Creating Opportunities for Astronomy Majors to Collaborate in Introductory Courses

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Abstract

The University of Maryland courses ASTR120 and ASTR121 form a two-semester introduction to astrophysics required for the Astronomy major. Here we report on successes and challenges of transforming the courses to be more student-centered, drawing on existing research-based strategies and creating a new lab curriculum that teaches skills relevant for professional astronomers. We aim to provide equitable learning opportunities for all potential Astronomy majors, by creating space for them to collaborate and reason about the content during class. We are adopting and building on materials that have been developed for Astronomy non-majors (including Peer Instruction questions and Lecture-Tutorials). We are also using two-stage exams, where the second stage allows students to collaborate outside of class, in order to reduce stereotype threat and better align our assessments with other changes to the course. This effort is supported in part by a grant from the University of Maryland TLTC Elevate Fellows program.

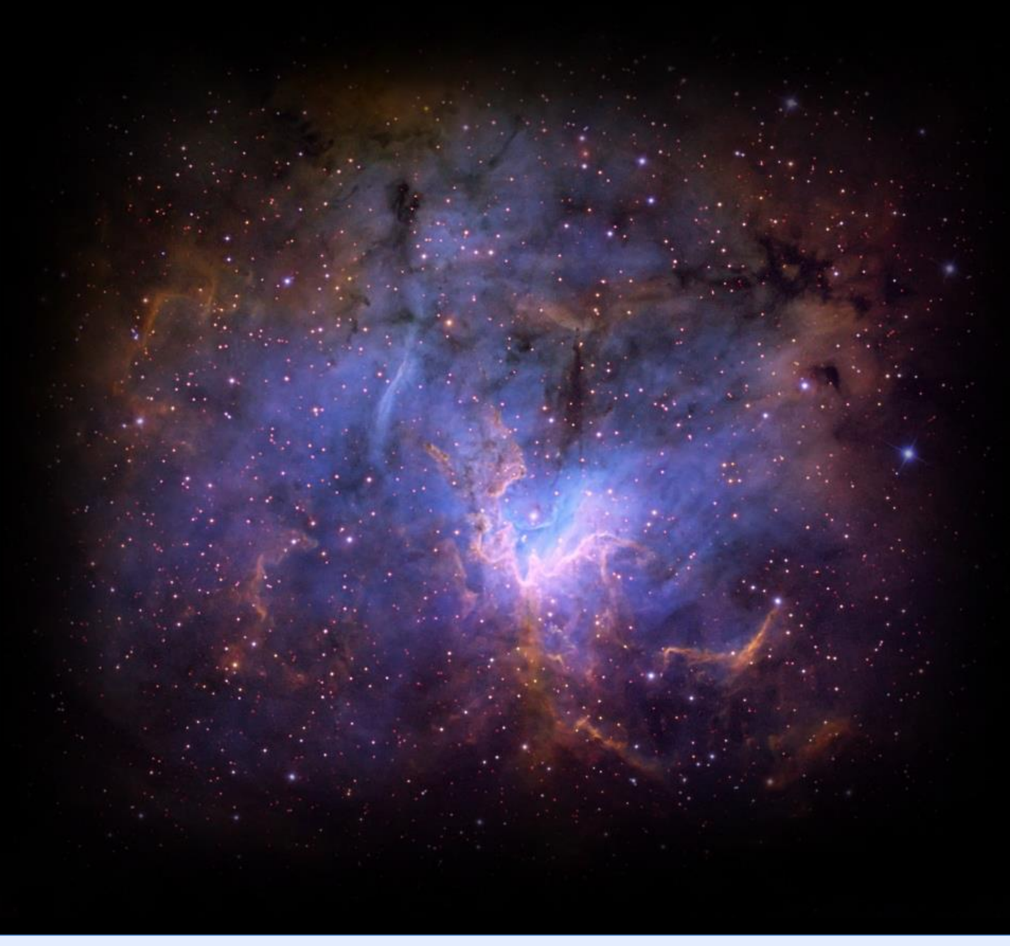
Come See Our Talk:

"Teaching the Skills of Professional Astronomy through Collaborative Introductory Labs"

Session: FK (Astronomy Education Research)
Location: Stamp Student Union - Benjamin Banneker A
Time: Wednesday, July 29th, 9:10-9:20 am

Description of ASTR120/121

We are in the process of transforming ASTR120 and ASTR121, a required two-semester sequence for Astronomy majors. These are the first two courses in the undergraduate astronomy sequence and span a range of topics including planets, stars, galaxies, and cosmology, along with underlying physics such as the behavior of light and the influence of gravity. ASTR120 is offered in a single fall section, with typical enrollment of 40–50 students; ASTR121 is divided into 2 spring sections, with typical enrollment of 35-40 students total. Each course consists of two 75-minute lectures and a 50-minute discussion section per week and ASTR121 also includes a 2-hour lab weekly. This spring ASTR121 had 2 LAs running the lab and 1 TA for discussion and grading (all undergraduates), with everyone, plus the instructor, committed to 2 office hours per week. In addition, free tutoring sessions were available for students throughout each week, run by astronomy major volunteers.



Transformation Components

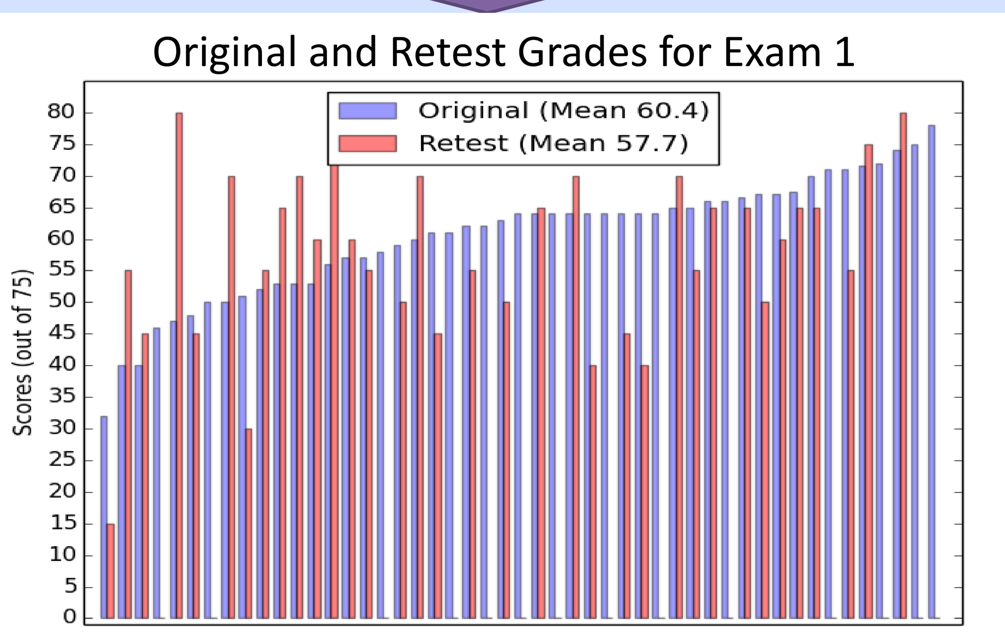
- Make the ASTR121 lab more relevant, collaborative, and engaging
  - Implement a "faded scaffolding" [1] approach to lab reports
  - Teach practical and relevant astronomy skills
  - Encourage collaboration in the form of lab partners and peer reviews
- Improve assessments
  - Base assessments on learning outcomes*
  - Provide students with opportunities to re-do their exams for partial credit
- Make discussion a fully collaborative activity
  - Adapt "Lecture-Tutorials for Introductory Astronomy" [2] for use in discussion section (recitation)
  - Provide time devoted to group collaboration on homework*
- Transform the lecture strategy
  - Focus on 2–3 learning outcomes per lecture*
  - Include related out-of-class activities*
  - Reduce lecture time for more interactive group learning in class *

* Indicates changes that have yet to be completed

Report on Successes in ASTR120 (Fall 2014) and ASTR 121 (Spring 2015)

Retest Improvement

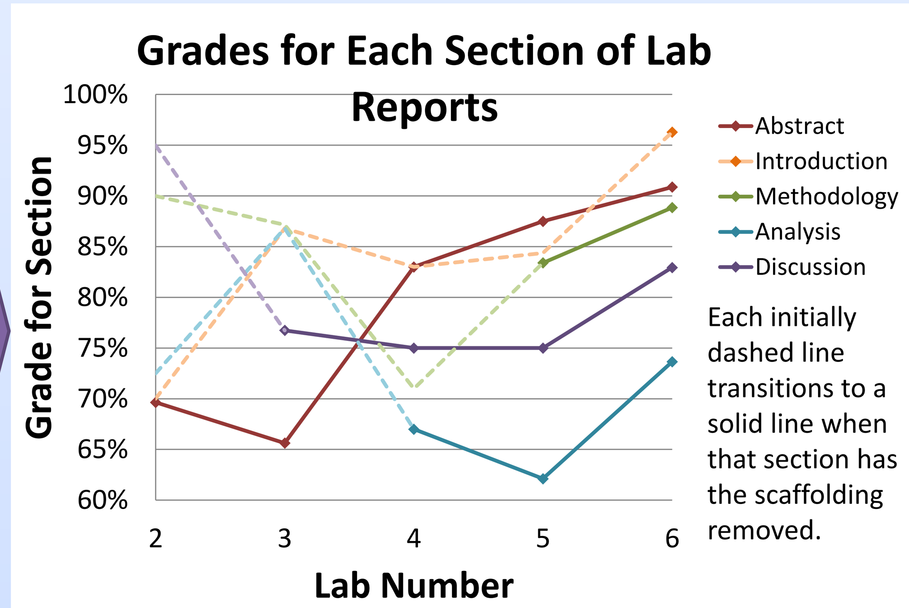
With our new retest policy, after finishing each in-class exam, students are given a take-home copy that they can re-do for partial credit, though it is graded much more strictly than the initial exam. The retest may help students to overcome anxiety and reduce the cognitive burden of stereotype threat. We see some evidence of this: on the first retest, several initially low-scoring students greatly improved their scores, with **the highest score overall being from the student who originally had the fifth-lowest score.**



Scaffolded Labs

To help students learn scientific writing skills, lab reports were designed using "faded scaffolding", meaning that at the beginning, lab report templates were provided with most sections partially pre-filled, but subsequent templates had fewer pre-filled sections, until the point where student are the responsible for all of the content. Students found this very helpful, saying things like, ***"I like the progressive changes in how much of the lab is pre-written because that gives us practice."***

The combination of grading with a detailed rubric and faded scaffolding resulted in a rise in lab report grades (shown on the left), despite the labs' increasing difficulty and length. Students found this helped them improve their work, with one reporting, ***"I really like having the comments and feedback on our lab reports"*** in a mid-semester evaluation.



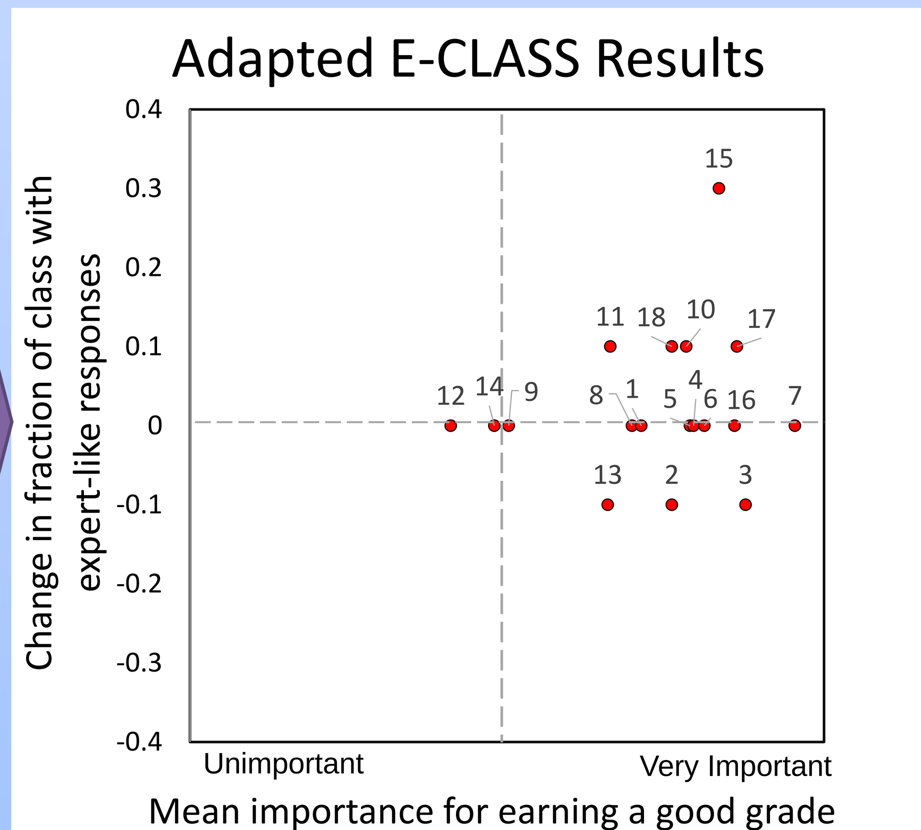
Group Work

A major component of the reform focused on student collaboration. Using an adapted version of Colorado Learning Attitudes about Science Survey for Experimental Physics (E-CLASS) [3], students showed a **30% increase in agreement with the statement, "Working in a group is an important part of doing astronomy experiments"** between the start and end of the course. Also, students found group work to be important to their grade, rating it on average 4.2 on a scale of 1 to 5, with 5 being the most important to earning a good grade. This opinion is reflected in mid-semester course evaluations, in which **27% of students listed working in groups as the thing they like best about the class,** making comments such as, ***"working in pairs does relieve some of the anxiety [associated with the work]".***

Independent and Critical Thinking

There was also a **10% increase in expert-like opinions on "thinking about the purpose of the instructions in the lab guide" and "overcoming difficulties without an instructors help",** reflecting our attempt to make lab activities less "cookbook-like" and give students an opportunity to work independently. Students visibly benefitted from and enjoyed this aspect of the lab, with one student writing in their mid-semester evaluation, ***"I like the amount of freedom we have to try different methods of solving the obstacle that we encounter in the lab."***

Key for E-CLASS Statements	
1	Considering sources of systematic error
2	Understanding assumptions that go into theoretical predictions when comparing them to data.
3	Doing error analysis to help understand results
4	Choosing an appropriate method for analyzing data without explicit direction
5	Understanding equations and physics ideas that describe a system when investigating it
6	Understanding provided theoretical equations
7	Using computers for plotting and analyzing data
8	Making predictions to see if results are reasonable
9	Thinking up my new questions to investigate.
10	Thinking about the purpose of instructions
11	Overcoming difficulties without an instructor
12	Systematically coming up with solutions to a problem
13	Communicating scientific results to peers
14	Reading scientific journal articles
15	Working in a group
16	Making conclusions based on data using scientific reasoning
17	Reporting results with the correct formatting
18	Confirming previously known results



Future Plans

We are encouraged by the successes we have had in this course transformation project so far, and hope to sustain these positive changes as new LAs, TAs and instructors become involved in teaching this course in the future. While we have started to incorporate more formative assessments and research-based materials, e.g., Peer Instruction questions and Lecture-Tutorials, into the lecture and discussion sections of both ASTR120 and ASTR121, the majority of our efforts so far have been focused on the lab component of ASTR121. In the coming year, we plan to focus our efforts on the class as a whole, including defining clear learning goals for every topic, writing new discussion activities, planning more interactive-learning class activities, and creating even more cohesion between the lab and the rest of the course.

Lab Materials

The materials designed for the ASTR121 lab are now available at http://ter.ps/9jm, which is accessible through the QR Code to the right.

References

[1] - Mcneill, Katherine L., David J. Lizotte, Joseph Krajcik, and Ronald W. Marx. "Supporting Students' Construction of Scientific Explanations by Fading Scaffolds in Instructional Materials." *Journal of the Learning Sciences* 15.2 (2006): 153-91.

[2] – Prather, Edward E., et al. "Research on a lecture-tutorial approach to teaching introductory astronomy for non-science majors." *Astronomy Education Review* 3.2 (2004): 122-136.

[3] - Zwickl, Benjamin M., Noah Finkelstein, and H. J. Lewandowski. "Development and Validation of the Colorado Learning Attitudes about Science Survey for Experimental Physics." (2013).

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