Experiences Supplementing NYS Regents HS Physics with ~~David~~ Sokoloff and ~~Ronald~~ Thornton's *Interactive Lecture Demonstrations* for Force and Energy.

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See sample 690ms.

Intro
Lit
ILD defns
5 ILDs
what I did — discrepancies from stds suggested for ILDs
~~student reactions~~
my student
my student reactions

Too Long - Too Vague
but getting better.

Abstract

~~In this paper I briefly describe and~~ review five of ~~David~~ Sokoloff and ~~Ronald~~ Thornton's Interactive Lecture Demonstrations ~~regarding~~ force and energy. I describe my experiences using these materials in ~~my~~ class of 25 NY Regents Physics. In general I find that the labs offer good support to the physics modeling curriculum which I currently use to teach mechanics. Students experiencing the demonstrations had high percentages achieving Mastery level on the NYS Regents Physics final exam.

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I am a teacher of high school physics. I live and work in New York State, and I and my students ~~are responsible to comprehensively cover~~ the state Regents Physics curriculum. My school district is small and rural. The average graduating class size is about 100 students. Roughly 20% of the senior class is enrolled in physics. Most of these students are going on to further education after high school.

Because we have prerequisites in place, the physics students in my district have a strong math background. Despite their ability in math, the students sometimes face difficulties dealing with underlying concepts of the subject. They have had no formal exposure to the use of technology in the classroom with the exception of calculators and word processors. Because of this shortcoming, helping students uncover the concepts studied in the physics classroom can be challenging. In an effort to overcome this difference between the 'plug and chug' mentality and deeper conceptual understanding for students I am teaching using the *Modeling Theory of Physics Instruction* as developed by David Hestenes and colleagues.

The idea of using multiple representations to deliver content is stressed throughout the modeling curriculum. The practical classroom application of this allows more students access to the content. Integrating several different ways to represent information and core concepts to students is the best approach to teaching to a variety of individual learning styles and providing the greatest number of students with a good conceptual understanding.

In the article *Promoting Active Learning Using the Results of Physics Education Research*, by Laws, Sokoloff and Thornton, micro computers and probe ware are described as a method to create an active learning environment in a large lecture format. The labs were performed in calculus-based college physics classes in five universities, but the activities themselves do not rely upon equations and are therefore within the capabilities of high school students. The Laws article also suggested that there is evidence that active learning methods work well in many different environments.

Because the *Modeling Theory of Physics Instruction* relies in part on the use of micro computers it seemed that the Interactive lecture demonstrations could supplement the modeling curriculum in a high school classroom.

David Sokoloff and Ronald Thornton's *Interactive Lecture Demonstrations* (ILD) offer a route to expand the curriculum to accommodate a technology with which my students are unfamiliar. ILDs allow a structured environment to elicit student pre-conceptions, present data with a different graphic model, and *introduce new technology to the students*.

Interactive Lecture Demonstrations are relatively simple activities to perform. The demonstrations always begin with simple descriptions of both the apparatus and student expectations. Students are passive participants as the instructor performs several scenarios in each session. The scenarios all follow the same format, making for a streamlined process, once students and teachers have become accustomed to the protocols.

After the students have been shown the apparatus (motion sensor, force probe, data logger, fan carts, track, and pulley) a specific type of motion is demonstrated and each student makes graphic predictions. These predictions are qualitative only and begin with simple position versus time graphs, but evolve to include velocity versus time graphs, acceleration versus time graphs and force versus time graphs.

Student knowledge is always elicited after seeing each specific demonstration. They are asked to fill in graphs on a "predictions" sheet. Once the students complete their prediction for a specific demonstration, they are shown the demo again, with all electronic data collection active. Real-time collection of the data students were asked to predict is generated. The class is then asked to discuss briefly any differences between predicted and observed patterns. Students then fill in correct versions of the graphs on the "results" sheet.

Each ILD lab is a collection of four or five related scenarios which are designed to incrementally challenge student pre-conceptions through this method of elicitation and rapid feedback.

In the first lab, students are introduced to the basic sensor hardware and the software. This is an excellent introduction to the capabilities of the apparatus. The first motion is so simple the nearly all the students are able to accurately predict the graph. Once they see the graph, they become confident that the device is recording an accurate model of the motion. In later more complex motions, when student predictions do not match the collected results, they trust the equipment rather than argue for their incorrect predictions.

The second ILD introduces a low friction motion cart, fan unit, and track set up. This lab is effective at introducing gravity as a source of acceleration.

The third ILD introduces a pulley, string, and mass set-up to provide the cart with acceleration and the force probe. The probe is attached to the cart and the string is tied to the hook on the force probe. The string runs over the pulley and the mass hangs freely. It is apparent to students in this activity that the mass is somehow acting on the cart although it is not immediately apparent to students that gravity is the responsible force acting on the mass.

ILD four uses two force probes and two carts or two probes and two blocks. The lab is designed to illustrate Newton's third law. This lab is different in that it does not ask students to draw graphic predictions. Students are asked to compare what graphs would look like verbally only.

The final ILD I explored was a return of the cart on the ramp using only the motion detector. It introduces the idea of energy. It treats both kinetic and potential energy.

In all cases students were asked to make predictions. In all cases students were also shown the actual graphs created by the probe ware. In all cases they transferred corrected graphical representation of observations onto results sheets.

I examined two different types of hardware and software to deliver the ILD content. I used Vernier and both Pasco hardware with its accompanying software. Both sets of materials introduced students to new technology which they had not previously encountered. Hardware used included motion sensors, force probes, data loggers, fan carts, tracks and pulleys. The software was real-time data plot software Logger Pro from Vernier and PASCO Data Studio 3.

The materials required for ILDs are reasonable for teachers in smaller districts with budget concerns. ILDs use a single set of hardware and software which costs about 500 dollars. The cost of running similar activities in small lab groups would be 500 dollars per lab group. This does not include the cost of computers.

The first year I performed ILDs there was only a single lab class. The second year I had two lab groups, and could administer an alternative set of labs to a second group. The second group was shown parallel activities and allowed to operate the probe ware, instead of watching me operate it. The second group was not given the prediction/result sheets and there was no elicitation. Students in the second group were asked to generate graphs of the parallel activities themselves. The second group could not overcome their unfamiliarity with the hardware and associated software. Most of my students have never used spreadsheets. I do introduce them to spreadsheets early in anticipation of the usefulness in creating graphic models throughout the course. However, many students in the second group remained uncomfortable with spreadsheets. Students who did experience ILDs were much more comfortable in developing their own graphs from spreadsheet data in later activities. Students who participated in ILDs became more adept at graph creation and were more likely to incorporate the graphical representations into their lab work in subsequent units. This seemed to be fostered for the ILD group through a careful construction of the connections between the observations and the models which described them. For each new idea explored, these steps are followed; eliciting their preconceptions, making observations, recoding data, discussing the results, and ultimately incorporating some model to describe the phenomena.

I experienced no significant differences in the quality and ability of the PASCO and Vernier devices. The ranges, sensitivities, and sample rates of both are adequate for all of the exercises in this set of ILDs. The software is also well suited to the activities. Both offer very similar capabilities, with only minor differences.

Both Vernier and PASCO motion sensors experienced some problems with detecting the fan cart. The fan generates 'noise' which can cause messy looking graphs. Several runs of some of the demos were required in order to acquire adequate graphical data. Neither system was any better or worse at dealing with the fan 'noise'. There is definitely a need to discuss this with students both before and during the labs.

Students experienced differences in performance on the New York State Regents Physics Exam. Both groups experienced a 75% passing ratio. The group who experienced the ILDs also achieved 12.5% mastery level. The group who did not have the benefit of the ILD had several students who were capable of mastery, yet none of them were able to achieve it. There were only a few questions on the June 2006 exam which favored the ILD students, but they did better on them as a group. A constructed response question which had students draw a graph was answered correctly by 87.5% of the ILD students. Only 75% of the non-ILD students were able to answer the question correctly.

In a post course interview of all of the student participants, I discovered that students who did not participate in the ILDs did not have any more than a general understanding of how technology is important in the physics classroom. One such student considered technology of the physics classroom to be limited to a stopwatch, a meter stick, and a calculator.

What is the Q?

Another non-ILD student, I will call Pamela, recognized the importance of multiple representations but felt that math was far more important. Pamela stated "A solid foundation in math helps with equations and understanding relationships" She also appreciated the use of technology, but failed to mention computer models as a technology we used. Her answer to a question about importance of technology in the understanding concepts in physics was "Yes, elevator, internet, lasers, Frisbee with ringer, scientific calculator, scales and spring scales. It helps to reinforce and enhance the lessons." Pamela is a student who is typically more comfortable using equations and numbers to understand the relationships in physics. She also stated that she would rather have information delivered in a more formal setting. She did not like being given a problem and having to investigate it to find a solution. She was disinterested in the activities using the probe ware since it lacked the structure she wanted and was not driven by equations. Pamela deferred to her classmates in activities involving micro computers and was not an active participant

Is this ILD relevant?

Another student, who I will call Erica, did participate in the ILDs. Erica is also a student who prefers to use equations and math to understand the underlying concepts in science. Erica found the use of multiple representations very valuable. She stated "Some people learn visually. I like to see and believe". When asked the same question about whether technology was important aspect in understanding concepts in physics she specifically mentioned the creation of graphs on the computer. Erica was a student who was inclined to the 'plug and chug' method. She was initially uncomfortable participating in Interactive Lecture Demonstrations since they did not always provide quantitative data. However, she did find value in the way they carefully guided her from simple activities she felt she understood, to increasingly complex situations. She stated that she made connections more easily when provided with good visual representations and multiple models. Erica developed a much greater appreciation of how technology could be used in the classroom that Pamela did.

In both cases the students were more comfortable with the mathematical aspects of science. In Pamela's case, she was uncomfortable with the equipment in an environment which lacked structure. She never incorporated the technology as an important aspect of the classroom. Consequently, she failed to value the graphical models as much as the mathematical models. Erica was more readily able to incorporate the technology into her view of which tools were valuable in the classroom. In later units such as electricity and waves, Erica was very comfortable using spreadsheets to create graphs. When the graphs did not match Erica's predictions later on, she began to ask more questions and was driven to try and uncover the conceptual nature. In later units, Pamela felt that creating graphs on the computer was a waste of time. It merely restated what students already knew through the equations. Pamela would produce a graph and hand it in regardless of what it looked like or if it matched her predictions. Anomalies in graphs did not inspire more questions for her. Quite the contrary, Pamela assumed that there was some mistake in the data, rather than a flaw in her understanding.

Conclusion

My overall impression of the ILDs is mixed. Generally, they were helpful. The ILD students were able to improve mastery performance and non-ILD students did not reach mastery. Since both groups had a 25% Regents exam failure rate, I will further conclude that students that are already struggling to understand physics on a conceptual level will not be helped by the addition of ILDs alone.

The instructions are user friendly and the software is very well streamlined. I was unfamiliar with both probe ware and software at the outset, and neither presented a significant problem. I spent some time practicing the activities before presenting them to students. I also made sure to touch on the discussion points the authors included as important.

Some data collection can be tricky and definitely does need to be practiced. The first activity "human motion" presents a few interesting problems. The texture of the fabric the target person is wearing can have an effect on the motion sensors ability to detect. Something very smooth is preferable to something rougher, like a sweater. The detector also picked up the oscillation of my legs swinging creating something looking more like a sine wave than the zero slope flat line students predict. Having a brief conversation about how swinging legs act like a pair of pendulums helped to explain the discrepancy.

Another problem that I had to overcome was the fact that these activities are sometimes difficult to do in a single class period. Our class periods are 40 minutes long. This places a severe limit on how much discussion can take place. There were questions with every activity and almost every single demonstration raised new questions. It frequently felt that there was not enough time to deal with every question. It was also rare that there was time at the end of the demonstrations to develop real closure.

As the labs progressed, and the activities became increasingly complex, there was less time for explanation and discussion. These later labs could be divided into two session activities, to allow students to explore their ideas. Their preconceptions are as valuable to the learning process as the concepts with which we hope instill in them. Students get their ideas from their own personal experiences and as such they have value.

One of the most valuable things that I felt students gained from ILDs was the integration of their own personal experience and the gradual broadening of that experience. At no point were they introduced to more than one or two new apparatus. Although initially the technology is unfamiliar, the progression of labs carefully builds on things they begin to find familiar. No single step is a great leap. They learn the capabilities of the probe ware by examining simple human motion. Once the probe ware had become an experience for them they are given an unfamiliar object (the fan cart) to explore. Each step allows a gentle progression without taxing students to question the devices themselves. They can focus on the relationships being explored without being distracted by the newness of the devices being used. This allows students to experience various interactions which become complex. Even though I would have liked more time to explore some of the more complex scenarios towards the final labs, students never complained that the tasks were too difficult. This was a pleasant change for me as my students are generally very vocal when they feel the material becomes too difficult. Even though their predictions were frequently incorrect, they still felt satisfied that they had an understanding of the relationships by the end of each activity.

Their comfort with the activities and the experience they gained was an important factor in their improved performance on the final exam. I would recommend Interactive Lecture Demonstrations on force to any high school physics teacher. I would especially recommend them to teacher with small enrollments which do not justify large budgets.

Bibliography

Laws, Priscilla, Sokoloff, David R., Thornton, Ronald K (July 1999) Promoting Active Learning Using the Results of Physics Education Research. *UniServe Science News* **13**

Sokoloff, David R. & Thornton, Ronald K. (2006) *Interactive Lecture Demonstrations, Active Learning in Introductory Physics*, New York: Wiley

Sokoloff, David R. & Thornton, Ronald K. (1997) Using Interactive Lecture Demonstartions to Create an Active Learning Environment. *The Physics Teacher*. **35** 340-346

Wells, Malcolm, Hestenes, David & Swackhamer, Gregg (July 1995). A Modeling Method for High School Physics Instruction. *American. Journal of Physics*. **63** (7), , 606-619