How does Multimedia Integrated within a Planetary Science Course Help Students with Difficult Material?

Rebecca Deutscher, Ph.D.
Center for Research, Evaluation, & Assessment
Lawrence Hall of Science, University of California at Berkeley

ABSTRACT

In this study, multimedia that is integrated within a middle school science planetary science curriculum was evaluated. The goal of the project was to evaluate the impact of using multimedia for material that is difficult and not easily observable within a science curriculum and examine its impact on student learning, understanding, interest, and motivation. In addition, getting feedback that then can be redesigned to help improve it in the next version. The curriculum that was evaluated was Full Option Science System (FOSS), an inquiry-based science curriculum. This study was part of a larger evaluation with 10 middle school teachers piloting the course. Data from the larger evaluation and from a classroom using observations and think-alouds with students were utilized in this study. Think-alouds were conducted with two animations: Phases of the Moon and Jupiter's Moons. As a result, students had a better understanding of the concepts and felt the multimedia made them more interested in learning about Planetary Science. The students also gave feedback that presently is being examined by curriculum developers and media specialists. By making these changes, the goal is to improve the animations quality. In future studies, we can examine the impact that a richer multimedia has on enhancing students' learning experiences, interest, and science skills.

SUBJECT/PROBLEM

There has been much research on how technology-based animations can enhance students learning experience in various topics. These animations can make difficult or unseen material more accessible, more understandable, and interesting or motivating to students (Blumenfeld et al., 1991). According to Kali and Linn (2008), visualizations play a large role in helping science learning at both the elementary and middle school level because it makes unseen and complex material visible. By making certain content more animated, it allows users to have a better understanding of the concepts and gain a richer picture of the process behind a particular topic. Bétrancourt (2005) discussed three major uses of animation in learning situations. The first situation included using animations to support dynamic processes that are not easily observable in other ways. This helps an individual make a mental representation of the process. The second situation is where there is a cognitive conflict in that what you predict will happen is not what happens in reality. The third situation is where an animation allows learners to explore a particular concept to help in their understanding.

There have been many studies in a variety of fields that have examined instructional animation versus static pictures. Höffler and Leutner (2007) conducted a meta-analysis on 26 primary studies. They found that overall animations were better than static pictures. This relationship was even stronger when the animation itself contributed to the content that was being learned. However, there were certain types of animations that were not better. Sometimes animations can confuse students more rather than help them. Morrison, Tversky, Bétrancourt (2002) found that some use of animations was not more effective and it overloaded them with

information and did not help them understand the concepts better. Mayer, Heiser, and Lonn (2001) found that when students received concurrent on-screen text that summarized or duplicated the narration during the animation, that they performed worse than those who did not have the on-screen text. This redundancy effect causes an overload for the learner that decreases performance. The researchers also added interesting, but irrelevant material to the animation that had a negative impact on student learning and retention. In 2005, Bétrancourt wrote a review article on animation and interaction in multimedia learning and felt there is potential to help people's understanding of certain ideas or concepts through animation. However, more research is needed to know when animation should be used and how it should be designed.

Kali and Linn (2008) discussed the importance of looking at the design of the visualizations and how that determines how effective they are as a tool. Gazit, Yair, & Chen (2005) designed a virtual solar system to help students understand a complex astronomy concept. At first students had difficulty with navigation, so features were changed to make it easier. After the redesign, the results indicated that the multimedia helped the students understand the concepts better. This shows the benefit of the animation, but also the importance of examining the quality and the need to redesign to enhance the students experience.

In this study, technology-based animations that are integrated within a middle school science planetary science course were evaluated. The goal of the project was to examine the impact that using multimedia within a science curriculum has on student learning, understanding, interest, and motivation. In addition, getting feedback to help redesign and improve the animations in the next version. More data will be collected at that point to find out the impact of the changes.

In this evaluation three main questions were examined.

1. Did students perform better after being presented with the science curriculum and the multimedia?
2. Did students who covered all the curriculum and multimedia related to a science course perform better than those who did not complete it?
3. How did the multimedia affect the students' experience with the material? This included understanding, interest, and motivation.

The science curriculum that was evaluated was Full Option Science System (FOSS). FOSS is a hands-on, inquiry-based science curriculum that was developed for both elementary and middle school students at the Lawrence Hall of Science, University of California at Berkeley. A part of this curriculum involves integrated multimedia to help students understand difficult concepts. The multimedia was designed to enhance the students' understanding of concepts that were being examined in the rest of the course. Many of these concepts are ones where an animation helps students with the dynamic process that would be difficult to see on paper. The multimedia also allows students to explore a concept in a different way to help their understanding. This study examined some of the multimedia from FOSS's middle school Planetary Science course.

DESIGN/PROCEDURE

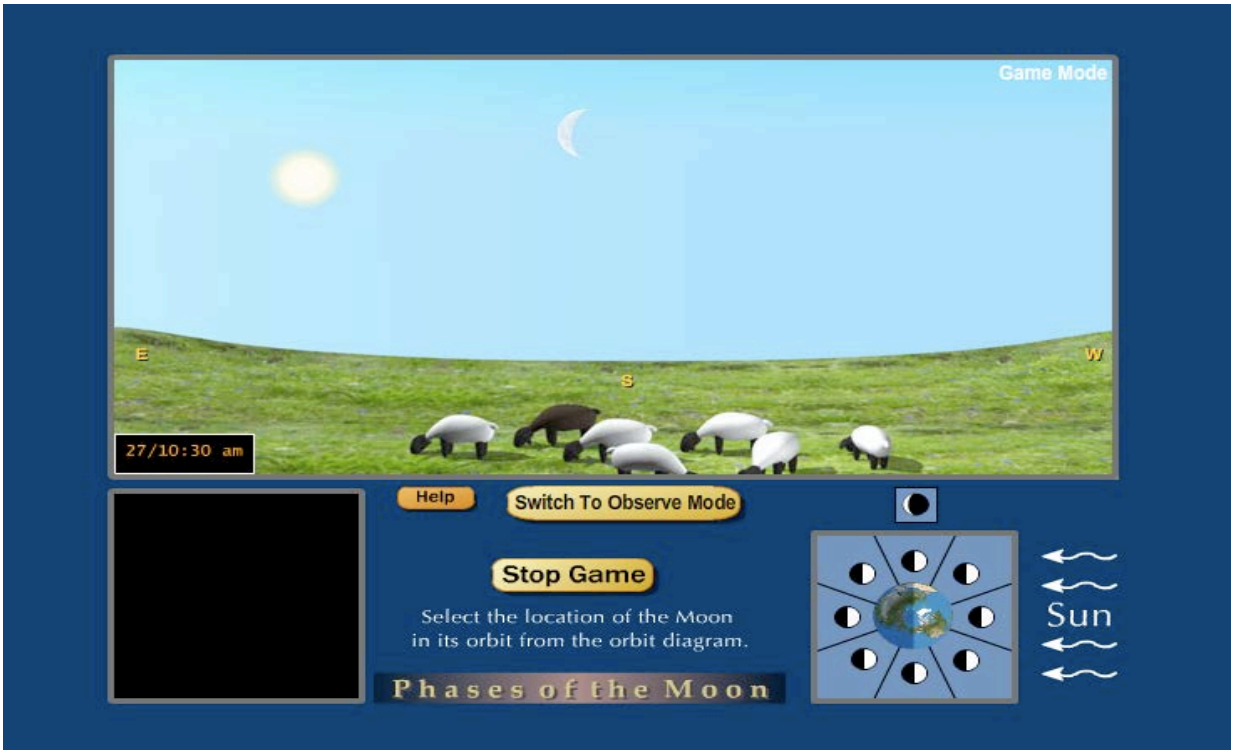
This multimedia study was part of a larger evaluation where the purpose was to test the effectiveness of a revised FOSS Planetary Science Course taught by middle school teachers. Teachers taught the course during a 12-week period in winter and spring of 2009. Ten teachers and 235 students participated. Teachers reviewed student work (student labs, written reports, mid-summative assessments called I-Checks, and pretest and posttest assessments) as they

normally did in the teaching of a unit. Teachers provided feedback on the 10 investigations that make up the curriculum. Each feedback form took approximately 45 minutes. These feedback forms asked them to reflect on all aspects of the course. This feedback was collected through SurveyMonkey.

The majority of the results from the multimedia study were from student and teacher feedback, observations, student think-alouds, and the pretest and posttest assessments. The data from these sources was both qualitative and quantitative. Two of the multimedia components that were viewed as essential to the course and help students visualize difficult material were Phases of the Moon and Moons of Jupiter. In one of the classrooms, involved in the Planetary Science evaluation, these two multimedia components were evaluated at a deeper level. The researcher observed and took notes on these two multimedia animations while they were being used in the classroom. Next the researcher met with students individually to have them do a think-alouds on these animations. The goal was to work with the students as soon as possible after being presented with the multimedia in class. As part of the think-aloud, students were asked to talk about their experiences and thoughts as they were going through it. The sessions were tape-recorded and each student took about 10 to 15 minutes. Eight students did think-alouds for Phases of the Moon and eleven students did think-alouds for the Moons of Jupiter.

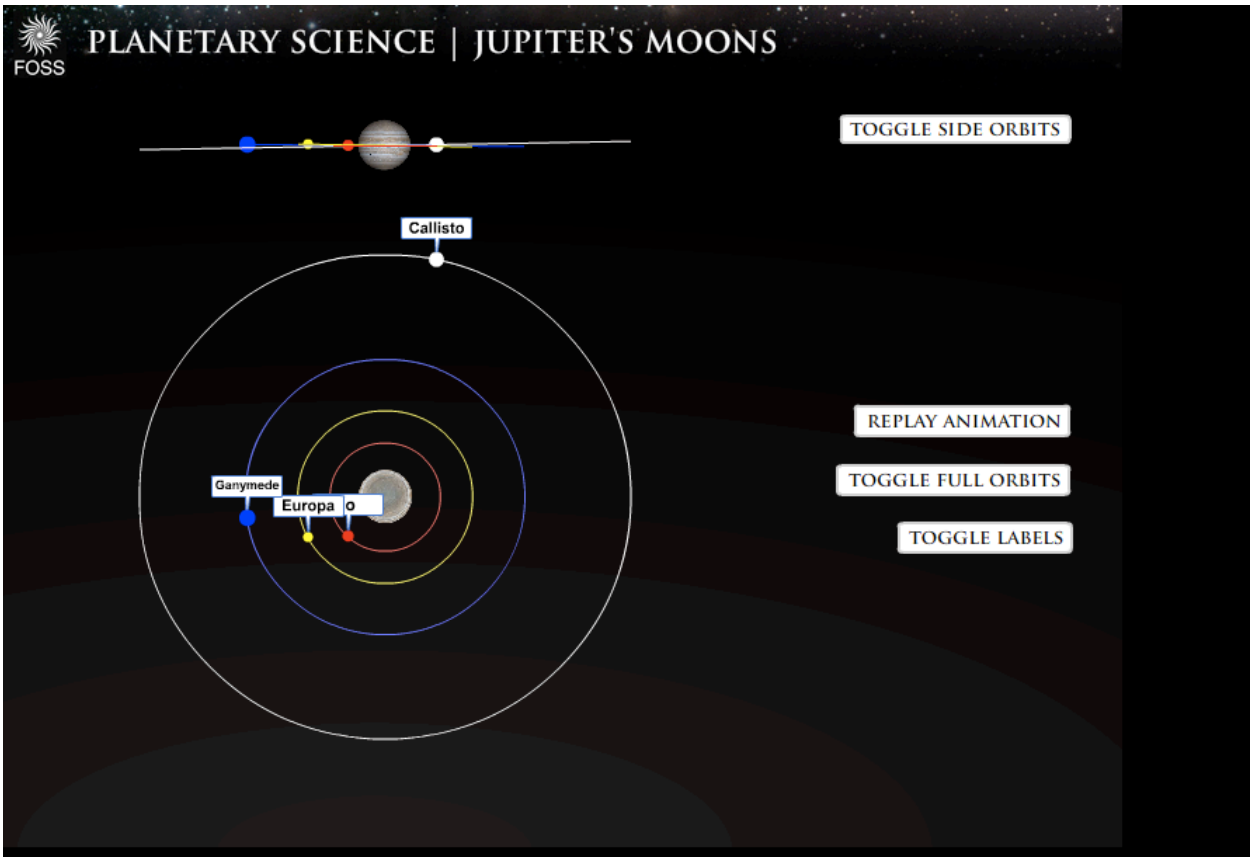
In the Phases of the Moon simulation, there were two modes. There was an “Observe Mode” where students had the opportunity to watch how the moon changed daily and hourly. There was also a “Game Mode” which was utilized in this study. Figure 1 displays a screenshot of Phases of the Moon. In “Game Mode” there was a scene showing a landscape setting with the moon. The students picked the correct moon phase. The students had the opportunity to visually see how the moon changes over time and during different times of the day.

Figure 1 – Screenshot from Phases of the Moon



The Moons of Jupiter multimedia involved two different pictures of the moons orbiting around Jupiter. Figure 2 displays a screenshot from the Moons of Jupiter. The top picture had a side view and the bottom picture showed a birds-eye view. The students were learning about orbital radius and orbital period during this part of the course. The students had the opportunity to view the moons orbit around Jupiter from two different perspectives. They also observed how quickly the moons orbit around Jupiter based on their distance from the planet. The students had control of turning on and off the orbit lines and moon name labels.

Figure 2: Screenshot from Moons of Jupiter



ANALYSES/FINDINGS

Pretest and Posttest Comparisons

All the students who participated in the course were given a pretest and posttest on the Planetary Science class. Two questions related to the topic of phases of the Moon and one question related to the moons of Jupiter topic. All of these questions covered both the content from the multimedia and the other curricula materials. We were interested in whether there were differences in how students performed on the pretest and posttest on these three questions based on their coverage of the material.

The first question was “Explain why the Moon looks different throughout the month (appears in different phases). Draw a diagram to help you explain.” The Phases of the Moon multimedia involved students seeing the phases of the Moon visually. The second question was

“Look at this image of a crescent Moon (see Figure 3). The image was taken from Earth. Draw a diagram to show a bird’s eye view of the Earth, Moon, and Sun at the time this picture was taken. Be sure to shade objects in your diagram to show day and night.”

Figure 3: Image of crescent Moon from Question #2

The third question related to the Moons of Jupiter, but students needed some of the information they learned from Phases of the Moon to answer this question. The question involved looking at a data table about some unknown planets and moons (see Figure 4).

Figure 4: Data Table from Question #3

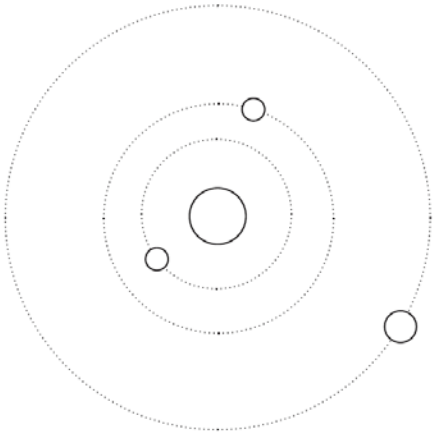
Star, Planets, and Moons in a Mystery Planetary System

Name	Name of star, planet, or satellite	**Radius**	Radius of object (in km)
Orbit	Star or planet it orbits	**Temp. Range**	°C (degrees Celsius)
Distance	Distance to the star or to the planet (in 1000 km)	**Orbital Period**	Orbital period (in Earth days)
		Rotational Period	Rotational Period (in Earth days)

Name	Orbit	Distance	Radius	Temperature Range	Orbital Period	Rotational Period
Alpha	Epsilon	108,200	6052	445°C to 480°C	225.0	243.0
Beta	Delta	1222	2526	-200°C to -50°C	16.0	16.0
Chi	Gamma	527	765	-120°C to 390°C	4.5	4.5
Delta	Epsilon	1,429,400	60,268	-140°C to 190°C	10,760.0	0.4
Epsilon			695,000	>6000°C		25–36
Gamma	Epsilon	57,910	2440	-180°C to 425°C	88.0	59.0

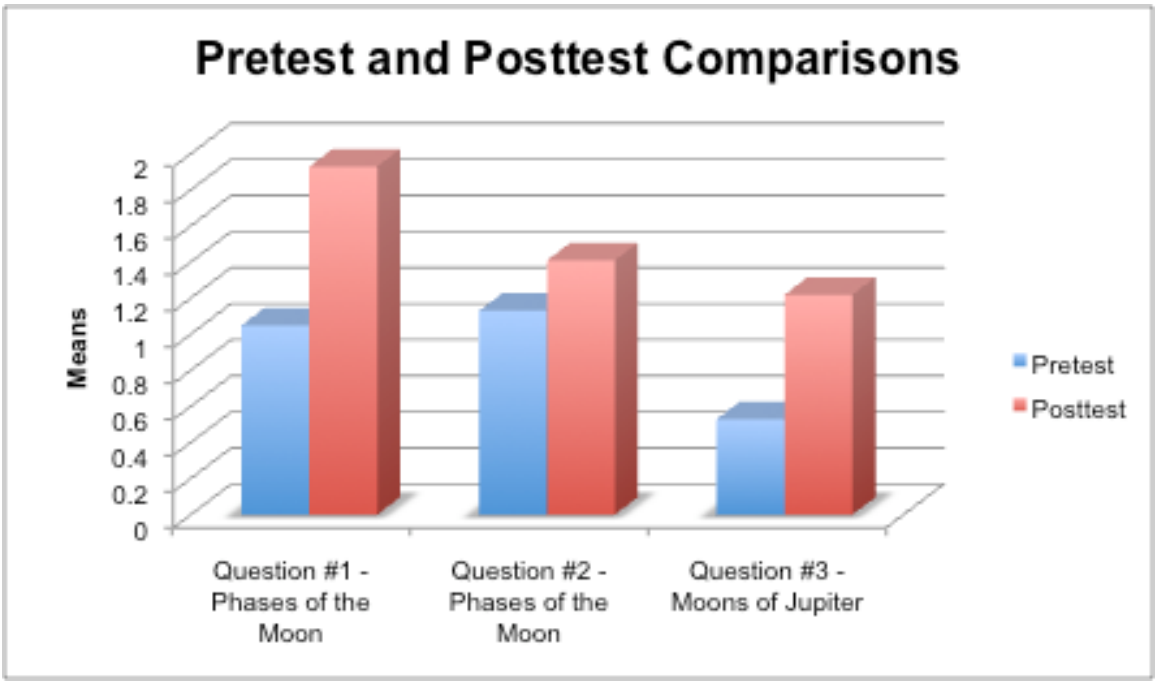
The data included information about distances and orbital radius. Students discussed moon distances earlier in the course and covered Jupiter's moons later. The question was "Draw the moons and their orbits in the correct locations" (see Figure 5).

Figure 5: Question #3 - Students draw the Moons and their Orbits



Overall the students performed better on the posttest than the pretest for all three questions. In Figure 6 a graph that compares the means is presented. In addition, Wilcoxon signed-rank tests were conducted to compare the pretest and posttest test scores. Significant differences were found with all three questions (Question 1: $z = -8.23$, $p < .01$, $r = -.44$, Question 2: $z = -2.88$, $p < .01$, r = -.16, Question 3: $z = -7.27$, $p < .01$, $r = -.39$).

Figure 6: Mean Comparisons of Student Pretest and Posttest Scores



In this evaluation, not all the teachers completed teaching the entire course. All of the teachers covered the material and the multimedia related to the phases of the Moon unit, but the moons of Jupiter topic (later in the course) was covered by six out of the ten teachers. All the students were given the pretest and posttest. As a result, comparisons can be made between classes that finished the material and those that did not finish.

The first comparisons between the two groups (those that finished all the material versus those that did not finish) were the phases of the moon questions (question #1 and question #2). These questions were covered by all the students and it was expected that if the two groups were comparable that they should perform similarly on the two questions. A Mann-Whitney analysis was done to make these comparisons and for questions #1 and #2 no significant differences were found between the two groups (question 1: $U = 2779.50$, $p > .05$, $r = -.10$, question 2: $U = 2952.50$, $p > .05$, $r = -.05$).

The second comparison was made between the two groups on question #3 (moons of Jupiter question). In this case, one of the groups had not covered the material. A Mann-Whitney analysis was conducted and there was a significant difference between the two groups ($U = 2577.50$, $p < .05$, $r = -.15$). The students who had covered the moons of Jupiter in their course performed better than those who did not have this topic.

Overall, this indicates that the curriculum helped improve the students' understanding of the material. The multimedia was an integral part in helping students to learn the material. Those students who did not have exposure to all the material did not perform as well as the students who covered more of the course. The next part of the study involved student think-alouds in which students discussed their experiences with the multimedia and how it affected their learning experience.

Phases of the Moon

Before the think-alouds, observations were conducted to find out how the teacher was using the multimedia during class time. The teacher started off with a very short demonstration of the multimedia and then the students worked on their own. Most of the students were working in pairs on the computer. Students had an opportunity to explore both the "observe mode" and the "game mode." The teacher gave the students a worksheet to fill out based on information they collected from this multimedia. Presently, this multimedia does not have a worksheet to go with it. The teacher felt this would be helpful and would bring more structure to the multimedia. The students became focused on answering the questions on the worksheet to show the teacher at the end of class. Many of the questions were not directly related to the multimedia, so as a result many students spent little time in class on this multimedia. This multimedia was covered in class near the end of the moon unit to help solidify the material. Students were exposed to the multimedia again during the think-alouds that were done soon after the unit was covered in class.

The eight students who participated in the think-alouds were asked whether the multimedia helped their understanding of the material. Five students felt it helped them better understand the material, two students felt it did not change their understanding, and one student felt that it made them understand the material less. The students discussed many ways it increased their understanding. Five students talked about how looking at the phases of the Moon helped them understand the process better including the relationship between the earth, the sun, and the moon, how the moon revolves around the earth over time, and a better understanding that it is a 29 day cycle. Two students discussed that they gained a better understanding of perspective taking and an individual's perspective. One student discussed the opportunity to look

at the phases over and over again helped in understanding and remembering the phases. Another student said that observing the phases made the student wonder how it works on other planets. There was one student that felt that the multimedia did not help understanding the material and felt that the teacher covered the material well in class. Overall, it seemed that most students felt that the multimedia helped their understanding of the material and made the concept more visible.

Students named many things that they liked about the multimedia. Many students said they liked the scenery including the sky, the moon, and the stars. One student talked about perspective and how it was helpful in understanding the moon in relation to north, south, east, and west. Several students thought it was fun and interactive. They felt that the multimedia made this topic fun to learn. One student said this multimedia made one think about the concepts and that it was challenging. Six of the students said that the multimedia made them more interested in learning about Planetary Science.

The students gave feedback on how to improve this multimedia. They had a variety of suggestions including needing better graphics, giving hints, and changing how elements are designed on the page. Much of this feedback has been discussed with the curriculum developers and media specialists who will be making changes based on the student input. Based on the student input, the curriculum developers and media specialists are in the process of making changes to the help features (both online and in FOSS's Teacher Guide) and changes to some of the graphics with this multimedia.

Moons of Jupiter

Observations were also conducted with the Moons of Jupiter multimedia. The teacher did this multimedia as a demonstration for the students. It was introduced by saying there are two views of Jupiter's moons and then the students were asked what they observed. Students discussed orbiting and how some moons have a faster orbit. One student was surprised by how circular the orbit was and expected it to be much more elliptical. This multimedia was covered in class near the beginning of the unit. After the students were shown this multimedia and viewed the moons orbit, they did some exercises to help them learn about orbital radius and orbital period. Students were exposed to the multimedia again during the think-alouds and had the opportunity to manipulate it on their own rather than observing a demonstration.

During the think-alouds, eleven students were asked whether the multimedia helped their understanding of the material. Nine of the students felt it helped their understanding and two of the students felt it did not change it. All of the students discussed how the multimedia helped them understand that Jupiter has many moons, that the moons are large, and that some are farther away than others. For some of these students having the opportunity to see Jupiter with its moons orbiting made this concept more real. Other students discussed learning about the different moons' orbits and how ones that are farther away have a slower orbit than ones that are closer. Other students discussed that they saw how the orbits are more circular in shape and they thought it would be more elliptical. There were also a few students that discussed how they learned the name of the moons because they were labeled in the multimedia. One student noted how peaceful everything looked and how if one thing happened with the moons orbiting Jupiter how it could disrupt the whole flow of things. A few students discussed how they saw how the side view of looking at the orbits was more confusing to see than the top view. A little earlier in the lesson, students had learned how Galileo was making observations with a telescope. They could appreciate how difficult it must have been for Galileo only seeing the moons from a side view.

The main purpose of the multimedia was to help students' understanding of the differences between the birds-eye view of Jupiter's moons and a side view. It did help students understand this concept, but it also helped with their understanding of what is happening with Jupiter's moons and their orbits. By being able to visually see this multimedia, the students had a richer understanding of this topic.

In regards to what students enjoyed about the multimedia included: there was both a side view and bird's-eye view of Jupiter's moons, how it showed the moons orbit around Jupiter, how it showed the names of the moons so they could be differentiated, how they had the ability to turn on and off the orbit lines, how the picture of Jupiter is fairly detailed, and how there is a starry background. Several students said it was fun, that they liked being able to interact with it, and that because it moves they could learn more. Six of the students said that the multimedia made them more interested in learning about Planetary Science.

The students also had feedback on how to improve this multimedia as well. They had a variety of suggestions such as increasing the size of the multimedia, changing how some of the buttons are labeled to make it clearer, and adding more information or facts about Jupiter and its moons within the multimedia. In addition, some of the students thought that Jupiter only had four moons since that was what the multimedia presented. Much of this feedback has been discussed with the development team who will plan to make changes based on the student input. The team plans to change some of the labeling and buttons on this multimedia to make it clearer. There is also discussion about having some links, so students could learn additional information about Jupiter and its moons.

Multimedia Themes

Some common themes developed through analyzing the think-alouds from both multimedia components to think about when developing and utilizing science multimedia with middle school students. The first theme that emerged involved the interactivity of the multimedia. Both of the multimedia components had some interactivity or control over the environment. Phases of the Moon had a game format and students interacted with the game, while the Moons of Jupiter involved students observing, but the students could turn on and off labels and orbit lines. This gave the students some control over the environment. The students enjoyed the interactive nature of both multimedia components. In developing multimedia, it seems that even adding a small amount of control, like labels, can help students have a more positive experience.

Students discussed having more help features or ways to find out more information. Some of the students felt the Phases of the Moon multimedia was confusing and having some help features would be useful. In the second multimedia, the students seemed to understand how to use the multimedia, but some students did not understand the purpose of the multimedia was to compare two perspectives of Jupiter's moons. In addition, some students also wanted to be able to learn more about Jupiter and its moons. Spending time with the help features and examining various ways to improve those features for students can enhance their experience.

Students seemed to enjoy having a challenge with the multimedia. They enjoyed trying to figure out what was going on with Phases of the Moon and the Moons of Jupiter. Neither of them were straightforward and students had to figure out what was going on and how to use them. Most students seemed to enjoy this aspect. Part of the reason video games are so popular is the challenge connected with playing them. Adding challenging features to the multimedia enhances the experience for many students.

Both of the multimedia components involved some type of perspective taking. They involved perspectives that students might not normally notice or perspectives that they cannot see in everyday life. Students often talked about liking the perspective-taking component of the multimedia. This is where multimedia can be very helpful to students. It allows them to see things in a different way and expands their understanding of various concepts.

In developing multimedia, we need to be careful that students do not misinterpret the content that is being presented. Since more of the material may be pictorial in nature, it is important to be careful what is included. In the Moons of Jupiter multimedia about half the students thought that Jupiter only had four moons since that was displayed in the multimedia. In the curriculum materials, a discussion that Jupiter had more than four moons was discussed, however, it is important that is also represented in the multimedia. This example reflects how easy it is for students to misinterpret information that is being displayed in a multimedia.

The last important theme is the importance of student input when developing multimedia. The students had a lot of ideas about changes that could be made to the multimedia. In addition, we were able to identify the features that students did not understand or misconceptions they had about the material. Gaining this feedback from the students was extremely valuable to improving the multimedia.

CONTRIBUTION/CONCLUSION

This paper examined how multimedia in a science curriculum helped students learn and understand material and concepts that would have been difficult to represent in other ways. The results indicated that the students performed better on the posttests than the pretests. Students understood the material better as a result of the combination of the curriculum with the multimedia component. All the items on the pretest and posttest had a component where students had to draw or visualize the concept. By viewing the multimedia and understanding the concepts at a better level, this helped students answer the questions. In order to understand more about the students' multimedia experience, students were asked about their perspective. For Moons of Jupiter and Phases of the Moon, students talked about some of the concepts they learned from the multimedia. The students learned about phases of the Moon and Jupiter's moons in some of their other curriculum material, but the multimedia added a visual component for many students so they better understood the phases and could see the continuity in the process. Also with Moons of Jupiter, students felt they understood better how the moons orbit the planet. For both of the animations, students felt the multimedia helped their understanding of the material.

In regards to interest, many students felt that the multimedia made them more interested in learning about planetary science. Some students said that they thought that the multimedia was fun and interactive. One student wondered about what happens with other moons and other planets. This excitement about learning and wanting to find out even more information about the topic was observed with these animations with these students. The students also gave feedback on how to improve the multimedia. Observations were also made of student understanding of the material. All of this feedback is currently being examined by the curriculum developers and media specialists to help improve the animations. By making these changes, the goal is to improve the quality of this multimedia in order to enhance the educational value. In future studies, we can then examine the impact that a richer multimedia can have on enhancing students' learning experiences, interest, and science skills.

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