A Multi-Institution Study on the Effectiveness of ClassAction to Promote Student Understanding in Astro 101

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Think-Pair-Share

A substantial research base on student learning in the introductory astronomy classroom has been developed over the past few years. It shows that the most effective methods of instruction have students actively engaged in the learning process. The most well-known example of learning through interactive engagement is Think-Pair-Share (or Peer Instruction in the terminology of Eric Mazur). In its simplest form this strategy involves halting lecture and posing a conceptually rich question to the class. Students then spend some time thinking about the question individually before voting by using their hands, colored flashcards, or personal response system. Depending upon the results, the instructor may choose to 1) move on, 2) ask students to discuss the question with a peer to convince the other student they are correct, then vote again, or 3) go over the concept in greater detail depending on the outcome of the first vote. Studies have shown that students benefit from thinking through the arguments and putting them in their own words, collaborating with peers, and receiving feedback on their understanding. The instructor benefits as well from the feedback on student understanding.

ClassAction

ClassAction is a computer database of conceptual questions for introductory astronomy that can be projected in the classroom. It aims to maximize the effectiveness of Think-Pair-Share and voting by providing flexibility in question choices, extensive resources for feedback, and high-quality questions requiring interpretation of visual prompts.

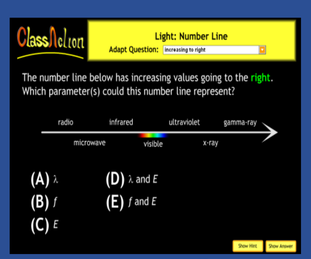
Each of the major topic areas of introductory astronomy has its own module and instructors may conveniently choose from an assortment of questions in each. Instructors have the capability to recast many of these questions into alternate permutations based on their own preferences and previous responses from the class. Modules also include outlines, graphics, and simulations which the instructor can utilize to provide feedback. ClassAction allows instructors to teach interactively in an extremely flexible manner. They can choose questions based upon student understanding of previous questions, have the resources at hand to provide instruction when needed, and can then recast the original question into an alternate permutation to see if their instruction took hold. Extensive computer simulations are included which allow instructors to provide feedback and further instruction on question topics.

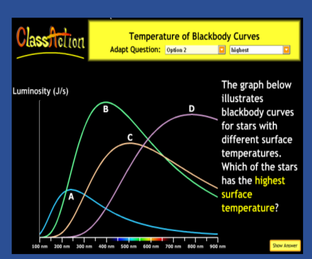
The success of Think-Pair-Share depends greatly on the quality of the conceptual questions being asked. ClassAction endeavors to “push the limits” of what constitutes a conceptually rich question by basing them upon:

- Visual Prompts – students are asked to interpret images, diagrams, and animations.
- Critical Thinking Skills – students are asked to extract information from graphs and charts, making interpolations and extrapolations, identifying functional dependencies, estimation, and lots of geometric reasoning.
- Organizational Diagrams – students are asked to work with different types of diagrams that help them organize and internalize their developing understanding. These include tables, schematic diagrams, Venn diagrams, flowcharts, and concept maps.

Light and Spectra Concept Inventory

The Light and Spectroscopy Concept Inventory (LSCI) is a multiple-choice assessment instrument which focuses on the electromagnetic spectrum, Doppler shift, Wien’s Law, Stefan-Boltzmann Law, and Kirchhoff’s Laws. There is strong overlap between the concepts covered on the LSCI and the ClassAction Light & Spectra Module. Two questions from the over 40 questions in this module are included below as examples.





A Multi-Institutional Study

A multi-institution study of the efficacy of the ClassAction Light & Spectra Module was undertaken to measure its effectiveness in promoting understanding among introductory astronomy students. A group of faculty from six varied insitutions collected LSCI data. Participating instructors were asked to:

- travel to the University of Nebraska for a 2-day workshop on using ClassAction materials in the introductory astronomy classroom
- construct diagrams detailing ClassAction sequences targeting the major subject areas of the LSCI
- teach exclusively with lecture and ClassAction materials during the light and spectra portions of the course
- hire undergraduate assistants to attend lectures and record information on ClassAction usage
- give the LSCI as a pre and post test (with local IRB approval)
- use ClassAction materials in topics other than Light & Spectra to gain familiarity with the product.

Figure 1 illustrates the normalized gain versus pretest percentage for 8 sections of introductory astronomy including more than 240 students. Gains ranged from 15% to 38% with an average gain per student of 27.9%.

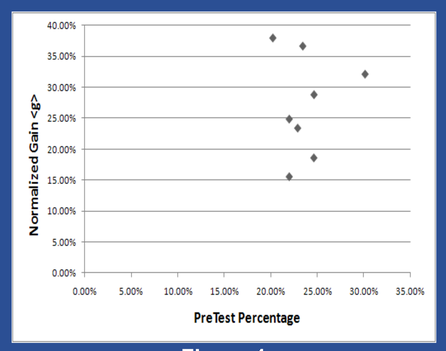


Figure 1

Prather *et al.* (Am. J. Phys., Vol. 77, No. 4, April 2009) report on LSCI pre and post test scores from 69 introductory astronomy classrooms. Our results parallel those of this larger study: pretest scores clustered around 25%, a similar average gain, and a substantial spread in gains. Prather correlates the gain with the usage level of interactive learning strategies. However, even among highly interactive classes he finds considerable variation in gain suggesting that proper implementation is a key factor.

ClassAction is a flexible tool and each instructor will use it very differently. To have a more uniform basis for comparison between classes, we totaled the number of ClassAction questions used pertaining to light and spectra. Figure 2 plots the gain versus the question usage for 5 classes. One can see that the question usage varies from 12 to 33. The gain and number of questions used are well-correlated, except for the outlier at (12,33%). Since all of the instructors were first-time users of ClassAction materials, it is possible that gains would rise with more experience and better implementation.

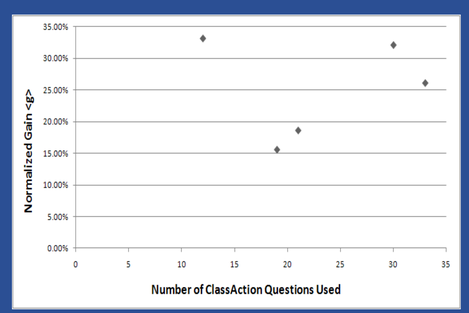
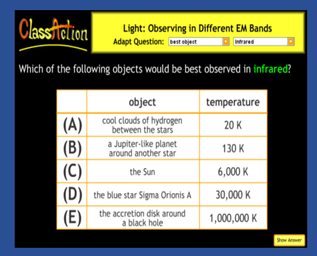
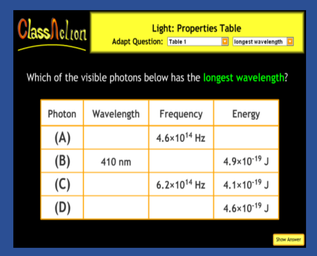


Figure 2

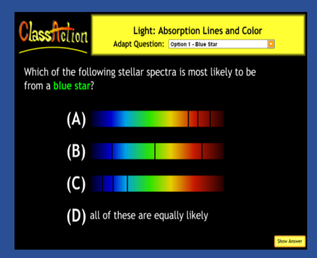
Improving ClassAction

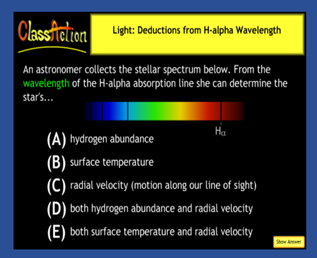
The results of this project as well as feedback from participating instructors are useful guides in improving ClassAction. Two participating instructors requested additional questions be added focusing on the bands of the EM spectrum and their wavelengths, frequencies, and energies. This is logically the first topic covered and was being emphasized since subsequent material builds upon it. Two new such questions are shown below.





We analyzed the gain by individual question and by subtopic (e.g. Doppler Shift). Two LSCI questions (#2 & #17) had gains near zero in several classrooms. These questions both dealt with which stellar parameters can and cannot be determined from spectra (e.g. does the wavelength of a line tell astronomers anything about temperature?). These concepts were not being covered by ClassAction materials. The two questions below attempt to rectify this issue.





ClassAction is still in active development and the goals of the project continue to evolve. Filling in sparse topic areas, refining questions, and better specifying linkages between questions and feedback mechanisms will continue for the foreseeable future. Two new major initiatives are in the works:

- A beta version of an editor that allows instructors to create their own modules containing any subset of ClassAction materials is now available on our web site.
- The capability to incorporate your own questions into ClassAction modules with this editor is under development.

All ClassAction materials are publicly available at **http://astro.unl.edu** for use over the internet or your own computer through convenient download by .zip file.

Acknowledgements

This material is based upon work supported by the National Science Foundation under Grant Nos. 0404988 and 0715517, a CCLI Phase III Grant for the Collaboration of Astronomy Teaching Scholars (CATS). Any opinions, findings, and conclusions or recommendations expressed in this material are those of the author(s) and do not necessarily reflect the views of the National Science Foundation.