Final Report:

Simulating the night sky to teach apparent nightly and seasonal celestial motion

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A one year study was performed in Physics 101, ‘Mysteries of the Sky’ during the 2008-2009 academic year*. My goal was to test how using planetarium software during lecture aided the students in learning how the stars appear to move each night, and through the seasons. When teaching this concept in the past, I would bring a globe to class and have student volunteers stand around the room playing the part of seasonal stars. (From Bozeman, these are the stars we see while looking toward the south. They rise and set each night just like the Sun, but *which* stars we see depend on the time of year. Orion is a nice example of a seasonal constellation (technically called an asterism), visible during the winter months only.) The other type of stars we see in Bozeman are circumpolar stars, or stars that appear to circle about Polaris. (We see them while looking north.) One student carries the globe around the Sun and calls out which stars are visible in the night sky as he or she travels around the Sun (seasonal stars) and we also discuss circumpolar stars.

My impression is that this illustrates the concept of apparent stellar motion to most students, but I have had students tell me after class that they did not understand the demonstration. Therefore I decided to try another approach: using planetarium software displayed on the screen in class. This software (Starry Night by Imaginova Inc.) can display how the night sky would look in Bozeman tonight. Within the program, time can be moved forward more quickly than it passes in life, allowing us to watch the night sky and how it changes over the course of a year in just a few minutes. It can be seen that Orion is visible in Bozeman during the winter months, but that it is in the sky during the day for most of the summer here, while the Little Dipper is visible every night of the year.

In order to test which method, if either helped the students understand why we see seasonal stars, I used one class as a control (using the globe and volunteers) and the other class as an experiment, showing them only the software during the apparent stellar motion lectures. Both sections took the Astronomy Diagnostic Test (Deming, 2002) as a pre-test and again as a post-test. This test is used to determine how much astronomy the students know coming into the class, and how much they have learned at the end of the class. There are several questions on the test related to apparent stellar motion. To further probe the differences between the sections, the first exam score (on which the topic of apparent stellar motion was covered) and overall class grade were tabulated for each student and averaged for each section.

A common method to measure how much a student learned about a given subject is to have them take a pretest, then retake that test again at the end of the semester (the ADT in this case). The results of both exams are then used to calculate a learning gain as follows:

$$g = \frac{post - pre}{post + pre}$$

Table One lists the average gain, exam one score and overall class grade for each of the sections. Comparison of each measure was done via a t-test. The purpose of this type of test is to determine the likelihood that the curves overlap. For example, we can see from the table that the average gain on the ADT in section one was .167 and .151 in section two. Thus it appears that students in the control had larger gains, but we must also take into account the *p*-value. The interpretation is this value is the likelihood that the curves overlap due to chance and we see that there is a 53.4% probability that these curves overlap, i.e. that the mean for both sections is actually *not* different. Therefore we must conclude that it is very likely that these averages overlap, and are not distinct from each other. This conclusion holds for the exam one scores and overall course grades as well. Although the p-value for exam one is .129, having an almost 13% chance that the curves do overlap is not generally acceptable (an acceptable level for *p* is generally 0.05 or less, more commonly called a 95% confidence level, or only 5% chance that the curves overlap due to chance).

What I learned from this experiment is that the use of planetarium software to show the concept of apparent stellar motion seems to be *no better* at getting across the concept than the old-fashioned method of using a globe and some star volunteers. However, as I get to know the software better I am finding that it can be used to explain many of the concepts covered in ‘Mysteries of the Sky’ so I plan to continue using it to supplement the more traditional demonstrations done in the course.

Table One			
Section	<g>	<Exam one score>	<Course grade>
One (control)	.167	.800	.785
Two (experiment)	.151	.777	.776
t-test *p* values	*.534*	*.129*	*.534*

References:
G. L. Deming. “*Results of the Astronomy Diagnostic Test National Project*”, Bulletin of the American Astronomical Society, Vol. 33, p.1424 (2001).

*This study has been filed with the University’s Internal Review Board and has exempt status.