Literature Review of Interactive Engagement

Research into Student Learning

Over the past few years a very substantial research base into student learning has been developed particularly for university classes of introductory physics. A very important contribution was made by David Hestenes from Arizona State University who developed a conceptual assessment known as the Force Concept Inventory (FCI) (Hestenes, Wells, and Swackhamer, 1992). It is a 29-item multiple-choice test for assessing student understanding of Newton's Laws of Motion. It has become a standard benchmark in physics education research because of universal agreement regarding the importance of the content and the deceptively simple nature of the test items. Hestenes report on over 1500 high-school students and 500 university students who took the FCI as a pre- and post-test for an introductory physics course. The results showed that the students did poorly on both the pre- and the post-test, and more importantly that conventional lecture-style instruction obviously provided minimal means for improvement.

Introductory Astronomy didn't fare much better as shown by Philip Sadler from Harvard University with his video "Private Universe" in 1987. In this video, 8th grade students and Harvard graduates were asked fundamental astronomical concepts like the reason for the seasons, the cause of the Moon phases, and why the stars rise and set later each day. Both groups of students performed very poorly. Developed in 2000, the Astronomy Diagnostic Test (ADT) (Hufnagel, et al., 2000), the astronomical equivalent to the FCI, confirmed what many feared – students simply were not learning fundamental conceptual information. Neil Comins (Comins, 2001) has documented over 1600 misconceptions astronomy students have exhibited.

Unfortunately, all of this confirms a common adage regarding conventional lecture-style instruction: "Information passes from the notes of the instructor to the notes of the student and through the minds of neither."

Interactive Engagement – part I

Instructional models whereby students participate in a process of investigation and discovery have been shown to improve student's fundamental understanding in science (Hake, 1998; Thornton and Sokoloff, 1990, 1998; Redish and Steinberg, 1999). In these methods, students are guided in investigating a phenomenon and encouraged to formulate the concepts on their own as opposed to being told what they are. However, these instructional models have most often been implemented in a laboratory setting. Creating interactive engagement curricular materials without the presence of a laboratory setting can be challenging.

Nonetheless, in light of unsuccessfulness of traditional instruction, numerous "active learning" approaches have been developed. For example, for physics: Sokoloff and Thornton (1997) utilize Interactive Lecture Demonstrations which are modifications of their microcomputer-based laboratory materials; Knight (1997) and Chabay and Sherwood (1995) have authored instructional textbooks with a high degree of interactivity; and Eric Mazur (1997) at Harvard University developed the Peer Instruction method of student discussion and voting with multiple choice concept questions (sometimes described as the think-share-pair method). For example, for astronomy: Adams (Adams, et al., 2003) have produced Lecture Tutorials for Introductory Astronomy – Preliminary Edition, which consist of a series of carefully designed questions that spark discussion and critical reasoning with no equipment required; a library of multiple-choice text based astronomical text-based questions in Peer Instruction for Astronomy (Green, 2003) designed for the think-share-pair method; and another library of text-based think-pair-share questions in Learner-Centered Astronomy Teaching: Strategies for Teaching ASTRO 101 (Slater and Adams, 2003).

To date, the most compelling evidence that these interactive approaches work was compiled by Hake (1998). He collected pre- and post-test scores on the FCI from 6,542 students nationwide in 62 different introductory classes. On average, the interactive engagement courses were more than twice as effective as traditional courses in promoting fundamental conceptual understanding.

Interactive Engagement – part 2

With current technology, interactive engagement curriculum development can be more comprehensive and more efficient for both the student and the instructor. In the book How People Learn (Bransford, et al., 2000), student's prior knowledge must be challenged, students need repeated exposure to the phenomena, and students' metacognitive skills must be enhanced. It is this last issue, the enhancement of students' metacognitive skills must be enhanced that ClassAction materials are designed to support.

ClassAction represents a technology that not only includes colorful and accurate images, but it also user controlled images, animations, and simulations. Additionally, this technology includes multiple choice questions which are dynamic in sense that with a simple "click" the instructor can adapt the same question slightly to see whether or not the students understand the information presented or are still confused. This means that the instructor can instantly create a follow-up question that will produce a repeated exposure to key concept(s) that will enhance metacognitive skills.

References

Adams, J., Prather, E. & Slater, T. (2003) Lecture Tutorials for Introductory Astronomy, Prentice Hall, 2003.

Astronomy Diagnostic Test: download site – http://solar.physics.montana.edu/aae/adt/

Bransford, et al. (2000) How People Learn: Brain, Mind, Experience, and School: Expanded Edition, National Academy Press.

Chabay, Ruth and Bruce A. Sherwood. (1995). *Electric and Magnetic Interactions*. John Wiley, New York.

Comins, Neil (2001). *Heavenly Errors*. New York: Columbia University Press.

Green, Paul J. (2003). *Peer Instruction for Astronomy*. Upper Saddle River, New Jersey; Prentice-Hall.

Hake, R. R. (1998). "Interactive-Engagement Versus Traditional Methods: A Six-Thousand-Student Survey of Mechanics Test Data for Introductory Physics Courses." *American Journal of Physics*, **66**(1), pp. 64-74.

Hestenes, D., M. Wells, and G. Swackhammer (1992). "Force Concept Inventory." *The Physics Teacher*, **30**(3), pp. 141-158.

Hufnagel, Beth, (2002). Development of the Astronomy Diagnostic Test, Astronomy Education Review, 1, 1.

Knight , Randall D. (1997). Physics: A Contemporary Perspective; Student Workbook, preliminary edition. Reading , Massachusetts, Addison-Wesley.

Mazur, E. (1997). *Peer Instruction: A User's Manual*. Upper Saddle River NJ: Prentice Hall. – see Project Galileo.

Project Galileo: Physics ConcepTests download site – http://galileo.harvard.edu

Redish, E. F., J. M. Saul, and R. N. Steinberg (1998). "Student Expectations in Introductory Physics." *American Journal of Physics*, **66**(3), pp. 212-224.

Slater, T. and Adams, J. (2003) *Lerner-Centered Astronomy Teaching: Strategies for Teaching ASTRO 101*. Upper Saddle River NJ: Prentice Hall.

Sokoloff, D.R. and R.K. Thornton. (1997). Using interactive lecture demonstrations to create an active learning environment. The Physics Teacher 35, 10, 340-347.