Modeling Modern Methods in High School Physics Classes

Hal Scheintaub, Governor Dummer Academy, Byfield, MA USA hscheintaub@gda.org

Abstract: Interactive computer models and simulations can extend traditional learning in high school biology classes (Scheintaub, 2004). Results of this study show that computer models can enhance high school physics learning, too. They do so by extending experiences beyond the limits imposed by text and lab. Computer models complement data gathering and analysis software to bring inquiry to the classroom. The author proposes that validation is critical to a model's effectiveness as a learning tool.

Introduction

Technology helps students perform experiments that are reliable enough to be an integral part of many inquiry-based high school physics courses. Students use Logger Pro software (Vernier) to collect meaningful data and Excel to analyze it. Students find mathematical relationships in their data and can make predictions based on those relationships. However, time and equipment restraints prohibit most experiments from being confirmed and most predictions from being tested. These constraints limit opportunities for students to design and conduct investigations. Consequently, students miss out on important parts of the scientific process. The author found that computer models could bring verification and student spawned experiments into high school physics classes. The computer models chosen (PhET, 2005, Molecular Workbench, 2005) generated data quickly. The models provided a fluid environment where trial and error was possible, and they were good enough to be used by students voluntarily. The models supported physics curricular goals and allowed for meaningful inquiry to happen in the classroom.

Design

In an introductory unit of two inquiry based physics courses, 28 students performed two physical experiments with springs (Scheintaub & Wilson, 2005). They established by experiment that the stretch of a spring was directly proportional to the mass hanging on it. Then students found that the period of a bouncing spring was not directly related to mass, but proportional to the square root of the mass attached. Appropriate textbook readings (Hewitt, 2002) and mathematical analysis accompanied the experiments. After doing and discussing the spring experiments, students were shown two interactive computer simulations of springs (PhET, 2005, Molecular Workbench, 2005). They established the validity of the computer models by duplicating the experiments that they had performed at the bench. They designed and ran experiments with their models. The spring experiments served several curricular goals. They revealed a role of mathematics in interpreting data. They helped set a tone of inquiry and investigation for the year, and they helped establish computers as an integral part of the course. The unit served as an introduction to a semester that would include the study of waves, sound and light. As a final activity, students considered the role of simulations, labs, text and lecture in their learning.

Results

Students cited the physical experiments as their favorite learning method (see Table 1). Computer models and class discussion were valued learning methods, too. The physical lab seemed most effective in specific content and general science learning, but computer models added an important new dimension. Loggerpro (Vernier) and Excel were used to collect and analyze data, but students reported that it was the computer models that taught them about the role of computers in experiments. Students used models to perform experiments of their own design that included investigations into the effect of friction on bounce and gravity on stretch. The latter experiment provided an opportunity to introduce the concept of force to the class. Five students said that they learned about the relationship between spring stiffness and period using models. Few of the student-designed experiments could have been performed physically in the school lab. Fifty percent of the students chose to use computer models to conduct an experiment that was a part of their unit test. Students cited comfort as the reason for their choice. The classes that used the computer models kept pace with classes that didn't. Classes took similar assessments, with no significant difference in grade distributions.

Discussion

This study shows how computer models can add extra dimensions to high school physics classes. In addition to supporting traditional concept learning, the models provided opportunities for inquiry. Students designed and conducted experiments not usually possible in school, and tested hypotheses. The combination of lab and computer model can be very powerful. The computer occupies a position of authority and influence in young people's lives; so when computer models give the same results that a student got in the lab on her own, she feels validated. The confidence generated by validation may stimulate learning. However, just as authority figures may have power by virtue of position, they have to earn respect by being relevant to the young person. So it is with the computer. Computer models in this unit achieve relevance by producing results that match the young person's real world experience. So the model validates experience and is validated by it; and once validated the student willingly learns from the model. The models cited here are only two of many that are available and will be used throughout the year. The author looks forward to reporting on student responses to other models in future communications.

Table 1. How & What Students Learned About Springs

What Students Learned *Spring Specifics*	**Learning Method →**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**Totals**
As mass increases, period increase nonlinearly		1	5	1	8	0	0	0	1	**16**
As mass increases, stretch increases		1	2	0	4	1	0	3	0	**11**
As stiffness increases, period decreases		1	0	0	0	0	0	3	2	**6**
distance vs. t graph is sine curve		2	1	1	3	0	0	1	0	**8**
Amp decreases, f remains constant		0	4	0	3	0	1	0	1	**9**
Springs are efficient systems		0	3	0	5	0	0	0	0	**8**
Springs have friction		1	0	0	1	0	0	1	0	**3**
Can use springs to find mass		0	0	0	2	1	0	1	0	**4**
Other comments and connections		1	4	1	6	1	3	1	3	**20**
General science (non-spring) learning										
role of computers in experiments		0	0	0	0	0	1	3	3	**7**
graphs and calculations		0	1	4	5	1	2	1	0	**14**
writing a lab report, do experiment		0	1	2	4	1	0	2	4	**11**
do a good experiment		0	0	0	3	0	0	0	3	**3**
how this class works		0	1	0	1	0	1	3	0	**3**
many variables are in an experiment		0	0	0	1	0	0	0	1	**2**
Totals		**7**	**23**	**9**	**43**	**5**	**8**	**15**	**12**	**122**

Learning Method **1**. text, **2**. class notes & discussion, **3**. doing homework **4**. performing experiment, **5**. writing up experiment, **6**. collaborating with classmates, **7**. PhET computer model, **8**. molecular workbench

References

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Vernier Loggerpro software version 2.2