilize alternative and clean sources of energy to meet the demands of a growing worldwide population. Your major breakthrough has proven to cut greenhouse gas emissions considerably, but it will take 20 years of research and development before large scale production of your clean energy solution can be put into place. Knowing that the amount of CO_2 released into the atmosphere gets larger each year, your team will need to use the model to predict how much air temperature will rise by the year 2032. Once that temperature is established, your team will need to determine how much human emissions of CO_2 will need to be reduced by to bring average air temperatures back down to 13 C. If your final recommendation results in a degree or two up or down (12-14 C), that's acceptable, but you want to make sure that your final recommendation does not result in air temperatures above or below that range. Specific instructions for running the model are provided on the next page. Good Luck!
Blue groups	The blue group is made up of various oceanographers and marine biologists. Your team's biggest concern has to do with rising ocean temperatures. Marine life is being threatened in many parts of the world. Warmer water leads to more severe hurricanes and typhoons. Plus, the ability of earth's oceans to trap CO_2

decreases as ocean temperatures rise, which compounds the problem.

Your team realizes that water takes much longer to heat up and cool down compared to air and that current trends predict a significant increase in air temperatures over the next two decades. You team needs to predict what effect 20 years of rising air temperatures will have on ocean temperatures. Team Blue will then have to use the model again to suggest how much humans will have to reduce carbon emissions to bring ocean temperatures back to 13 degrees by 2052.

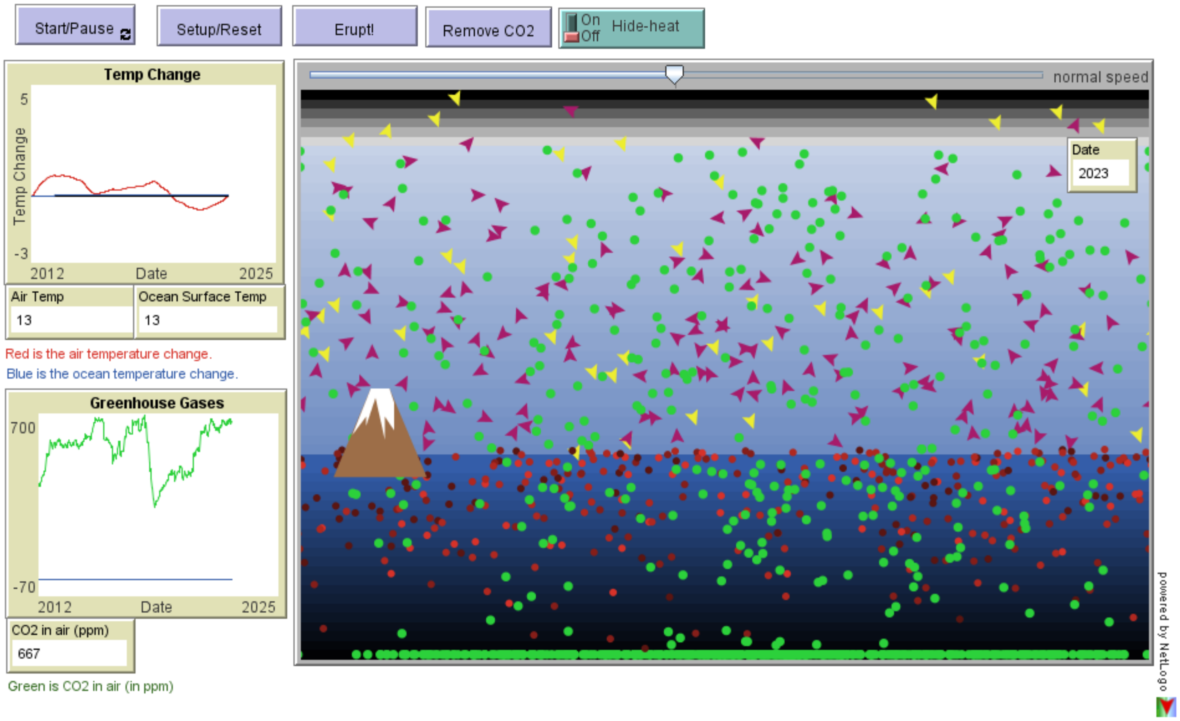
If your final recommendation results in a degree up or down (12-14 C), that's acceptable, but you want to make sure that your final recommendation does not result in ocean temperatures above or below that range.

Specific instructions for running the model are provided on the next page. Good Luck!

Appendix C

Student activity with interactive computer model

Preliminary activity with the model will emphasize operational procedures and allow only limited modifications to the model. The extent to which the model can be manipulated and the nature of the concepts being investigated increase in complexity as the unit progresses. An example of an intermediate global climate change model is displayed in Figure C3.



Air Temp: 13

Ocean Surface Temp: 13

Red is the air temperature change.

Blue is the ocean temperature change.

CO2 in air (ppm): 667

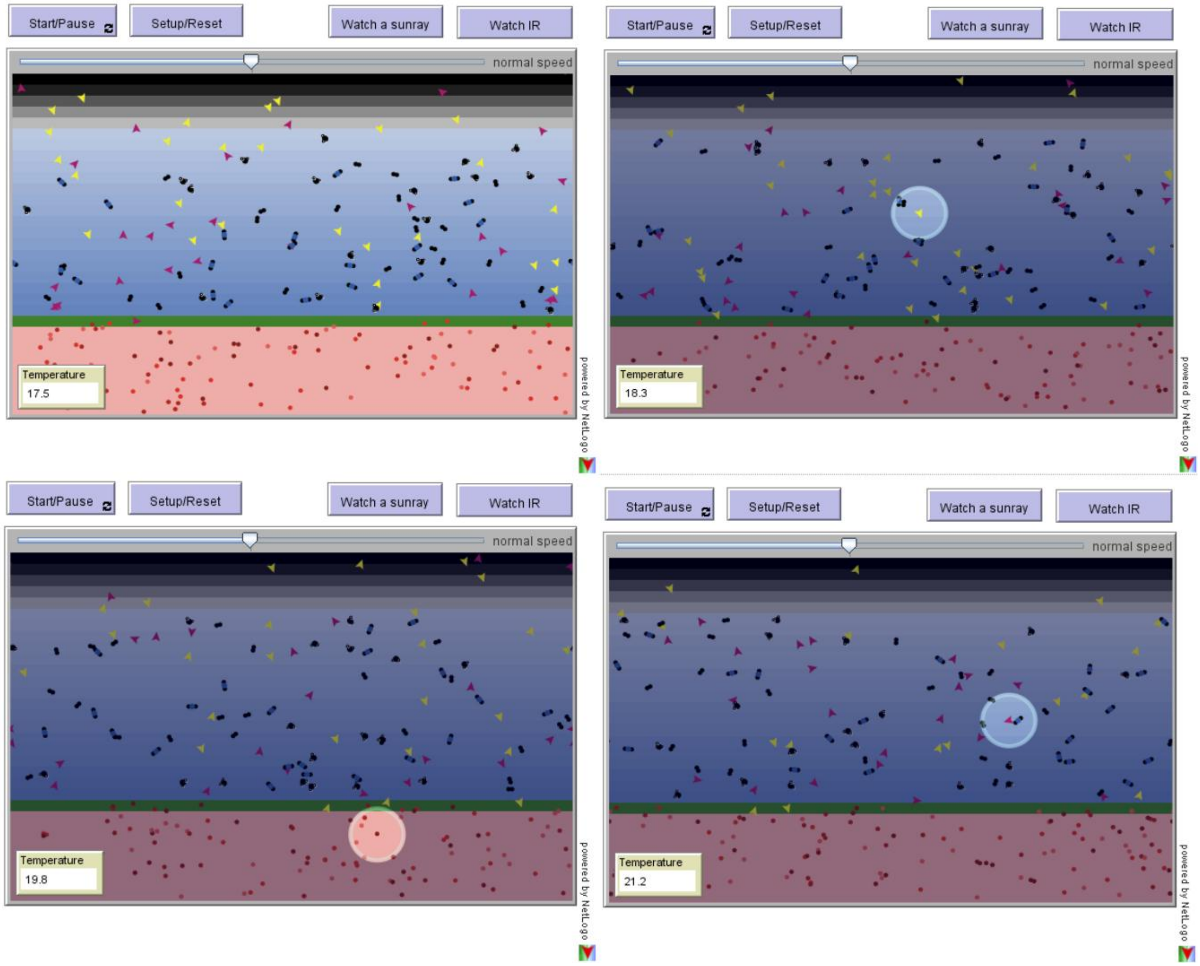
Green is CO2 in air (in ppm)

Date: 2023

Figure C3. Global climate change interactive computer model. Model components showing animation window (right), output data graph (left) and variable controls (top).

The general model selected and revised for this research allowed students to manipulate a number of input variables to establish starting conditions. Various processes regarding the greenhouse effect were simulated through the use these interactive computer models. The model can be set to allow modifications while it is running or restrict changes as needed. Activity is displayed as an animation in the models' main window. Data for factors such as temperature, carbon dioxide levels, and amount of clouds are displayed as tables and graphs offset from the main animation window. The data displays accurately portray changes as they occur in the model, allow students to identify trends that may occur over time, and permit them to view and gather specific data over the entire span for any graphical representation presented by the model. The rate at which the model operates can also be manipulated by adjusting a slider tool that appears above the animation window allowing the student to speed up or slow down time. The model can be quickly reset to the prior setup and rerun as many times as warranted.

Before actual participation with the greenhouse effect model began, students will learn about the role that models play in science and received instructions for proper usage and operation of the model. Initial use of the greenhouse effect model was intended to reinforce key concepts presented earlier in the inquiry unit. For example, when in trying to clarify how sunlight is transformed to heat and eventually released in the form of infrared radiation, students will first be prompted to run the model and isolate one of many sun rays entering Earth's atmosphere. As shown in Figure C4, these isolated rays have a unique appearance and are easy to track on what appears to be a very busy display screen. Individual rays may reflect off of Earth's surface while others are absorbed by the ground and transformed into heat energy. The highlighted symbol now represents heat energy as a red dot displaying erratic motion in the ground. It eventually escapes back into the atmosphere as infrared radiation. Some of the infrared radiation that moves away from the Earth's surface escapes into space. If the infrared symbol strikes a greenhouse gas particle in the upper atmosphere though, it is reflected back towards Earth. Students also had the option to isolate IR and compare and contrast it to sun rays.



Temperature 17.5

Temperature 18.3

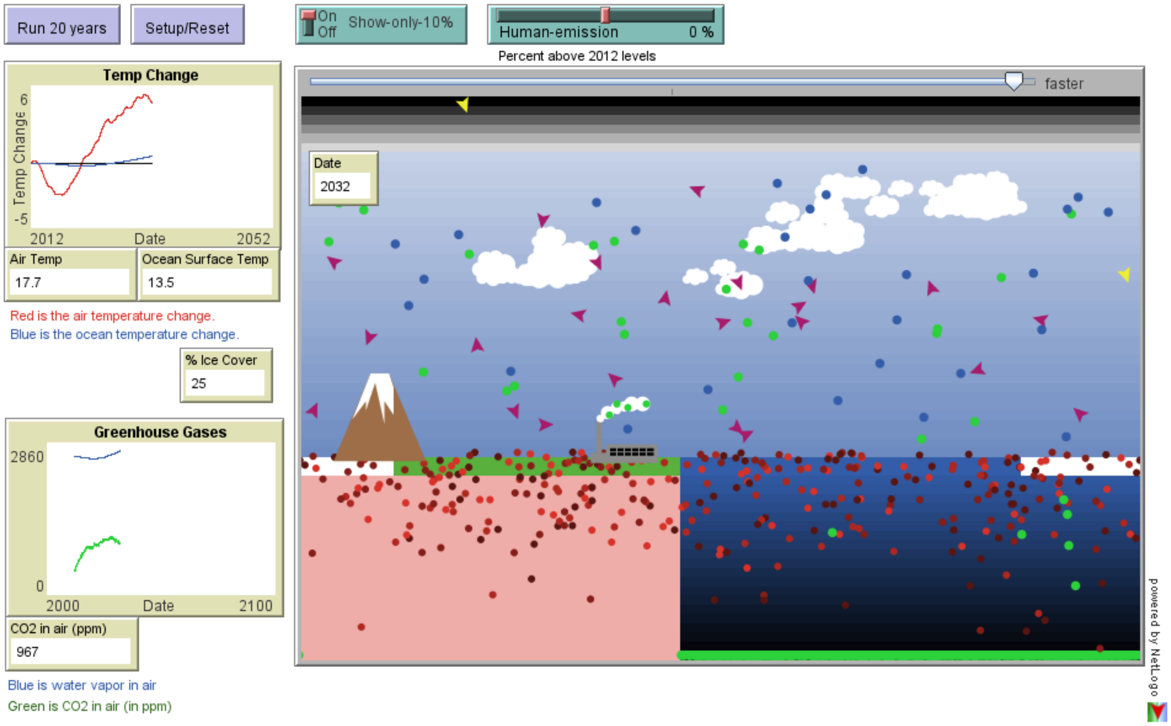
Temperature 19.8

Temperature 21.2

Figure C4. Watch feature in WISE interactive computer model. Animation windows before activating feature (top-left), isolated sunray as it moves towards earth's surface (top-right), heat in ground (bottom-left), and infrared radiation released from ground (top-right).

After isolating numerous rays and recording their behaviors after each one, students may conclude that sunlight is not affected by carbon dioxide as it passes right through the atmosphere. Keen observers will notice though that infrared radiation is affected by carbon dioxide and can get turned back towards Earth. As more and more of the infrared radiation becomes *trapped* by this insulating layer of carbon dioxide, the temperature indicator in the model rises. This model reaffirmed content that was delivered previously through a video clip, text descriptions, and a multi-step simulation.

Subsequent interactions with the greenhouse effect model permitted numerous modifications, but only to one selected variable at each at each step. Students were able to examine the effects of carbon dioxide levels in the atmosphere and the relationship to Earth's temperature. A similar sequence of events was used with various models to test other attributes regarding the global climate change. The model developed and implemented for the challenge scenario where data was gathered and analyzed for this study is displayed in Figure C5. This interactive model displays more sources of data output than previous versions and includes new content variables for clouds and water vapor.



Human-emission 0 %
Percent above 2012 levels

Air Temp 17.7

Ocean Surface Temp 13.5

Red is the air temperature change.
Blue is the ocean temperature change.

% Ice Cover 25

Date 2032

CO2 in air (ppm) 967

Blue is water vapor in air
Green is CO2 in air (in ppm)

Figure C5. Screenshot of inquiry model used for challenge scenario.

Appendix D

Classroom teacher activity with WISE interactive learning module

Student progress and on-task behaviors are monitored in real time through the unit's teacher view integrated into the module and by looking over the shoulders of students engaged in the program. Teachers have access to a dashboard-like view that identifies the overall progress that each individual group has made at any given point in time, thus allowing for quick and efficient intervention for those that may be working too slowly or others that may be speeding through the unit with a lack of concentration. If events arise that warrant the attention of the entire class, teachers can pause all computer activity and draw awareness towards the specific procedure or concept that warrants clarification. One of the more recent classroom management features allows the teacher to identify and display student work as exemplars. WISE teachers are encouraged to evaluate student work on a nightly basis and provide electronic feedback to praise their accomplishments and to redirect their attention as needed.

The classroom teacher has complete access to the students' online journal and submitted answers. They can also examine various types of activity data to determine factors such as the amount of time pairings spent within each step and the number of times students retrieved hints. Teachers are encouraged to demonstrate to students early into the unit that their activity is being monitored closely and that assistance is available through the online forum should they need it. Electronic conversations between students and their teacher often emerge and this just adds to the already rich conversational aspect of each project.

VITA

Scott E. Stuckey was born and raised in Kettering, OH. After attending two years at Miami University in Oxford, Scott transferred to the University of Miami in Coral Gables, FL where he received his Bachelor of Science degree in Biology in 1978. Dr. Stuckey received his Master of Arts in Instructional Media degree in 2001 from Appalachian State University in Boone, NC. He earned his Ed.D. in Educational Leadership from Appalachian State University in the Fall of 2012.

Dr. Stuckey is currently employed as an Instructional Technology Facilitator for Catawba County Schools located in the foothills of North Carolina. Prior to his current role, Dr. Stuckey taught Biology and Physical Science for ten years at the high school level. Prior to moving into the educational field, Scott owned and operated a commercial photography studio located in Miami, FL. Dr. Stuckey currently resides in Hickory, NC.