Applying Learner-Centered Methods to Introductory Astronomy Courses at Youngstown State University

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Youngstown State University (YSU) is an urban, open-enrollment commuter university in northeast Ohio with a 2006 enrollment of 13,183 students. At YSU, the main introductory astronomy class for non-science majors had an annual enrollment of 1,027 students in 2006. Many of our students are the first in their family to attend college, and our classes contain a large fraction of non-traditional and working-class students. The overall structure of our introductory astronomy course is similar to that at many universities and colleges, with two important exceptions.

First, all of our astronomy classes are held exclusively within the Ward Beecher Planetarium (WBP), which contains 145 seats and is 40-foot in diameter. WBP was recently upgraded with the CHRONOS star projector and the Sci-Dome all-dome video projector. This allows us to create and develop planetarium presentations to illustrate difficult astronomical concepts such as the motion of stars through the sky, the path of the Sun through the ecliptic, and the phases of the Moon. Second, both of the astronomy faculty at YSU have attended and adopted techniques from the *Teaching Excellence Workshops* (Tier I & Tier II) given by the Center for Astronomy Education. In these workshops, we were exposed to learner-centered techniques including Peer Instruction[1,2] (aka Think-Pair-Share), the *Lecture Tutorials* (LTs) *for Introductory Astronomy*[3], and Ranking Tasks[4] Here, we present some initial results on applying these techniques to our classrooms, with an eye to what techniques worked well for us, and what needs more work. We also look into the benefits of a planetarium in an introductory astronomy classroom.

Our assessment data thus far comes from two sources: the results of multiple choice questions from exams and from mid-term and end of the semester student evaluations. Our exams are not kept by students, so differences between various semesters should be significant. We quote the normalized gain, $\langle g \rangle$ [5], with our errors deriving from the binomial distribution. For the student evaluations, we evaluated Likert scale survey questions and also manually searched for particular comments in the free response sections. For the Likert results, we average the scores, where a score of "5" indicates strongly agree, and "1" indicates strongly disagree.

Does access to a planetarium aid in student learning?

In summer 2006, our institution replaced the 39-year old A3P Spitz projector in our classroom with the new Goto CHRONOS star projector. As a result, we used our planetarium sparingly in spring 2006, and used the new CHRONOS system extensively in fall 2006. This allows us to estimate how much our planetarium aids in student learning. To do this, we compared exam questions in common to both semesters, and divided the questions into two categories: those that could be answered by the planetarium presentations alone, and those that could be answered from other materials. We then compared the normalized gains from each set of questions, which are listed below. We might expect a higher gain from the questions that would utilize the planetarium, but that is not what we found. The normalized gain found was indistinguishable in both samples, within the errors.

There are a number of hypotheses that might explain the lack of difference between the two samples. The number of questions and students is small, and it is non-trivial to separate out planetarium/non-planetarium questions in our exams. Pessimistically, it may be that planetaria allow students to revert back to passive watching, as opposed to active learning. More research on this topic is clearly necessary. However, it is abundantly clear that our students are wildly enthusiastic about the planetarium. We reviewed our mid-term and final student evaluations, and noted the number of times a student explicitly requested more planetarium presentations, or mentioned it positively. We found that approximately 40% of our students on the mid-term evaluations requested more planetarium presentations, or mentioned the presentations positively. We take these numbers as lower limits – we have yet to see an evaluation that was negative about the planetarium and our presentations with it.

Do student assistants aid student learning in Lecture Tutorials?

One of the major innovations of the Center for Astronomy Education is the creation of the Lecture Tutorials (LTs). These interactive workbook assignments are interwoven with our lectures, and are now a major part of our classes. We originally ran the LTs alone, with a single professor attempting to help 30-40 groups (with 3-4 students per group) within an interactive period. After observing one of the CAE instructors while they were teaching their own course, we noted that they used 2-3 assistants during the interactive phase to help answer questions. Although their classes are about as twice as large as ours, we thought that our students might benefit from additional assistance. We recruited a skilled undergraduate student who took the class previously to answer questions during the interactive period for each class section. The student assistant had no other educational duties (though they did sit in on each class).

To measure their effectiveness, we divided our exam questions into those that were answered by the LTs, and those that were not. We then compared these exam questions over a semester when we had no student assistants, and one where we had assistants. We found the following results for two separate assistants:

	<g>, (mean)	Std. Dev. of mean	<g> (median)	N Questions
Non-LT (F3 – F2)	0.115	0.02	0.031	59
LT (F3 – F2)	0.149	0.02	0.099	88

From the results, it seems clear that the student assistants were beneficial towards student understanding of the material. One interesting question is: 1) whether this gain is solely due to additional assistants or 2) is it the peer nature of the assistants that creates for better active learning. We plan to test this in future semesters by using different assistants – both student assistants and instructors at our university.

What do our students think of active learning in astronomy?

Slater [6] describes the "Hidden Contract" between students and instructors – the students sit quietly and learn passively, and the teacher lectures in the front of the class. Breaking this "Hidden Contract" causes distress for many students – and many of the active learning techniques do just that. Most of the techniques we have adopted have had varying levels of resistance from students. This can be seen in Likert results from mid-term student evaluations, given below:

Question: Did this technique help you learn? (5 = strongly agree, 3, neutral, 1 strongly disagree). (All values are averages. Each letter code corresponds to a different semester):

	Lectures	Lecture Tutorials	Peer Instruction
D5 (N = 46)		3.39	
D6 (N = 36)		4.39	
F1 (N = 69)	3.61	**2.97**	**2.55**
F2 (N = 176)	3.94	3.19	3.81
F3 (N = 122)	4.23	3.98	4.16

We can attribute some of the low opinion scores to inexperience in using the techniques, but our results also show that improvement can be dramatic with practice. In our case, two changes were most beneficial: 1) giving the correct answers to the questions at the end of Peer Instruction, and 2) more thorough debriefing of the LTs. However, the resistance to LTs is still much higher than that of any other active learning techniques. From comments, the students are afraid that they "got the wrong answers" in their work groups and very, very much want to know whether their work is correct. The students can check their work by speaking to the professors – but very few do. Part of this may be due to the commuter nature of our university, where students take courses in blocks to allow themselves time for employment, and therefore can rarely attend office hours. We noted the fraction of times in evaluations that the students wanted some way to check their work on the Lecture Tutorials, and found that up to 24% of the students would like further feedback.

To conclude, we have found that adopting a student-centered approach has been positive overall for our classes, with clear gains in student understanding. However, there are also challenges, most notably, dealing with student resistance in a positive manner. The educational benefit of a planetarium is still open to question. We plan further studies on implementing these techniques in future semesters.

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