Macromedia Flash in Physics Education
ASPIRE's Interactive Online Labs and Lessons

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Abstract

Flash provides the ASPIRE team a means to create interactive virtual learning environments, where teachers and students can explore places and things previously limited by the classroom or simply by time constraints. Flash can become an immersive world for online science education. Producing curriculum support material in Flash provides many benefits for teachers and students.

Teachers are provided with an affordable tool, which aligns to local and national curriculum standards. This material provides a rich classroom experience at little cost to the educator, while also satisfying the curriculum goals. Students can participate in an engaging learning experience, where science becomes an experience beyond a textbook lesson or a classroom lab. Situations are presented that would be either difficult to reproduce due to cost or scale. For example, students can investigate the causes of tides in the ASPIRE Flash activity "Gravity and Tides."

Flash, the software available for authoring these activities, can produce a mathematically correct, physically based model that students can observe and investigate. These lessons provide a high-quality experience; meanwhile, the cost and speed of production of these activities continue to decrease.

1 Flash and ASPIRE Lessons

Flash technology has opened the Web to a vast number of interactive sites that have been designed to sell, promote, dazzle and impress. Indeed, designing a multimedia site has now become an art form exclusive to the Internet. When the team at the Astrophysics Science Project Integrating Research and Education, or ASPIRE, saw Flash in action, they saw an opportunity to create something different and new. Flash can become an immersive world for online science education. Initial production of ASPIRE Flash lessons created immediately observable benefits, including greatly reduced production time and cost. Additionally, Flash productions increased the level of interactivity and production quality.

Flash provided the ASPIRE team a means to create interactive virtual learning environments, where teachers and students can explore places and things previously limited by the classroom or simply by time constraints. As an astrophysics outreach program, the ASPIRE team determined that the lessons best suited for online visualization were based on Earth Systems curriculum dealing with astronomical subjects. Upon completion, this first set of lessons would create a 'virtual planetarium.' This production would follow a modified instructional development model, customized to use local and national curriculum standards. [Gentry 1994; USOE 1995]

"Gravity and Tides" is the first set of Flash lessons that the ASPIRE team completed as part of the virtual planetarium. The immersive quality of the lessons exceeded the expectations of the ASPIRE team and work immediately progressed to other subjects. Flash is able to integrate basic physical formulas to produce simulations. These simulations result in an accurate model of gravity and tides in our local solar system. Because the simulation is mathematically based, the student can interactively manipulate the model to explore variations of the model. The virtual lab provides a rich hands-on experience that a teacher would be challenged to reproduce in the classroom. These lessons are unique in that they have integrated curriculum and activities. They are also free of charge for anyone who wishes to use them.

2 ASPIRE

ASPIRE is the educational outreach program for the High Resolution Fly's Eye Cosmic Ray Research Group (HiRes) at the University of Utah. The HiRes research group has operated at the University of Utah since 1991, and is funded by the National Science Foundation. In 1997, the NSF charged HiRes scientists with forming an educational outreach program. A committee of scientists, educators and administrators held a summit to determine how HiRes could best serve K-12 educators and administrators.

At the end of the meetings, it was determined that the greatest need for science education outreach was at the middle school level. According to studies by Project 2061, a national science education reform panel, textbooks for science teachers and students at the middle school level have been found to be unsatisfactory. [Roseman et. al. 2001] Recreating textbook situations was neither the answer to this complex issue, nor is a visit practical or possible by research scientists to an area as large as the Utah. A consensus was reached to provide the 7th, 8th and 9th grade teachers with online activities, so that they can benefit from the outreach program, regardless of proximity to the University of Utah.

A team was assembled with teachers, scientists, programmers and artists to produce web-based activities. The first ASPIRE lessons were produced as applets written in Java. One unique feature to these lessons that is still difficult to find on the web today is that the curriculum is integrated into a web page that serves both as lesson and lab. Instead of having a lecture day and then a lab day, the student experiences both on the Web. These lessons were well received and continue to be used in schools in Utah as well as nationally and internationally.

The benefits of using Java were immediately obvious. Students could virtually interact with the computer in a simulation that could not be easily or affordably reproduced in a classroom. Computers have an appeal that engages students, who otherwise may not participate in the classroom. Teachers could spend valuable classroom time answering the students' questions about the lessons instead of lecturing. The lessons developed were designed to adhere to national science education reforms, so that any teacher could feel comfortable utilizing these activities and know that the students were exploring concepts and ideas that may be found on an end-of-level test.

While the lessons were successful, Java presented some drawbacks. These included technical difficulties for the users. Java is expensive to program as well. ASPIRE hires students at the University of Utah to provide an enriched work experience. A

considerable amount of time and budget was devoted to learning Java. At that time, the benefits of the science lessons and labs far outweighed the drawbacks.

3 FLASH

In October of 2000, Macromedia released Flash 5. The previous versions of Flash were used by many designers to create exciting web pages and interactive animations, but had not been considered by ASPIRE for more intensive programming functionality. With Flash 5, however, the new ActionScript language allowed the additional level of flexibility needed to create interactive science labs. The most recent browsers were being released with built-in support for the Flash viewer as well, which eliminated some of the previous technical concerns. ASPIRE designed a production model for a preliminary activity, and the Tides and Gravity Simulator was developed.

3.1 Creating a Realistic, Physically-based Tide Simulator

The first completed activity was the Tides and Gravity lessons. This unit is actually a set of 4 separate lessons and labs written by 8th grade science teacher, Gina Ward. Production started with a storyboard session to determine how the activity should progress, and what level of interactivity the students could have with the lab portion of the lesson. Tides are the result of planets and satellites in motion and their mutual gravity in our solar system. They can be mathematically explained using Newton's Universal Law of Gravitation:

$$F = \frac{GMm}{r^2}$$

How could the ASPIRE team turn this mathematical formula into an exciting interactive lab for 9th grade students? Students in a land-locked place like Utah rarely get to observe tides and students all over would have a hard time seeing what tides would look like from outer space.

The lab would allow students to 'see' what tides look like, if they had a birds-eye view of our solar system. The tide movie was created in Flash using the new capabilities that are now available through ActionScript. The concept of the movie is simple. There are three rotating objects: the Sun, Moon, and Earth; the Earth is surrounded by molecules of water. Due to the complex math between each object on the screen animating and updating each frame, the number of water particles is limited.

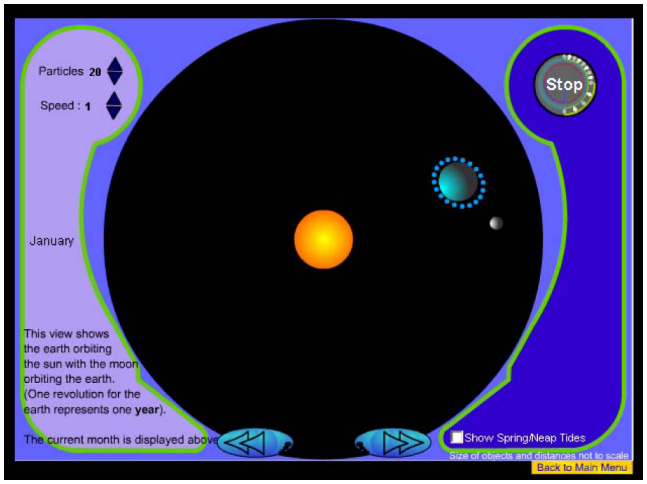

Figure 1 ASPIRE Tide Simulator

This interactive lab, combined with the curriculum lesson written by Gina Ward, creates a rich classroom experience. The students can explore and observe the high tides and low tides that happen as a result of lunar cycles. They can examine and explore why there is a bulge not only facing the moon, but also on the opposite side. As a guided inquiry-based activity, another version of this lab was created where a second moon could be added. The students hypothesize what they think will happen when an additional moon is added to the Earth's orbit, and then observe the results in the next simulation. Because the Flash movie is based in the model, adding another body is a simple exercise.

After the tides lesson and lab was created, other activities were designed to complement the "Tides Simulator". Now when students explore "Gravity and Tides", the first activity is an exploration in critical speed. The second activity is actually an exploration in how Newton's Universal Law of Gravitation works, without having to crunch numbers, but rather observe the relationship of the formula relative to the sun, Earth, and moon. The tide simulator is the third activity, followed by a final activity, where the student takes real, historical data from Monterey Bay over the course of a year.

The result of this activity is a rich interactive experience. The level of immersion that this activity offers is greater than ASPIRE had been able to produce prior to working in Flash. The movies can accept text input fields and dynamically interact with the text. With the previous online lessons, students worked from a printed lab book, and converted data taken on the computer to their paper booklet. The dynamic text function allows students to answer questions, hypothesize and receive immediate interaction from the computer. Flash can also write a text file to be printed so homework can be printed out and submitted.

Exploring the lessons becomes more than just a 'read-and-click' activity. One of the criteria in deciding to develop an ASPIRE activity rests on the necessity of the computer. If a teacher can create by other means a classroom experience just as easily and inexpensively as an ASPIRE lesson, then there is little point in producing it. If a lesson can save a teacher time and money, then value is found in creating the activity.

The artwork and environment can help create an environment where the student can read and explore; meanwhile the experience is enriched with the interactivity. Simply reading on the computer presents the same problems as simply reading a textbook. Experiencing a concept or idea engages students, and an engaged student is a learning student.

Other benefits in the production model became immediately obvious. The method of working between programmers and artists is more closely connected. Programmers can set up a file system with placeholder artwork, which the artist can then incorporate. Java programmers had difficult enough time explaining their code to each other, let alone allowing the artist to load and manipulate the files. The communication between programming and artwork becomes closer with Flash. Flash is not only a tool to program, but also an animation and graphics package. This software design creates a production model in which the line between art and technology becomes blurred with use.

The time in producing a Flash lesson has exponentially decreased compared to Java. A single applet in Java took up to a year to program, while the entire "Gravity and Tides" lesson took under a month. Because of this reduction in production time, the cost of each lesson has decreased. To date, four lessons have been published to the web site in support of the virtual planetarium. ASPIRE plans to complete the virtual planetarium by the end of summer 2002, which will more than double the amount of content available on the web site with over 20 individual lessons and labs. This production phase will last a little over a year with a reduced staff of 4 or 5, compared to the body of work that took 3 years to

complete with a larger staff. The overall effectiveness of these activities will be observable after classroom testing and assessment.

4 Conclusion

Lessons and activities designed for classroom use on the computer can greatly increase the availability of support materials for teachers and students. As newer technologies are developed for authoring multimedia, these types of activities will become increasingly easy and affordable to develop. The lessons that ASPIRE has developed with Flash demonstrate this. ASPIRE has taken steps to provide curriculum appropriate support material that transcends traditional textbook lessons. These methods will support current science education reform efforts while supporting the curriculum standards.

The resulting activities provide many benefits for teachers and students alike. Students can participate in a visually exciting; engaging activity that meshes traditional textbook learning with a hands-on activity. Participation can lead to investigation of subjects previously difficult to visualize or investigate. Teachers have a greater pool of resources to pull from while developing curriculum for the classroom. Because these lessons are digital and online, cost is minimal or free for educators. Curriculum support materials that are aligned with the most current standards will provide valuable resources, both in content and cost, for science educators and students.

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