Global Relay of Observatories Watching Transients Happen (GROWTH) Partnerships for International Research and Education (PIRE) Project Quarter 4 Formative Report (Fall 2017 Courses)

GROWTH PIRE Project is funded by the National Science Foundation

GROWTH is an international scientific collaborative project in astronomy, studying the physics of fast-changing events in the cosmos like supernovae, neutron stars or black hole mergers, and near-earth asteroids. The intention of this project is to continuously observe and gather data of cosmic transient events in the first 24-hours after detection, before many of them fade away in intensity below the sensitivity of telescopes. Project activities are conducted among undergraduate students, graduate students, postdocs, partner institution faculty, and researchers. This report presents formative (process) feedback on GROWTH courses and should be used by instructors to modify courses, as appropriate.

Evaluation report contents

Course highlights and evaluator recommendations

Course evaluations for the three courses offered in Fall 2017 were completed by 39 respondents. Of those 39, eight were females, three were URM, and seven were first-generation college students. While not an explicit goal of the project, recruitment of diverse populations into STEM courses and fields should be a focus for project leads as it is encouraged by the NSF PIRE program. The following are the major highlights from each of the three courses that were evaluated.

- Nearly all students reported increases in their knowledge, skills and techniques, and interest in astronomy and astrophysics after completing the courses. This was especially true for respondents' understanding of the research process in astronomy and astrophysics, for which all respondents reported increases. Undergraduate respondents agreed that using telescopes enhanced their learning and graduate students reported the course increased their skills in operating the telescopes. Across all courses students attributed gains to the hands-on aspects of the courses, especially the chance to investigate their own research questions using data they manipulated.
- Across the courses, respondents had increased excitement and passion for the field and an increased interest in research and careers in astronomy/astrophysics; however, many of the students were already highly interested before participating in the course. Among undergraduates, the course did little to change their plans regarding graduate school, because most already planned to attend before taking the course.

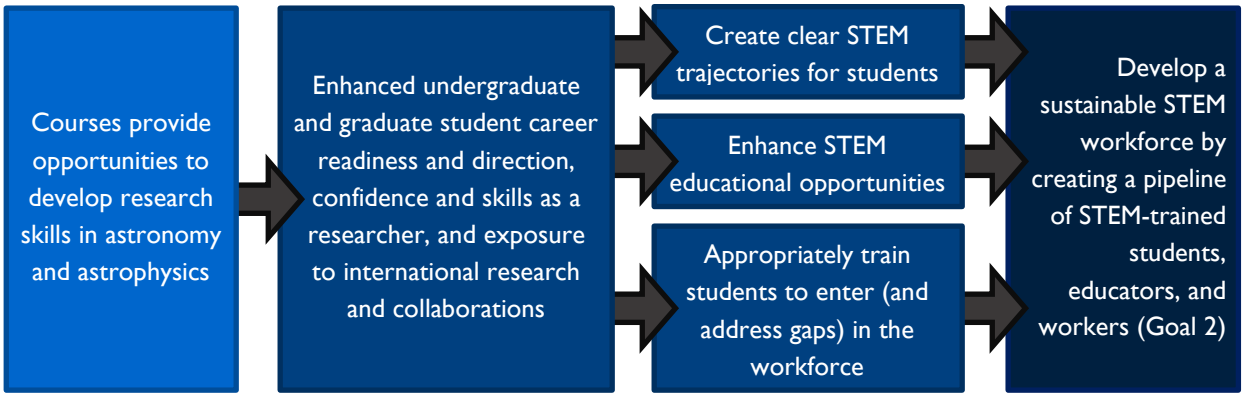
The following are recommendations for course instructors. Project leads should share the evaluation results with instructors and discuss the best ways to help interested students stay connected to the project.

- Some respondents wanted more assistance with telescope design and data analysis and several students were interested in continuing to conduct research projects. When possible, instructors should connect those students to GROWTH or other research opportunities after the course ends. Instructors should ask students about their interest before the conclusion of the course to ensure they know who those students are and get them connected to the right faculty, considering both interest areas and student skill level. Linking students to research projects after the course will help to strengthen the STEM pipeline that GROWTH aims to create, as these project opportunities can better prepare students for the workforce and help clarify STEM trajectories.
- As many GROWTH courses attract students highly interested in the field, the project might consider offering undergraduate level courses to a broader audience to reach those who have had less exposure to astronomy/astrophysics. Given the success of the data-driven courses, GROWTH leads and instructors should consider developing a model course that can be used at any institution as an introduction to the field. This may present an opportunity to reach students who are less interested and recruit them to the field. These model courses should include hands-on components where students can experience many aspects of the research process. Project and evaluation overview

Project overview

In 2015, the California Institute of Technology (Caltech) received funding for a Partnerships for International Research and Education (PIRE) grant from the National Science Foundation (NSF) for the (GROWTH) project. Caltech leads the GROWTH partnership with fourteen universities and research institutions (six in the USA and eight across the world in seven countries: India (two partner universities), Sweden, Taiwan, Japan, Israel, Germany, and the United Kingdom). GROWTH runs courses that support the Education and Workforce Development goal (Goal 2) of the project, which focuses on developing a sustainable STEM workforce by creating a pipeline of STEM-trained students, educators, and workers.

The diagram below illustrates the short, medium, and long-term outcomes of GROWTH courses.



Evaluation approach

The evaluators are conducting two types of evaluation for this project: a formative evaluation to monitor project implementation and give ongoing feedback to principal investigators, and a summative evaluation to assess the impact of the project and progress made toward reaching stated goals. This is a formative evaluation report that provides feedback on the implementation of three courses: Observational Astronomy (ASTR 310) at the University of Maryland, College Park; Clocking Dead Stars with Radio Telescopes (PHYS 194) at the University of Wisconsin, Milwaukee; and Astronomical Techniques (ASTR 680) at San Diego State University. Each section of this report includes an overview of the course, graphics that display ratings of course components and student growth in knowledge, skills, and interest in STEM, and participant comments. Findings from this report should be used by project leads to make revisions to future courses, as appropriate, and to demonstrate the project's progress to NSF. The following are the evaluation questions examined in this report:

1. To what extent have undergraduate and graduate students increased their knowledge and skills through research conducted within the courses?
2. To what extent have undergraduate students, graduate students, and postdocs developed an interest in the field, scientific careers, and continuing education after the course?

Evaluation measures

Evaluators developed surveys in conjunction with project administration and activity leads. Surveys contained Likert-scale items and open-ended questions that measured participants' knowledge and skills related to activity objectives, future educational and career plans, and plans to utilize knowledge and skills gained. All Likert items are on a 5-point scale. The following assessment tools were developed or revised and utilized for the activities reported in this evaluation report:

- ASTR 310 evaluation form
- PHYS 194 evaluation form
- ASTR 680 evaluation form

Data collection and analysis

All of the course evaluation surveys were administered through Survey Gizmo at the conclusion of the course. Quantitative results were analyzed using descriptive statistics in Excel, and qualitative data were coded for themes.

Overview of GROWTH courses

GROWTH graduate and undergraduate courses are offered at partner institutions both nationally and internationally. GROWTH courses incorporate project data to engage students in data-driven discovery and to expose them to actual research in astronomy and astrophysics. Ultimately, the courses aim to develop students' interest in research and astronomy/astrophysics. Three GROWTH courses were offered in Fall 2017. The table below displays the name and location of each course included in this report, along with the level of students participating in the course, and survey response rate. Results for all course evaluations should be interpreted with caution given the small sample sizes.

Course	Institution	Student level	Number of students (survey response rate)
Observational Astronomy (ASTR 310)	University of Maryland, College Park	Undergraduate	32 (94%)
Clocking Dead Stars with Radio Telescopes (PHYS 194)	University of Wisconsin, Milwaukee	Undergraduate	6 (50%)
Astronomical Techniques (ASTR 680)	San Diego State University	Graduate	8 (75%)

Evaluation participant demographics

	ASTR 310 (n=30)	PHYS 194 (n=3)	ASTR 680 (n=6)	Total (n=39)
Gender				
Male	22 (73%)	2 (67%)	4 (67%)	28 (72%)
Female	7 (23%)	0 (0%)	1 (17%)	8 (21%)
Other/Prefer not to answer	1 (3%)	1 (33%)	1 (17%)	3 (8%)
Race/Ethnicity				
Asian	5 (17%)	0 (0%)	0 (0%)	5 (13%)
Black/African American	2 (7%)	0 (0%)	0 (0%)	2 (5%)
Hispanic/Latino	0 (0%)	1 (33%)	0 (0%)	1 (3%)
White/Caucasian	20 (67%)	2 (67%)	4 (67%)	26 (67%)
Multiracial	1 (3%)	0 (0%)	1 (17%)	2 (5%)
Prefer not to answer	2 (7%)	0 (0%)	1 (17%)	3 (8%)
First-generation college student				
Yes	3 (10%)	2 (67%)	2 (33%)	7 (18%)
No	25 (83%)	1 (33%)	4 (67%)	30 (77%)
Do not know/Prefer not to answer	2 (7%)	0 (0%)	0 (0%)	2 (5%)

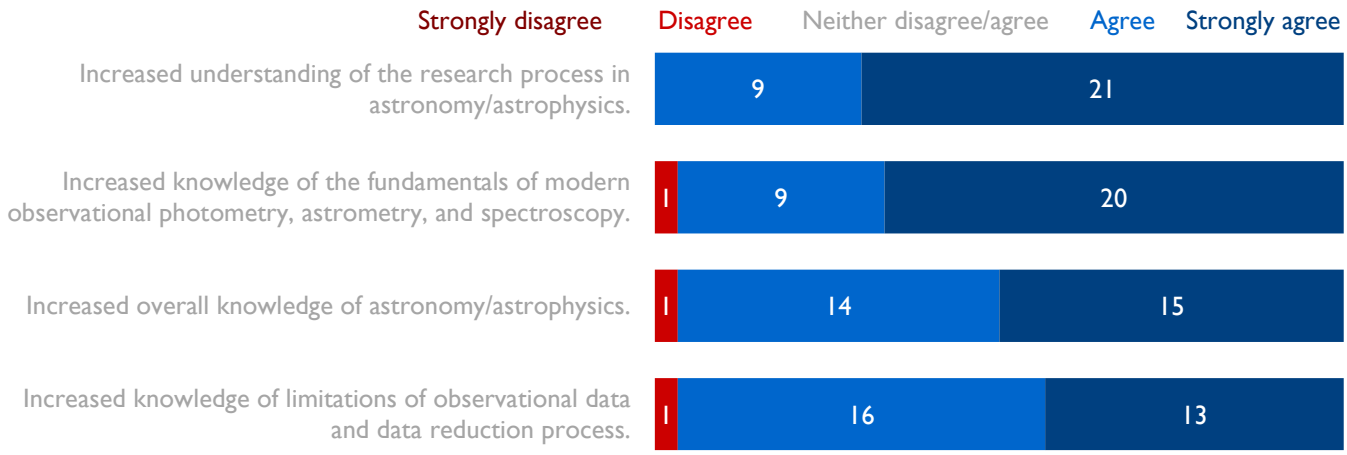
Observational Astronomy Course (ASTR 310)

Observational Astronomy is an undergraduate course offered at the University of Maryland, College Park. Thirty-two students were enrolled in the course and 30 completed evaluations. During the course, students are expected to understand and contribute to all parts of the collaborative research process, including utilizing large data sets to formulate and answer questions and communicate results orally and in written form. They are expected to gain knowledge of optical telescopes and charge-coupled devices (CCDs), be able to explain and utilize fundamentals of modern observational photometry, astrometry, and spectroscopy, and discuss limitations of observational data and the data reduction process.

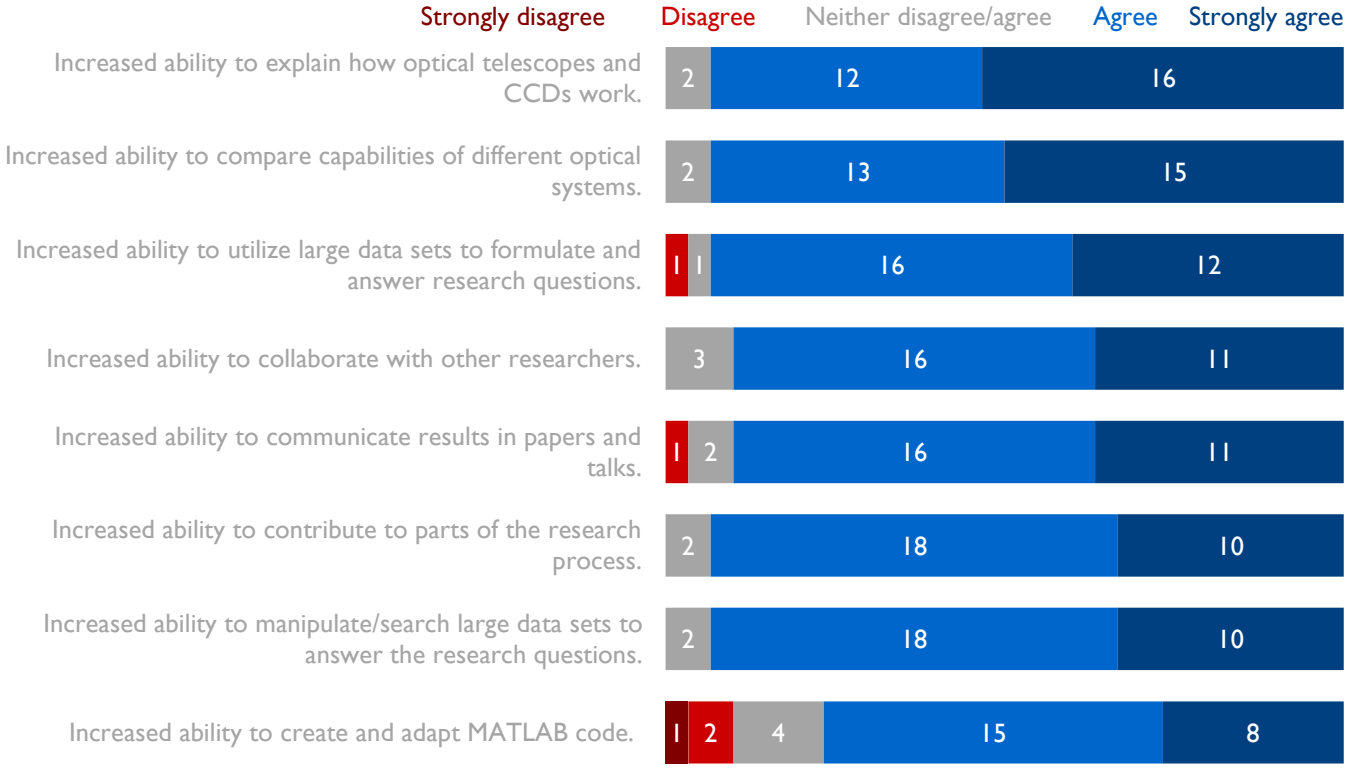
Course impact on knowledge, skills and techniques, and interest in astronomy/astrophysics

Respondents rated their level of agreement with fifteen statements about the impact of the course on increasing their knowledge of the field, skills and techniques, and interest in the field. Overall, the course was effective in impacting the respondents in the identified areas. All but one of the respondents reported increased understanding of the field. Given the emphasis on teaching the whole research process, it is not surprising that most respondents agreed that they had increased understanding of the research process in astronomy/astrophysics.

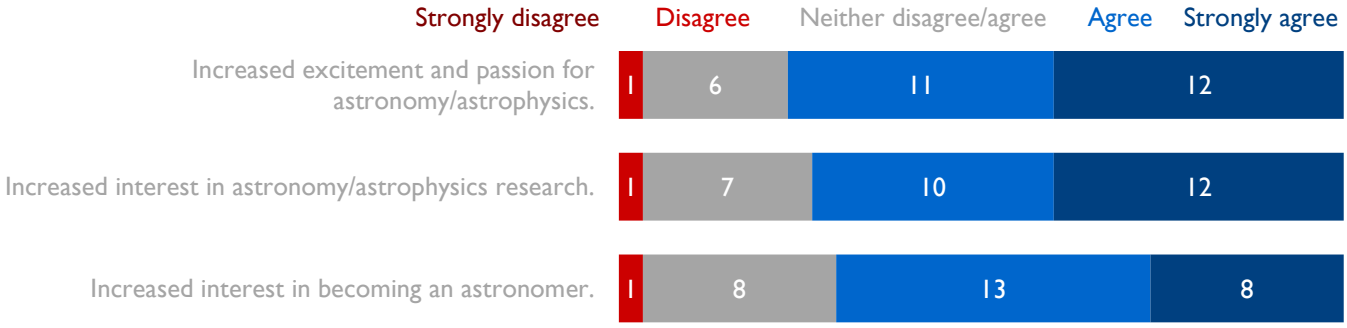
Respondents shared that they greatly appreciated being able to participate in a project from initial formulation of research questions to reporting the results of their research. One respondent noted, "I never really had a full glimpse into the whole research process before this class. Through this course I was able to work through the whole process and have a much greater understanding of the process," and another shared, "This class has improved my understanding of how to ask scientifically interesting questions, work with real data, write scientific papers, and give good scientific talks." In addition, about half of the respondents commented that they gained new knowledge regarding the various aspects of the research process.



Generally, most respondents agreed or strongly agreed that their skills and techniques increased during the course. This probably stemmed from the hands-on aspects of the course. One respondent noted, "I wasn't sure how actual observations and research was done in astronomy, and this course bridged the gap between basic astronomy knowledge and doing research." Ability to create and adapt MATLAB code had more variation in ratings than other areas; however, this is a much more specific skill that may take more time to learn, which likely explains why fewer students felt their ability increased.



Compared to skills and techniques, more respondents were neutral regarding statements about the course's impact on increasing their interest in the field, interest in astronomy/astrophysics research, or becoming an astronomer. Perhaps because more students in the course are sophomores, they are already in astronomy/astrophysics majors, or a related field, and thus more committed, interested, and excited by the field when they sign up for the class.



In written responses, 22 respondents (73%) noted that they had increased interest in conducting research in astronomy/astrophysics due to increased understanding of the astronomy/astrophysics field and research process. Specifically, they enjoyed the opportunity to engage in the research process from start to finish and use real-world data. Although a few respondents noted that they did not want to conduct research in astronomy/astrophysics, they shared that they were still generally interested in research. All but three respondents had an increased interest in participating in research projects, as they were motivated by the course, wanted to learn more, and also contribute to the field. Four respondents noted they were already conducting research and would continue to do so after the course.

Twenty-one respondents (70%) reported increased interest in becoming an astronomer, and shared that this was due to increased understanding of the field and experience gained during the course. Some stated that they were already interested in becoming astronomers before the course with one stating, "I was already planning on becoming an astronomer, but this course helped me solidify that plan by exposing me to some of the things I might do as an astronomer." A few respondents noted that while they may not have a decreased interest in becoming an astronomer, they changed their minds on what type of astronomy they are interested in.

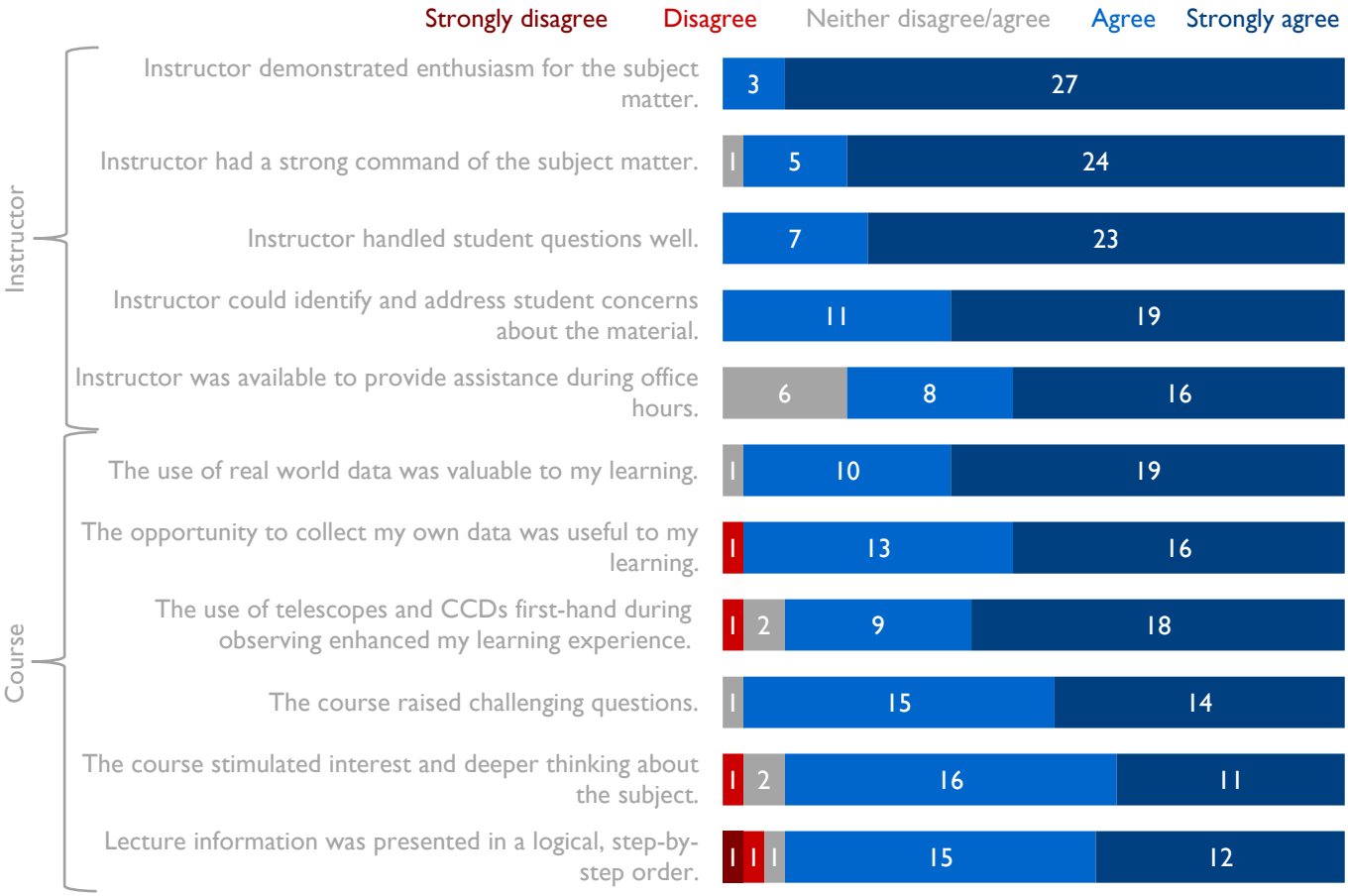
Course impact on education and career trajectories

Almost two-thirds of respondents did not plan to change their major as a result of the course. However, most of these respondents were already astronomy or related majors. The other third were also astronomy or related majors, but shared that the course affirmed their decision and commitment to the major.

Twenty-three respondents (77%) were interested in pursuing graduate school in astronomy and/or astrophysics or a related field. Most of these respondents (52%) were already planning to attend graduate school, sharing that the course did not influence this plan. Others (48%), who were also already planning to attend graduate school, shared that the course made them more interested in doing so, especially because of the research experience gained. Two respondents shared that they were less likely to attend graduate school but did not give specific reasons as to why this was the case.

Course effectiveness

In general, respondents felt the instructor knew the material well, was enthusiastic about the topic, handled questions well, and could identify and address student concerns. They also felt the course was interesting and valuable. A few respondents did not feel the material was presented in a logical order, a theme that has come up recurrently in the course evaluations for the GROWTH project. Most likely, because these are introductory classes for undergraduates, they are unclear as to why material is presented in a certain order. Instructor should mention both at the beginning of the semester and throughout, how the curriculum is laid out and why.



Suggestions for improvement

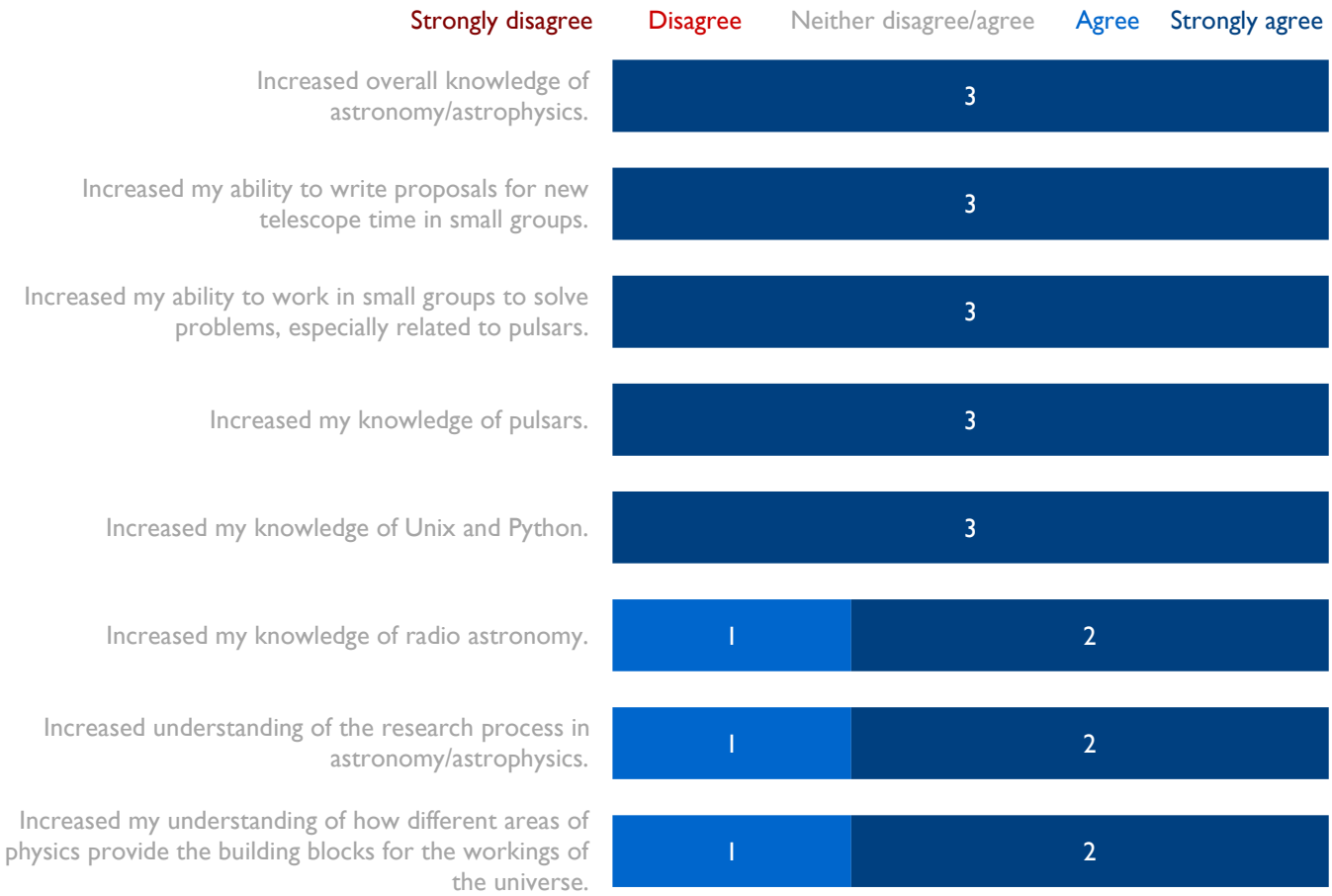
Four respondents suggested having fewer writing activities at the end of each class. Other respondents mentioned that they would have liked more information on telescope design and data analysis, and guidance when developing their hypotheses for the research project.

Clocking Dead Stars with Radio Telescopes (PHYS 194)

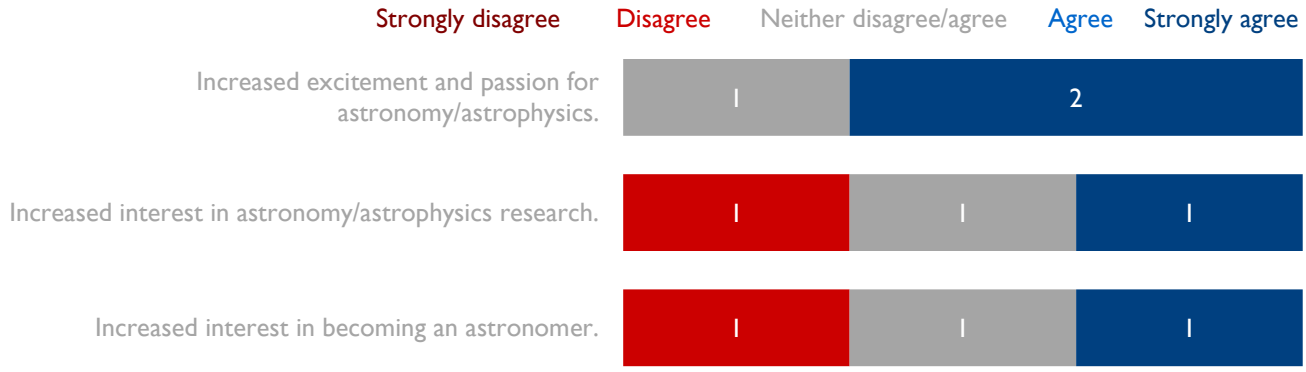
Clocking Dead Stars with Radio Telescopes is an undergraduate course offered at the University of Wisconsin, Milwaukee. Six students were enrolled in the course and three completed evaluations. During the course, students are expected to gain knowledge of pulsars and radio astronomy and gain experience with coding in UNIX and Python and conducting observations using the Green Bank Telescope. Students gain experience in the research process by working in groups to identify and determine characteristics of pulsars and write telescope proposals.

Course impact on knowledge, skills and techniques, and interest in astronomy/astrophysics

Respondents rated their level of agreement with thirteen statements about the impact of the course on increasing their knowledge of the field, skills and techniques, and interest in the field. Overall, the course was effective in impacting the respondents in the identified areas. All respondents agreed that the course increased their knowledge of the field and abilities in key course areas. Respondents mentioned ways in which the course impacted their understanding of the research process, including performing "real" science, conducting group projects, writing observation proposals, and gaining knowledge of journal databases.



Not all respondents had an increased interest in astronomy/astrophysics, conducting research, or becoming an astronomer. One of the respondents noted that he/she was applying to REU programs to continue to participate in astronomy/astrophysics research. The other two respondents noted that while they would like to continue to participate in astronomy/astrophysics research, they would rather conduct research in other fields.

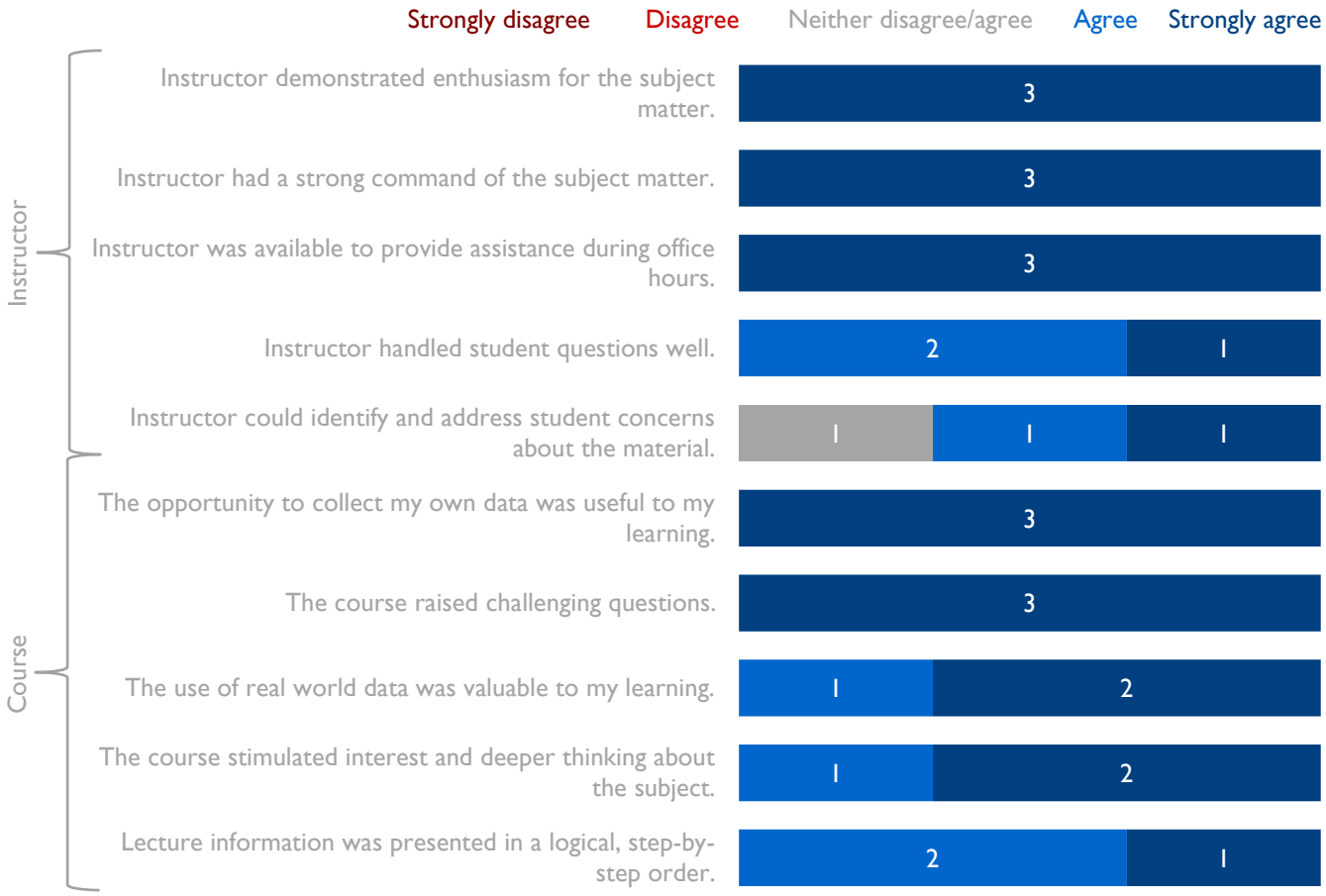


Course impact on education and career trajectories

Two respondents shared they were content with their STEM majors and that the course confirmed their interest to remain in their majors. The other respondent started the class as a physics major, but realized this was not for him/her and changed his/her major, though did not specify the new major. The two STEM majors are planning on pursuing graduate school in astronomy/astrophysics or related fields and shared that the course influenced this decision. They both mentioned that they wanted to go to graduate school to continue to do research in the field. The non-STEM major was undecided on graduate school but is open to the possibility of pursuing a graduate degree.

Course effectiveness

Generally, respondents agreed the course was well organized and conducted. They also agreed the instructor was effective at both teaching the material and responding to students. Ratings suggest the course is well put together and provides a hands-on experience that motivates and engages students.



Suggestions for improvement

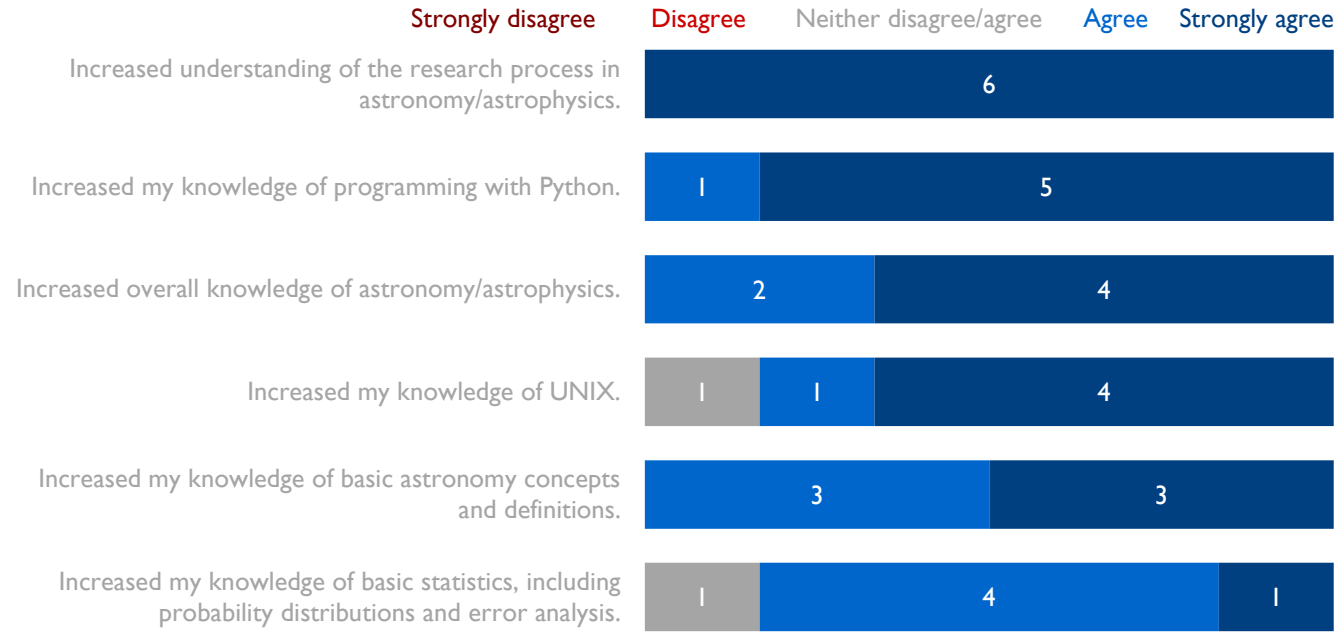
One respondent suggested that the course should be open to all levels of students, rather than just first-year students. Another respondent felt that the material may be a bit advanced for some first-year students and suggested different prerequisites, such as a higher-level math course, or more simplified math in the course itself. The third respondent suggested going into more detail on the material.

Astronomical Techniques (ASTR 680)

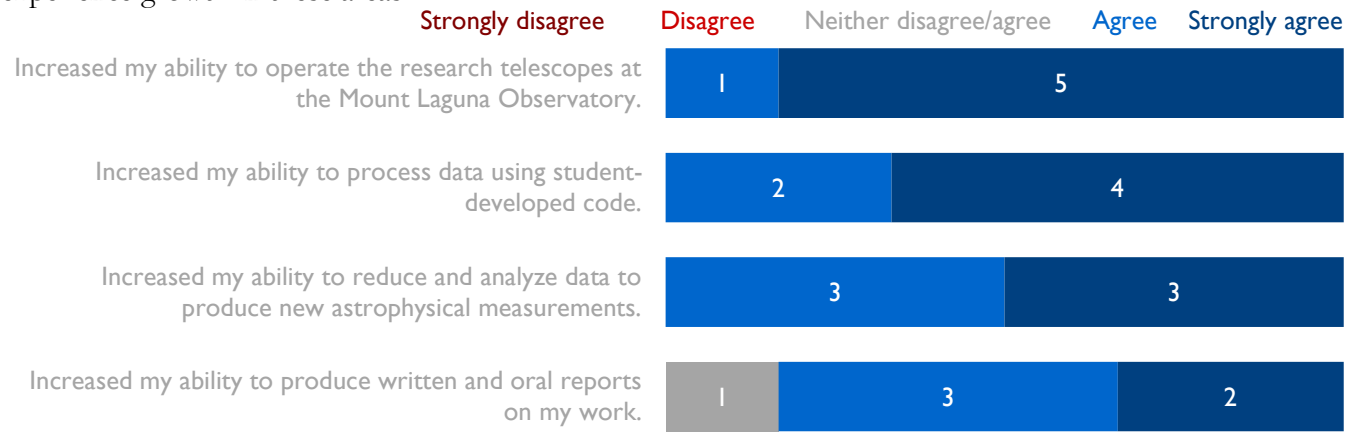
Astronomical Techniques is a graduate course offered at San Diego State University. Eight students were enrolled in the course and six completed evaluations. During the course, students are expected to gain experience in coding in both Python and UNIX and with telescope and instrument operation, and knowledge of basic statistics, astronomy concepts, and astronomical software. The course also features visits to the Mount Laguna Observatory for students to gain experience operating the telescope.

Course impact on knowledge, skills and techniques, and interest in astronomy/astrophysics

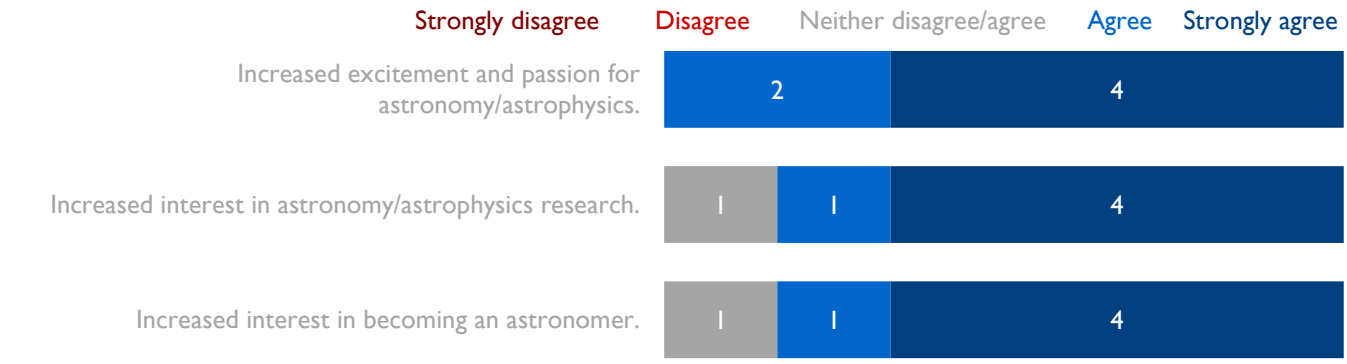
Respondents rated their level of agreement with thirteen statements about the impact of the course on increasing their knowledge, skills and techniques, and interest in the field. Overall, the course was effective in impacting the respondents in the identified areas. All respondents reported increased knowledge of the field, including the research process, basic concepts and definitions, and programming with Python. Respondents noted that the course provided hands-on research opportunities, which allowed them to see how research would be done in their careers as astronomers.



Respondents also reported increased ability to work with data, operate telescopes, and produce written and oral reports after the course. The hands-on nature of the course likely helped students to gain new skills and experience growth in these areas.



All respondents agreed that they had increased excitement and passion for astronomy/astrophysics. Five respondents reported an increased interest in research and in becoming an astronomer, and mentioned that working with the data and gaining confidence in their skills contributed to this increase. They shared that experiencing the research process made the field and the career seem more accessible and fulfilling. One respondent shared that while the course did not increase their interest in research, it did reaffirm it. All respondents noted that they were interested in participating in further research in the field.

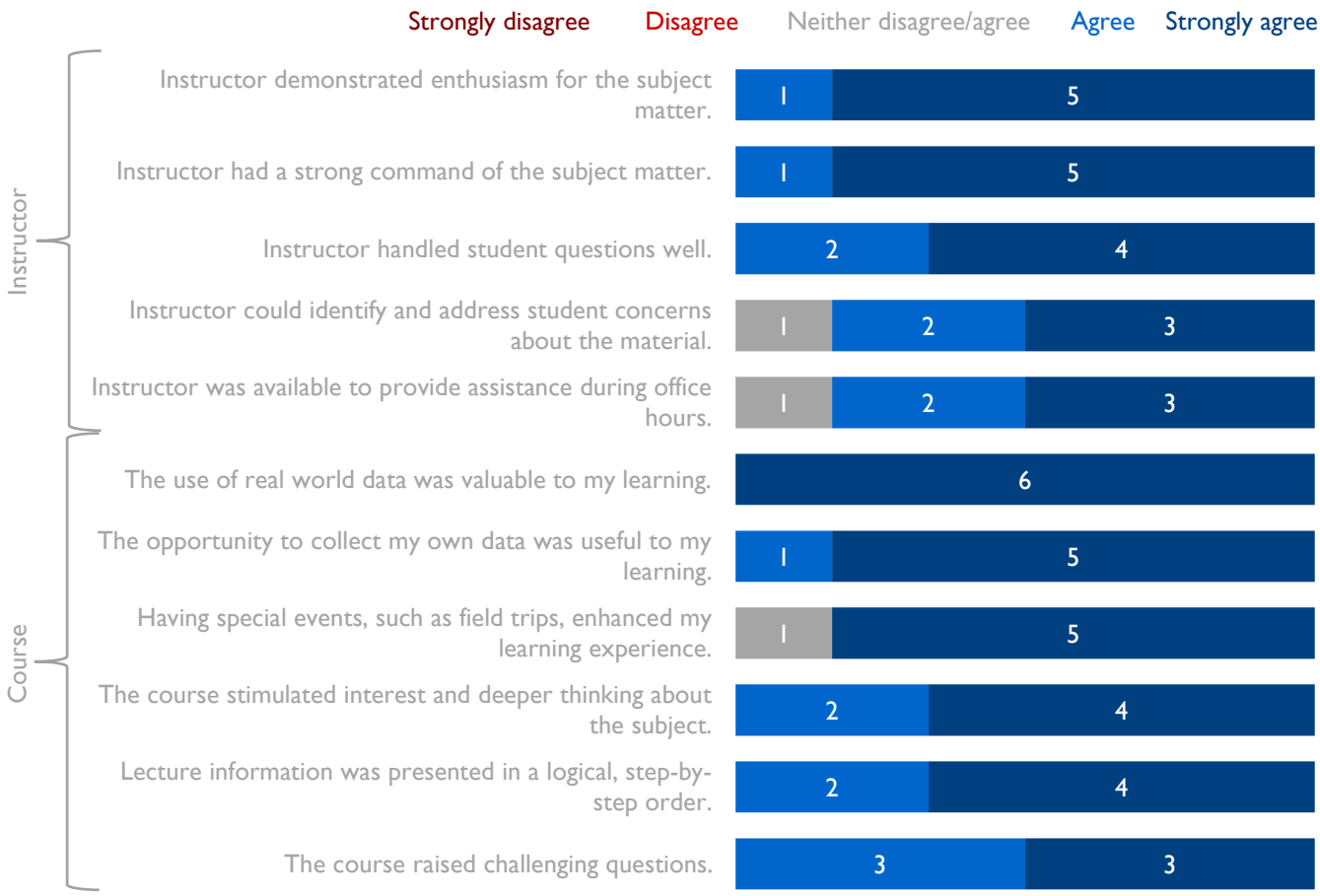


Course impact on education and career trajectories

All six respondents were enrolled in Master's programs in astronomy or astrophysics. Four respondents felt the course affected their interest in pursuing further education or a career in the field. One of those four noted that the course helped him/her to become less fearful of the field and another thought that the coding and research were fun. Two did not believe the course affected their interest in pursuing further education, noting that their commitment and interest did not change. All but one respondent were planning to enroll in Ph.D. astronomy or astrophysics programs.

Course effectiveness

Generally, respondents agreed the course was well organized and conducted. They also agreed the instructor was effective at both teaching the material and responding to students. All respondents agreed that using real world data that they collected was valuable and useful to their learning.



Suggestions for improvement

A few respondents wanted more opportunities to create their own code for the data, with one suggesting finding a middle ground between doing all of the coding themselves and having it provided for them. Another respondent, however, noted that he/she appreciated having the code made for them as it allowed him/her to learn more. Other respondents wanted lectures that were not finished during the class time to be continued at a later date. While they noted this did happen sometimes, they would have appreciated if this happened more often.