# Report on the Use of the SMART Board Interactive Whiteboard in Physical Science

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### Purpose

The purpose of this project was to integrate the SMART Board into physical science courses for non-science majors where students must visualize complex phenomena and follow arguments involving the time evolution of physical quantities. We studied how effectively students were able to learn the material when the technology is included in the traditional lecture sessions of courses in Physical Science and Astronomy.

In the past, we have seen evidence (*1) for statistically significant differences in pre/post test scores on astronomy diagnostic exams that reflect gender differences. We used selected test items to look for any gender differences in test scores for course material taught with and without the SMART Board. We also developed and administered an attitude survey to measure student response to the SMART Board.

### Background

As we read student lab reports and exams, we observed that there is poor student understanding for several topics in physical science courses. Students in physical science courses find it difficult to plot isobars on weather maps and to use a weather map to predict the future weather for a given city. Visualization of three-dimensional phenomena such as the movement of a weather front is also a challenge. Astronomy students are not successful in completing a project on sunspots because they do not understand how to analyze data from a sequence of images. Finally, students misinterpret Hertzsprung-Russell diagrams and therefore do not understand the evolutionary information that the diagram contains. We wished to apply the SMART Board technology to class activities and find out if it could decrease these student difficulties.

### Class Activities

We teach two courses in physical science (PHS 101 and PHS 112) that require students to visualize physical quantities such as air pressure. We used the SMART Board to develop class activities for weather maps, especially the technique of plotting isobars on a weather map.

We integrated a web site (www.ametsoc.org/dstreme/) into the lecture on weather maps. The site has maps of pressure, temperature with isotherms, and detailed station models for the U.S. We downloaded the latest pressure map and introduced students to drawing isobars on the map.

After the instructor drew in one or two isobars, student volunteers came up to draw in additional isobars. Students used different colors to emphasize differences in air pressure. Since class size was small, almost every student could participate in the process. Even students who were not drawing on the SMART Board gave suggestions as to how to change or improve an isobar. The instructor saved the student isobar map and then downloaded the detailed weather map and saved it to SMART Notebook as well. As the instructor switched back and forth between the official U.S. weather map and the student map, students could compare how well they constructed the isobars. Since the instructor had saved the previous day's weather map also, students could compare how fronts moved in the past 24 hours.

At the end of the lecture, students took home an assignment that asked them to revisit the web site, print a pressure map and then draw a complete set of isobars. They applied their knowledge of station model notation and interpreted the data to describe the current weather in various cities.

Later in the semester, students took an exam which included five questions on weather maps. The same exam questions were administered to two control groups of students who had the same homework assignment but who did not have the SMART Board during the lecture on weather maps.

In addition to the motion of weather systems, there are other phenomena that change in time. Students in both physical science and astronomy (AST 101) study the behavior of sunspots. During the last three semesters, astronomy students studied the location, number, size, and appearance of sunspots. Students collected data from Catania Astrophysical Observatory (www.ct.astro.it/sunoac.html) that posts daily images of the sun, yet they found it very difficult to interpret what they observed.

To address these student difficulties, we developed an interactive lecture using the SMART Board that modeled how to collect and analyze sunspot data. Before the interactive lecture, the instructor downloaded and saved in SMART Notebook several days of images of the solar photosphere. Many large sunspots and spot groups were evident in the images. The instructor circled one sunspot on the first day's image and then circled the same spot with different colors on the next images. As the instructor touched each image in the time sequence, students could observe how the spot changed location on the solar disk. Student teams had printouts of the images as well.

The instructor demonstrated how to measure changes in location of the spot with respect to the first day's position. Students used their printouts to measure the movement of the spot using units of centimeters per day across the images.

Finally, the instructor downloaded an image of the solar chromosphere for the same day as the first photosphere image. The instructor asked the students to compare the two images and describe all the evidence that the circled sunspot was related to an active region in the chromosphere. By the end of the class period, student teams analyzed the sequence of photosphere images and constructed data tables that included the size and position of each sunspot for each of the images. Later in the week students used the data tables to write a short sunspot report. Twenty-eight students in a class of thirty-one successfully completed the report.

Students learned first-hand that: (1) sunspots seem to move westward on the sun because of its rotation, (2) numbers of sunspots change with time, (3) numbers of spots in groups change in time, (4) size of individual spots change in time, (5) the shape and size of the umbra and penumbra of spots change with time, and (6) active regions in other layers of the sun are related to sunspot regions in the photosphere.

Finally, students were tested on their knowledge of solar activity on an exam. The exam included seven questions related to a solar image; the same questions were given to two control groups of astronomy students.

Courses in both physical science and astronomy include information on how stars age and die. Students in both science courses always struggle to learn about stellar evolution and how to analyze a Hertzsprung-Russell diagram (HR diagram). Many students come away from a traditional lecture thinking that the diagram represents a constellation outline rather than a mathematical relationship between stellar brightness and surface temperature. We tested to determine if the addition of the SMART Board technology would reduce student misconceptions and increase student knowledge.

The SMART Board became part of an interactive lecture and class graphing activity where students created the diagram for a sample of seventy-five stars. The instructor downloaded an HR diagram for the twelve brightest stars in the sky from a NASA web site (http://observe.arc.nasa.gov/nasa/space/stellardeath/stellardeath_1ai.html). Students had copies of a NASA-JPL publication "Star Classifications" that gives the absolute magnitude and surface temperature of stars and asked students to graph the data. The instructor demonstrated how to graph one star, then asked students to begin their individual graphs.

As students plotted points, the instructor asked each student to plot one data point on the HR diagram shown on SMART Board. The technology also permits the addition of color to represent actual stellar colors, so students graphed their data point in the color closest to the actual surface color of the star. As the students completed their graphs, the instructor asked them to look for any major groupings on the graph.

Student teams concluded that the points were not randomly scattered on the graph and that there were at least three main groupings of data points. The lecture pointed out that astronomers called the groupings the main sequence, the supergiant branch, the giant branch, and a fourth group called white dwarfs. Students completed the graph for homework and turned in their HR diagrams the next class period.

At the next lecture, the change of brightness and surface temperature as a star ages was shown as a dynamic process represented by a sequence of data points (an evolutionary track) on the graph for only one star. Test questions related to the HR diagram appeared on an exam at the end of the stellar evolution unit. Students in control sections of astronomy and physical science took the same test questions.

## Results and Evaluation

### Studies of Student Knowledge Gain

We administered the test questions on weather maps to four sections of students. Two test sections (PHS 112-002, PHS 101-002) of students used the SMART Board during lecture and two sections (PHS 101-059, PHS 112-001) were controls. We looked at the test results for each question and calculated the fraction of students who had it correct. We performed an analysis of variance (Var) on several combinations of the data.

For each test section, we found *no statistically significant* difference in the fraction of women who had the question correct as compared with the fraction of men who had the question correct. For each control section, we also found *no statistically significant* difference in the fraction of women who had the question correct as compared with the fraction of men who had the question correct. When we compared test and control sections of women to women or if we compared men to men, we found *no statistically significant* differences in the fractions of students who had the question correct.

We followed up the study of variance with t-tests. We performed a t-test for scores of women and men in the PHS112-002 test section. There was a 16% probability that the mean scores of the men and women came from the same population. This means that there *was a statistically significant* difference in the scores. Although the mean score for women and for men is the same, the standard deviations are different. There is a larger spread in the test scores for the men. We cannot conclude if the women "did better" then the men, but at least they performed equally well.

We looked at the t-test results for the control section of PHS 112-001 and found *no strongly significant* difference in the scores of the women and men. Finally, when we analyzed the t-test for the PHS 101-002 test section, we found that there *was a statistically significant* difference in the scores of men and women. In this case, the women's scores were *higher.*

The second set of exams covering the study of sunspots was given to three groups of astronomy students. For the test section AST 101-002, there *was a statistically significant* difference in the scores of the women and men; the women scored *higher* than the men did. We found *no* statistically significant difference in the scores of men and women in the control groups.

There were other interesting results. There *were statistically significant* differences in the scores of men in the test group as compared to men in the control groups. Men in the test group scored *higher*. There *were also statistically significant* differences in the scores of women in the test group as compared to women in the control groups. Women in the test group scored *higher*.

We wondered if women in the test group were an unusually talented group of students, so we performed a t-test on the final exam scores of the women and men in the test section of AST 101-002. There *was a statistically significant* difference in the scores of women and men. In this case we found what other researchers discovered—the *men scored higher* than the women on the astronomy final exam.

The last set of content tests we analyzed covered the topic of the Hertzsprung-Russell diagram. The test section of students was PHS 112-002 while the control sections of students were PHS 101-002 and PHS 112-001.

When we performed a t-test for women in the PHS 101 control section to women in PHS 112 test section, we found that there is a 71% probability that the two means are from the same population. There was *no strongly significant* difference in the scores of the women.

The t-test for men in the same two sections indicated that there was a 31% probability that the means were from the same population. There *was a statistically significant* difference in the scores of the men; in fact, the men in the *test section scored lower* than the men in the control section.

When we compared both the test and control sections of PHS 112, we found that there is *no statistically significant* difference in the scores of the women in the test section to the women in the control section. The same statement can be made for the men.

**Other Uses of the SMART Board**

In addition to our formal study of student knowledge of physical science course content, we—or our colleagues—used the SMART Board for classes outside of the original project. Our colleague in mathematics, Dr. S. M. Koswatta, used the SMART Board in a MTH 202 lecture. Dr. Koswatta assigned a project that required the use of Maple software. This software performs symbolic math and has the capability to draw surfaces and volumes. Students often visited Dr. Koswatta and cited difficulties with Maple, so he decided to borrow the SMART Board and to explain the proper use of the software.

Dr. Koswatta reported that students were excited during that session and that they appreciated the opportunity to see Maple up on the screen with all notations and underlines on the code. As anecdotal evidence for the success of the SMART Board lecture, Dr. Koswatta said that no student needed to visit his office regarding the Maple project after the lecture. At the end of the lecture, Dr. Koswatta gave his students the same attitude survey that physical science students used.

One of us used the SMART Board to teach basic concepts in chemical bonding to PHS 111 students. The "drag and move" feature was a clever method to teach ionic and covalent bonding by moving individual electrons or the entire electron dot notation on the SMART Board. In PHY 203 for engineering majors we also used the "drag and move" feature to overlap atomic energy levels for copper and produced the energy band structure characteristic of a metal. We used the same feature to show the migration of electrons and holes at a junction of p-type and n-type semiconductor materials. Color differences allowed us to show majority and minority charge carriers clearly. Students in PHS 111 and PHY 203 also responded to the attitude survey.

**Attitude Survey of Students Who Used SMART Board**

We administered the same attitude survey to all sections of students who had used the SMART

Board during a class. The survey (Appendix A) asked eight questions and allowed a free response to two questions. Histograms of student responses are shown in Tables I – V.

Students in MTH 202, PHY 203, PHS 101, PHS 111 agreed that class presentations that included the SMART Board were interesting to them. Students in PHS 101 believed that the SMART Board helped them remember more of the lecture. The students who enjoyed writing on the SMART Board were in PHY 203 and PHS 101. No students found the Board to be a distraction. Engineering students liked the drag and move option while the PHS 111 students were neutral about it. All groups except AST 101 students felt that the use of color helped them better understand ideas. In general, students disagreed with the statement that they would have preferred that the instructor use the SMART Board less often.

When students responded to what they liked *least* about the SMART Board, common answers were: the time delay when writing, the screen was small, it was too easy to accidentally erase it, and the length of time to set it up. (We have the SMART Board on a rolling stand that is used between 3 classrooms. The computer is a laptop with a network cable.)

**Conclusions**

As we look at the data, we find that the use of SMART Board may help women gain knowledge in physical science classes. We were interested in any gender-based differences in learning since data from results of the Astronomy Diagnostic Test indicated that men scored higher than women on that test. Women in PHS 112 did as well as the men on content exams for the study of weather maps. The women in PHS 101-002, also, scored higher than the men on this same exam. However, this may be a gifted group of women. The instructor reported that the women in this small class earned A or B as a final grade in the course while the two men in the class completed the semester with grades of C.

The strongest evidence that SMART Board may aid in learning comes from the study of women in AST 101-002. These women scored higher than the men on the content exam for solar activity, yet they did not outperform the men on the final exam for the course. In addition, most students surveyed had a positive response to the SMART Board. Students self-reported that lectures featuring the Board were more interesting and that the use of color helped them understand ideas better. It may be obvious, but if the students find the class interesting, they may retain more of the information.

We plan to extend the use of the SMART Board to classes for engineering majors this summer. Topics such as free-body diagrams in mechanics and circuit diagrams in electricity seem to be suited to interactive lectures with the Board.



**Notes**

1. "Pre-Course Results from the Astronomy Diagnostic Test, 2000." Beth Hufnagel, Timothy Slater, Grace Deming, Jeff Adams, Rebecca Lindell Adrian, Christine Brick, Michael Zeilik 2000. *Pub Astrom Soc Australia*, Vol. 17, No. 2.

**Appendix A**

**Student Survey: Spring 2000**

Please respond to these questions regarding the SMART Board. Place your answers to the first eight questions on the Scantron form. Use the following code:

a = Strongly Agree
b = Agree
c = No opinion
d = Disagree
e = Strongly Disagree

1. Class presentations that included the SMART Board were interesting to me.
2. I believe that I remembered more of lectures when SMART Board was used.
3. I enjoyed the opportunity to write on/use the SMART Board for myself.
4. The SMART Board was a distraction for me.
5. The ability to write on or interact with a Web document was valuable to me.
6. The instructor's use of the "drag and move" option on the SMART Board made ideas clearer to me.
7. The use of color on the SMART Board helped me to better understand ideas.
8. I would have preferred that the instructor use the SMART Board less often.
9. The thing I LIKED BEST about the SMART Board was:
10. The thing I LIKED LEAST about the SMART Board was:

**Table I**

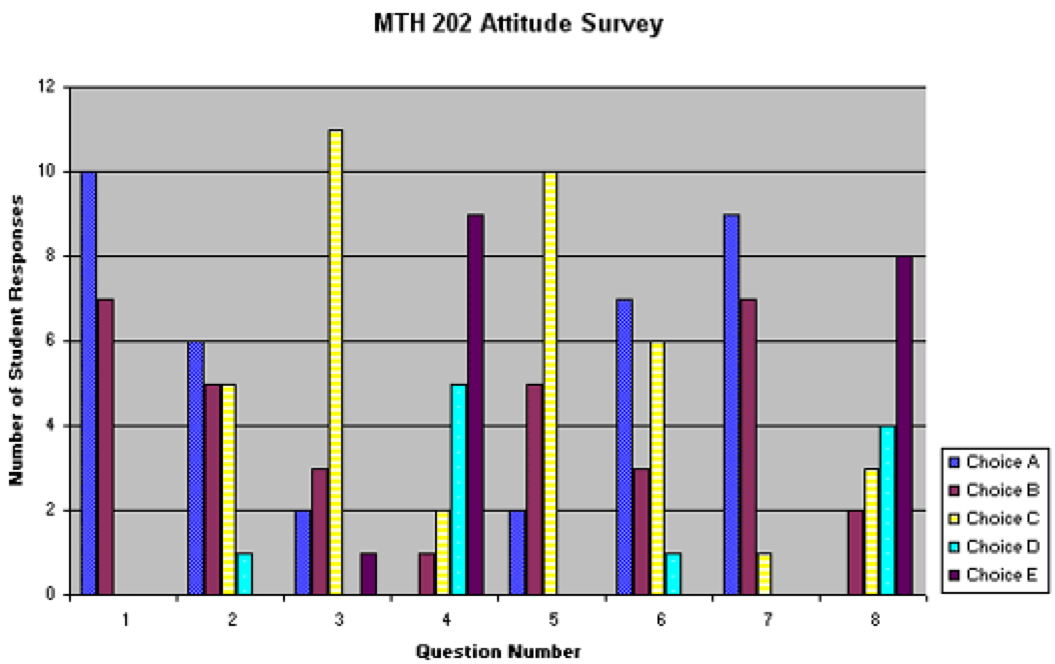



**Table II**

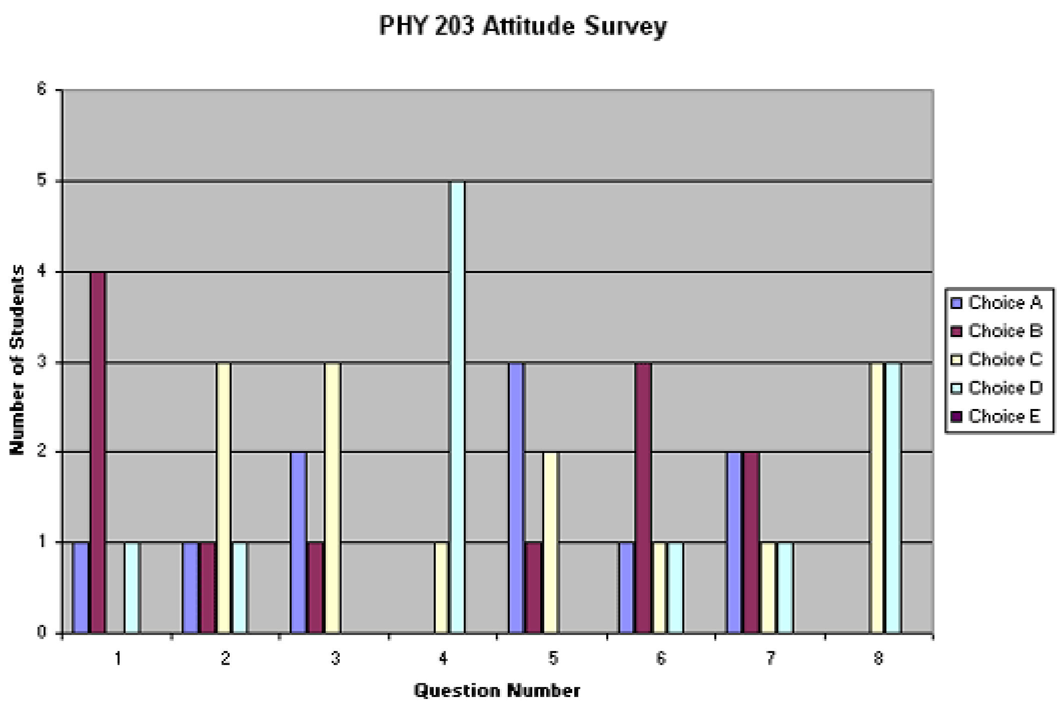



**Table III**

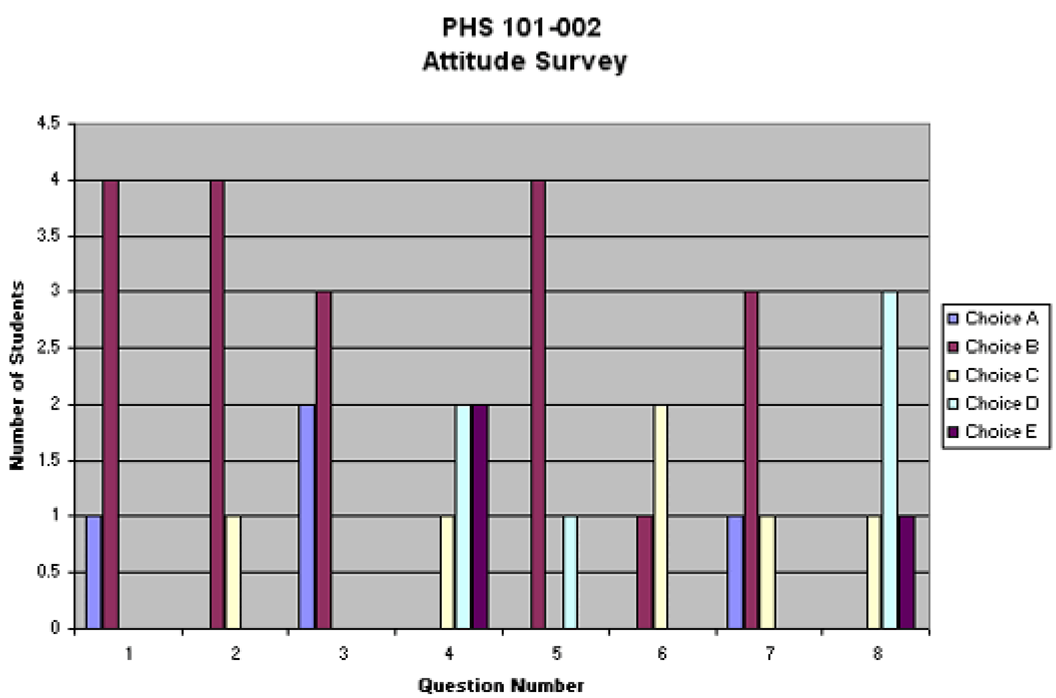



**Table IV**

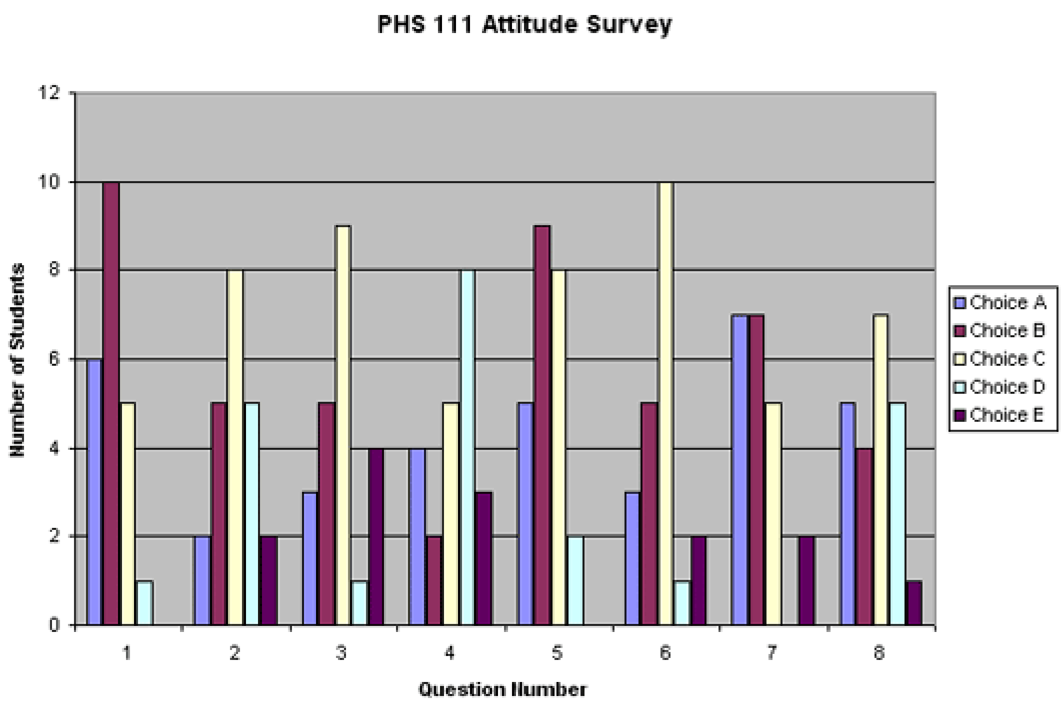
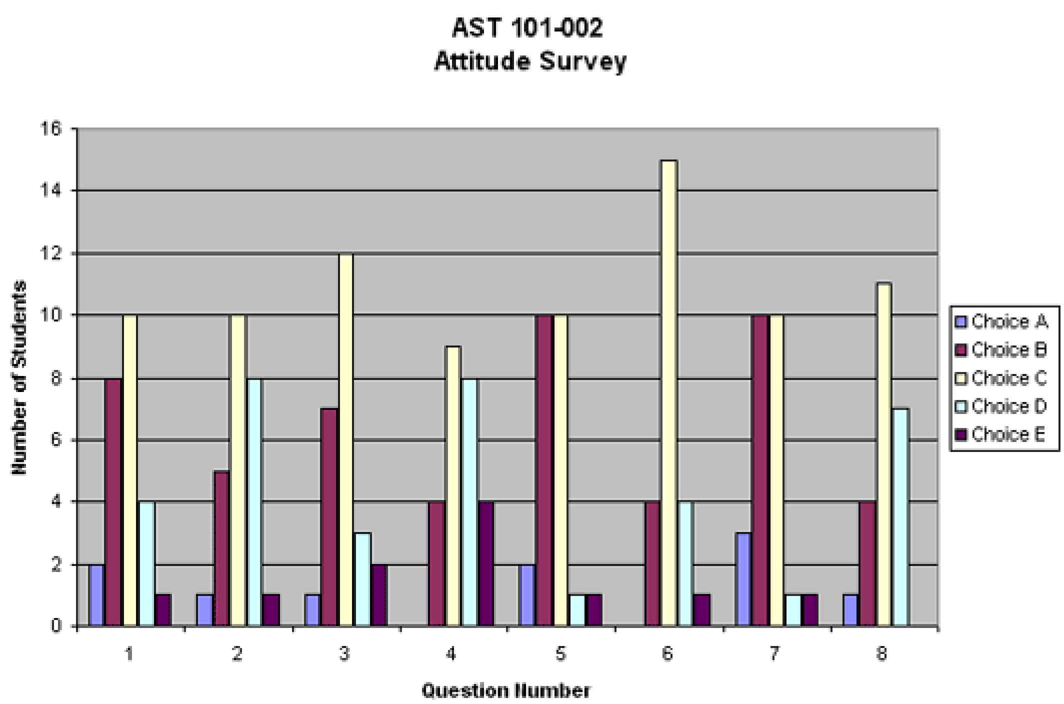



**Table V**




**Biographies**

**Dr. Deborah Damcott** is an assistant professor of physical sciences at Harper College and holds a PhD in nuclear science from the University of Michigan. She is a member of the American Society of Engineering Educators and the American Association of Physics Teachers.

**Janet Landato** is also an assistant professor of physical sciences at Harper and has an MS in astronomy from Penn State. She is a member of the American Association of Physics Teachers and now serves on the Astronomy Education Committee.

**Collette Marsh** is an instructor of physical sciences at Harper and has an MS in space physics from the University of Alaska at Fairbanks. She developed and teaches a Web-based course in physical science.

**Background**

The first president of the University of Chicago, Dr. William Rainey Harper, initiated programs to bring education into the community for those people who could not become resident students at a university. This concept was the basis for the eventual founding of William Rainey Harper College. In 1967, Harper College opened with an enrollment of about 1,700 students. Today the College's enrollment stands at approximately 23,000 students of all ages participating in degree credit, continuing education and extension courses on the Harper campus or at other locations throughout the district. Harper College offers instruction at many off-campus locations, including high schools, hospitals and public libraries. It is a comprehensive community college dedicated to providing excellent education at a reasonable cost, promoting personal growth, enriching the community and meeting the needs of a changing world.