Global Relay of Observatories Watching Transients Happen (GROWTH) Partnerships for International Research and Education (PIRE) Project Quarter 2 Formative Report (covers activities from May-August 2017)

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 Spring 2017 were completed by 16 respondents. Of those 16 respondents, four were females, one was URM, and six were first-generation college students. Five undergraduate students were STEM majors. While not an explicit goal of the project, recruitment of diverse populations into STEM courses and fields should be a focus for project leads. The following are the major highlights from each of the three courses that were evaluated.

- In all courses, respondents thought that the instructors and course structure were effective; however, in two of the three courses, some respondents indicated that the course material was not presented in a logical order.
- Most of the undergraduate students (n=11) reported that the course they took did not have an impact on their major. This is most likely due to the respondents taking the courses as general education requirements for their universities or already being set with their majors. Three respondents indicated they were planning to add additional degrees. One is planning to add a physics double major and two plan to add astronomy minors, one of whom made the decision to do so after taking the course.
- Across the courses, respondents reported the course they took had little impact on their interest in the field, especially interest in becoming an astronomer. This could be attributable to most undergraduate students not being STEM majors and graduate students already being interested in the field. Additionally, thirteen of the students were interested or already participating in astronomy/astrophysics research.

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.

- To address feedback about the order in which course material is presented, adjustments could be made. However, it may be best for instructors to share with the students how the course is structured and why. This is something they can remind students of throughout the course. Instructors can help students synthesize material and make connections between lectures.
- Although many respondents have set education plans, they enjoyed using data and going on field trips and found them useful to their learning. Instructors should continue to use those methods to keep students engaged and generate more interest in the field and in doing research.
- Since several respondents are interested in conducting astronomy/astrophysics research, project leads should discuss the best way to get those students connected to the project. Leads could ask course instructors to gauge interest before the course ends and to share opportunities and activities with which students can get involved. Interested students could also be added to the GROWTH newsletter email list.

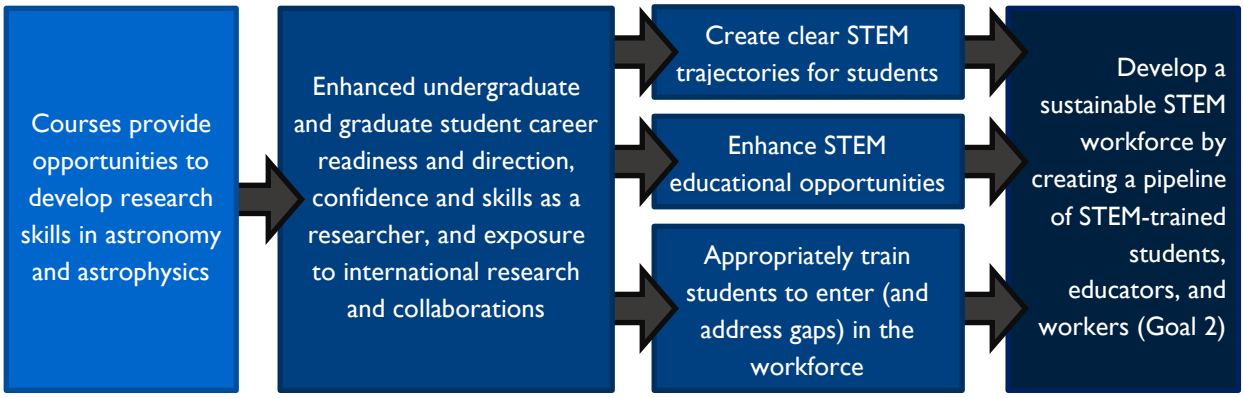
Evaluation results to be presented next quarter: Summer Research Program evaluations, Graduate Student and Postdoc Internship evaluations, Project Annual Progress survey, and Project Social Network Analysis

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 Global Relay of Observatories Watching Transients Happen (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 (YSC2217), Advanced Astronomical Observations (AS6005), and Advanced Introductory Astronomy (A51). Each section of this report includes an overview of the activity, 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 students, graduate students, and postdocs increased their knowledge and skills through research experiences?
2. To what extent have undergraduate students, graduate students, and postdocs developed an interest in the field, scientific careers, and continuing education?

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:

- YSC2217 evaluation form
- AS6005 evaluation form
- A51 evaluation form

Data collection and analysis

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

Overview of GROWTH Courses

GROWTH courses are offered at different partner Universities both nationally and internationally. Courses are for undergraduate and graduate students and vary in length. 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. Four GROWTH courses were offered in Spring 2017; however, one of the courses (Automated Discovery of the Universe-AY3) ran from January to March and was reported in the GROWTH annual report. The table below displays the name and location of each course included in this report, along with the types of students and survey response rate. Results for all course evaluations should be interpreted with caution given the small sample sizes.

Course	Institution and location	Student level	Number of students (survey response rate %)
Observational Astronomy: YSC2217	Yale-NUS College, Singapore	Undergraduate	6 (67%)
Advanced Introductory Astronomy: A51	Pomona College, USA	Undergraduate	19 (37%)
Advanced Astronomical Observations: AS6005	National Central University, Taiwan	Graduate	7 (71%)

Observational Astronomy Course (YSC2217)

Observational Astronomy (YSC2217) is an undergraduate course offered by Yale-NUS College in Singapore and taught by a project member from a US partner institution. Six students were enrolled in the course and five completed evaluations (83% response rate). One of these students only partially completed the evaluation and therefore, the sample size varies throughout this section. This course has a heavy focus on observing astronomical phenomena and conducting scientific research with the observations. The course aims to do the following:

- Expose students to the fields of astronomy and astrophysics.
- Increase student knowledge of the research process and how to conduct their own research in astronomy/astrophysics.
- Increase student knowledge and skills in modern astronomical techniques.
- Increase student oral and written presentation skills.

Demographics of survey respondents (n=4)

- Three respondents were male.
- Three respondents were Asian and one was white.
- Three respondents were college sophomores and one was a college senior.
- Two respondents were first-generation college students[1].
- One respondent was a STEM major.

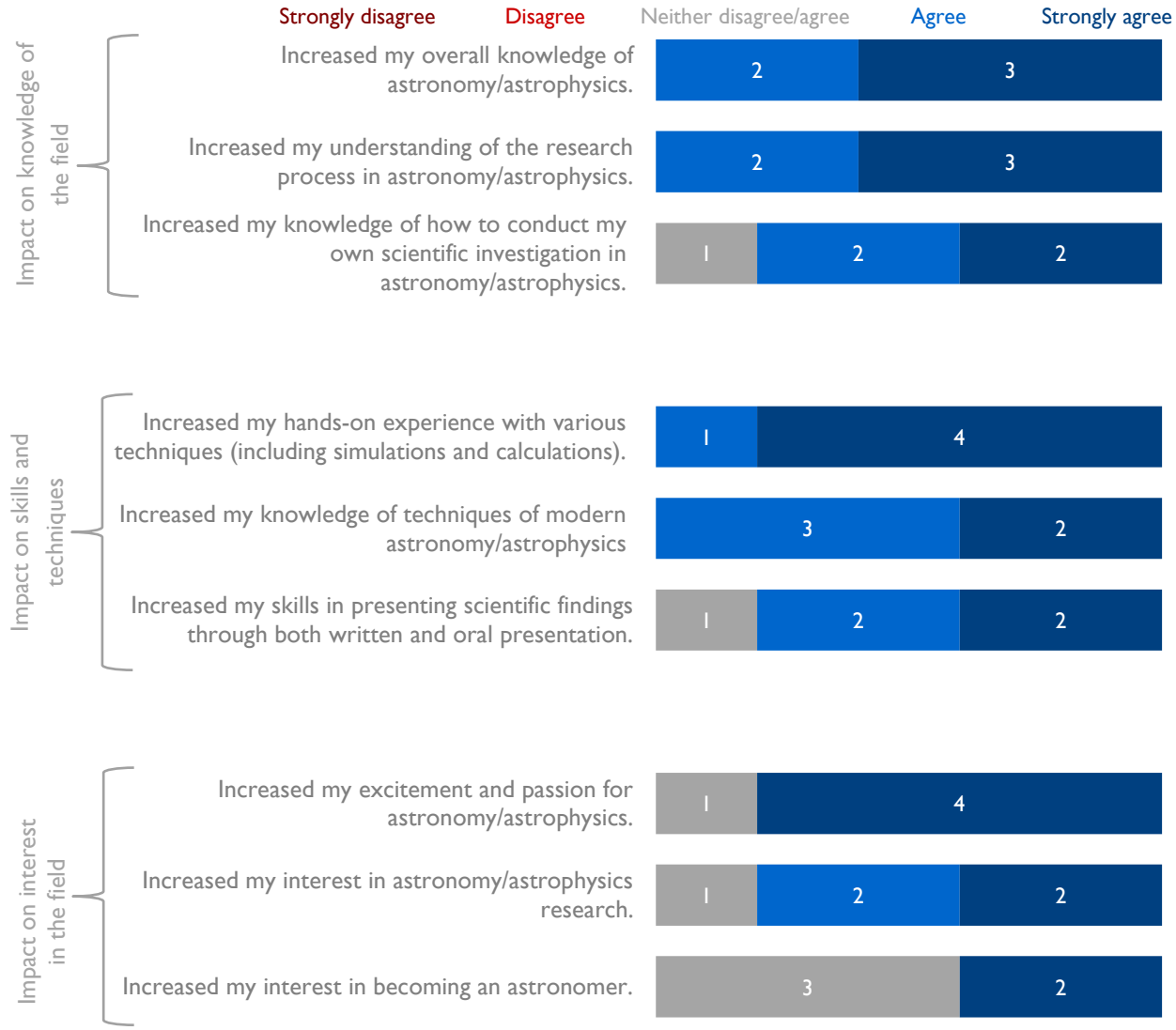
Course impact

Respondents (n=5) rated their level of agreement with nine statements, which were organized into three impact areas:

- **Impact on knowledge of the field:** three statements about knowledge of general astronomy/astrophysics, understanding of the research process, and how to conduct their own research.
- **Impact on skills:** three statements about skills related to experiences with hands-on techniques, knowledge of general techniques, and written and oral presentations.
- **Impact on interest in the field:** three statements about excitement, interest, and passion for astronomy/astrophysics, astronomy/astrophysics research, and being an astronomer.

1. A first-generation college student is an individual whose parents never enrolled in postsecondary education.

The course impacted respondent knowledge, skills, and interest similarly. However, three out of five respondents were neutral about having an increased interest in becoming an astronomer. Comments show that the one STEM major decided to add a physics major because of the course. Three respondents shared that although they enjoyed the course, they plan to stay in another field.



Respondents who indicated that the course increased their understanding of research, interest in conducting astronomy/astrophysics research, or interest in becoming an astronomer were prompted to explain how the course impacted them in these areas. Respondents most frequently noted that the course helped them to understand all pieces of the research process and how difficult and time consuming it can be. One respondent stated, "Although I've always been interested in astronomy, I had no idea how astronomy research is actually done. Taking this course gave me a strong introduction to the astronomical research process, particularly photometry and source detection with algorithms like DAOphot."

All respondents also offered examples of how the course impacted their interest in conducting research in astronomy and astrophysics. Two respondents reported their interest increased and that the course was enjoyable, but they would not want to conduct research as part of their career or major. Another respondent noted that the course provided them opportunities to use the tools and instruments and that, "being able to use the astronomical tools puts a lot of astrophysics into perspective…which makes for a more sophisticated understanding of the physics of the cosmos."

Influence on educational and career trajectories

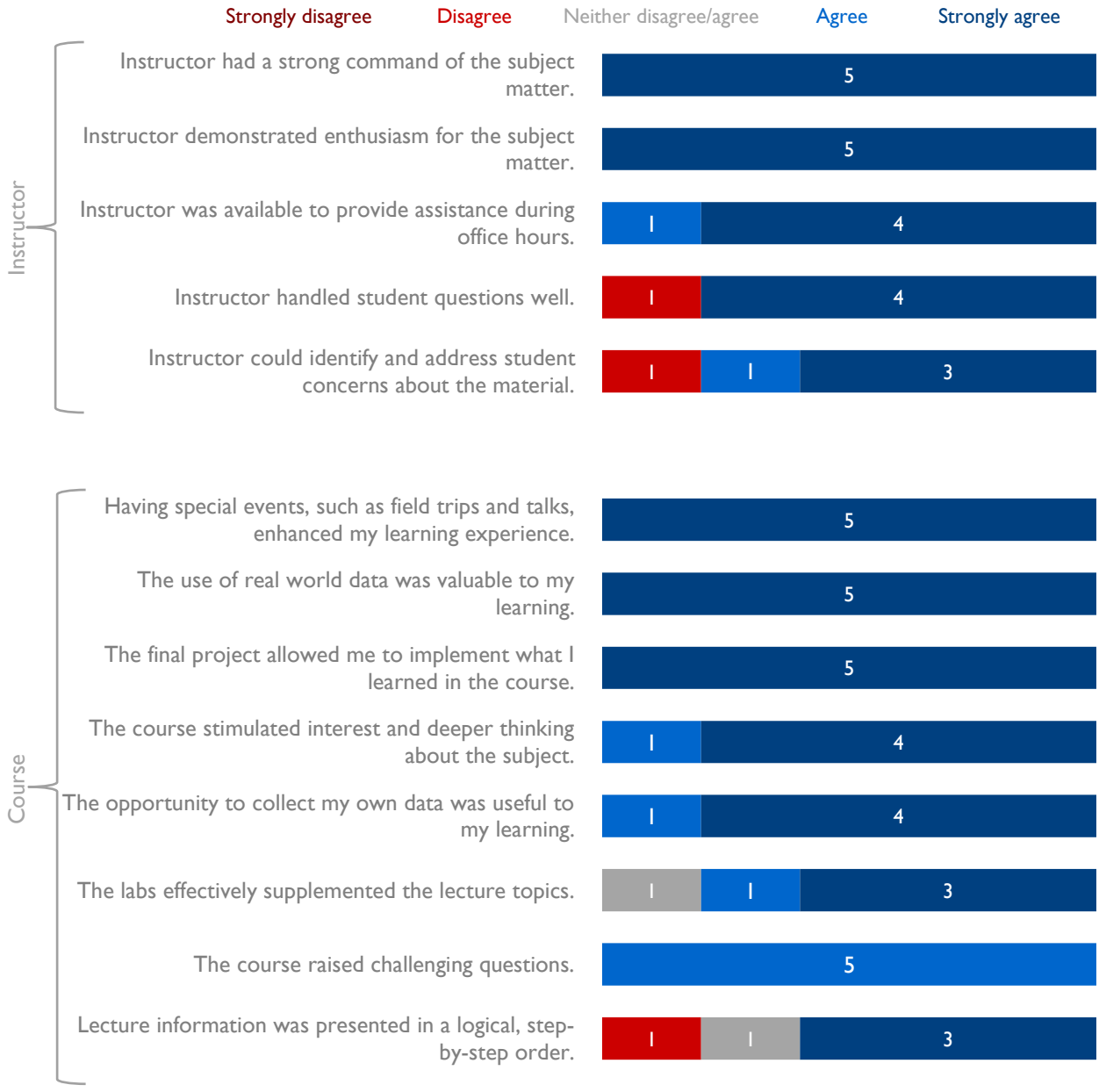
This was an undergraduate course and the education/career trajectory questions pertained to their plans for their major, graduate school, and continued involvement in astronomy/astrophysics research. Three respondents were not STEM majors and did not have plans to switch to a STEM major. These respondents enjoyed the course, but did not have enough interest to change their major. The one STEM major planned on staying in his/her major and also intended to add physics double major as a result of taking the course.

When asked about their interest in pursuing graduate school, two of the respondents were interested, one of which was the STEM major. The other two respondents were undecided. Three of the four respondents reported that the course did not affect their interest in graduate school, with two noting they already wanted to attend.

Two respondents were interested in participating in astronomy/astrophysics research projects, one out of personal interest, and the other to contribute to the field. The other two did not wish to participate in research projects as they do not see them as relevant to their future plans. Project leads should determine the best way to stay connected to students who are interested in conducting research and identify how these students can continue to be involved with GROWTH.

Course effectiveness

Nearly all respondents found the instructor and the course effective. Respondents found the course was structured well and offered a valuable learning experience. Ratings also suggest that some adjustments may be needed to the order in which the material is presented. Alternatively, instructors may need to explain the course setup to students so they better understand how the course is structured and why. One respondent did not feel that student questions were handled well or that the instructor was able to identify student concerns.



Course suggestions

One respondent suggested that there should be clearer explanations of course material, which would benefit those who did not have an introduction to the topics in previous courses.

Advanced Introductory Astronomy Course (A51)

Advanced Introductory Astronomy (A51) is a course offered by Pomona College in California. Nineteen students were enrolled in the course and seven completed evaluations (37% response rate). This is an advanced introductory course to astronomy and explores the modern and historical scientific techniques that have been implemented to develop the current view of the Universe and its evolution. The course aims to do the following:

- Provide the foundation and the critical eye to track new discoveries and understand their broader implications.
- Provide an overview of the Universe.
- Focus on scientific methods and inquiry that have led to both the questions and answers regarding the formation and evolution of our Universe and its components.

Demographics of survey respondents (n=7)

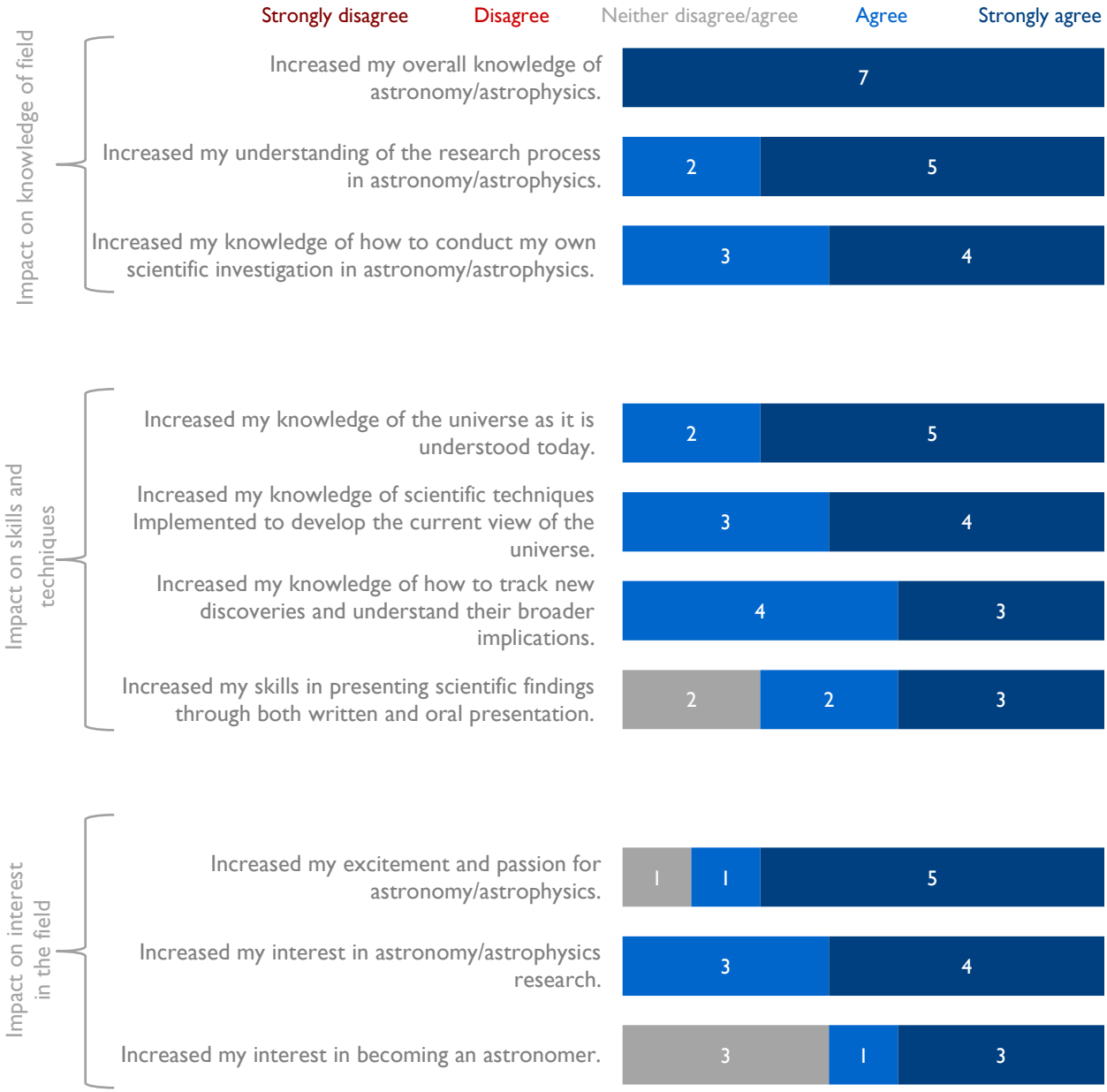
- Three respondents were female.
- Three respondents were Asian, two were Caucasian, one was Black., and one was multiracial (Caucasian and Asian).
- Three respondents were college juniors, two were college sophomores, and two were college freshmen.
- No respondents were first-generation college students.
- Four respondents were STEM majors.

Course impact

Respondents (n=7) rated their level of agreement with ten statements, which were organized into three impact areas:

- **Impact on knowledge of field:** three statements about knowledge of general astronomy/ astrophysics.
- **Impact on knowledge and skills:** four statements about skills related to conducting research, analyzing data, and written and oral presentation.
- **Impact on interest in the field:** three statements about excitement, interest, and passion for astronomy/astrophysics, astronomy/astrophysics research, and being an astronomer.

Findings suggest that the course had a positive impact on students' knowledge of the field. Notably, all seven strongly agreed that their overall astronomy/astrophysics knowledge increased, suggesting the course provided a good introduction to the topic area. Two respondents neither disagreed nor agreed that their skills in presenting scientific findings through both written and oral presentations increased, suggesting that instructors should make this an area of focus for future iterations of the course. Three respondents neither disagreed or agreed that they had an increased interest in becoming an astronomer, two of which are non-STEM majors and likely are already set in their degree plans.



Respondents who indicated that the course increased their understanding of research, interest in conducting astronomy/astrophysics research, or interest in becoming an astronomer were prompted to explain how the course impacted them in these areas. All respondents shared that the course impacted their understanding of the research process by exposing them to different types of astronomy related to research and labs. One respondent also shared that "the final research project was helpful for me to understand the planning and execution required to conduct a successful study. It showed me to persevere along the process despite obstacles that came along the way."

Four of the seven respondents shared that the course greatly impacted their interest in becoming an astronomer. One of the four respondents shared that although the workload and time commitment of being an astronomer is not appealing, they found the course material to be interesting and the hands-on experience sparked his/her interest in becoming an astronomer. Another respondent shared they have now decided to pursue an astronomy minor, sharing that they will take both physics and astronomy classes next year, which should allow him/her to complete the astronomy minor.

Five of the seven respondents stated that they are now more interested in astronomy/astrophysics research. One of those five shared, "I am very interested in continuing learning how to conduct research in astronomy/ astrophysics. I will be taking ASTR101, Techniques in Observational Astrophysics, next year." The other two noted they were not interested enough to continue conducting research in the field.

Influence on educational and career trajectories

A51 was an undergraduate course and the education/career trajectory questions pertained to their plans for their major, graduate school, and continued involvement in astronomy/astrophysics research. None of the respondents planned on changing their majors. Two shared that the course played a role in their decision to remain in their major, while the other five reported it did not. However, two of those five do plan to minor in astronomy and one of those respondents made this decision after taking the course.

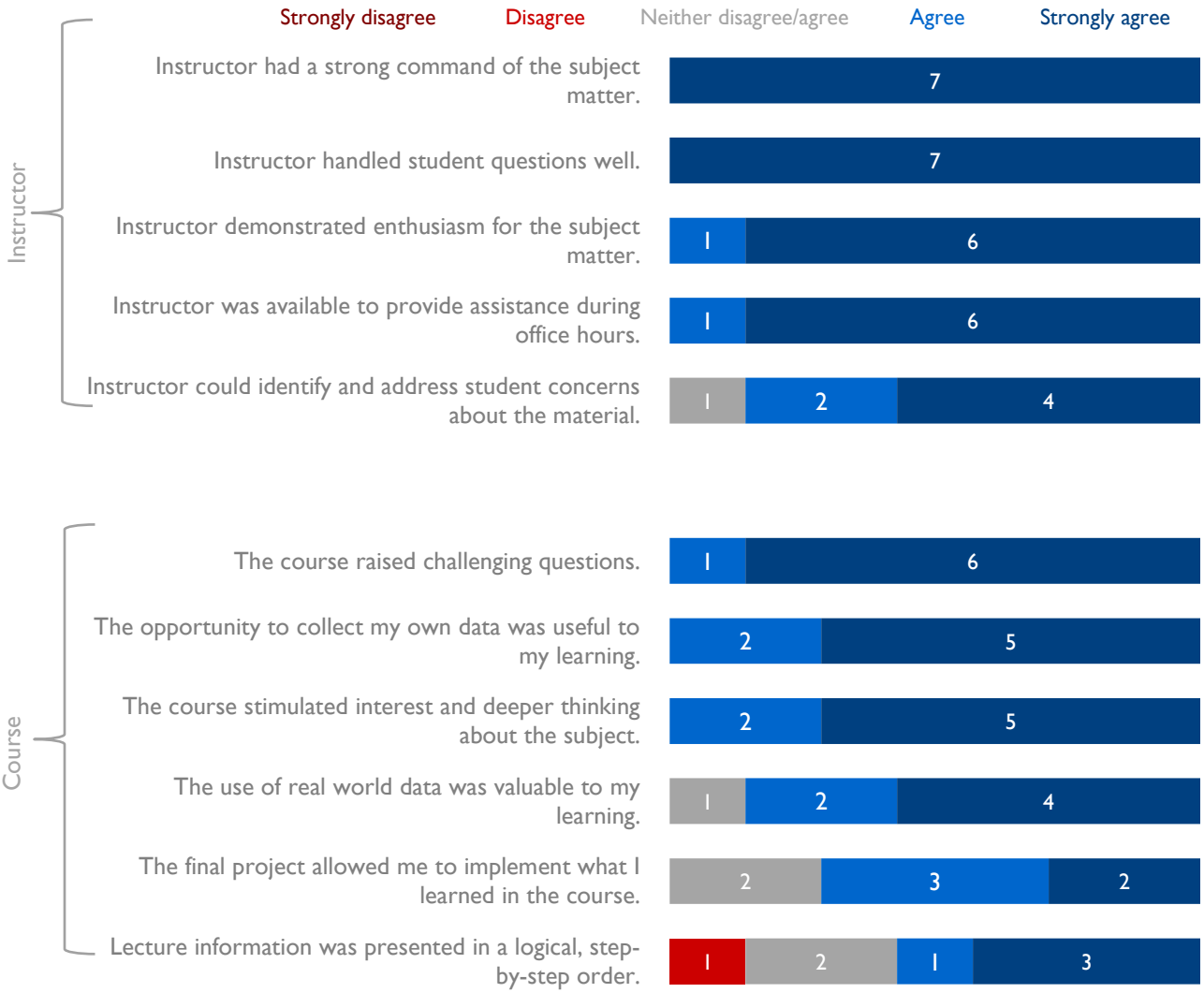
Four respondents reported an interest in pursuing graduate school, however only one planned to do so in an astronomy/astrophysics related field, physics. The other three respondents were undecided at the time of the survey about their interest in graduate school. The respondent who planned to pursue a physics graduate degree reported that the course affected his/her decision, stating he/she is now more intentional about it. The other six reported that the course did not affect their interest. Of the six respondents, however, two explained that they were already planning to attend graduate school, and three other respondents reported that the course was not relevant to their graduate school plans.

Four respondents reported being interested in participating in astronomy/astrophysics research. Two of the four were interested in the research from an education and career perspective, one of

whom stated he/she was interested "because I will be able to see if I should continue to pursue astronomy research as a career or focus solely on physics related paths." Two respondents were already participating in the research and one was not interested in the opportunity.

Course effectiveness

Generally, respondents felt the instructors were knowledgeable about the material and facilitated the course well. All respondents strongly agreed the instructor had a strong command of the subject matter and handled student questions well. One area for improvement may be the order in which the material is presented. However, respondents did not provide any specific feedback in this area. Alternatively, the instructor may just need to share more on how the course is structured and why.



Course suggestions

Only one respondent provided a suggestion for improvement: having one less midterm. Another respondent commented and praised the professor for his enthusiasm and teaching style.

Advanced Astronomical Observations Course (AS6005)

Advanced Astronomical Observations (AS6005) is a course offered by National Central University, Taiwan. Seven students were enrolled in the course and five completed evaluations (71% response rate). This course is a continuation to their Observational Astronomy course offered in the fall semester. AS6005 teaches students the basic skills needed for optical astronomy, including data reduction and analysis. The course aims to do the following:

- Teach about telescope operations and basic observations, followed by image reduction and photometry with IRAF using data taken from Lulin Observatory.
- Teach about time series analysis using archival data from the PTF/iPTF Project and other interactive activities such as remote observing and guest lecturing.

Demographics of survey respondents (n=5)

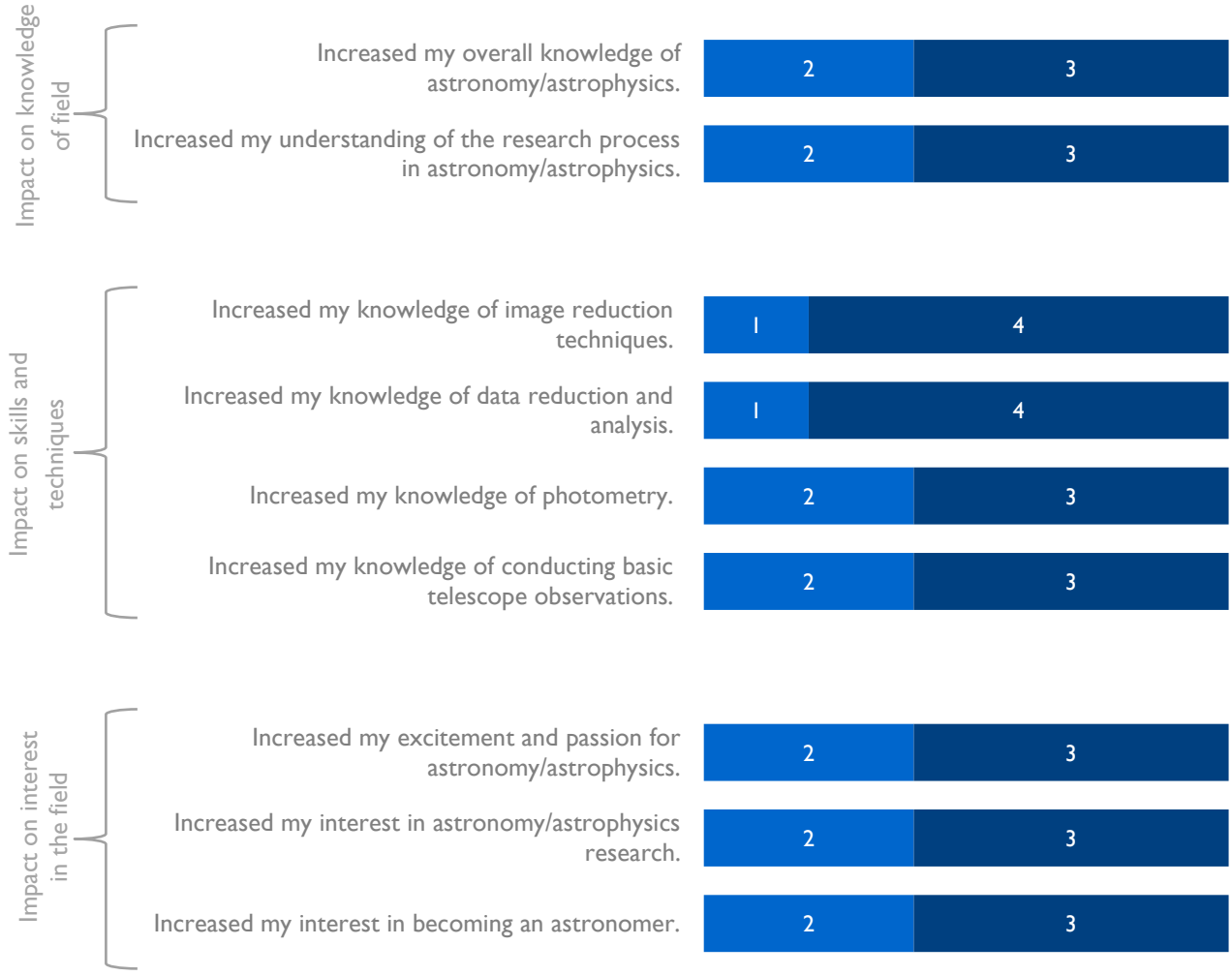
- All respondents were male.
- All respondents were Asian.
- Four of the respondents were first-generation college students.
- All respondents were STEM majors in Masters in Arts (MA) programs.

Course impact

Respondents (n=5) rated their level of agreement with nine statements, which were organized into three impact areas:

- **Impact on knowledge of field:** two statements about knowledge of astronomy/ astrophysics, specifically understanding of the research process in astronomy/astrophysics.
- **Impact on knowledge of skills:** four statements about knowledge of skills related to image reduction techniques, data reduction and analysis, photometry and conducting basic telescope observations.
- **Impact on interest in the field:** three statements about excitement, interest, and passion for astronomy/astrophysics, astronomy/astrophysics research, and being an astronomer.

There were similar trends in how the course impacted respondent knowledge, skills, and interests, with all students agreeing or strongly agreeing with all statements. It is worthwhile to note that all but one respondent strongly agreed their knowledge of image reduction techniques and data reduction and analysis increased. Given this is an advanced graduate course, students are likely highly motivated to engage and learn. The course certainly impacted these students and findings suggest the course is likely structured well and has a positive learning environment.



Respondents who indicated that the course increased their understanding of research, interest in conducting astronomy/astrophysics research, or interest in becoming an astronomer were prompted to explain how the course impacted them in these areas. Respondents noted that the course impacted their understanding of the research process by giving them clear concepts and practices. One respondent shared that from the beginning to the end of the course, "all the calibration processes are easy to understand and to fulfill." Another respondent shared that he learned how to obtain and analyze reliable data. One respondent stated, "By analyzing the data, I realize that an

image has many things to do before it can be used to research, and I'll take more attention on the photo that I use for research from any observation."

All respondents also offered examples of how the course impacted their interest in becoming an astronomer. One stated that, "I learned how to use large and professional telescopes and process data to know the properties of stars, galaxies, and other objects. That is what I couldn't do before this course. After this course, I feel more like that I am becoming an astronomer rather than an amateur."

With regard to how the course impacted their interest in astronomy/astrophysics research, all respondents shared that they gained new knowledge and skills. One shared, "After this course, I can do many things by myself. That is really helpful for me to do my research."

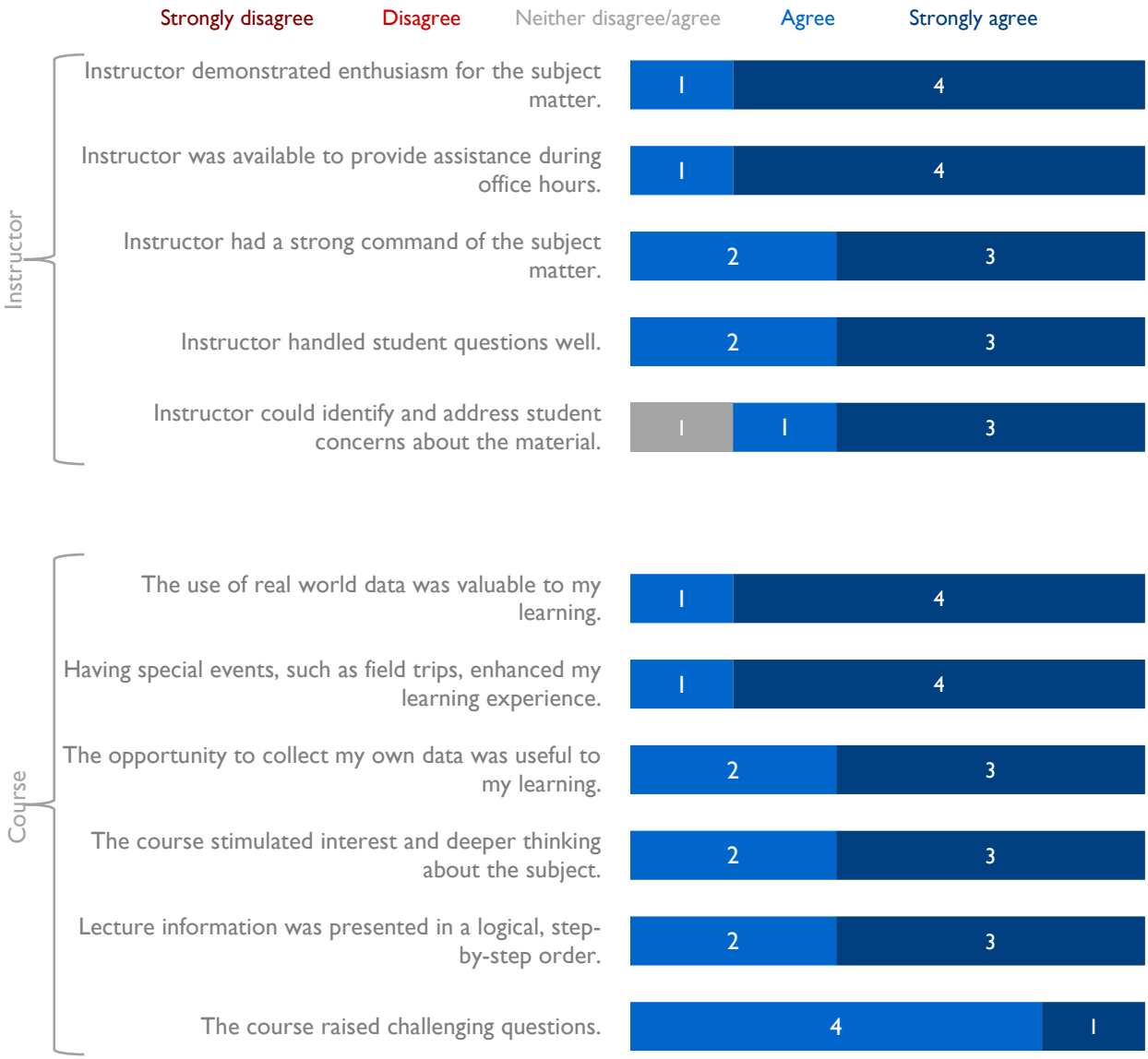
Influence on educational and career trajectories

All respondents (n=5) are Masters students in astronomy/astrophysics. Four shared that the course positively affected their interest in pursuing further education or a career in STEM, specifically stating that they gained new knowledge of data processing and new analysis skills, with one commenting that because of the course, he could "process real data for the first time." On the other hand, another respondent stated that he was unable to assess how the course had affected him.

Three respondents intend to pursue a Ph.D., while the other two were undecided at the time. All of the respondents reported they were interested in participating in astronomy/astrophysics research projects, because of their interest in the field.

Course effectiveness

Generally, respondents felt the instructors were knowledgeable about the material and facilitated the course well. One respondent neither disagreed nor agreed the instructor could identify and address student concerns about the material. All but one respondent strongly agreed that the instructor was enthusiastic and available to provide help, and that using real-world data and going on field trips enhanced their learning. Findings suggest the class provided a positive environment where students were motivated to learn.



Course suggestions

Respondents would like to see more examples provided in course lectures with one respondent specifically asking for more information on the types of calibration methods in all fields of astronomy. Another respondent would like to see more examples for the processed data, and one would like more opportunities to learn the basics of Linux.