Impacts of a Course-Based Undergraduate Research Experience in Introductory Astronomy Using Robotic Telescopes

Archana S. Dobaria, Temple University, archana.dobaria@temple.edu
Janelle M. Bailey, Temple University, janelle.bailey@temple.edu
Kimberly Coble, San Francisco State University, kcoble@sfsu.edu

Abstract: As part of a general education undergraduate astronomy course at a minority-serving university in the Midwestern US, students completed an observing project with the Global Telescope Network (GTN), where they participated in realistic practices used by professional astronomers, including proposal writing and peer review. This study investigates students' experiences and perceived impacts of participation in the project. The iteratively coded and analyzed data includes an essay assignment [N = 59] administered over seven semesters. Students were prompted to address what they liked, disliked, or would change about the project experience.

Keywords: authentic research, robotic telescopes, course-based undergraduate research experience (CURE), scientific practices

Introduction and background

The purpose of the Global Telescope Network (GTN) project was to introduce students in a general education introductory astronomy course (ASTRO 101) to authentic scientific practices. Curricula that include realistic scientific research practices such as writing proposals, conducting peer review, collecting and analyzing data, and sharing findings vary in design and implementation (Krim et al., 2019). They have been referred to in the literature by a variety of descriptions (Wooten et al., 2018); here we adopt the term *course-based undergraduate research experiences* (CUREs), which has been extensively used in biology, chemistry and increasingly other STEM fields (Corwin et al., 2015). In the field of astronomy, the use of robotic telescopes at an introductory undergraduate level shows significant benefits (Gomez & Fitzgerald, 2017).

Our goal in this study is to determine and document the impact of an observing project that employed authentic scientific practices on ASTRO 101 students in a studio-style class setting. Research questions posed during the coding process were a helpful tool to explore the purpose of this curriculum. The questions are: What did students take away from the GTN project regarding content and affect? Did students describe their experience as including authentic scientific practices and tools?

Methods

The ASTRO 101 class studied here is intended to introduce the students to basic astronomical concepts and serves students in science and non-science majors. The class was offered at Chicago State University, a minority-serving university in the Midwest. There was no collection of individual demographics in order to maintain the anonymity of the population.

The GTN observing project curriculum contains six major steps of authentic research, following a general introduction to astronomical objects and software for observation planning. These steps can be summarized as: (1) selecting the observation object and writing a proposal abstract; (2) writing a detailed observing proposal; (3) peer review of the proposals; (4) participating in an instructor-guided panel discussion of proposals; (5) carrying out the observations with a remote telescope; and (6) presenting results to the class. At the end, students wrote a one-page reflection essay to express their thoughts and an assessment of the GTN project, focusing on "what you liked, what you disliked, and what you would change about the project experience and why." This study examines 59 reflection essays collected in seven semesters (Fall 2008-Spring 2014) in classrooms of 15-20 students.

These reflection essays were iteratively coded into emergent categories and themes based on students' self-described experiences. Starting with a line-by-line data analysis, we created and defined categories from the collection of written narrative data. Thereafter, axial coding was used to combine original codes into major categories and to define subcategories and their relationships. These categories and themes counted and bar plots created. The data coding process was done by multiple research assistants with an inter-rater reliability test to establish the reliability of the process (Cohen's kappa = 0.457). After having a thorough inter-rater group discussion to reach 100% agreement, the nominal data table was finalized.

Results and discussion

Nine categories emerged from the data, each with several themes. Table 1 lists the frequency counts for each category per semester. Notable categories include *Positive Affect, Knowledge, Affective Shifts,* and *Practice of Science.* More than one theme often appeared in a given essay, resulting in 371 coded response themes.

Table 1: Frequency counts of categories as a group for each semester

Categories	Spring 2014	Spring 2013	Fall 2012	Fall 2010	Spring 2010	Fall 2009	Fall 2008
Positive Affect	25	21	15	21	24	23	9
Knowledge	5	8	6	10	7	3	2
Affective Shifts	8	10	2	11	6	3	2
Work style Preference	11	10	2	11	6	3	2
Practice of Science	5	9	5	9	5	4	3
Changes	3	7	3	3	3	7	0
Difficulties	4	2	3	0	5	1	1
Dislikes	1	2	4	5	5	2	0
Things I would do differently	2	2	1	2	1	1	0

Because of the nature (self-reported) and timing (during the semester) of the project, we acknowledge its limitations and results should be interpreted with caution. However, these data suggest that there is a positive outcome from the use of CUREs in introductory astronomy. Therefore, we believe that continued use of CUREs can be valuable for instruction and that more robust research design in future efforts can further enlighten us on their efficacy.

Conclusion

In conclusion, the study finds that students expressed an overall strong positive affect, increased perception of self-efficacy, enjoyment of the experience of peer review, an appreciation for being able to use real scientific tools and to take on the role of astronomers, as well as a small number of dislikes such as real-world constraints on observing. The category of positive affect had the greatest number of responses and very few dislikes or suggested changes. Students' affective shifts were positive, including described increases in self-efficacy. The highlight of the project for many students was the peer review process. Students showed an appreciation for being able to take on the role of scientists and excitement about making observations and using astronomical tools, indicating they valued these realistic scientific practices and experiences.

References

Corwin, L.A. Graham, M. J. & Dolan, E. L. (2015). Modeling course-based undergraduate research experiences: An agenda for future research and evaluation, *CBE Life Sci. Educ.* 14 (1), es1

Krim, J.S. *et al*. (2019). Models and Impacts of Science Research Experiences: A Review of the Literature of CUREs, UREs, and TREs, *CBE—Life Sci. Educ.* 18 (4), ar65

Gomez, E. L., & Fitzgerald, M. T. (2017). Robotic telescopes in education. *Astronomical Review*, *13*(1), 28-68.

Wooten, M. M., Coble, K., Puckett, A. W., & Rector, T. (2018). Investigating introductory astronomy students' perceived impacts from participation in course-based undergraduate research experiences. *Physical Review Physics Education Research*, *14*(1), 010151.

Acknowledgments

We gratefully acknowledge the support of National Science Foundation (NSF) CCLI Grant #0920293, as well as additional funding from the Illinois Space Grant Consortium and San Francisco State University. We would also like to acknowledge Dr. Kevin M. McLin of Sonoma State University, who was the director of the Global Telescope Network (GTN), for providing telescope time and technical support in using the robotic telescopes and for consulting on the curriculum. We also thank Dr. Lynn R. Cominsky of Sonoma State University for her support of the GTN and this research project. Our sincere thanks go to Alejandra Le of Chicago State University and Katie Berryhill of Solano Community College who laid the groundwork for data analysis.