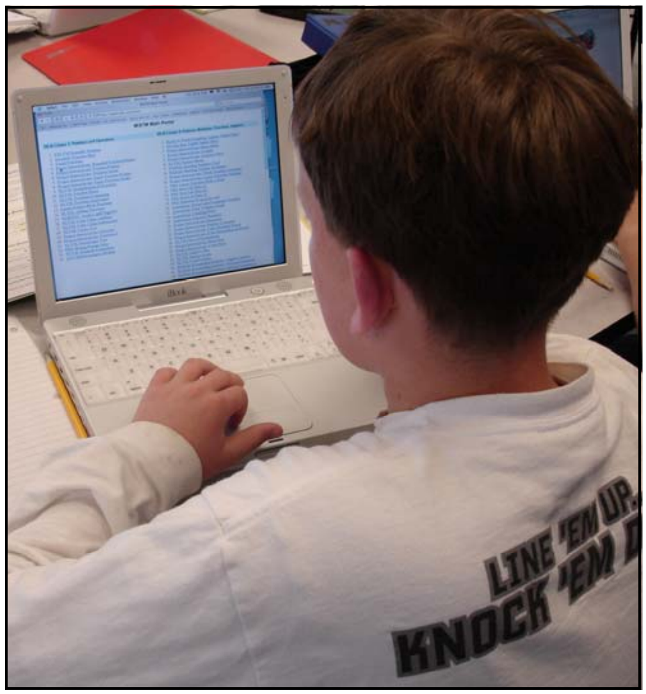
RESEARCH BRIEF

Using Laptops to Facilitate Middle School Science Learning:

The Results of Hard Fun



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UNIVERSITY OF SOUTHERN MAINE
Center for Education Policy, Applied Research, and Evaluation

MAINE INTERNATIONAL CENTER FOR DIGITAL LEARNING

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Executive Summary

Over the past decade, the amount of technology available to students has increased considerably. Internet resources and educational computer software have become more readily available to students within their classrooms. As a result of these changes, many educators have begun to ask how to implement aspects of these technologically-advanced tools and resources into their curriculums. In addition, many districts are actively encouraging teachers to adopt and put into practice technology-based resources and applications.

As the Maine Learning Technology Initiative (MLTI) enters its seventh year of implementation, the need to expand upon the current research is essential. In an effort to gather information about implementing technology within various educational contexts, the Center for Education Policy, Applied Research, and Evaluation (CEPARE) at the University of Southern Maine collaborated with a science teacher from Bristol Consolidated School to conduct an action research study to determine how the use of technologically-advanced tools and resources might affect academic achievement and student engagement in the science classroom.

Pre- and post-assessments illustrated greater comprehension levels among the students who were assigned to complete a technology-rich project in comparison to students who were asked to complete a more traditional science project. In addition, a retention assessment revealed greater retention of information among those who had completed the technology-rich project. Lastly, student engagement appeared to be higher among those who were working directly with their laptops to complete their science projects.

The post-assessment and the student interviews revealed that many of the students found the technology-rich project to be more challenging and time-consuming; however, many of the students also agreed that the project was more fun and engaging. These statements are illustrative of Seymour Papert's concept of "hard fun", by which Papert describes the idea that children enjoy being challenged and that they have greater learning outcomes when they are given the opportunity to actively construct new knowledge in an exciting way.

Using Laptops to Facilitate Middle School Science Learning: The Results of Hard Fun

"It took more effort, but it was more fun"

Alexis M. Berry **Sarah E. Wintle**

Introduction

Since the fall of 2002, the Maine Learning Technology Initiative (MLTI) has provided all 7th and 8th grade students in the state of Maine, as well as their teachers, with laptop computers. MLTI started as a vision of former Maine Governor Angus King to transform the way Maine had educated students in the past and to prepare students for a changing, more technologically-advanced world. As the MLTI laptop program has now entered its seventh year of implementation, the legislature, educators, and researchers alike are curious to know more about how this technology may be successfully facilitated within various classroom settings. In particular, many individuals are curious about the impact that the MLTI program may have on academic achievement and on student engagement within the classroom.

In order to expand upon the current research and to gather information about implementing technology within various educational contexts, the Center for Education Policy, Applied Research, and Evaluation (CEPARE) at the University of Southern Maine (USM) has collaborated with a science teacher from Bristol Consolidated School, Kevin Crafts, and his two eighth grade science classrooms. This collaboration was organized to conduct an action research study in an effort to measure the impact of MLTI integration on student engagement and academic achievement. As a teacher who believes in the potential benefits of implementing technology within the classroom, Crafts saw this project as an opportunity to examine the impacts of his program. This report describes the collaborative action research project undertaken by Kevin Crafts and CEPARE to help evaluate the applications of the MLTI laptop program in a science classroom.

Background

Beginning in 2002, the MLTI program provided laptops to all 7th and 8th grade students and teachers in the state of Maine. In addition, Airport wireless networking, Internet access, and a variety of educational software has been provided. Furthermore, technical assistance and professional development for effectively integrating the laptops into the classroom curriculum have been provided to educators on an ongoing basis.

Throughout the development of the MLTI program, research has been conducted in order to provide an ongoing evaluation of the program's efficacy and value. For example, in October 2007, CEPARE published a research brief that described the impact of MLTI on students' writing skills (Silvernail & Gritter, 2007). In March 2008, CEPARE published a study that described Maine's Impact Study of Technology and Mathematics (MISTM), which examined how professional development might help to improve middle school mathematics performance (Silvernail, 2008). Additionally, during the fall of 2007, CEPARE worked collaboratively with Sanford (Maine) Junior High School in an effort to determine whether or not an intervention to improve students' website evaluation skills was effective (Pinkham, Wintle, & Silvernail, 2008). All of these studies have shown that MLTI has been successful in improving student learning.

In a continuing effort to expand the research on MLTI and student performance, more information about how this technology may be used in various educational contexts needs to be gathered. This research project, in particular, focuses on how the MLTI laptop program may be implemented within a science classroom. More specifically, this report describes an action research study designed to answer the following research question:

> Is the use of the laptops to create narrated animations more effective than having students create traditional paper diagrams and reports in helping students learn the concepts related to Earth's axis angle?

Methodology

Initial project planning meetings took place in June 2008. During these meetings, CEPARE staff, Crafts, and Bristol Consolidated School principal Jennifer Ribeiro met to discuss project goals and plans.

Goals of the Project

The primary goal of this research project was to examine how the MLTI program, more specifically, laptop computers, might impact the academic achievement and general classroom engagement of students within a science classroom. In particular, student engagement, student comprehension of the material, and student retention of the material would be observed. Crafts chose the science unit during which the observations and data collection would occur. He planned to introduce the concept of Earth's axis angle and the cause for the seasons to both of his eighth grade science classes. One of his classes (Control Group) would be taught in the traditional manner and would be asked to complete a traditional paper diagram and report as a final project. The other class (Experimental Group) would be taught the material in the traditional manner; however, they would have access to interactive, educational websites for their final project and would be asked to turn in a narrated animation podcast.

In order to examine how the technology would impact academic achievement and general classroom engagement, a number of measures were used in the study. First, a pre-assessment was administered to all of the students in order to establish a benchmark comprehension level of axis angle concepts. This pre-assessment measured comprehension, as well as attitudes about science, comfort-level and skill-level with regard to making animations, and 21^{st} Century skills. In addition, Crafts was asked to complete daily teacher logs of classroom activities throughout the study. A post-assessment measured student comprehension and contained several opinion questions, which asked students to explain what they liked and disliked about completing their science projects. A retention assessment was also administered roughly a month after Crafts had completed the unit in order to measure the students' retention of learning. This assessment contained questions which were similar to those asked in the pre- and post-assessments, but were not identical.

In addition to the assessments and the teacher log, observations and interviews were conducted with both Crafts and his students. These were conducted in an effort to gather more information about how the technology was being introduced to the students, to measure student engagement levels, and to gather a better understanding of the level of student interest regarding the projects.

Project Staff

Kevin Crafts, the science teacher at Bristol Consolidated School worked collaboratively with CEPARE staff to complete the research project goals. CEPARE staff assisted with creating the assessments and daily teacher logs, as well as with conducting interviews, observations, and data analysis.

Experimental and Control Groups

In this research project, Crafts' two eighth grade science classes served as the Experimental and Control Groups. After teaching both groups how to create animations on their laptops during a previous science unit, Crafts began teaching the unit about Earth's axis angle. Both classes were similar in terms of prior achievement and both of the classes received similar instruction with regard to the concepts related to the axis angle of the Earth; however, the final project assignments differed.

Group A, which consisted of 13 students, was assigned as the Control Group. This group received traditional classroom instruction during the axis angle unit and was expected to develop a paper diagram and a report, summarizing their learning.

Group B, which consisted of 12 students, was assigned to be the Experimental Group. This group was given the same classroom instruction during the axis angle unit; however, during the time they were given to complete their final projects, they were provided access to educational websites, such as ExploreLearning.com. In addition, they were expected to develop a narrated animation podcast as a final project.

Both of Crafts' classes met once per day for a 40 minute duration. Each class was given the same amount of time to work on the project during class and the same amount of time to work on the project at home. Each group was given 3 days to work on the project during class time and roughly three weeks to work on the project at home. The final projects for the axis angle unit for both groups had similar expectations of the students: students were required to create an image of the earth as it revolves around the sun, demonstrating how the axis tilt causes changes in seasons.

Intervention

Although both Group A and Group B were introduced to the concepts of axis angles by completing the same lab, using Styrofoam balls and a light bulb, their hands-on final projects differed. Group A was expected to complete a paper diagram that demonstrated the Earth's position as it revolved around the sun. In particular, the students were asked to use a compass and a protractor to draw the Earth's axis at the correct angle. In addition, Group A was asked to draw the Earth with another, different axis angle to demonstrate their understanding of the concept by completing another application. Throughout the duration of the project, the students in Group A had access to the Internet via their laptop computers; however, they were not formally directed to use any specific Internet resources. Instead they were given atlases and books to use in order to find temperatures within specific cities during various seasons.

Group B, the Experimental Group, was directed to complete a narrated animation as a final project for this science unit. Similarly, Group B was expected to demonstrate the Earth's position as it revolves around the sun. In particular, they were expected to explain how the Earth's axis angle influences the seasons. This group was also expected to make a change in the Earth's axis angle in order to demonstrate their understanding of the concept and the effect it would have on the seasons. Group B received access to educational Internet resources, such as explorelearning.com.

Measures

Assessments:

The pre- and post-assessments were designed by CEPARE staff in conjunction with Crafts. Both the pre- and the post-assessments were designed to measure the following: comprehension level of terminology and concepts related to the axis angle of the Earth, attitudes about science, comfort-level and skill-level in regard to making animations, and 21st century skills. The post-assessment was designed to be nearly identical to the pre-assessment in order to compare possible changes within and between groups. In addition to the information included in the pre-assessment, the post-assessment also included questions to gather data about the students' experiences and opinions about the axis angle project. In particular, the students were asked to describe the most difficult part of their project as well as the most fun part. All of the assessments were web-based. As a result, each child was able to complete the assessments on his/her own laptop during class time. The pre-assessment was administered before Crafts began introducing the axis angle unit. The post-assessment was administered after the axis angle unit had concluded and each child had completed his/her project. A copy of these assessments can be found in Appendices A and B.

A third assessment was designed in order to measure the retention of learning over a period of roughly one month, during which neither of the classes spent time covering the axis angle concepts. This brief assessment consisted of 10 questions written by Crafts. The questions were not identical to the questions asked in the pre- and post-assessments;

however, they were designed to measure the comprehension of similar concepts. After about one month had passed since the completion of the axis angle unit, Crafts asked his students to complete the retention assessment. A copy of the retention assessment can be found in Appendix C.

Daily Teacher's Log:

In addition to the assessments used to gather data about the students, others methods were also used. Crafts was asked to complete a Daily Teacher's Log in order to create a record of daily class activities, occurrences, difficulties, positive experiences, and teaching outcomes. A copy of the Daily Teacher's Log can be found in Appendix D.

Interviews:

A pre-interview was conducted with Crafts before he began teaching the axis angle unit, and a post-interview was conducted with Crafts after the completion of the unit. These interviews were intended to collect information about class demographics, student engagement levels, challenges, and benefits of asking the students to complete the specific projects. Finally, a web conference was conducted with two students from each group to gather data about general attitudes, challenges, and benefits related to the projects.

Observations:

CEPARE staff conducted a classroom observation on the first day during which the students in both classes were given class time to work on their final projects. This observation was aimed at collecting information about student engagement. A partial-interval data recording form was used to collect information about on/off-task behavior, which included: manipulation of materials/websites unrelated to the assignment, talking to peers or teacher about topic(s) unrelated to the assignment, putting head down on desk, and being out of his/her seat for a reason unrelated to the assignment. Data on three different students was collected in 15 second intervals for a period of 5 minutes each. Inter-observer agreement varied from 85% to 100% agreement.

Results

CEPARE Classroom Observations

Classroom observations were conducted on the first day that the students were given an opportunity to work on their projects during class. A summary of the classroom observations conducted by CEPARE staff may be found in the Table 1. As shown by the data in the table, it is clear that the students in Group B, the Experimental Group, spent more of their class time engaged in the activity and participating in on-task behavior. In fact, in all cases, on-task behavior was higher in Group B in comparison to Group A.

Table 1: Pre and Post 7th & 8th Grade SJHS Student Results	
Student	**Percentage of Intervals During Which Student was On-Task**
Group A	
1	62.5%
2	92.5%
3	55%
Average	70%
Group B	
1	100%
2	100%
3	100%
Average	100%

Overall, all of the Experimental Group students were on-task, as compared to 70% of the Control Group students. During the observation, there was an apparent difference in the socialization level between the two classes. Group A spent more time socializing and conversing about topics unrelated to the assignment, while the students in Group B remained on-task. In addition, there was a difference in classroom noise-level when comparing the two classes.

Assessment Results

The results of the pre- and post-assessments may be seen in Table 2.

Table 2: Pre- and Post-Assessment Results					
Group	**Pre-Assessment**		**Post-Assessment**		
	Mean of Student Scores	Standard Deviation	Mean of Student Scores	Standard Deviation	Post-Assessment Effect Size
Group A	52.38%	20.52	81.25%	15.94	.61
Group B	42.36%	19.93	90.97%	12.03	

Table 2 provides a comparison between Group A and Group B in regard to the average of students' scores on both the pre- and post-assessments. Based on the data displayed in Table 2, the students in Group B answered more questions correctly than the students in Group A on the post-assessment. In fact, the average of the students' scores in Group B increased from 42.36% to 90.97%, while the student's scores in Group A increased from 52.38% to only 81.25%. In addition, the Effect Size on the post-assessment was .61, indicating that the Experimental Group students scored approximately 2/3 of a standard deviation above the Control Group students. Thus, academic achievement of the students in the Experimental Group was greater in comparison to the students in the Control Group.

The results of the retention assessment may be seen in Table 3. The information in Table 3 provides a comparison between Group A and Group B in regard to the average of the students' scores on the retention assessment.

Table 3: Retention Assessment Results			
Group	**Retention Assessment**		
	Mean	Standard Deviation	Effect Size
Group A	63.08%	17.02	1.42
Group B	87.27%	9.04	

When comparing the results of the retention assessment, it is clear that the students in Group B, the Experimental Group, answered more of the questions correctly in comparison to the students in Group A. Based on the results of the pre- and post-assessment, as well as the retention assessment, it is apparent that the students in Group B had a higher level of comprehension in regard to axis angle concepts. In addition, nearly a month after the class had completed the unit, Group B had a higher level of retention of learning.

Teacher Observations/Interviews

In a post-interview, Crafts stated that both of the groups were relatively engaged and enthusiastic during the hands-on components of the final projects. However, Crafts also noted that many of the students from Group A, the Control Group, lost their enthusiasm and waited until the last minute to complete their reports. On the other hand, the students in Group B completed the narration component of their projects and their animations simultaneously, which appeared to keep the students engaged despite the demand to gather and present detailed, scientific information. Crafts also stated that the students in Group B benefited from the access to the educational websites. On explorelearning.com, the students were able to view a variety of virtual labs. More specifically, they were able to view interactive animations on the website that modeled how the sun strikes the Earth at different times throughout the year.

There were, however, some challenges that Crafts faced while his students worked on the animation podcast project. Crafts did not have a great deal of experience making animations on the laptops. He stated in the pre-interview that he was still in the process of creating a practice animation and that he was hoping that in doing so he would run into some of the same difficulties as his students would and as a result would be able to help them. In addition, it was harder to check the progress of the students in Group B because their work was saved on their laptops, rather than on large pieces of paper. As a result of this difference, it was more challenging for Crafts to catch small errors as the students in Group B progressed.

Despite the minor challenges that existed with the narrated animation podcast project, Crafts affirmed that the students in Group B had a richer learning experience by having to create the animations. He stated that the students in this group seemed to have a more well-rounded understanding of the concepts. During the post-interview with Crafts commented about the animation project:

> *"Well it was a challenge, even for the top students. It was more work and it really forced them to understand the concept…In the future I'm definitely going to use the animation project in my class again."*

Student Interviews

Interviews with two students from both the Control and Experimental Groups were conducted after the projects had been completed. From these interviews, it became clear that both groups seemed to enjoy the hands-on components of the projects. In particular, the students in Group A seemed to have a definite preference for the drawing component of their projects, rather than for the report component. During the web conference interview, the two students responded as follows to the following question: "What was the most fun part about the axis angle project?"

"Writing the report was a little more boring. The hands-on part of the diagram was better though."

–Student 1 (student interview)

"I liked doing the hands-on part because it was fun and I really like being creative."

–Student 2 (student interview)

When discussing the project with the students from Group B, they too felt as if the hands-on aspects of their axis angle assignment made the project more interesting to complete. In addition, both of the students that participated in the web conference agreed that making the animation required a richer understanding of the subject matter. They both described the animation podcast project as being more time-consuming and tedious than the paper diagram project; however, both of the students agreed that they would have chosen the podcast project had they been given a choice between completing either of the projects.

"You can just copy a picture from the book if you make a diagram on paper. But, you really have to get it to make a whole animation. You have to memorize the script and then you keep replaying to make sure you got it right."

–Student 3 (student interview)

"It was fun to make the animations. It was fun because I'm pretty good at it, and it makes the viewers like it more."

– Student 4 (post-assessment)

"I like doing podcasts, it's great to work with garage band and is much more fun than creating a diagram."

– Student 5 (post-assessment)

"The most fun was creating the little animations for the podcast. It was fun because I got to use my imagination, and I was drawing."

– Student 6 (post-assessment)

"I liked it. It was probably more work than doing a diagram but I felt challenged and I like to be challenged."

– Student 7 (post-assessment)

"You really have to understand it. You can watch the animation on the explorelearning.com website, but then you really have to get it to make your own. It took more effort, but it was more fun."

–Student 8 (student interview)

Summary

The data gathered from this project suggest that Crafts provided a successful example of how to integrate technology into a science classroom. In addition, the results of this project imply that the students who completed the animation podcast project had a higher level of comprehension, a higher level of retention, and higher levels of engagement in comparison to the students who completed the paper diagrams and the reports. Thus, it may be concluded that the intervention used in this project provides an example of the successful use of the MLTI laptops within a science classroom in order to increase the academic achievement and the general engagement of the students.

In addition to the increased engagement, comprehension, and retention of learning, it appears as if the students in the Experimental Group enjoyed the project despite the fact that it may have taken more time and effort than the paper diagram and the report. As one student stated, “It took more effort, but it was more fun”. In his work, Seymour Papert, a noted mathematician who was part of The Future of Learning Group, organized by a group of individuals from MIT, found that people learn best when they are given the opportunity to actively construct new knowledge, rather than having knowledge presented to them. One day, while working with first-grade students as they learned how to program computers using the computer language called Logo, a young boy described the work as both “hard” and “fun”. In a 2002 article, Papert writes,

> *“Once I was alerted to the concept of "hard fun" I began listening for it and heard it over and over. It is expressed in many different ways, all of which all boil down to the conclusion that everyone likes hard challenging things to do. But they have to be the right things matched to the individual and to the culture of the times.”*

This action research project demonstrates that the concept of “hard fun” may have great implications for educators. With access to the MLTI laptops, teachers have the capacity to offer their students activities that are both challenging and engaging. In addition, curricula may be adapted so that it is reflective of the fast-paced, technology-rich world that we currently live in. As a result, children may be more engaged in the classroom and may experience higher levels of achievement.

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Appendix A

Pre-assessment Instrument

Demographic Information

1. Are you a:

- ◯ Male
- ◯ Female

2. What kinds of grades did you receive last year in school?

- ◯ Mostly A's
- ◯ Mostly B's
- ◯ Mostly C's
- ◯ Mostly D's

Opinions About Science

3. Below are multiple statements about science. Please mark the response that best describes what you think/feel about each statement. These are opinion questions. There is no right or wrong answer.

	Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
I think that being a scientist would be exciting.	◯	◯	◯	◯	◯
I would rather listen to someone talk about science than do a hands-on science activity.	◯	◯	◯	◯	◯
I think that science is important.	◯	◯	◯	◯	◯
I would rather use computers to learn about science than read a science book.	◯	◯	◯	◯	◯
I learn more from listening to the teacher's explanations than from doing experiments and activities.	◯	◯	◯	◯	◯
Science is fun.	◯	◯	◯	◯	◯
My teacher makes learning science fun and interesting.	◯	◯	◯	◯	◯
If I don't understand a science topic I read more about it in a book.	◯	◯	◯	◯	◯
I enjoy doing activities in science class.	◯	◯	◯	◯	◯
If I don't understand a science topic, I can learn more about it on the Internet.	◯	◯	◯	◯	◯
We learn about important things in science class.	◯	◯	◯	◯	◯
Science class projects are boring.	◯	◯	◯	◯	◯
I know how to use the Internet to find information about science.	◯	◯	◯	◯	◯
Using the Internet is a good way to learn about science.	◯	◯	◯	◯	◯
I usually understand what we are doing in science class.	◯	◯	◯	◯	◯
Science challenges me to use my mind.	◯	◯	◯	◯	◯
I enjoy using the computer in science class.	◯	◯	◯	◯	◯
I would like to take more science courses in the future.	◯	◯	◯	◯	◯
I enjoy doing projects and activities in science.	◯	◯	◯	◯	◯
Using a computer helps me understand what I am	◯	◯	◯	◯	◯

learning about in science.

4. Different people like to learn in different ways. In your opinion, how do YOU like to learn about science? Choose the TOP THREE ways that you like to learn about science from the list below:

- ☐ Reading from a science text book
- ☐ Taking notes during science class
- ☐ Doing hands-on science activities
- ☐ Listening to a teacher talk about science
- ☐ Watching videos/animations about science
- ☐ Seeing diagrams about science
- ☐ Finding helpful websites about science
- ☐ Using a computer to do science activities
- ☐ Talking in groups about science

Opinions About Animations

5. How did you learn how to create animations on your laptop? (You may check more than one box if more than one answer applies)

- [ ] I do not know how to create animations on my laptop.
- [ ] I taught myself how to create animations on my laptop.
- [ ] A friend taught me how to create animations on my laptop.
- [ ] A teacher taught me how to create animations on my laptop.

6. Below are some statements. Again, please mark the response that best describes how you think/feel about each statement. These are opinion questions. There is no right or wrong answer.

	Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
I feel comfortable creating animations on my laptop.	○	○	○	○	○
Watching animations helps me learn.	○	○	○	○	○
I am excited to make more animations in the future.	○	○	○	○	○
I make animations in my free time.	○	○	○	○	○
Creating animations make learning in class more fun.	○	○	○	○	○
Making animations on my laptop is confusing.	○	○	○	○	○
I can create animations to explain things to other people.	○	○	○	○	○
I can create animations that help me learn about science.	○	○	○	○	○

7. In the space below, describe what types of animations you have made on your laptop:

21st Century Skills

8. Describe your ability to do each of the following activities:

	I don't know how to do this	I can do this, but sometimes I need help	I can do this by myself	I can teach others how to do this
Use a word processor (AppleWorks, Word, etc.) to write and print an assignment	○	○	○	○
Use a spreadsheet to enter and calculate numbers	○	○	○	○
Use a spreadsheet to create charts or graphs	○	○	○	○
Use a database to enter information	○	○	○	○
Use a database to search for and sort information and create reports	○	○	○	○
Use online discussions to gather information	○	○	○	○
Use e-mail to send and receive messages	○	○	○	○
Use multimedia software (like iMovie) to create products	○	○	○	○
Use presentation software (like Appleworks, Keynote, PowerPoint, Hyperstudio, etc.) to create presentations	○	○	○	○
Use a digital camera and/or scanner to transfer pictures into the computer	○	○	○	○
Use web authoring software to create web pages	○	○	○	○
Use search engines (like Google, Yahoo, etc.) to find information on the Internet	○	○	○	○
Limit or focus Internet search results using words like "or", "and" or "not"	○	○	○	○

9. Thinking about your computer use THIS YEAR at school, indicate how much you agree or disagree with each of the following statements:

	Strongly Disagree	Disagree	Somewhat Disagree	Somewhat Agree	Agree	Strongly Agree
Using a laptop helps me to be better organized.	◯	◯	◯	◯	◯	◯
I am more likely to revise/edit my work when it is done on a computer.	◯	◯	◯	◯	◯	◯
I do more work when I use a computer.	◯	◯	◯	◯	◯	◯
I am better able to understand my schoolwork when I use a computer.	◯	◯	◯	◯	◯	◯
I am more interested in school when I use a computer.	◯	◯	◯	◯	◯	◯
The quality of my work improves when I use a computer.	◯	◯	◯	◯	◯	◯

Science Comprehension

10. When does the sun strike the equator directly?

- ◯ Winter
- ◯ Summer
- ◯ Spring/Fall

11. Why do we experience summer conditions?

- ◯ We are closer to the sun when we experience summer.
- ◯ The northern hemisphere is tilted toward the sun and the sun's rays are more directly striking the north.
- ◯ We have higher CO_2 levels in the summer.

12. What would the seasons be like if Earth was tilted on its side like Uranus?

- ◯ They would stay the same.
- ◯ We would have extreme winters and extreme summers.
- ◯ It would be super windy.

13. When we are experiencing winter, what season is Christchurch, New Zealand experiencing?

- ◯ Winter
- ◯ Spring
- ◯ Summer

14. What would the seasons be like if the Earth's axis was not tilted?

- ◯ The seasons would be constant year-round and dependent on latitude.
- ◯ We would experience more than 4 seasons.
- ◯ Nobody would experience winter weather.

15. Why do we experience winter conditions?

- ◯ The northern hemisphere is tilted away from the sun and the sun's rays are striking the north less directly.
- ◯ We are further from the sun when we experience winter.
- ◯ The CO_2 level drops drastically during the winter.

16. What latitude does the sun strike directly overhead at 12:00 PM during the summer solstice?

◯ 51.5 degrees South

◯ 23.5 degrees North

◯ 47.5 degrees North

◯ 36.5 degrees South

◯ 32.5 degrees North

17. What latitude does the sun strike directly overhead at 12:00 PM during the winter solstice?

◯ 47.5 degrees South

◯ 32.5 degrees South

◯ 51.5 degrees North

◯ 23.5 degrees South

◯ 36.5 degrees North

18. What day experiences the longest period of sunlight in the northern hemisphere?

◯ Summer solstice

◯ 4th of July

◯ New years day

◯ Winter solstice

◯ Spring solstice

19. What day experiences the least amount of daylight in the northern hemisphere?

◯ Summer solstice

◯ 4th of July

◯ New years day

◯ Winter solstice

◯ Spring solstice

20. During the summer solstice, which pole has 24 hours of darkness?

◯ The North Pole

◯ The South Pole

◯ Both

◯ Neither

21. During the summer solstice, which pole has 24 hours of daylight?

- ◯ The North Pole
- ◯ The South Pole
- ◯ Both
- ◯ Neither

Appendix B

Post-assessment Instrument

Demographic Information

1. Are you a:

- ◯ Male
- ◯ Female

2. What kinds of grades did you receive last year in school?

- ◯ Mostly A's
- ◯ Mostly B's
- ◯ Mostly C's
- ◯ Mostly D's

Opinions About Science

3. Below are multiple statements about science. Please mark the response that best describes what you think/feel about each statement. These are opinion questions. There is no right or wrong answer.

	Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
I think that being a scientist would be exciting.	◯	◯	◯	◯	◯
I would rather listen to someone talk about science than do a hands-on science activity.	◯	◯	◯	◯	◯
I think that science is important.	◯	◯	◯	◯	◯
I would rather use computers to learn about science than read a science book.	◯	◯	◯	◯	◯
I learn more from listening to the teacher's explanations than from doing experiments and activities.	◯	◯	◯	◯	◯
Science is fun.	◯	◯	◯	◯	◯
My teacher makes learning science fun and interesting.	◯	◯	◯	◯	◯
If I don't understand a science topic I read more about it in a book.	◯	◯	◯	◯	◯
I enjoy doing activities in science class.	◯	◯	◯	◯	◯
If I don't understand a science topic, I can learn more about it on the Internet.	◯	◯	◯	◯	◯
We learn about important things in science class.	◯	◯	◯	◯	◯
Science class projects are boring.	◯	◯	◯	◯	◯
I know how to use the Internet to find information about science.	◯	◯	◯	◯	◯
Using the Internet is a good way to learn about science.	◯	◯	◯	◯	◯
I usually understand what we are doing in science class.	◯	◯	◯	◯	◯
Science challenges me to use my mind.	◯	◯	◯	◯	◯
I enjoy using the computer in science class.	◯	◯	◯	◯	◯
I would like to take more science courses in the future.	◯	◯	◯	◯	◯
I enjoy doing projects and activities in science.	◯	◯	◯	◯	◯
Using a computer helps me understand what I am	◯	◯	◯	◯	◯

learning about in science.

4. Different people like to learn in different ways. In your opinion, how do YOU like to learn about science? Choose the TOP THREE ways that you like to learn about science from the list below:

- [ ] Reading from a science text book
- [ ] Taking notes during science class
- [ ] Doing hands-on science activities
- [ ] Listening to a teacher talk about science
- [ ] Watching videos/animations about science
- [ ] Seeing diagrams about science
- [ ] Finding helpful websites about science
- [ ] Using a computer to do science activities
- [ ] Talking in groups about science

Opinions About Animations

5. How did you learn how to create animations on your laptop? (You may check more than one box if more than one answer applies)

- ☐ I do not know how to create animations on my laptop.
- ☐ I taught myself how to create animations on my laptop.
- ☐ A friend taught me how to create animations on my laptop.
- ☐ A teacher taught me how to create animations on my laptop.

6. Below are some statements. Again, please mark the response that best describes how you think/feel about each statement. These are opinion questions. There is no right or wrong answer.

	Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
I feel comfortable creating animations on my laptop.	○	○	○	○	○
Watching animations helps me learn.	○	○	○	○	○
I am excited to make more animations in the future.	○	○	○	○	○
I make animations in my free time.	○	○	○	○	○
Creating animations make learning in class more fun.	○	○	○	○	○
Making animations on my laptop is confusing.	○	○	○	○	○
I can create animations to explain things to other people.	○	○	○	○	○
I can create animations that help me learn about science.	○	○	○	○	○

7. In the space below, describe what types of animations you have made on your laptop:

Axis Angle Projects

You recently completed a science class project about axis angles. The questions on this page relate to that project.

8. What was the MOST DIFFICULT part about the axis angle project? WHY this part difficult for you?

9. What was the most FUN part about the axis angle project. WHY was this part the most fun for you?

10. In general, did you ENJOY working on your axis angle project. WHY or WHY NOT?

21st Century Skills

11. Describe your ability to do each of the following activities:

	I don't know how to do this	I can do this, but sometimes I need help	I can do this by myself	I can teach others how to do this
Use a word processor (AppleWorks, Word, etc.) to write and print an assignment	◯	◯	◯	◯
Use a spreadsheet to enter and calculate numbers	◯	◯	◯	◯
Use a spreadsheet to create charts or graphs	◯	◯	◯	◯
Use a database to enter information	◯	◯	◯	◯
Use a database to search for and sort information and create reports	◯	◯	◯	◯
Use online discussions to gather information	◯	◯	◯	◯
Use e-mail to send and receive messages	◯	◯	◯	◯
Use multimedia software (like iMovie) to create products	◯	◯	◯	◯
Use presentation software (like Appleworks, Keynote, PowerPoint, Hyperstudio, etc.) to create presentations	◯	◯	◯	◯
Use a digital camera and/or scanner to transfer pictures into the computer	◯	◯	◯	◯
Use web authoring software to create web pages	◯	◯	◯	◯
Use search engines (like Google, Yahoo, etc.) to find information on the Internet	◯	◯	◯	◯
Limit or focus Internet search results using words like "or", "and" or "not"	◯	◯	◯	◯

12. Thinking about your computer use THIS YEAR at school, indicate how much you agree or disagree with each of the following statements:

	Strongly Disagree	Disagree	Somewhat Disagree	Somewhat Agree	Agree	Strongly Agree
Using a laptop helps me to be better organized.	○	○	○	○	○	○
I am more likely to revise/edit my work when it is done on a computer.	○	○	○	○	○	○
I do more work when I use a computer.	○	○	○	○	○	○
I am better able to understand my schoolwork when I use a computer.	○	○	○	○	○	○
I am more interested in school when I use a computer.	○	○	○	○	○	○
The quality of my work improves when I use a computer.	○	○	○	○	○	○

Science Comprehension

13. When does the sun strike the equator directly?

- ◯ Winter
- ◯ Summer
- ◯ Spring/Fall

14. Why do we experience summer conditions?

- ◯ We are closer to the sun when we experience summer.
- ◯ The northern hemisphere is tilted toward the sun and the sun's rays are more directly striking the north.
- ◯ We have higher CO2 levels in the summer.

15. What would the seasons be like if Earth was tilted on its side like Uranus?

- ◯ They would stay the same.
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19. What latitude does the sun strike directly overhead at 12:00 PM during the summer solstice?

- ◯ 51.5 degrees South
- ◯ 23.5 degrees North
- ◯ 47.5 degrees North
- ◯ 36.5 degrees South
- ◯ 32.5 degrees North

20. What latitude does the sun strike directly overhead at 12:00 PM during the winter solstice?

- ◯ 47.5 degrees South
- ◯ 32.5 degrees South
- ◯ 51.5 degrees North
- ◯ 23.5 degrees South
- ◯ 36.5 degrees North

21. What day experiences the longest period of sunlight in the northern hemisphere?

- ◯ Summer solstice
- ◯ 4th of July
- ◯ New years day
- ◯ Winter solstice
- ◯ Spring solstice

22. What day experiences the least amount of daylight in the northern hemisphere?

- ◯ Summer solstice
- ◯ 4th of July
- ◯ New years day
- ◯ Winter solstice
- ◯ Spring solstice

23. During the summer solstice, which pole has 24 hours of darkness?

- ◯ The North Pole
- ◯ The South Pole
- ◯ Both
- ◯ Neither

24. During the summer solstice, which pole has 24 hours of daylight?

- ◯ The North Pole
- ◯ The South Pole
- ◯ Both
- ◯ Neither

Appendix C

Retention Assessment

1. Retention Survey (A)

In the following survey, you will be asked to complete several multiple choice questions related to the axis angle unit that you completed last month.

Try to do your best work.

Thank you for your participation.

2. Axis Angle Project

1. You recently completed a project about the axis angle of the Earth. Which of the following projects did you complete?

- ◯ A paper diagram and a report
- ◯ A narrated animation

3. Retention Survey Questions

*** 1. As viewed from the northern hemisphere, what direction does the Earth revolve around the sun?**

- ◯ A. clockwise
- ◯ B. left to right
- ◯ C. right to left
- ◯ D. counterclockwise

*** 2. Choose the best description for how the Sun appears during the day in our sky (44° North) in winter and in summer.**

- ◯ A. The Sun appears about the same in both summer and winter.
- ◯ B. The Sun appears higher in the sky in winter than in summer.
- ◯ C. The Sun appears higher in the sky in summer than in winter.
- ◯ D. It depends if you are 44° North in America, or 44° North Germany.

*** 3. Choose the best description for how the Sun appears during the day in the sky at 0° on the Equator in winter and in summer.**

- ◯ A. The Sun appears about the same in both summer and winter.
- ◯ B. The Sun appears higher in the sky in winter than in summer.
- ◯ C. The Sun appears higher in the sky in summer than in winter.
- ◯ D. It depends if you are 0° in Africa or 0° South America

*** 4. What happens to the strength of sunlight and the amount of daylight hours that reach us (44° North) as the Earth travels one half way around the Sun from its Winter solstice (Dec. 21) position?**

- ◯ A. The sunlight stays the same.
- ◯ B. The strength of the sunlight increases but the length of daylight decreases.
- ◯ C. The strength of the sunlight and the hours of daylight decrease.
- ◯ D. Both the strength of the sunlight and the hours of daylight increase.

*** 5. If the Earth had no tilt to its axis, what would happen to the strength of sunlight and the amount of daylight hours that would reach us (44° North) as the Earth traveled one half way around the Sun from the Dec. 21, position?**

- ◯ A. The sunlight would stay the same as the Earth traveled around the Sun.
- ◯ B. The strength of the sunlight increases but the length of daylight decreases.
- ◯ C. The strength of the sunlight and the hours of daylight decrease.
- ◯ D. Both the strength of the sunlight and the hours of daylight increase.

* **6. What month of the year does Christchurch, New Zealand have the longest period of daylight?**

◯ A. March

◯ B. June

◯ C. September

◯ D. December

* **7. What day or days, do we experience the same amount and strength of sunlight as someone living 44° south of the Equator?**

◯ A. December 21

◯ B. June 21

◯ C. March 21 and September 21

* **8. What would happen to the North Pole on June 21 if the Earth was tipped 90° on its side like Uranus?**

◯ A. It would receive direct sunlight.

◯ B. It would be very cold

◯ C. It would be in total darkness

◯ D. it would be the same as today.

* **9. When the Earth travels one fourth of the way around the Sun from its Dec. 21 position, how many hours of daylight will we have?**

◯ A. about 18

◯ B. about 12

◯ C. about 8

◯ D. about 20

* **10. How many hours of daylight does someone living on the Equator experience on June 21?**

◯ A. about 18

◯ B. about 12

◯ C. about 8

◯ D. about 20

Appendix D

Daily Teacher's Log

Daily Teacher's Log			
Date:	Group (circle one): A B	# of Students Present:	*Duration of total class period:* *Time spent teaching/lecturing:* *Time spent completing demonstrations/hands-on activities:* *Time given to students to work on project:*
Description of in-class activities:			
Concept(s) and terminology you were able to teach today:			
Difficulties experienced during class period:			
Positive experiences during class period:			
General reflections about today's class period:			

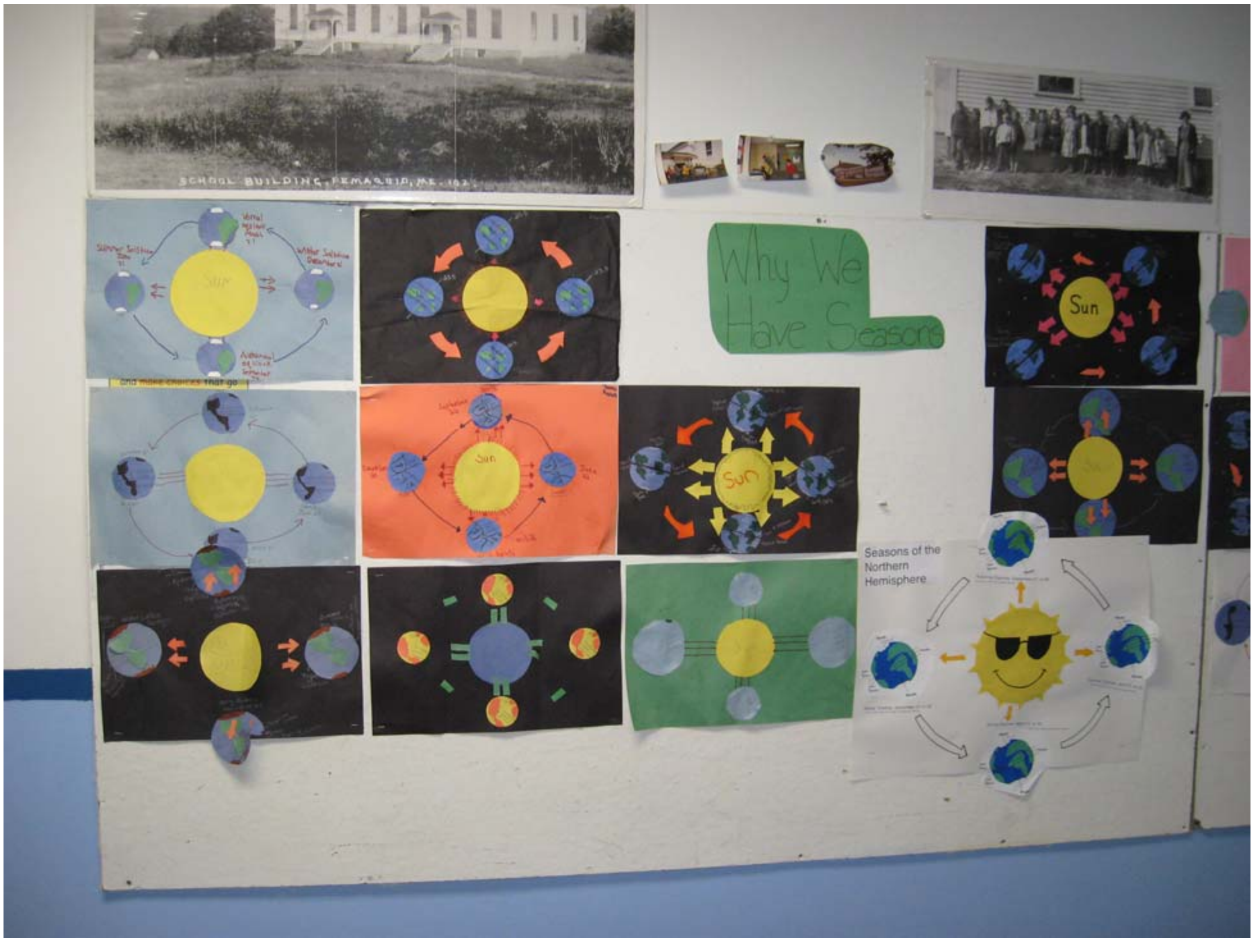
Appendix E

Project Timeline & Tasks

Task	Key Participants	Dates
Meet with science teacher (Kevin Crafts) in order to develop objectives and goals	CEPARE and science teacher	9/12/08
Create pre- and post-assessments to measure attitudes about science, skill-level and comfort-level with animation programs, 21st century skills, and comprehension of axis angle concepts	CEPARE and science teacher	September 2008
Create a teacher log to help record daily activities, teaching goals, frustrations and successes	CEPARE	September 2008
Teach all of the students how to create animations	Science teacher	September 2008
Conduct telephone interview with science teacher to gather information about the students, to talk about his teaching goals, and to discuss how he introduced the animation programs to the students	CEPARE and science teacher	10/15/08
Administer the pre-assessment to both science classes	CEPARE and science teacher	10/21/08
Teach axis angle unit to both classes: the children in classroom A must complete a traditional paper diagram and report, the children in classroom B must complete a narrated animation podcast	Science teacher	10/21/08-11/14/08
Fill out a teacher log for each class every day throughout the axis angle unit	Science teacher	10/21/08-11/14/08
Conduct observations in both classrooms in order to measure general engagement	CEPARE	10/29/08
Administer post-assessment to both science classes	CEPARE and science teacher	11/20/08
Conduct telephone interview with science teacher to gather information student engagement, observable differences, challenges, and benefits to using both teaching methods	CEPARE and science teacher	11/24/08
Develop questions for the retention assessment that measure the students' comprehension of axis angle concepts	CEPARE and science teacher	12/09/08-12/11/08
Conduct web conference interview with students from both classes in order to gather information about their learning experiences	CEPARE and BCS students	12/10/08
Conduct brief web conference with science teacher in order to further discuss the results of the post-assessment survey	CEPARE and science teacher	12/10/08
Administer retention assessment	Science teacher	12/16/08
Prepare final report	CEPARE	January 2009

Appendix F

Examples of paper diagram projects



Appendix G

Examples of podcast animation projects

Examples of students' podcast animation projects from Kevin Crafts' science class can be found by following the link below:

http://www.bristol-cs.u74.k12.me.us/Science/Astronomy_and_Axis_Angle_
Podcasts/Astronomy_and_Axis_Angle_Podcasts.html

Authors' Biographic Sketches

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Since she began working as a Research Assistant at CEPARE, Alexis has been involved with research projects related to the *Maine Learning Technology Initiative* (MLTI). Before working at CEPARE, Alexis worked as a clinical specialist at a day treatment center, which was designed to help keep high-risk children within their own schools, homes, and communities. Alexis received her B.A. in Psychology from the University of New Hampshire in 2007. She is currently enrolled in her second year in the University of Southern Maine's doctoral program in School Psychology.

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In her role as a Research Associate at CEPARE, Sarah is responsible primarily for the research associated with the *Maine Learning Technology Initiative* (MLTI) which provides laptop computers to all 7th and 8th grade students, as well as to all middle school and high school teachers in Maine's public schools. Prior to her work at CEPARE, Sarah was a Recruiter for The New Teacher Project and worked to place traditional and alternate route teachers in high need classrooms across the state of Virginia. Sarah's experience in the classroom included two years teaching high school history as part of the Teach for America program. Sarah holds a B.A. in American Studies and African American Studies from Smith College.

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