Evaluation of GROWTH NSF PIRE Project

Annual External Evaluation Report

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Prepared for:
Mansi Kasliwal, Ph.D.
Project Director, Caltech NSF PIRE
California Institute of Technology
1200 East California Boulevard
Pasadena, California 91125

Prepared by
Lisa Kohne, Ed.D.
Elizabeth McGee, M.A.
Tyler Johnson, M.A.
Lily Nuñez, B.A.
SmartStart Evaluation and Research
4482 Barranca Pkwy Ste. 220
Irvine, CA 92604
Phone: 949.396.6053

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Section 1. Executive Summary

What is the international impact on the development of the principal discipline(s) of the project? What is the international impact on other disciplines?

The GROWTH project's research combines both astronomy and astrophysics to study three research themes: cosmic explosions (supernovae), small near-earth asteroids and the electromagnetic identification of gravitational wave sources. The project's physical infrastructure (i.e. a global network of telescopes) and the research infrastructure (i.e. a network of researchers from 13institutions from 7 countries) uniquely positions the GROWTH project's research to function in transdisciplinary ways, and by consequence make unique and groundbreaking scientific discoveries. The project's ability to become *groundbreaking* is contingent on their ability to leverage their unique global position as an innovative scientific collaborative (i.e. scientists and telescopic network). Year 1 findings prove promising in this regard, with project participants indicating the GROWTH project has had an impact on the way they are approaching their work and research, including their ability to disseminate findings, garner insights and to collaboratively make scientific discoveries (Section 4).

Publishing in academic, peer-reviewed journals is one method of measuring the strength and productivity of the international collaborations. The external evaluator assessed the impact of the 15 journals articles published by project participants in Year 1 (Section 4.3) through calculating the Eigenfactors of each publication. Eigenfactor is the level of importance a journal has in the scientific community. Overall, the project's publications had strong Eigenfactors indicating that journal articles were robust in both their reach and impact. Additionally, publications were used to better understand collaboration frequency (i.e. how many times a partner institution has collaborated on publications), and consistency (i.e. how often two partner institutions have collaborated together). Within this analysis it was found that Caltech had authorship on all 15 publications; additionally, Caltech showcased a strong collaborative relationship with the University of Maryland, with a total of 10 joint publications. This finding indicate that Caltech represents a *hub* for collaborative research activity and also speaks to the potential need to build up other institutions as research *hubs* over the course of the project.

What is the impact on human, physical and institutional resources that form an international infrastructure? What is the global impact on the society beyond science and technology?

Human, physical, informational, and institutional resources work to form and sustain project infrastructure. In the context of this project, infrastructure refers to the structures, systems, and facilities that help to enable project functioning and, ultimately, impact. There are two main infrastructures that need to be developed and sustained as part of this project. The first is an international research infrastructure that works to facilitate astronomy and astrophysics research. The second is an international educational infrastructure that works to support astronomy and astrophysics education.

International research infrastructure

Over the course of the project, the project's human resources (e.g. # of faculty, # of faculty hires, # of post-doctoral students, # of graduate students), physical resources (e.g. equipment purchases), as well as other, emergent informational and institutional resources will be tracked to ensure the project's research infrastructure is created and has the capacity to sustain itself. Year 1 was critical to establishing foundational infrastructure for the project. This included developing a network of researchers from 13 institutions (representing 7 countries) and purchasing telescopic

equipment (and leveraging of existing telescopic equipment), both of which helped to establish the central human and physical infrastructures of the project.

International educational infrastructure

The education infrastructure involves the construction of an astronomy-astrophysics educational pipeline, which is intended to accelerate education and training in astronomy-astrophysics, and ultimately contribution to the STEM workforce globally. This involves attracting students to astronomy-astrophysics undergraduate and graduate degrees, attempting to retain students in these programs and ultimately employ students within this field. To build this infrastructure, faculty within the project has begun to share and leverage international, astronomy-astrophysics data for classroom use, providing students with hands-on, experiential learning within the classroom. Furthermore, faculty show a commitment to sharing and leveraging best practices in teaching pedagogies and strategies (e.g. active learning, flipped classroom). Over the course of the GROWTH project, the various indicators will be tracked (e.g. # of courses, # of internships, # of undergraduate students that indicate intentions to pursue graduate school, # of graduate or post-doctoral students that indicate intentions to pursue careers in the field), as well as other, emergent indicators, to ensure the project's educational pipeline has been effectively built and has the capacity to sustain itself. The construction of the educational infrastructure contributes to the long-term sustainability of the project's research infrastructure, as continued research in the areas of astronomy-astrophysics is contingent on a new generation of scientists entering these fields.

The project needs to consider how they can ensure that student exposure to the topics of astronomy and astrophysics will indeed influence student retention in these majors and pursuit of careers in these fields. Student responses to surveys indicated a mixed response as to whether course and internship experiences influenced their decision to enter the field. Findings indicated that student internship experiences were more significant in influencing student intentions to stay in the field, as opposed to course enrollment (i.e. AY3). This may be because students enrolling in internships are farther along in their educational trajectory and are therefore more inclined to have confidently selected a major. Another factor is that students in enrolled in the AY3 course may be non-majors, and therefore it is not feasible to assume a single course would influence their academic trajectory. Given this, project leadership should determine whether their intention is to influence both majors and non-majors, or whether they strategy is focused on existing astronomy-astrophysics majors. Additionally, internships were also more successful in providing students with a greater understanding of the career opportunities available in these field.

Sustainability

Over the duration of the project, GROWTH leadership will be surveyed to gauge the project's potential for sustainability (Section 4.5). Having a clear project vision is shown to contribute significantly to the project's sustainability. In Year 1, faculty, researchers, and leads identified the project as having a strong vision and that this vision is clearly articulated to team members. GROWTH leadership had some concerns about having adequate staff to complete the project's goals. Ensuring a project's team both believes adequate resources are available and has adequate resources at their disposal, are shown to promote sustainability. Consequently, both *perceptions* of resource availability and *actual* resource availability should be addressed by project leadership moving forward.

Overview of Key Findings and Recommendations

The below chart outlines the project's key findings and recommendations. These findings and recommendations are outlined in greater detail in Section 4 of this report.

Key Findings	Recommendations
Progress made towards broader impacts	
Goal 1: Research/Knowledge	
Knowledge attainment • On average, 57% of participants indicated they were *moderately* or *extremely knowledgeable* in the three research areas. ***Project impact on participant work and research*** • Overall, 57% of participant's said knowledge obtained through the project has impacted their work and research. • Participants qualitatively described how the knowledge obtained through the project had impacted them, which included knowledge gains and innovative thinking. ***Discoveries and dissemination of findings*** • 65% of participants indicated they have made scientific discoveries and 62% of participants indicated findings from their scientific discovery are being utilized in the field. • 15 journal articles have been published by project participants. The most impactful journal the project published in was the Astrophysical Journal, which has a Normalized Eigenfactor of 58.3, which translates to it being 58 times as influential as the average journal.	***Knowledge attainment*** • Examine ways to further increase current participant (and new participant) knowledge about project goals. It is assumed as research collaborations grow, participant knowledge should grow in participant's areas of concentration and across the research themes. ***Project impact on participant work and research*** • Brainstorm concrete strategies for individual researchers to connect their research to the larger GROWTH project's research. ***Discoveries and dissemination of findings*** • Target high impact publications (as defined by Eigenfactor analysis) to publish research.
Goal 1: Education and workforce development	
Education and career trajectory • 100% of students indicated their intentions to pursue a graduate degree were moderately true or definitely true. Students were less sure about their plans to pursue a career related to astrophysics, with 47% of students indicating plans to pursue a career were definitely true, and the remainder of students indicated their plans to pursue an astrophysics career were moderately true (35%) and somewhat true (12%). ***International Graduate and Postdoctoral Internship Program*** **Satisfaction** • Overall students described their internship experience favorably, especially in regards to its meaningfulness and intellectual growth. • Students qualitatively indicated the travel component of the internship was one of the most satisfying internship components. **Effectiveness** • A majority of students (75%) stated they strongly agreed they felt adequately prepared for this experience. Specifically, a majority of students	***Education and career trajectory*** • Education leads should meet regularly to discuss plans for implementation of project courses. • Educate students about the GROWTH project (and its research areas) and how it relates to course material. • Develop plans for scaling up the course in other partner institutions, both within the USA and internationally. ***International Graduate and Postdoctoral Internship Program*** **Satisfaction** • Connect mentors and mentees prior to internship. This will support mentors and mentees in solidifying internship expectations and research project specifics. • Brainstorm strategies to support role clarity to students entering internships. This includes: GROWTH expectations and mentor expectations. **Effectiveness** • Create and disseminate documents to provide greater clarity to interns on logistical aspects of trip (transportation from airport, specifics of housing

Key Findings	Recommendations
(75%) found all support from their home institutions to be very or extremely useful and a majority of students (85%) found all support from their visiting institutions to be very or extremely useful. • Participants were most polarized on an item asking if they felt "part of a community," with 50% of participants indicating they strongly agreed and 25% indicating they disagreed. Two of the three focus group students indicated they felt isolated. They suggested it would be helpful to become better integrated with their mentor's existing graduate students, as this would help to facilitate feelings of support, combat feelings of isolation. • Two of the three focus group students said it would be helpful to receive more clarity regarding the expectations of their internships. **Impact** • Overall, a majority (94%) of the students found the internship 'met their expectations,' 'met their needs,' 'was a rewarding experience,' and 'was valuable to their academic and professional growth.' • One student indicated the potential value in having all internships connect post-internships to talk about experiences and learnings. ***AY3- Automated Discovery of the Universe Course Evaluation*** **Effectiveness** • Students (86%) agreed or strongly agreed about the seminar's overall effectiveness. **Impact** • Students (100%) strongly agreed the seminar "increased [their] knowledge of present day time domain astronomy," "increased student hands-on experience with time series astronomical data," and "increased student ability to apply software tools to analyze astronomical data sets from modern day optical observatories (PFT)."	accommodations (e.g. what to bring, what is provided, etc.). • Consider revising final deliverable for internships. A format where all interns can share (e.g. in-person or virtual presentation) may be more impactful in sharing internship experiences and research. **Impact** • Communicate connection between internships and larger project, so student interns understand how their role as an intern fits within larger project vision. • Communicate connection between intern's research and GROWTH project research, so student interns understanding how their internship research is aligned with GROWTH project research. • Ensure intern research is aligned with research of GROWTH project and attempt to strategically allocate internships based on student interest, how an institution can accommodate an intern area of interest, or intern needs of intuitions. • Consider having student intern's do presentations at annual meetings, as a method for students to gain presentation skills, share their work, and also better illustrate how intern research relates to the larger GROWTH project. • Consider expanding internships to also include teaching components. This could help expand GROWTH's influence on the astronomy-astrophysics education and career pipeline, by also impacting teaching-centric careers. • Establish GROWTH trajectories/pipelines for student interns to transition to post-internship. This will ensure internships are not a 'one-off' activity, but rather one method within the project to engage students in astrology and astrophysics. ***AY3- Automated Discovery of the Universe Course Evaluation*** **Effectiveness** • Target seminar outreach and recruitment to existing astronomy/astrophysics majors, to ensure the seminar is impacting the educational trajectory of students, as findings indicate the seminar in and of itself is not likely to impact non-astronomy/astrophysics majors' educational trajectories. **Impact** • Continue to facilitate seminar in its current format, as results indicated the seminar is conducive to student learning. All students indicated the seminar course increased their knowledge of astronomy. • Integrate guest lectures into seminar content to speak to their astronomy/astrophysics education and career trajectories, as a method of informing students of education and career options in this field. This could be 20-40 mins of one lecture

Key Findings	Recommendations
	within a semester. • Circulate or present astronomy/astrophysics resources (e.g. conference opportunities, research opportunities, internship opportunities) to seminar students. This could represent 20-40 mins of one lecture within a semester.
Goal 3: Capacity Building (partnerships and sustainability)	
International collaborations • Participants were asked how often they collaborate within their institution and outside (both within and outside their country). Participants generally rated their frequency of activities highest among their own institutions, then between institutions in their own country, and last, between institutions outside their country. ***International research collaboration capacity*** • In assessing collaborative capacity (i.e. how skilled they are to perform collaborative work), 73% of project members stated they had previously participated in research collaborations with scientists from other countries. The most polarizing item was whether participants had received training to prepare them to participate in interdisciplinary and/or international research collaborations, with 36% of participants saying this was definitely true, and 20% saying this was not true. ***Project sustainability capacity*** • In assessing the project's sustainability capacity, project leadership rated flexibility of funding from multiples sources highest. Project leads rated the project's integration into partner institutions lowest.	***International collaborations*** • Encourage more interinstitutional collaborations (i.e. internships, educational collaborations) both within and outside of participant's country of origin, through incentivizing collaborative participation of this kind. ***International research collaboration capacity*** • Consider providing collaborative training to project participants (including project management tools that support collaboration), as 20% participants indicated not having ever received training to prepare them to participate in interdisciplinary and/or international research collaborations. ***Project sustainability capacity*** • Brainstorm strategies to integrate the GROWTH project into its project membership's institutions, as awareness of the project will help to garner institutional support. Some examples include: having institutions support GROWTH interns and having institutions introduce new courses in astronomy/astrophysics, and ensuring the project is promoted within each of the former. • Consider greater collaborative decision-making around the project's budget to enhance feelings of transparency and empowerment around the project's budget.

Section 2. Introduction

2.1 Project background

In 2015, the California Institute of Technology received funding for a Partnerships for International Research and Education (PIRE) from the National Science Foundation (NSF) for the Global Relay of Observatories Watching Transients Happen (GROWTH) project. The NSF PIRE program has four major objectives that drive the GROWTH project[1]:

1. Support excellence in science and engineering research and education through international collaboration.
2. Promote opportunities where international collaboration can provide unique advantages of scope, scale, flexibility, expertise, facilities, or access to phenomena, enabling advances that could not occur otherwise.
3. Engage and share resources and research infrastructure within and across institutions to build strong international partnerships.
4. Create and promote opportunities for students and early career researchers to participate in substantive international research experiences.

The GROWTH project 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. GROWTH is led by Caltech and has partnered with thirteen universities and research institutions (six in the USA and seven across the world in India, Sweden, Taiwan, Japan, Israel and Germany). 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.

Scientific Drive

The GROWTH project will focus on three scientific themes in the field of time-domain astronomy. These are cosmic expositions (supernovae), small near-earth asteroids and the electromagnetic identification of gravitational wave sources. The GROWTH project seeks to answer the following specific scientific questions:

1. Where are heavy elements synthesized?
2. What are the final fates of stars?
3. Where are the small near-earth asteroids and what are their orbits?

Project goals

The GROWTH project has three strategic goals. These goals and their areas of focus are described in Figure 1.

Figure 1. Project Goals

Goals	Goal Definition	Project Vision
Goal 1: Knowledge/ Research	Advance knowledge and research in identified areas of astrophysics.	Accelerate education and training in astrophysics and astronomy and contribute to the development of the STEM workforce. Create a strong collaborative network of scientists and telescopes that catalyze scientific and educational achievements.
Goal 2: Education and Workforce Development	Contribute to education, training and development of the STEM workforce	
Goal 3: Capacity Building (*Partnerships and Sustainability*)	Create a strong collaborative network of scientists and facilities that catalyzes educational and scientific achievements in astronomy and astrophysics.	

[1] National Science Foundation, http://www.nsf.gov/pubs/2014/nsf14587/nsf14587.htm#pgm_desc_txt

Evaluation purpose

This evaluation will be conducted for the project's duration. The evaluation is intended to provide the project with information to inform progress, make programmatic improvements, act as a guide as to determining whether the project is achieving its ultimate intended impact, and if the project has the capacity to sustain impact beyond the project. The evaluation also serves as a record for the NSF, as proof that the project is meeting the terms of the NSF grant.

2.2 Evaluation methodology

Evaluation framework

Impact of this GROWTH project is intended to be international and multi-faceted, making the project complex and systemic in nature. Often, evaluations of specific interventions are focused on end-results to determine whether (and how) an intervention has worked (Preskill & Gopal, 2014). PIRE grants do not represent an implementation of a single intervention to create change rather, involve multiple strategies, interventions, partnerships and the leveraging of people and resources to create change. As a result, this evaluation will be oriented and understood through the lens of collective impact.

Collective impact occurs when institutions, groups or leaders from different sectors collaborate to solve a specific social problem by using a common agenda, aligning their efforts, and using common measures of success (Kramer & Kania, 2011). When applied to evaluation, collective impact helps mitigate challenges associated with examining complex systems and calls for a more emergent approach that better aligns with the multifaceted nature of complex problems (Kania, Kramer, and Russell, 2014; Patrizi, Thompson, Coffman, and Beer, 2013). Collective impact will help to access whether the overall initiative is working towards the same goals to ensure individual efforts are aligned. Figure 2 describes characteristics of complex systems and the evaluation implications that result from working within this complexity (Preskill & Gopal, 2014).

Figure 2. Complex systems and implications for evaluation

Characteristics of complex systems	Implications for evaluation
Always changing; never static	Design and implement adaptive, flexible, iterative evaluations.
Everything is connected; events in one part of the system affect all other parts.	Seek to understand and describe the whole, system, including components and connections.
Information is the fuel that drives learning and helps the system thrive.	Support the learning capacity of the system by strengthening feedback loops and improving access to information.
Different sources of energy and convergence can be observed at different times.	Identify points of energy and influence, as well as ways in which momentum and power flow within the system.
Cause and effect is not a linear, predictable or one-directional processes; much more iterative.	Explain non-linear and multi-directional relationships between the initiative and its intended and unintended outcomes.

Evaluation approaches

The evaluator uses three evaluation approaches, developmental, formative, and summative evaluation to assess different stages in the project's lifetime. These approaches are not mutually exclusive and are used in combination throughout the project, helping to explore different evaluation questions. All three evaluation approaches include analysis of both qualitative and quantitative data, and utilize a variety of data collection strategies as detailed later in the report in the data collection section. These three approaches are outlined below in Figure 3.

Figure 3. Evaluation approaches

Approach	Approach Description
Formative (Process) Evaluation	Focuses on *how* outcomes or impacts are achieved. This includes the assessment of the quality/effectiveness of the processes, activities and strategies that facilitate impact. As well as assessing why impacts are (or are not) occurring through the identification of obstacles and facilitators to implementation.
Outcome Evaluation	Assess the effectiveness of the project in producing desired change. Outcome evaluation focuses on impact, value and significance and the difference made for them as a result of a process, activity, and/or strategy.
Developmental Evaluation	Assesses complex project components by enabling continuous feedback loops to facilitate ongoing project development.

Core evaluation questions

Figure 4 contains the evaluation questions related to each of the goal areas of the project. Evaluation questions guide the focus of the evaluation design.

Figure 4. GROWTH evaluation questions

Project goal	Evaluation questions
Goal 1: Research	**Has the PIRE grant advanced new knowledge, collaboration, and discoveries in astronomy and astrophysics?** • What knowledge/discoveries in astronomy and astrophysics have been advanced through the grant? • How has the project increased research opportunities for students and researchers in astronomy and astrophysics? • How has the project facilitated and encouraged international (human and infrastructural) collaboration that advances research in astronomy and astrophysics?
Goal 2: Education and Workforce Development	**Has the PIRE grant developed a sustainable STEM workforce by creating a pipeline of STEM-trained students, educators, and workers?** • Has the pipeline created clear STEM trajectories for students, educators, and workers? • Have students been appropriately trained to enter (and address gaps) in the workforce? • Have STEM educational and career opportunities been enhanced through the PIRE grant? • Have relationships that allow for the transfer of knowledge and expertise between international partners (such as internships) been successful?
Goal 3: Capacity Building (Partnerships & Sustainability)	**Has the PIRE grant enabled GROWTH scientists to collaborate and develop international relationships strengthen research that will support educational and scientific achievements in the field of astronomy and astrophysics?** • How has the project demonstrated international collaboration? **Has the PIRE grant developed and implemented strategies that will lead towards sustainability of programs and impacts that have been achieved?** • How has the project enhanced identification of needs and trends in research, education, and the workforce? • How has the project leveraged the needs, trends, and points of synergy amongst research, education, and workforce development to enhance infrastructure?

Data collection

Data sources

Figure 5 contains all of the data sources that will be utilized during the project's duration. A description of each source and its purpose are listed below.

Figure 5. GROWTH data sources (description and purpose)

Data Source	Description	Purpose
Baseline & Post Surveys	All project participants complete baseline and annual post-surveys.	Assess progress made towards achievement of project goals and objectives.
Evaluation Surveys	Key individual project activity (e.g. internships).	Assess satisfaction, usefulness, and achievement of activity objectives. Provide feedback to improve implementation and quality of activities, and identifying participant needs for future events. Results help activities remain adaptive, promoting an iterative approach.
Project Participant Focus Groups & Interviews	Evaluator interviews key project leads, researchers, education component members, and student interns annually (with the expectation of Year 1).	Provide detailed and nuanced information regarding impact. Insights identify patterns, potential problems and points of leverage, allowing project course correction on an ongoing basis.
Project documents & data	Project reports, plans, agendas, minutes, and etc. Project data on participants, proposals, awards, presentations, publications, and collaborations are collected and analyzed.	Provide information on plans and accomplishments. Track progress made on project outputs compared and identified targets.

Data collection and analysis

SmartStart is committed to customizing data collection and analysis based on the needs of the project and its data. SmartStart proposes to utilize the following data collection and analysis techniques for this project's qualitative and quantitative data. Focus group and interview participants will be recruited using purposive sampling; with snowball sampling being utilized where appropriate. Qualitative data from open-ended survey questions, focus groups and interview responses will be analyzed using NVivo software and coded for themes using an open-coding approach. Quantitative data will be analyzed with SPSS software using mean and response frequencies, t-tests, ANOVA, and regression where appropriate. Surveys will be administered through an online survey software platform, www.surveygizmo.com. Social Network Analysis (SNA) data will be collected through surveys and mapped and analyzed using online SNA software (Gephi).

Evaluation timelines

Reporting

As shown in Figure 6, four reports will be delivered to the project administration over the project's duration. These are organized into quarters. Each quarterly report activities will have been conducted during the prior quarter and assessed as to how these impact the GROWTH project. Each of these quarterly reports will be accompanied by a newsletter for dissemination to project members. The Annual Report will contain the similar information types as in the quarter reports, but serves as a retrospective view of how the project over the past year has progressed and how all of the individual moving parts in the project are coming together to achieve the project's larger vision. create impact. The Summative Report will serve as proof of the project's impact on the field of astronomy and astrophysics the formation of an international collaborative network, as well as providing a plan to sustain impacts made.

Figure 6. Evaluation deliverable timelines

Report type	Evaluation methodologies included	Date	Year of Delivery
Quarter 1 deliverable	Evaluation development	June 14	Year 1
	Process, outcome and developmental (Year 2, 3 4, 5)		Year 1-5
Quarter 2 (Annual Report)	Process, outcome and developmental	September 1	Year 1-5
Quarter 3 deliverable	Process, outcome and developmental	December 14	Year 1-5
Quarter 4 deliverable	Process, outcome and developmental	March 14	Year 1-5

Surveys

As shown in Figure 7, surveys will be distributed throughout the project duration. The below table includes survey dates, purpose, and participants for the central surveys of the project.

Figure 7. Evaluation survey timelines

Survey	Date	Purpose	Participants
Baseline-Post survey			
Baseline	Annually at the time of the Annual meeting	Assess knowledge and skills related to research knowledge, collaboration and education, of new participants at project entry	All project participants as they join the project
Post	February (annually)	Assess knowledge gains of participants after project	All project participants
Social Network Analysis* (included in the Baseline-Post survey)			
Project Partner Collaboration	Year 1 - 5	Assess international collaborations within the project	All project participants
Sustainability* (included in the Baseline-Post survey)			
Sustainability	Year 1 - 5	Assesses the project's capacity to sustain infrastructure and impact beyond the duration of the project.	Project administration and leadership
Graduate/Postdoc and Undergraduate Internship Surveys			
Graduate/Postdoc	Upon completion of internship (annually)	Assess impact and experience of internships	Graduate/Postdoc project members
Undergraduate	Upon completion of internship (annually)	Assess impact and experience of internships	Undergraduate project members

*included as part of the Baseline-Post survey

Deliverable dissemination plans

The deliverable dissemination plan, displayed in Figure 8, is a way of organizing and displaying the types of reports and includes the target audience, purpose, content, and distribution details of each report. This allows for an *'at a glance'* understanding of plans for reporting and conveying results.

Figure 8. Deliverable dissemination plan

Report Type	Stakeholders	Purpose	Language	Distribution	Timing
Annual Report	National Science Foundation	2, 4	High-level, yet descriptive	Email, Reverse Site Visit	Annually
Quarter deliverable	Project Leads	1, 2, 4, 5	Quarter specific, but applicable to similar activities	Email, Meeting, Presentation	Quarterly
Newsletter	Project Members	1,3	Simple and broad	Email, Website	Two weeks after report

Purpose

1. Update on Activities
2. Reporting to Funders/Directors
3. Immediate Recommendations
4. Long-term Recommendations
5. Specific Recommendations

2.3 Demographic description of project participants

GROWTH is led by Caltech and has partnered with thirteen universities and research institutions (six in the USA and seven spread across the world in India, Sweden, Taiwan, Japan, Israel and Germany). There are 64 individuals involved in the GROWTH project that consist of faculty, researchers, post-doctoral fellows, and graduate students.

The following participant data, shown in Figure 9, was obtained from records kept by project administration and was obtained by the external evaluation as of May 2016.

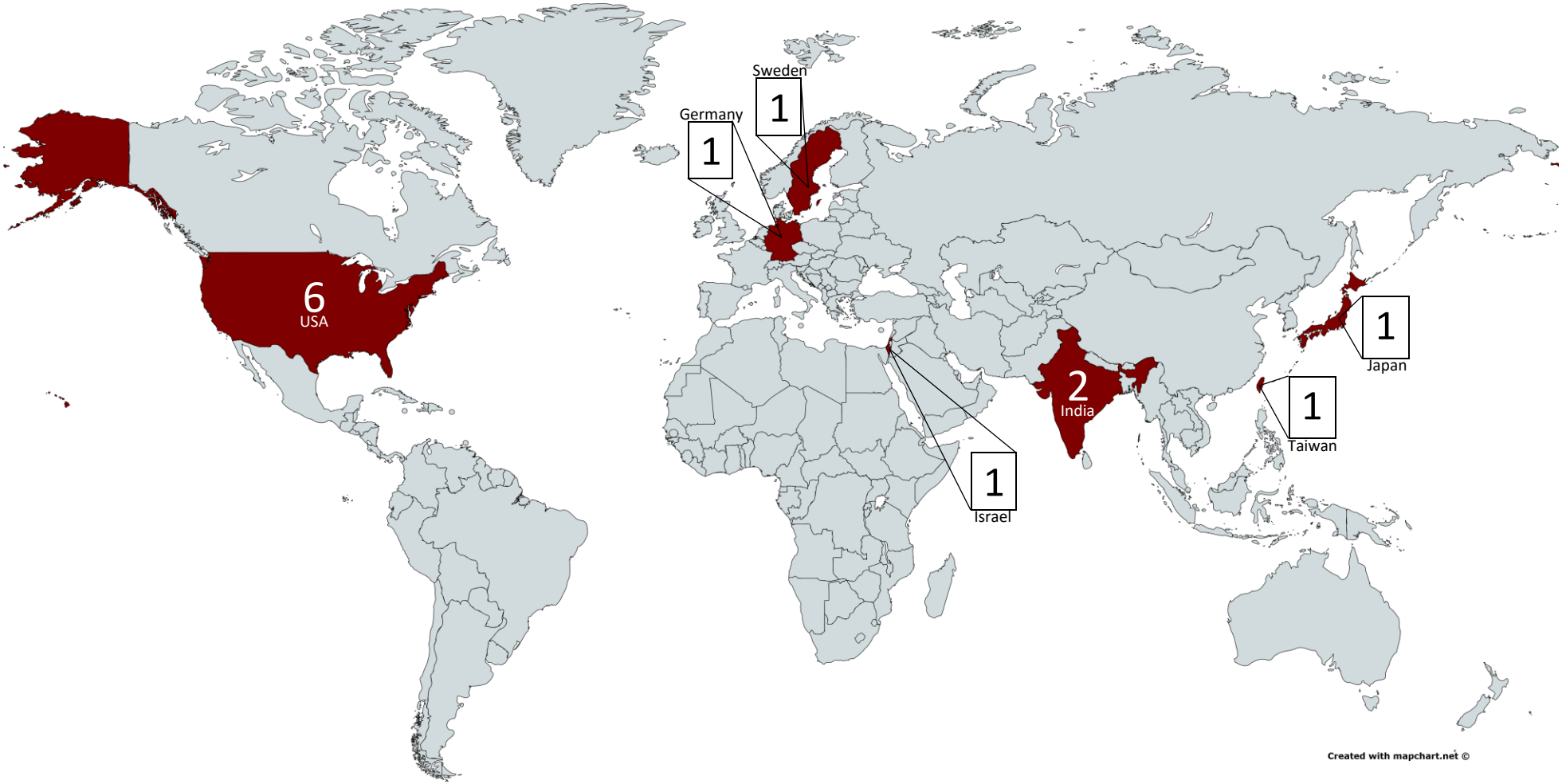
Figure 9. PIRE participant demographics

		Project participants 2016	
		# (n=64)	%
Gender			
Male		42	66%
Female		22	34%
Role in project			
Graduate students (PhD Student)		21	33%
Principle investigators		18	28%
Postdoctoral fellows		17	27%
Undergraduate students		8	13%
Name of primary institution/organization			
California Institute of Technology (Caltech)	California, USA	16	25%
Humboldt University	Germany	2	3%
Indian Institute of Astrophysics	India	1	2%
Inter University Centre for Astronomy and Astrophysics (IUCAA)	India	3	5%
Los Alamos National Laboratory	New Mexico, USA	1	2%
National Central University, Taiwan	Taiwan	1	2%
Oskar Klein Centre, University of Stockholm	Sweden	11	17%
Pomona College	California, USA	2	3%
San Diego State University	California, USA	3	5%
Tokyo Institute of Technology	Japan	9	13%
University of Maryland, College Park	Maryland, USA	9	13%
University of Wisconsin, Milwaukee	Wisconsin, USA	3	5%
Weizmann Institute of Science	Israel	3	5%

GROWTH membership distribution

Figure 10 provides an overview of the GROWTH project membership distribution by country. In the map below, nations that have an institution involved in the project are colored, with the number of institutions participating notated within the country. This map will be updated as more institutions and, therefore, more nations are involved in the project.

Figure 10. GROWTH partner nations



Section 3. Evaluation Findings

Given its complexity and the interconnectivity of its many moving parts, the GROWTH project can be described as a ***collective impact initiative***. Collective impact initiatives aim to change highly complex systems and involve multiple processes, activities, programs, and strategies, all of which operate in mutually reinforcing ways (Preskill & Gopal, 2014). As a result, simply taking a snapshot of a single intervention's effectiveness at one point in time does not tell a holistic story of this project's impact. As such, the evaluator sought out an approach that is able to speak to how the project it's *collectively* achieving impact.

3.1 Logic Model

The evaluator's logic model (Figure 11) helps project leadership to conceptualize how the project is operating as a collective impact initiative to achieve its broader impacts. This logic model explains how project activities contribute to short and long-term outcomes, and how project outcomes ultimately contribute to the overarching project vision. Specially, the logic model illustrates the manner in which the GROWTH project activities contributes to the development of a strong collaborative network of scientists and telescopes, which work together to accelerate education and training that contribute to the development of a STEM education and workforce trajectory.

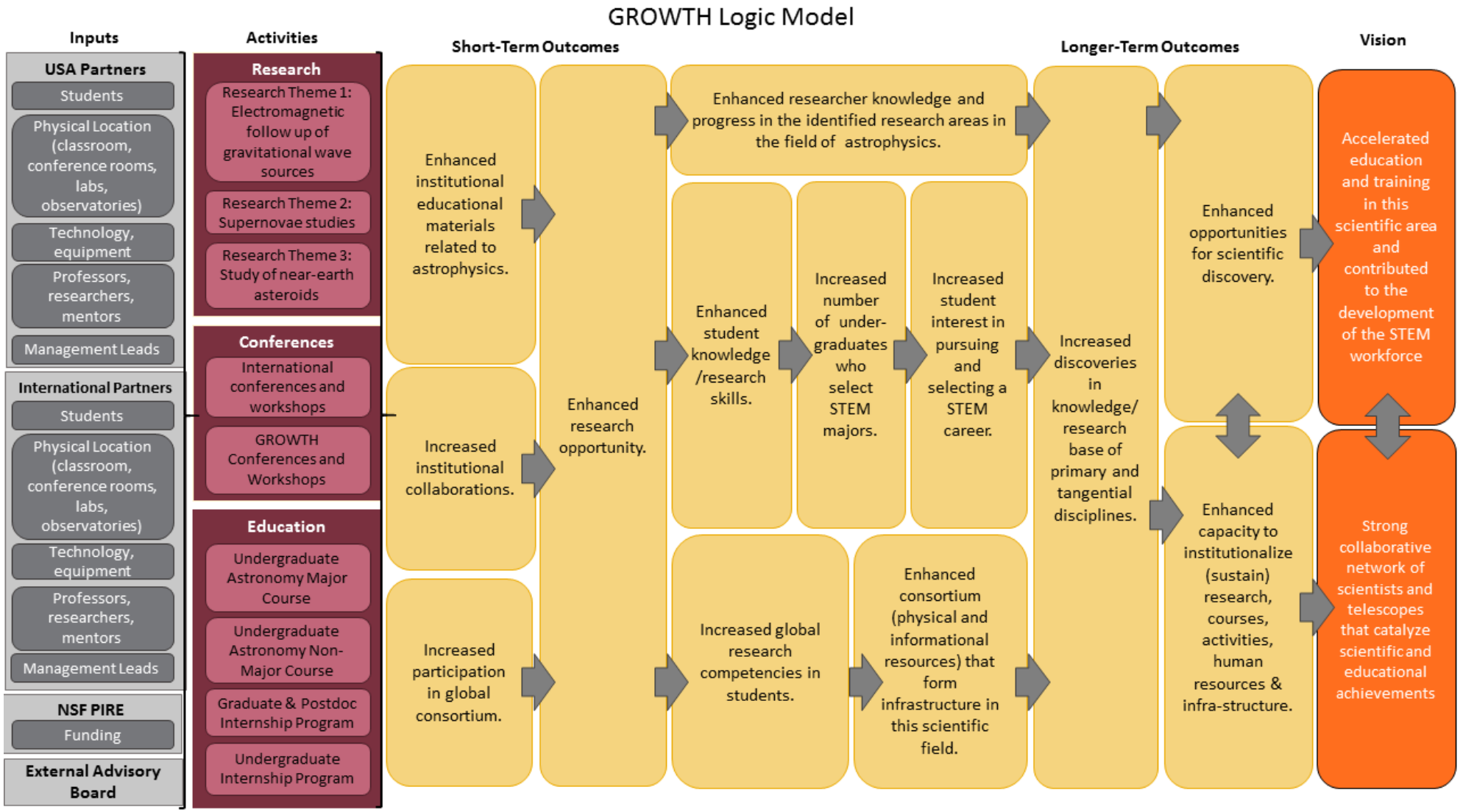
All GROWTH activities, strategies, and processes should make sense within the context of the logic model. Any investment in time and resources (i.e. personnel, equipment, etc.) should be strategically positioned to create, leverage, and/or scale-up progress toward the GROWTH project vision. Before taking on new project process, activity, and/or strategy, project leadership should systemically vet new investments against the logic model to ensure strategic alignment.

Quick Tips

A logic model is a visual tool that is often used to illustrate collective impact initiatives. It provides a map linking activities to a broader, large-scale vision. A logic model enables users to strategically plan how activities and resources lead to short and long-term outcomes. These outcomes are mapped out to show how they, *in combination*, produce a desired vision (Taplin and Clark, 2012).

Project leads should examine alignment between new or evolved processes, activities, and/or strategies, and the logic model. Maintaining continued alignment will ensure project investments remain strategic.

Figure 11. GROWTH project logic model



3.2 Progress towards broader impacts

The evaluation of the GROWTH project for Year 1 is based on a mixed methods approach of quantitative and qualitative data. The quantitative data, collected through surveys, will form the primary data source of the evaluation, while the qualitative data (collected through focus groups) will supplement and contextualize quantitative data. In Year 1, the main data collection tool used for the GROWTH project is the baseline survey. The baseline survey was created by the external evaluation team in conjunction with project administration with the intention of assessing the baseline for the project in the areas of research collaboration, workforce development, and education. The baseline survey will be administered annually, to access growth across each of these areas for the remainder of the project. Additionally, the results of the baseline can illuminate project areas of strength and areas of growth. For Year 1 of the project, 35 of the 64 members of the project completed the baseline survey, for a response rate of 55%. Based on their role in the project, each member received tailored questions regarding their experience in the project. Surveys will be disseminated based on individual activities occurring in the project. In Year 1 this included the international internships (response rate: 80%) and the AY3 seminar course, which was offered a Caltech (response rate: 57%). To further elucidate participant experiences abroad, a focus group was completed with three students that had participated in the international internship.

This section will include the progress that has been made in Year 1 towards the broader impacts of the project. The chart below outlines, by goal, areas of focus for project impact that have contributed to the broader impacts. In the succeeding sections, contributions to broader impacts will be broken down by Goal and the areas of focus outlined below.

Figure 12. Areas of focus for project impact, categorized by goal areas

<table>
<tr><th colspan="2">Goal 1: Knowledge/Research Advance knowledge and research in identified areas of astrophysics.</th><th>Goal 2: Education and Workforce Development Contribute to education, training and development of the STEM workforce</th><th>Goal 3: Capacity Building (Partnerships and Sustainability) Create a strong collaborative network of scientists and facilities that catalyzes educational and scientific achievements in astronomy and astrophysics.</th></tr>
<tr><td colspan="2"></td><td></td><td></td></tr>
<tr><td rowspan="4">Areas of focus for project impact</td><td>Project impact on research knowledge</td><td>Project impact on education and career trajectory</td><td>Project impact on the frequency of and impact on institutional and interinstitutional collaborations</td></tr>
<tr><td>Project impact on participant work and research</td><td rowspan="3">Project impact on educational and career trajectory as seen through:
2016 International Graduate and Postdoctoral Internship Program
AY3- Automated Discovery of the Universe Course Evaluation
2016 International Undergraduate Internship Program (data not available)</td><td>International collaborations as seen through publications</td></tr>
<tr><td>Project impact on the discoveries and the dissemination of research findings</td><td rowspan="2">Project impact on international research collaboration capacity</td></tr>
<tr><td>Project impact on Journal publications</td><td>Project sustainability capacity</td></tr>
</table>

Goal 1: Research/Knowledge

The following section details the project's impact towards Goal 1. All project activities and strategies (and corresponding evaluation data) that are considered to contribute to the achievement of Goal 1 are featured here. Goal 1 evaluation results are divided into "project impact on knowledge and work" and "contributions to the scientific community."

Research focus of project participants

The research component of the project is composed of three research themes: electromagnetic follow-up of gravitational wave sources, supernovae studies, and study of near-earth asteroids. The plurality of participants in the project (46%) are involved in Theme 1: electromagnetic follow-up of gravitational wave sources. Project research theme participation is shown in Figure 12.

Figure 13. Area of research focus

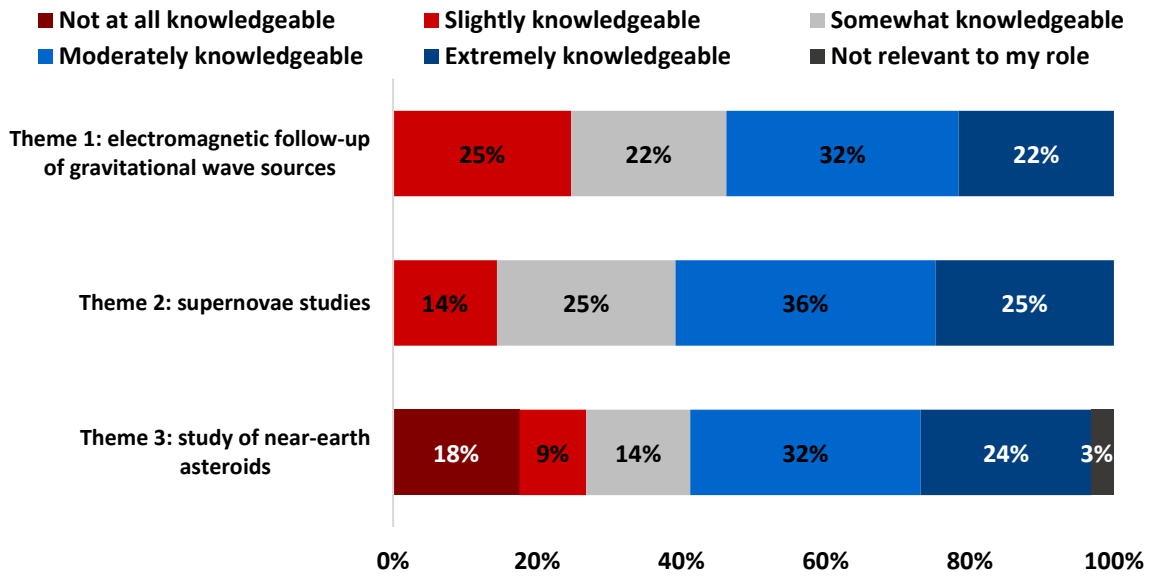
Research theme	Number of participants	Percentage of participants
Theme 1: electromagnetic follow-up of gravitational wave sources	15	46%
Theme 2: supernovae studies	12	34%
Theme 3: study of near-earth asteroids	6	17%
Did not answer	2	6%

Project impact on knowledge and work

Project impact on research knowledge

Using data from the baseline survey, the evaluator assessed the impact the project had on knowledge in the three areas of research. GROWTH participants (n=35) rated their knowledge of the project's three research themes on a Likert scale. Likert scales ranged from 1 to 5, where *1=not at all knowledgeable* and *5=extremely knowledgeable.*

Figure 14. Project impact on research knowledge



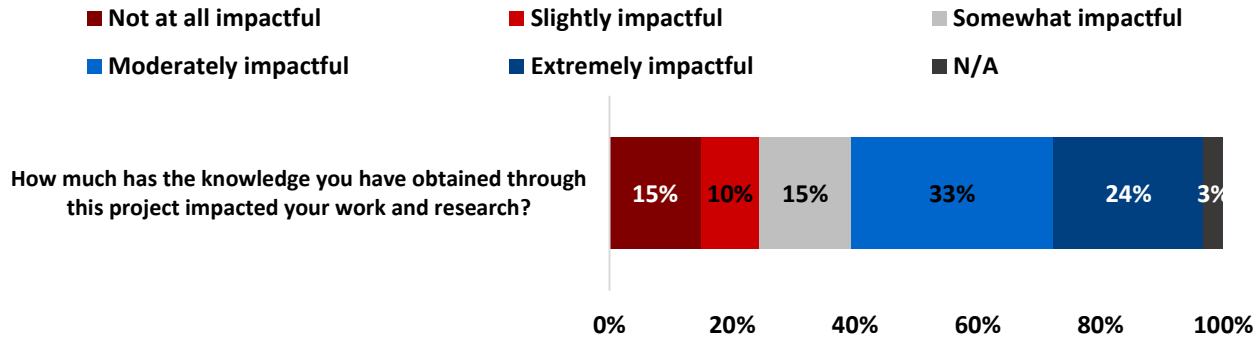
Participants were most knowledgeable about research Theme 2 (supernovae studies) with 61% of participants indicating they were *moderately* or *extremely knowledgeable*. Overall, research Theme 3 (study of near-earth asteroids) had the largest percentage of participants (18%) that indicated they were *not at all knowledgeable* of this area of research. This demonstrates that project participants are coming into the project with high levels of knowledge, which helps to support the project's international research infrastructure.

Undergraduate and graduate students were asked if their knowledge of the research themes came as a result of this project. The evaluator found that most students did not obtain the knowledge as a result of their participation in the project, but rather came into the project with pre-existing knowledge. This is to be expected, as students that are knowledge in these areas would be more likely to have chosen to participate in the project's research.

Project impact on participant work and research

Using data from the baseline survey, the evaluator assessed the impact that the new knowledge attained from project had on participants' work and research. Participants were rated on a Likert scale ranging from 1 to 5, where 1=*not at all impactful* and 5=*extremely impactful*. As shown in Figure 14, a majority of participants (58%) rated their new knowledge from the project has *moderately* or *extremely* impacted their work or research, indicating even though the project is in its first year, it is successful in influencing work and research.

Figure 15. Project impact on participant work and research



Within the baseline survey participants qualitatively described how the knowledge obtained through the project had impacted them in a variety of ways. The following themes emerged:

1. Knowledge gains and innovative thinking
2. Collaborative infrastructure
3. Technological infrastructure
4. Financial support
5. Career Trajectory

Below are participants' qualitative responses featured under each of the five themes identified.

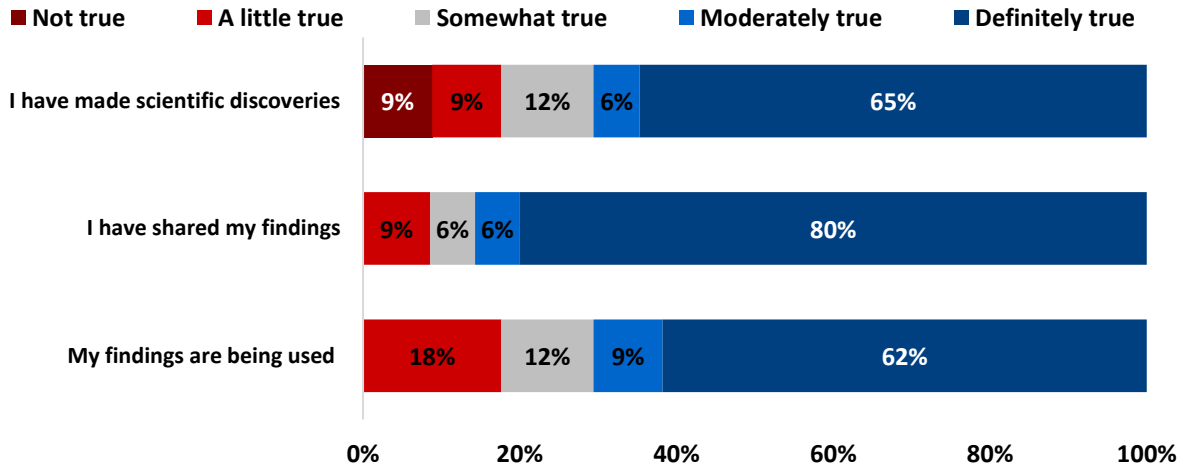
Knowledge gains and innovative thinking	• Understand more about those subjects. • I'm just getting started in research, so this was really helpful enhancing my ability to understand what types of questions are good to ask and what data is available to me. • Thinking about how to utilize the GROWTH network has encouraged me to think of new approaches to time-domain followings.
Collaborative infrastructure	• It put me in contact with people and program I would not otherwise have access to. • New partners and capabilities identified • My research is based on data from PTF/PTF and preparing for ZTF so it is vital, both the international collaboration and data. • Forming collaborations with researchers at other partner institutions
Technological infrastructure	• Get to know and talk to a lot of researchers of different backgrounds • GROWTH also provides access to telescopes over the globe.
Financial support	• My research is partially financially supported by GROWTH.
Career Trajectory	• For one thing, the LIGO EM-follow up project got me a job at Caltech; but more importantly, it has defined every hour of my professional life for the past four or five years, and launched my career's trajectory

Contributions to scientific community

Discoveries and the dissemination of findings

Using baseline survey data, the evaluator assessed participants' contributions to the scientific community through participant ratings on a Likert scale ranging from 1 to 5, where 1=*not true* and 5=*definitely true*. The project participants were asked three questions about their contributions to astrophysics as shown below in Figure 15. Participants' contributions to the scientific community and collaborations are significant with 62% indicating their findings are being used, and 65% of participants indicating they have made scientific discoveries.

Figure 16. Discoveries and the dissemination of findings



Journal publications

Creating publications for academic, peer-reviewed journals is one major aspect for measuring the strength and productivity of the international collaboration at the center of the GROWTH project. In the 2015-16 project year, project members have contributed fifteen publications in astronomy and astrophysics. Publications will be tracked over the course of the project.

Figure 17. Project publications by year

Project year	Publications
Year 1 (2016-17)	21
Year 2 (2017-18)	Not Yet Reported
Year 3 (2018-19)	Not Yet Reported
Year 4 (2019-20)	Not Yet Reported
Year 5 (2020-21)	Not Yet Reported
Total Project	**21**

The evaluator assessed the impact of the 21 journals published by project participants. Figure 17 contains the journals to which project members have submitted articles, Eigenfactors (standard and normalized) of the journals (used to assess impact and reach), and publications in each journal. An Eigenfactor is the level of importance a journal has in the scientific community and includes the numbers of articles published by the journal in comparison to all scientific articles published. There is no set range for Eigenfactors, as they are a percentage of a whole that each journal holds in regards to its influence in journals from Thomson Journal Citation Reports, which includes all journals from 1997-2014. Results indicated that the most impactful journal the project was published in was *the Astrophysical Journal*, which has a Normalized Eigenfactor of 58.3. This translates to being 58 times as influential as the average journal. Additionally, results show that project members have been published in journals that, on average, have a Normalized Eigenfactor of 37.1.

Figure 18. Impact of journals published for Year 1

Journal	Number published articles	Eigenfactor	Normalized Eigenfactor
arXiv	8	-	-
Astronomy and Astrophysics	2	0.280	31.4
The Astrophysical Journal	7	0.521	58.3
The Astrophysical Journal Letters	2	0.169	18.9
Monthly Notices of the Royal Astronomical Society	2	0.354	39.7
Journal average	**21**	**.331**	**37.1**

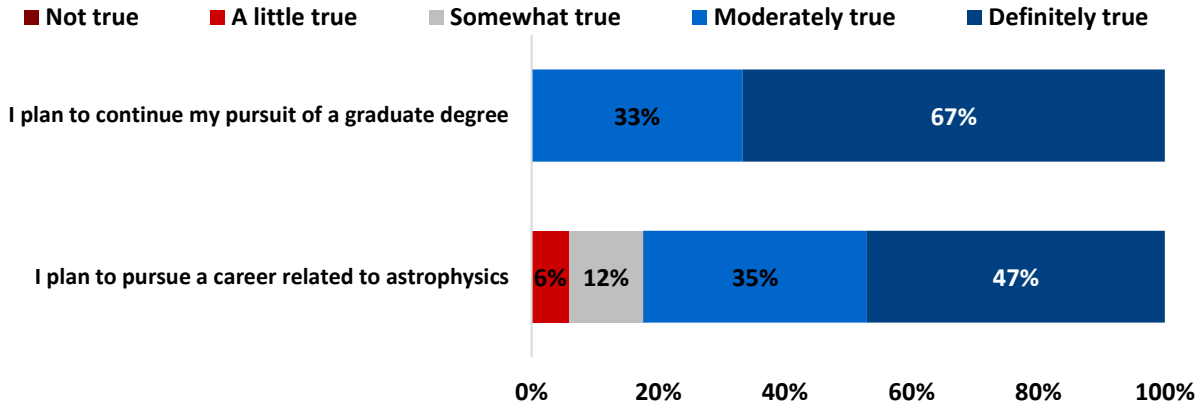
Goal 2: Education and workforce development

The following section details the project's impact towards Goal 2. All project activities and strategies (and corresponding evaluation data) that is considered to contribute to the achievement of Goal 2 is featured here. Goal 2 evaluation results are divided into "education and career trajectory" and "activities conducted in 2016 [including international internships and introductory seminar for undergraduates]".

Education and career trajectory

Within the baseline survey data, students in the project (n=12), both graduate and undergraduate, were asked a series of questions about their future plan related to graduate school and careers. As shown in Figure 18, when asked if they had plans to continue their pursuit of a graduate degree 100% responded with *moderately or definitely true*. Students were less sure about their plans to pursue a career related to astrophysics, with 47% of students indicating plans to pursue a career were *definitely true,* and the remainder of students indicated their plans to pursue an astrophysics career were *moderately true* (35%) and *somewhat true* (12%).

Figure 19. Education and career trajectory



Activities conducted in 2016

2016 International graduate and postdoctoral internship program

PIRE graduate and postdoctoral fellows have opportunities to further their own research knowledge and skills through participation in international research internships with project members. Student internships took place between November 2015 and August 2016. A total of five students participated in the internship program.

International internships' objectives provide opportunities for graduate students and postdocs to:

- advance research skills in astronomy and astrophysics
- develop intercultural competences and ability to successfully work in diverse international teams

Surveys & focus group

Surveys of interns' experiences were developed with project administration to assess intern experiences and impact (Appendix B). Surveys were completed by four of five interns. Evaluations contained both quantitative and qualitative components, both of which were used in conjunction in assessing success and impact of internships. Qualitative responses are used throughout this section and are displayed in call-out boxes.

On July 27, 2016 at the 2016 Science Conference, a focus group was conducted with two students involved in graduate and postdoctoral internship program and one student who was part of the undergraduate internship program. Focus group protocol used a series of open-ended questions, which can be found in Appendix C. Focus group responses were analyzed qualitatively using an open coding approach.

The following section outlines findings from the internship surveys and the focus group. Findings are primarily organized by survey and focus group questions, although some significant themes emerged outside of the prescribed question, and are reported as such.

Demographics

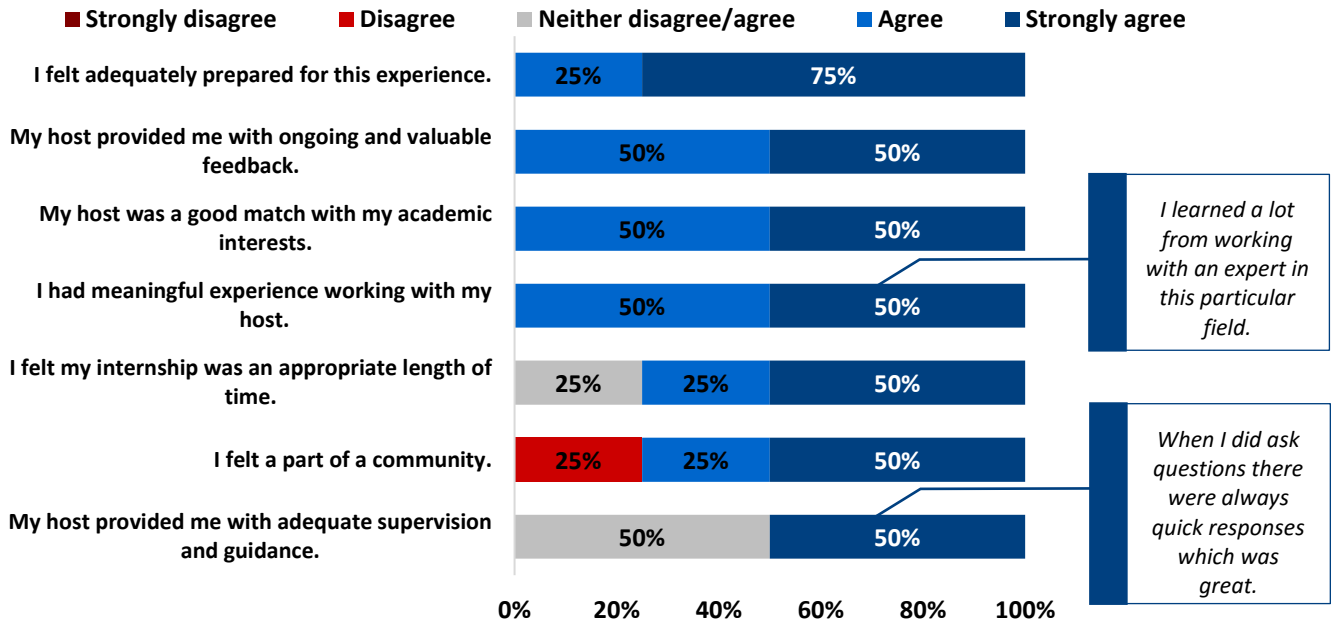
Four out of the five graduate students and postdoctoral fellows that went on international internships responded to the evaluation survey. Intern demographics are as follows:

- Three of the four participants were female.
- Three of the four participants were Caucasian/White. One participant did not wish to identify their race/ethnicity.
- Three of the four participants were graduate students in the project and one participant was a postdoctoral fellow.
- No participants were first generation college students.
- Of the three major research areas of the GROWTH project, three of the participants were working in *understanding of newborn supernovae* and one participants was working in *r-process nucleosynthesis*.
- Three of the four participants have been on previous internships before this most recent internship.

Internship management

As shown in Figure 19, participants responded to seven Likert scale items asking them about the overall management of their internship experience. Response categories ranged from 1 = *strongly disagree* to 5 = *strongly agree*. When asked if participants felt adequately prepared for this experience, 75% *strongly agreed*. Participants were most polarized on the itemhat asked if they felt "part of a community," with 50% of participants indicating they *strongly agreed* and 25% indicating they *disagreed*. Other polarized experiences included participant feedback on the length of the internship and whether or not the host provided "adequate supervision and guidance."

Figure 20. Internship management

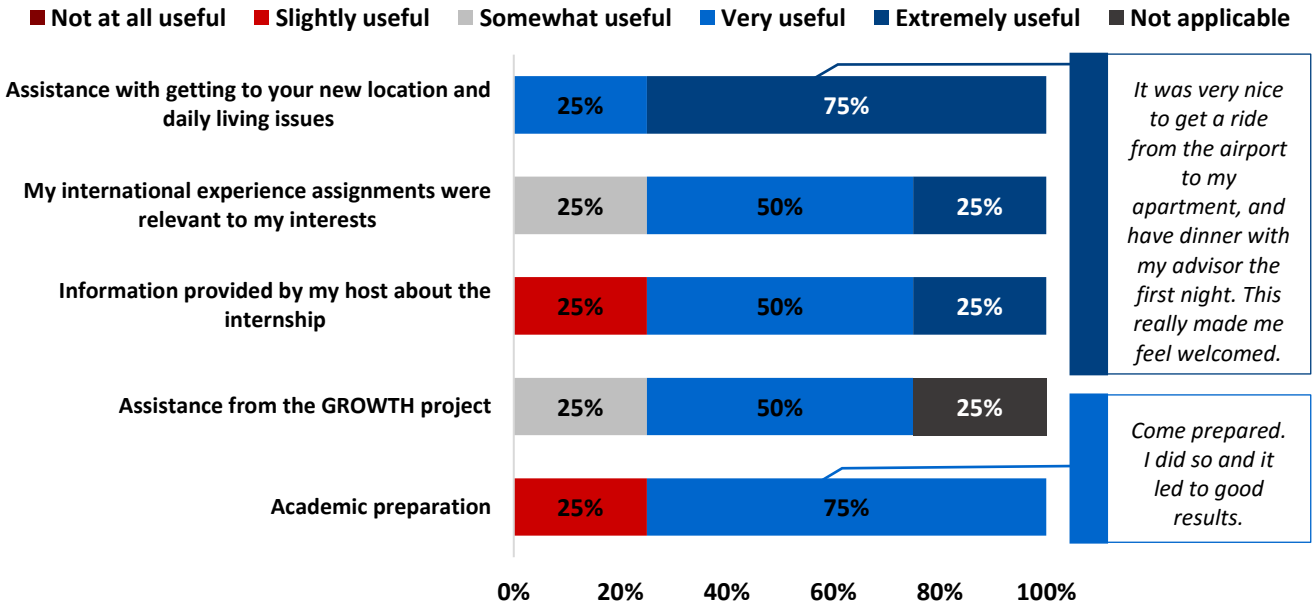


Institutional support

Home institution

As shown in Figure 20, participants rated usefulness of supports provided by their home institutions before their internship on a 5-point Likert scale from 1 = *not at all useful* to 5 = *extremely useful*. Overall, a majority of participants (75%) found all support from their home institutions to be *very* or *extremely useful*.

Figure 21. Usefulness of home intuition support



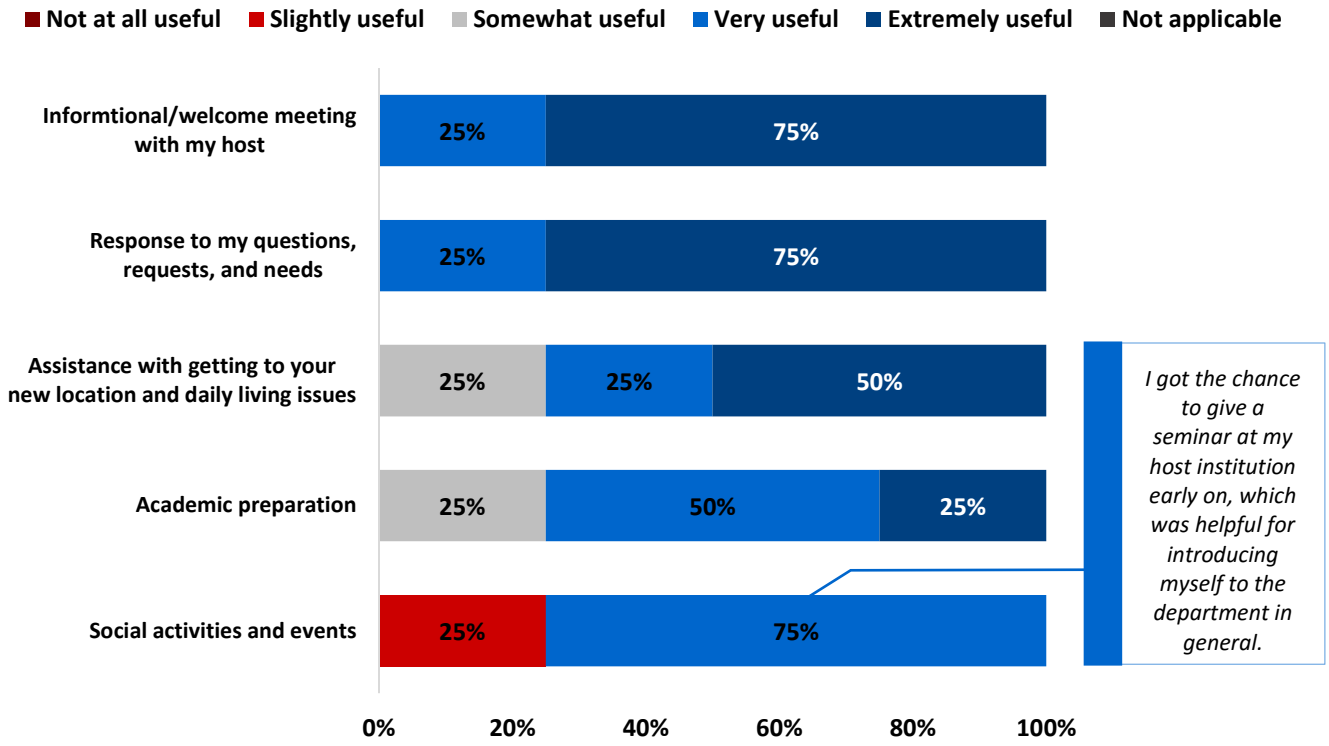
In the focus group, students were asked: **What information and/or assistance was provided that proved useful from their home institutions?** The following key findings emerged; some students said:

- It would have been helpful to receive more specifics regarding their accommodations (i.e. what to bring, what would be included, what to expect when you land, etc.).
- It would be helpful to receive more information regarding expectations of their internships, including expectations of GROWTH and of their Internship Mentor.

Visiting institution

As shown in Figure 21, participants rated usefulness of supports provided by their visiting institutions during their internship on a 5-point Likert scale from 1 = *not at all useful* to 5 = *extremely useful*. A majority of participants (85%) found all support from their visiting institutions to be *very* or *extremely useful*.

Figure 22. Usefulness of visiting institution support



In the focus group, students were asked: **What other information and/or assistance was provided that proved useful to you?** The following key findings emerged; some students said:

- It would be helpful to receive more clarification regarding expectations of their internships from their advisor prior to beginning their internship, specifically, defining what project(s) the student would be working on, and what their role would be within this project.
- It helpful to receive a formal welcome upon their arrival (e.g. a pick-up from the airport, dinner on the first night with their mentor).
- They didn't have as much interaction with their mentor as anticipated. Students indicated it would be helpful to obtain the support/mentorship from graduate students at their visiting institution, to support them in feeling more comprehensively supported.
- They felt socially isolated. Students suggested it would be helpful to become better integrated with their mentor's existing graduate students, as this would help to facilitate feelings of support, combat feelings of isolation, and provide greater opportunities for socialization.

Internship satisfaction

The evaluator assessed overall satisfaction with the internships through focus group responses. Students were asked: **What was <u>most</u> satisfying about your internship?** The following key findings emerged.

- All students indicated that the travel component of the internship was one of the most satisfying things about the internships.
- Some students indicated that the internships experience was greater for defining their research interests.
- Some students indicated that the internships represented a greater career builder (e.g. good for their resume), which would help facilitate future career pursuits.

Areas of improvement

The evaluator assessed areas of improvement through focus group responses. Students were asked: **What was <u>least</u> satisfying about your internship?** The following key findings emerged.

- Some students indicated that there were not clear expectations (both from the GROWTH project and their home institution) was the least satisfying part of their experience.
- Some students indicated that the internships were extremely unstructured. Furthermore, the expectation by GROWTH to complete a weekly schedule was at odds with the level of structure provided by their mentors.
- Some students indicated that the GROWTH project's recommendation for having a weekly schedule was not something communicated to their mentors, therefore, there was no buy-in from their mentors to supporting interns in fulfilling this requirement.
- One student felt the internships were research-centric and did not focus on teaching aspects. They felt that this was limiting because some interns' future careers in this field may be in teaching and research, or teaching only. it might be worth expanding internships to include a teaching component.

Internship experience

As shown in Figure 22, students rated their agreement with statements regarding their **experiences** during their internship, concerning meaningfulness of the internships, intellectual growth, and networking opportunities. Students also ranked the **importance of these experiences** on a 5-point Likert scales. Likert scales ranged from 1 = *strongly disagree/not important* to 5 = *strongly agree/extremely important*. The table below is organized from the statement with the *highest agreement* to the *lowest agreement*. The statement "I feel like my contributions made a difference" was rated with the highest level of agreement and importance, with participants, on average, *strongly agreeing* with the statement and rating it as *extremely important*.

Figure 23. Internship experiences and importance of experiences

	Level of agreement	Level of importance
I feel like my contributions made a difference.	4.75	4.25
I had ample opportunities to use my existing skills in practice.	4.75	4.00
I gained confidence in doing research in this field.	4.50	4.00
I was assigned tasks that were meaningful to me.	4.25	4.25
I was exposed to new ideas.	4.25	3.75
I was intellectually challenged.	4.25	3.75
I had opportunities to work with like-minded people.	4.00	3.50
I had ample opportunities for networking.	4.00	3.25
I learned new ways of approaching my work that were specific to the culture I was visiting.	4.00	3.00
I learned how to conduct scientific research with international collaborators.	3.75	4.00
I gained a passion for doing research in this field.	3.75	3.75
I assumed additional responsibility as my experience increased.	3.75	3.00
I gained a global awareness; expanding my worldview.	3.25	3.25
I felt engaged in the local community.	3.25	3.00

The software I developed during the internship was later put to extensive use by the collaboration

It has made me more likely to consider moving abroad for part of my career.

Perceived value of internship experience

The evaluator assessed the overall experience of the internship through assessing if student needs and expectations had been met and if the internships was perceived by students as having value.

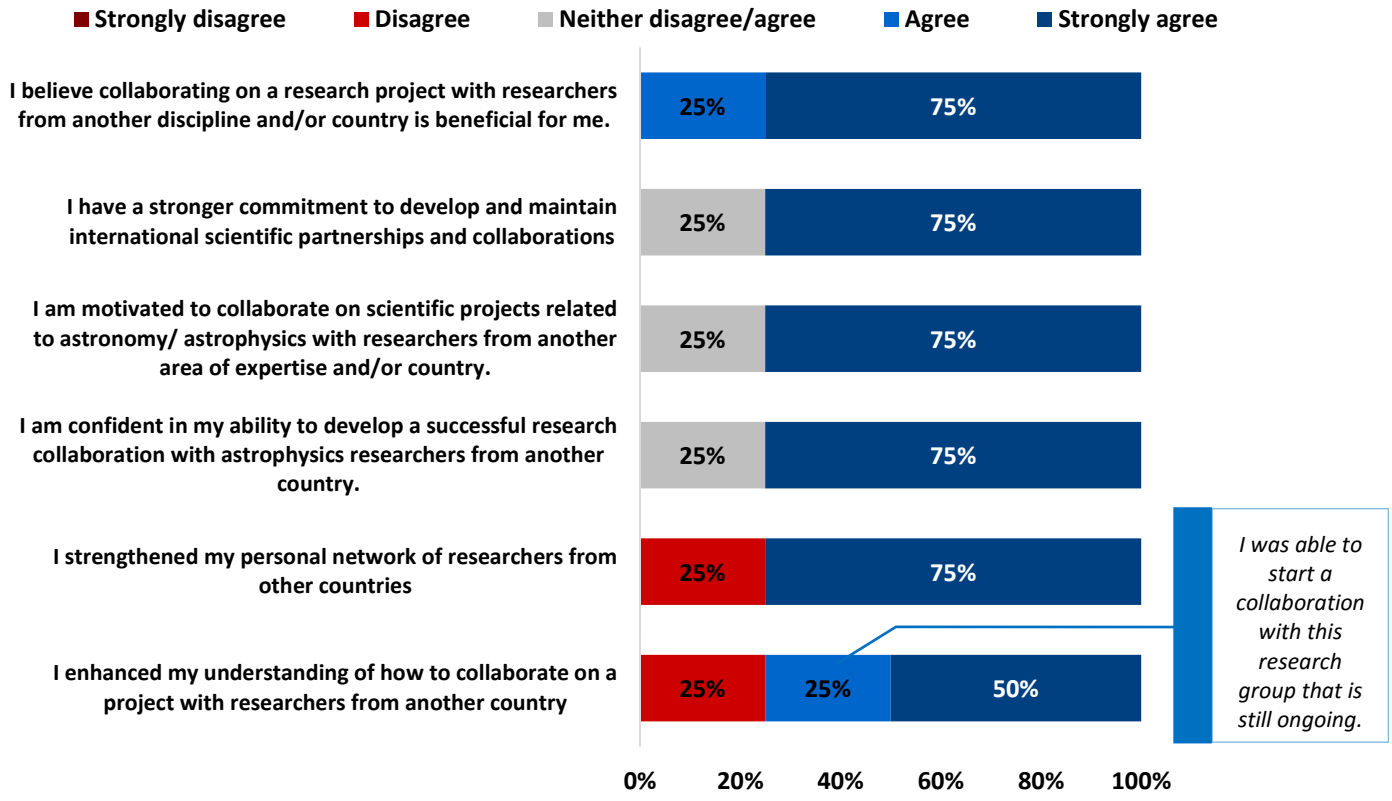
- **100% of students** indicated the internship had **met their expectations**.
- **75% of students** indicated the internship had **met their needs**.
- **100% of students** indicated the internship **was a rewarding experience**.
- **100% of students** indicated the internship was **valuable to their academic and professional growth.**

Impact of internship experience

Impact on collaboration capacity

As shown in Figure 23, the evaluator assessed the impact on collaborative capacity through assessing student ratings of agreement on statements relating to beliefs, confidence, and motivations around collaborations on a 5-point Likert scale from 1 = *strongly disagree* to 5 = *strongly agree*. On average, a majority of participants (79%) found that their internship experience positively impacted their beliefs, confidence, and motivations regarding international collaboration.

Figure 24. Impact on collaboration capacity



Impact of new knowledge on work and research

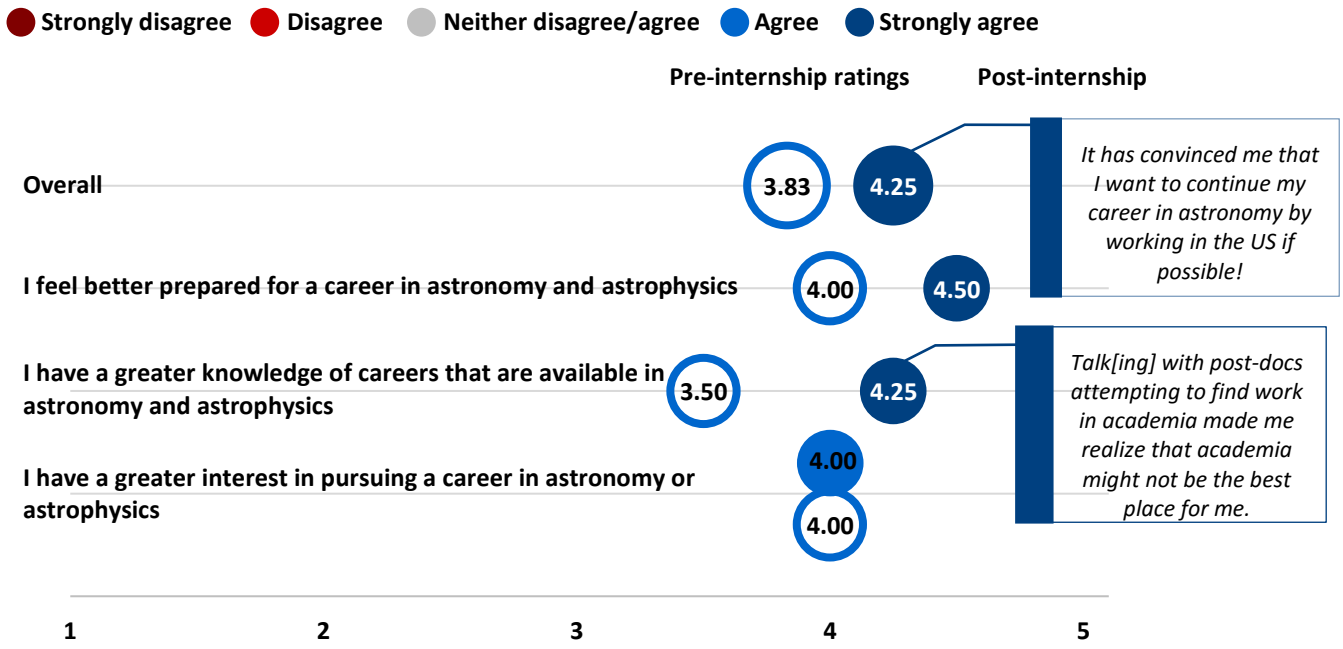
The evaluator assessed whether the knowledge obtained through the internship had an impact on the student's work and research through the assessment of a Likert scale responses. Likert scale categories ranged from 1= *not at all* and 5= *extremely*. Students experienced differing levels of knowledge increases of their areas of research.

- **50% of participants** indicated the internship had ***a great deal*** of an impact on their understanding of their research area.
- **25% of participants** indicated the internship had ***somewhat*** of an impact on their understanding of their research area.
- **25% of participants** indicated the internships had ***slight*** impact on their understanding on their research area.

Impact on career readiness and direction

As shown in Figure 24, the evaluator assessed the impact on career readiness and direction through assessing student ratings of agreement on statements before and after their internship experience. Response categories ranged from 1= *strong disagree* and 5= *strongly agree.* Overall, as a result of their internship experience, students' career readiness increased (3.83 in the pre to 4.25 in the post). Findings indicate that students experienced the largest pre-post gain in "greater interest in careers that are available in astronomy and astrophysics," which increased from *agree* (3.50) to *strongly agree* (4.25). Students experienced no gain in their interest in pursuing a career in astronomy or astrophysics, which was 4.00 in the pre and post. Qualitative responses indicated students lack of pre-post change in career interest in astronomy and astrophysics was due to their existing intentions to pursue careers in these fields.

Figure 25. Impact on career readiness



Within the focus group students were asked: **What <u>impacts</u> do you believe participating in this internship has had on you?** The following key findings emerged.

- All students indicated that the internships helped to inform their careers directions. Some students became more interested in pursuing research; others became more interested in pursuing teaching in the field.
- Some students indicated that the internship helped with obtaining some soft skills, such as assertiveness and personal independence.

Unexpected Outcomes

Analysis of focus group data was considered for frequency or importance of themes within participant responses. The evaluator identified two unexpected outcomes from the focus group. These unexpected outcomes were not directly related to the stated outcomes of the internships, but emerged during the focus group. The following themes of "institutional impact" and "post-internship learning" emerged from the data and is described below.

Intuitional impact

Students were not explicitly asked about the impact their internship had on their home intuition. Regardless, this theme emerged an important unexpected outcome of the project. One student spoke to how his/her internships allowed him/her to utilize equipment that was not normally available at his/her home intuition. This forced the student to think about how this data could be utilized using her home intuition's existing equipment. This has the potential to enable the student's home institution to leverage data in a way previously not thought of.

Post-internship learning

Despite not being explicitly asked about post-internship learning it arose as a significant theme within the focus group data. The following key findings outline several student intern ideas that could help support students in post-internship learning.

- One student indicated the potential value in having all interns connect post-internship to talk about experiences and learnings.
- Some students indicated that they would prefer the final deliverable for the internship to be presentation-based, not report based.
- One student indicated that it would be helpful to consolidate the final deliverable, so that students can share their knowledge and learnings across experiences.
- Some students indicated a desire to be better integrated/connected into the GROWTH project after their internships.

AY3- Automated Discovery of the Universe Course Evaluation

The freshman seminar titled "AY3 – Automated Discovery of the Universe" was offered by the California Institute of Technology, from January to March 2016, as an introductory course to astronomy and the techniques and tools necessary for analysis of astronomical and astrophysical data. Seven students were enrolled in the seminar, four of which completed the evaluation survey.

The seminar objectives were to enhance student:

- Exposure to astronomical phenomenology and physics research.
- Excitement in astronomical phenomenology and physics research.
- Ability to deal with big data sets, grounded in astronomical phenomenology and physics.
- Ability to connect diverse catalogs, grounded in astronomical phenomenology and physics.
- Ability to invent new algorithms, grounded in astronomical phenomenology and physics.

Seminar evaluations, shown in Appendix C, were developed by the evaluation team in conjunction with project administration to assess the effectiveness, usefulness, and impact of the seminar on the students enrolled in it. Both quantitative and qualitative components were included in the evaluation. If comments were provided by students, they are included to elaborate on ratings of items.

Demographics

In total, seven students enrolled and attended the seminar, with 4 completing the seminar evaluation, for a 57% response rate, however, only three students completed the demographics section of the evaluation. The seminar evaluation respondent demographics are as follows:

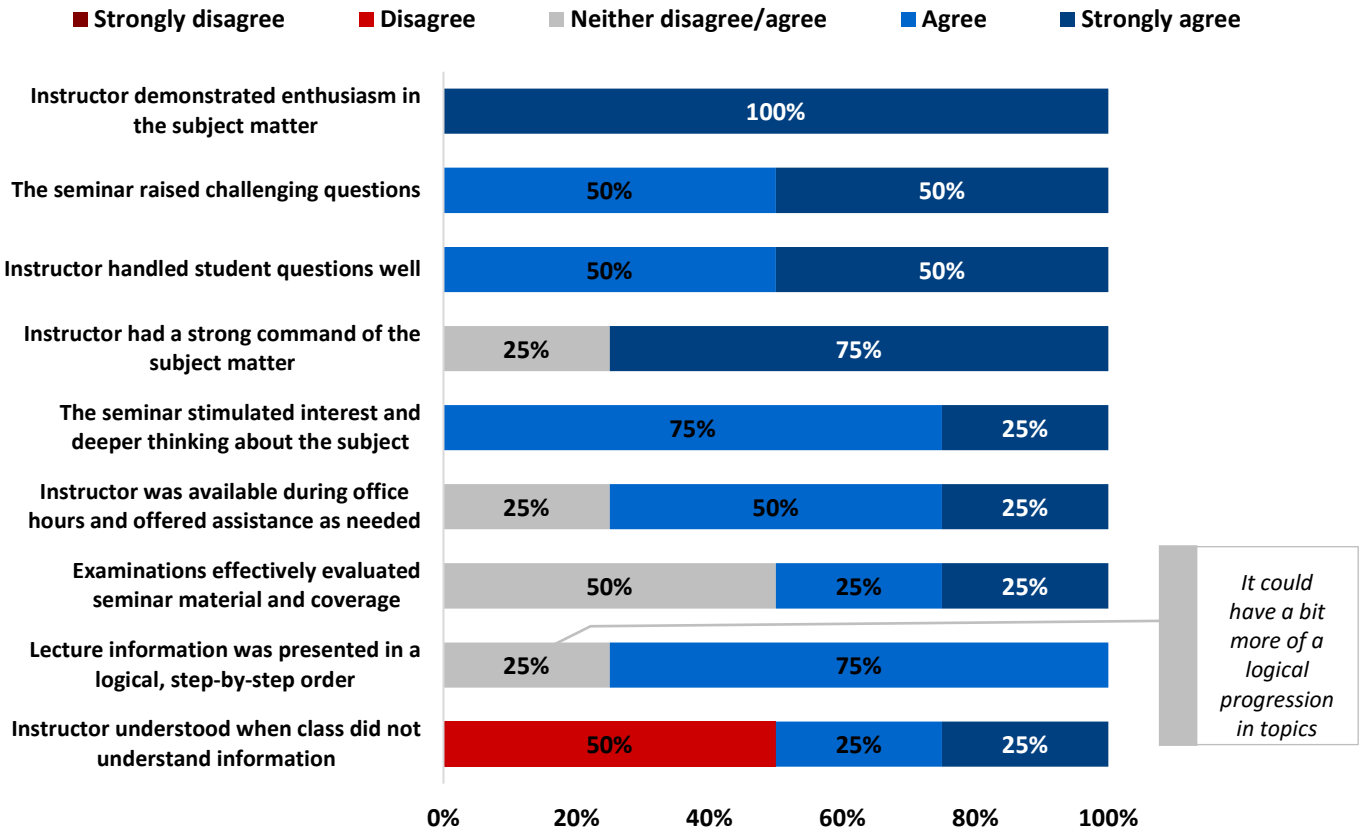
- Two of the three respondents were female.
- Two of the three respondents were Caucasian/White and one participant was Middle Eastern.
- Two of the three respondents were college freshmen and one student was a college senior.
- No students were first generation college students.

Seminar effectiveness

The evaluator assessed seminar effectiveness through assessing student ratings of agreement on statements relating to seminar usefulness and effectiveness. Response categories ranged from 1= *strong disagree* and 5= *strongly agree.* Students responded to nine Likert scale items asking about the effectiveness of the course, as shown in Figure 25.

The four students in the seminar all (100%) *strongly agreed* that the "instructor demonstrated enthusiasm in the subject matter," however, half (50%) of the students *disagreed* that the "instructor understood when the class did not understand information." Of the other two statements with the highest level of agreement, the students all (100%) *agreed* or *strongly agreed* that "the seminar raised challenging questions" and that the "instructor handled student questions well." This indicated that the instructor was able to convey the information well to students and that the seminar stimulated thought about the topic. The two other lowest rated statements pertained to exams and the ordering of the lecture information. While students mostly agreed with these positive statements, these could be areas of improvement to the course.

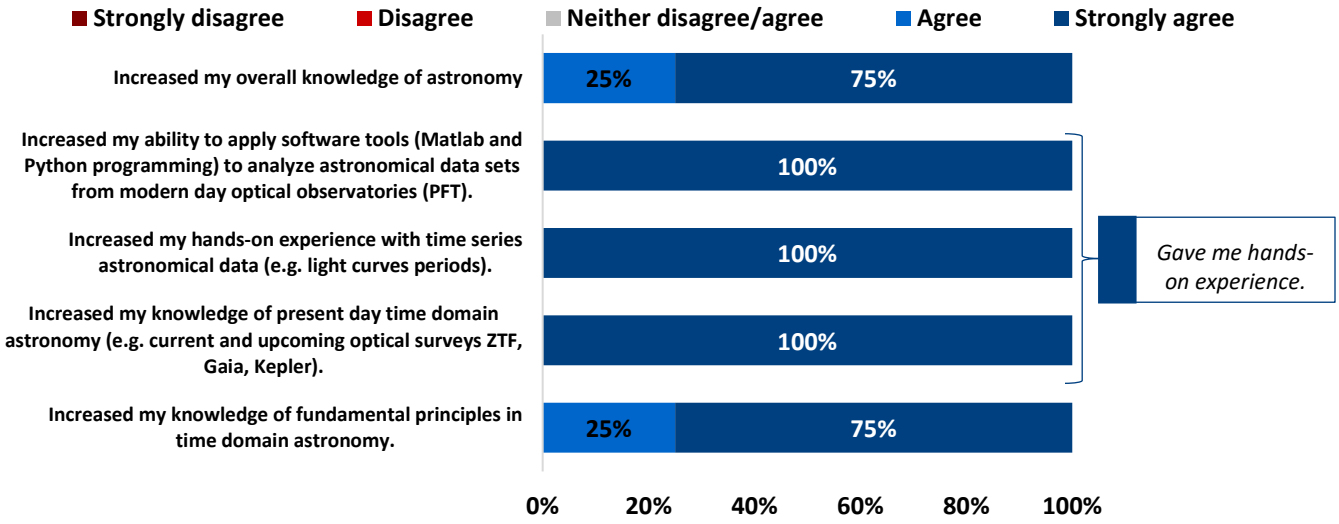
Figure 26. Seminar usefulness and effectiveness



Impact on knowledge

As shown in Figure 26, the evaluator assessed seminar impact on student knowledge using a Likert scale. Students responded to Likert scale items asking their level of agreement (1= *strong disagree* and 5= *strongly agree*) with whether the seminar's impact across five knowledge items. All students indicated that the internship had a great impact of their knowledge of astronomy and astrophysics and their knowledge of tools used in these fields.

Figure 27. Seminar impact on knowledge



Educational and career trajectories
The evaluator assessed whether the seminar had impacted student educational and career trajectories through the assessment of Likert scale responses.

Passion
Students were asked if the seminar impacted their excitement for passion for astronomy. Likert scale categories ranged from 1= *strongly disagree* and 5= *strongly agree.*

- 50% of participants *strongly agreed* the seminar ignited their excitement/passion for astronomy.
- 25% of participants *agreed* the seminar ignited their excitement/passion for astronomy.
- 25% of participants *disagreed* the seminar ignited their excitement/passion for astronomy.

STEM major

- 3 (75%) were enrolled in **STEM** majors
- 1 (25%) was enrolled in **non-STEM** majors.

STEM majors of participants	Non-STEM majors of participants
Astrophysics Computer Science Geophysics	Economics

In the survey's open-ended responses students were asked how the seminar had impacted them. The following themes emerged.

Major retention	Three of the students planned on staying in their major and one student was planning on changing their major to planetary science.
Impact of seminar on decision in selecting a major related to astronomy or astrophysics	All four of the students (100%) responded that the seminar did not impact their decision.
Intentions to attend graduate or professional school	Three of the students (75%) were undecided about attending graduate or professional school and one student (25%) was planning on attending. The one student planning on attending graduate school is choosing to receive a degree in planetary science.
Impact of seminar on interest in pursuing post-secondary education, professional opportunities, and/or a career?	Three of the students (75%) said the seminar did not affect their interest and one student (25%) said the seminar did affect their interest. The one student who did find that the seminar affected their future plans stated that, "[the seminar] gave me a better taste of research."

Goal 3: Capacity Building (partnerships and sustainability)

The following section describes the project's impact towards Goal 3. All project activities and strategies (and corresponding evaluation data) that is considered to contribute to the achievement of Goal 3 is featured here. Goal 3 evaluation results are divided into "frequency of and impact on institutional and interinstitutional collaborations," "international collaborations as seen through publications," "international research collaboration capacity," and "project sustainability capacity."

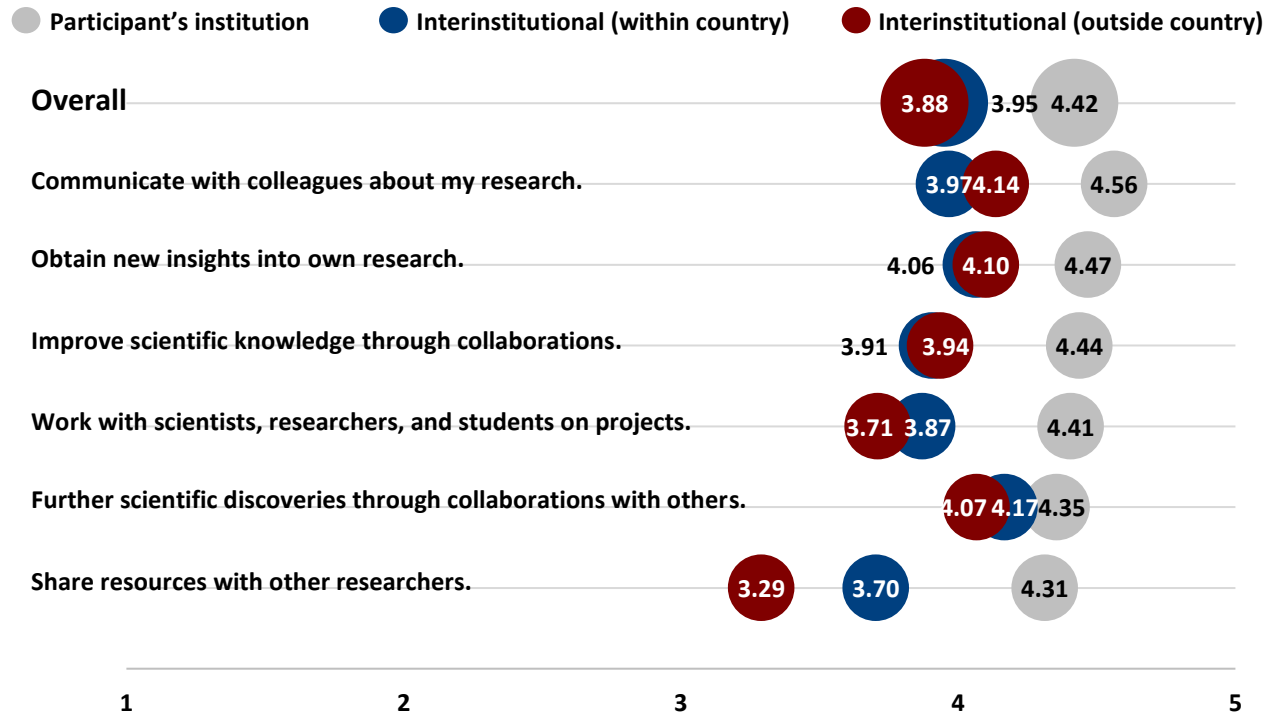
Frequency and impact of collaborations

The collaboration between the international partners in the GROWTH project is the major mechanism through which the project will meet its goal to form an international network of telescopes. One way to accomplish this collaborative network is through the sharing and integrating knowledge between partners. Through the use of baseline survey data, the evaluator assessed the frequency of collaborative activities occurring in the project on three levels.

1. The participant's institution
2. Interinstitutional (within the participant's country)
3. Interinstitutional (outside the participant's country)

As shown in Figure 27, participants (n= 35) indicated often they collaborate within and outside their institution (both within and outside their country). Participants generally rated their frequency of activities highest among their own institutions, than between institutions in their own country, and last, between institutions outside their country. This is to be expected at the start of a project, but as the project advances, it is expected that the frequencies of interinstitutional collaborations will increase.

Figure 28. Frequency and impact of institutional and interinstitutional collaborations



International collaborations assessed through publications

One method of assessing international collaborations is publications. Publications that have resulted from the project members and partner institution were used as a proxy measure for international collaborations, as these publications can be used to show both the frequency of collaboration and the extent that a publication involves international partners. The evaluator mapped out the publications that project members have authored by project partner institution to assess international collaborations. The publication network figure is shown in Figure 28.

Understanding the publication network diagram

To read the publication network diagram, the partner institutions involved in publications have been mapped on their exact geolocation. ***Nodes* depict intuitions, while *lines* depict the collaborations which have occurred between institutions.** The more publications two institutions have collaborated on, the thicker the lines.

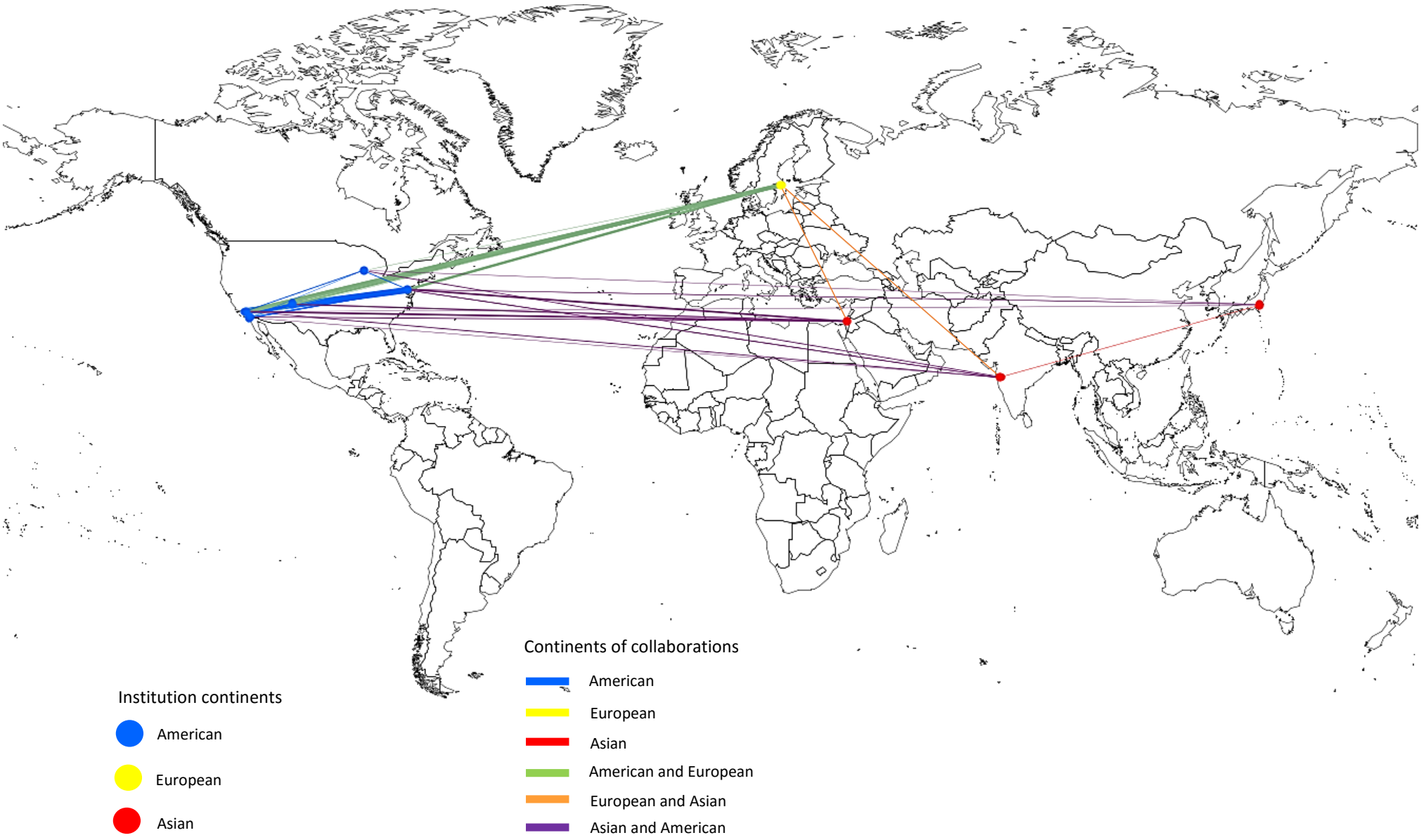
- Blue nodes (●) are American institutions: Los Alamos National Laboratories, University of Wisconsin, Caltech, University of Maryland, and San Diego State University.
- Blue lines (—) signify collaborations between American institutions on publications. The line thickness signifies how many publications the institutions collaborated on; thicker lines signifying more collaborations on publications and thinner lines signifying less collaborations on publications.
- The yellow node (●) is the European institution Stockholm University.
- Red nodes (●) are Asian institutions and they include: IUCAA, Weizmann Institute and Tokyo Institute of Technology. Red lines (—) signify collaborations between Asian institutions on publications.
- Green lines (—) signify collaborations between American and European institutions.
- Purple lines (—) signify collaborations between Asian and American institutions.
- Orange lines (—) signify collaborations between European and Asian institutions.

Publication network map analysis

Key terms to understand collaborations: *frequency* is how many times an institution has collaborated on individual publications; *consistency* is how often two partner institutions have collaborated together.

- Stockholm University has frequently and consistently collaborated with institutions in the United States.
- IUCAA, Weizmann Institute and Tokyo Institute of Technology have also frequently collaborated with institutions in the United States.
- There are lower levels of collaboration between institutions in European and Asian countries.
- Within the United States, Caltech and University of Maryland have frequently and consistently collaborated.
- Taiwanese and German partners were not present on any publication so far in the project.
- Pomona College and the Indian Institute of Astrophysics were not present on any publication in the project so far.
- A Caltech researcher has collaborated on 20 of the 21 publications, so far in the project.

Figure 29. GROWTH publication network map



To provide further detail for Figure 28, Figure 29 displays each of the fifteen publications with respective institutions and authors. A list of publication titles (corresponding to the numbers in the Figure 29) can be found in Appendix E.

Figure 30. Year publications by author and institution

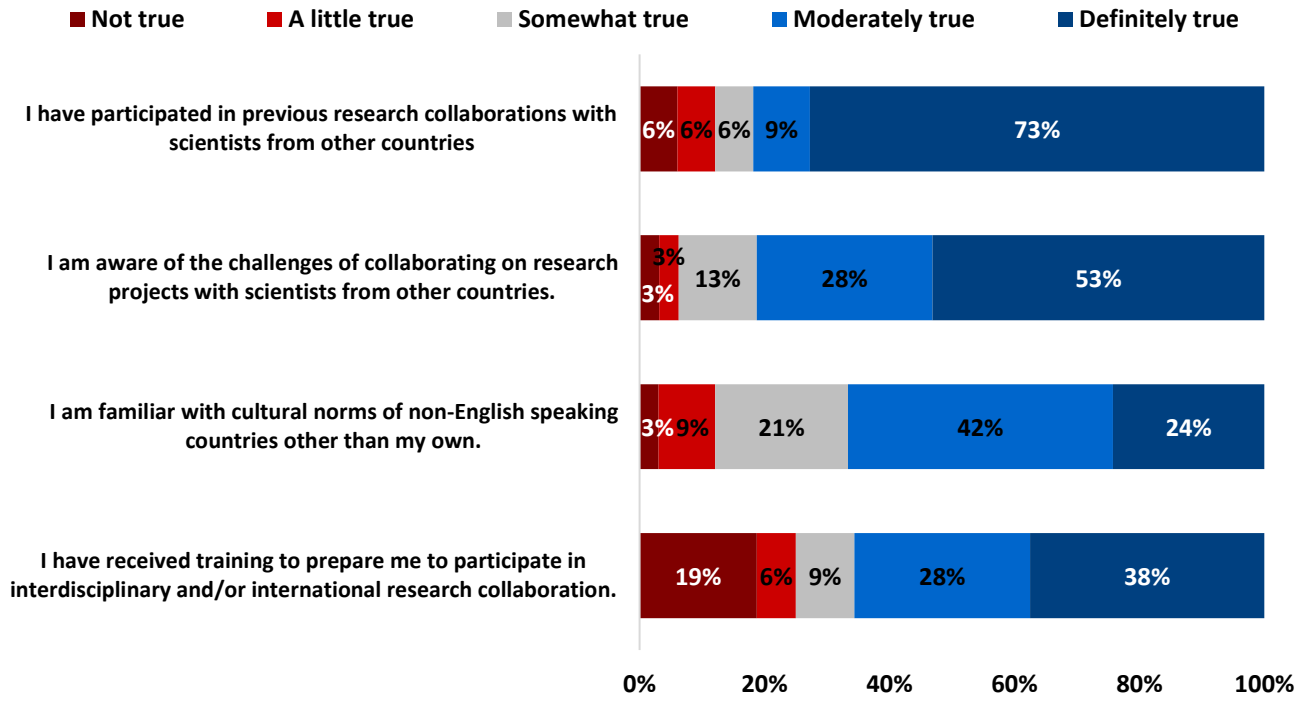
Publication	Caltech	UMD	Los Alamos	SDSU	UWM	Stockholm University	Weizmann Institute	IUCCA	Tokyo Tech
1	Kasliwal	Cenko Singer							
2	Cao Kasliwal								
3	Kasliwal Lunnan		Wozniak			Karamehmetoglu Taddia			
4		Cenko				Amanullah Goobar Taddia			
5	Blagorodnova Cao Kulkarni Kasliwal		Wozniak			Taddia			
6	Bellm Cao Cook Kasliwal Kulkarni Kupfer Prince	Cenko Singer			Brady Kaplan Qi van Sistine			Bhalerao	Kawai
7	Cao	Cenko	Wozniak			Amanullah Ferretti Goobar Petrushevska			
8	Cao Kulkarni					Papadogiannakis			
9	Bellm Cao Cook Kulkarni Kasliwal Lunnan Prince	Cenko Singer		Quimby	van Sistine	Ferretti		Bhalerao	

Publication	Caltech	UMD	Los Alamos	SDSU	UWM	Stockholm University	Weizmann Institute	IUCCA	Tokyo Tech
10	Cao Kasliwal Kulkarni	Cenko					Ofek		
11	Cao Kasliwal Kulkarni	Cenko				Amanullah Goobar			
12	Cao Kulkarni Kasliwal	Cenko							
13	Lunnan								
14	Kasliwal	Singer							
15	Kasliwal	Cenko Singer							
16	Cao Kasliwal Kulkarni	Cenko	Wozniak	Quimby			Ofek		
17	Bellm Cao Kasliwal Kulkarni	Cenko Singer Toy							
18	Cao Kasliwal Kulkarni	Cenko	Wozniak			Taddia	Ofek		
19	Kasliwal Lunnan		Wozniak			Taddia			
20	Cao Kasliwal Kulkarni	Cenko				Taddia			
21	Cao Kulkarni Yan	Cenko	Wozniak	Quimby			Ofek		

International research collaboration capacity

Through the use of baseline survey data, the evaluator assessed the current collaborative capacity (i.e. how skilled they are to perform collaborative work) of project participants. As shown in Figure 30, a majority of project members (73%) stated they had previously participated in research collaborations with scientists from other countries. The most polarizing item was whether participants had received training to prepare them to participate in interdisciplinary and/or international research collaborations, with 38% of participants saying this was *definitely true*, and 19% saying this was *not true.*

Figure 31. Research collaboration capacity

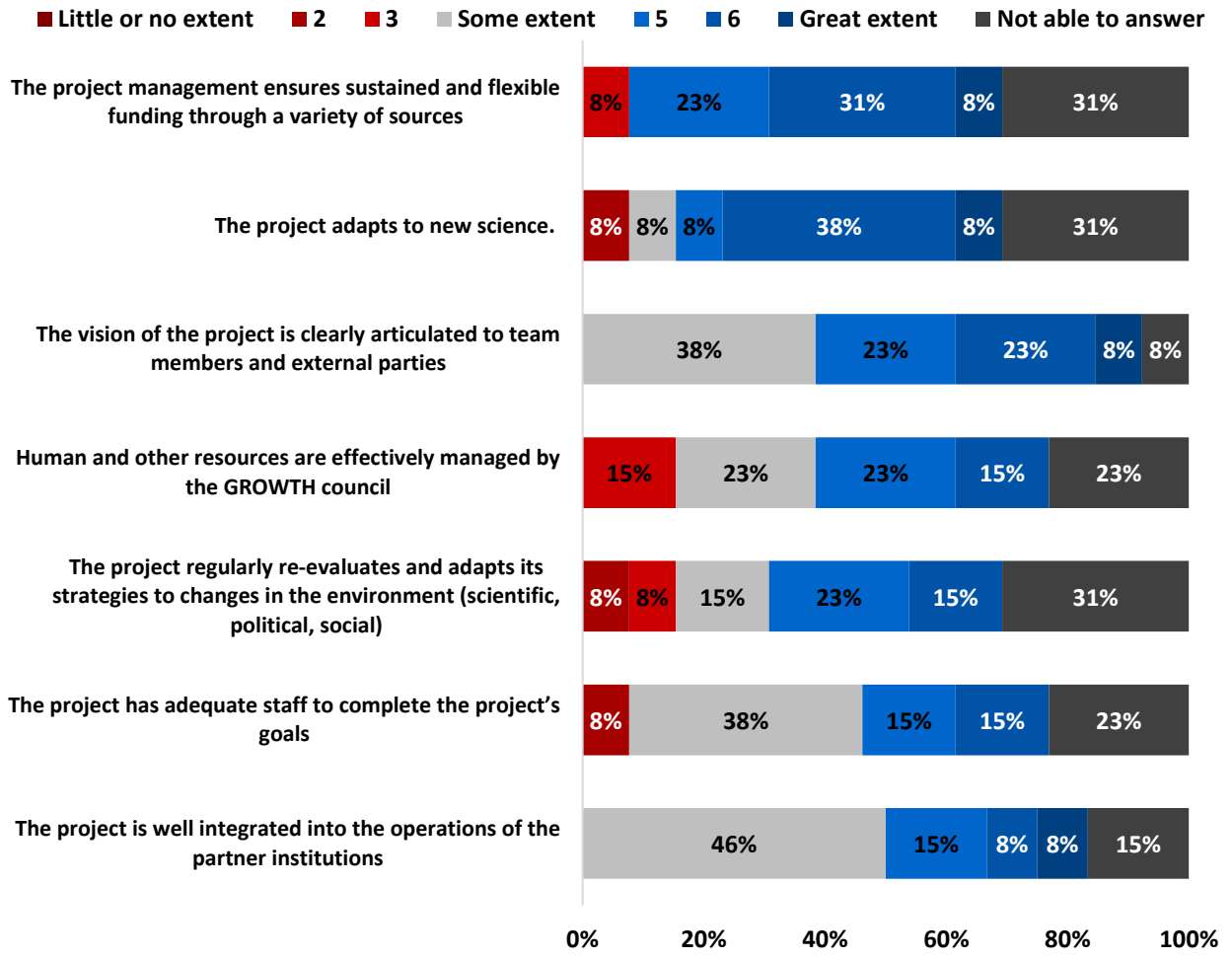


Project sustainability capacity

The evaluator assessed the current sustainability capacity of the project, using items adapted from the Project Sustainability Assessment Tool (PSAT)[2] and surveying all project faculty, researchers, and leadership (n=12). These questions were designed to allow leadership to start planning and addressing how the project is going to be sustainable after funding end from the current grant and what areas need to be improved upon to assist in this sustainability plan.

As shown in Figure 31, the project faculty, researchers, and leads identified the project having the strongest sustainability component of "project management ensures sustained and flexible funding through a variety of sources" with a majority of respondents (54%) rating it greater than *some extent*. The lowest rated sustainability component, by respondents, was "the project is well integrated into the operations of the partner institutions." The project should seek to recruit new members into the project, not only to foster sustainability, but to, also, increase the influx of new individuals and perspectives into the project. Additionally, project leads should begin to integrate the project into the respective partner institutions to help further bolster and sustain the project. A large portion of project participants indicated they were '*not able to answer'*. This number should decrease as project awareness increases with time.

Figure 32. Project sustainability capacity



[2] Developed by researchers at Washington University. Retrieved from http://www.sustaintool.org.

Section 4: Key findings and recommendations

Findings and recommendations for this report were created from examining project activities from Year 1 (and their intended impacts), against outcomes described in the logic model. As the evaluation continues to mature, a more rigorous examination of project activities in relation to the logic model will be able to be performed.

Key findings

Progress made towards broader impacts

Goal 1: Research/Knowledge

Knowledge attainment

- On average, 57% of participants indicated they were *moderately* or *extremely knowledgeable* in the three research areas (i.e. electromagnetic follow-up of gravitation wave sources, supernovae studies, and the study of near-earth asteroids). This demonstrates that project participants are coming into the project with high levels of knowledge, which helps to support the project's international research infrastructure.

Project impact on participant work and research

- Overall, 57% of participant's said knowledge obtained through the project has impacted their work and research. This is a promising finding, given how early it is in the project and an expectation that this number will grows in subsequent years.
- Participants qualitatively described how knowledge obtained through the project had impacted them, which included knowledge gains and innovative thinking. Additionally, participants described the benefits in terms of financial support and impact on career trajectories.

Discoveries and the dissemination of findings

- Project participants were asked questions about their contributions to the astronomy-astrophysics scientific community. Highlights include, 65% of participants indicating they have made scientific discoveries and 62% of participants indicated findings from their scientific discovery are being utilized in the field.
- 15 journal articles have been published by project participants. The most impactful journal the project published in was the *Astrophysical Journal*, which has a Normalized Eigenfactor of 58.3, which translates to it being 58 times as influential as the average journal. Project members have been published in journals that, on average, have a Normalized Eigenfactor of 39.0.

Goal 2: Education and workforce development

Education and career trajectory

- Undergraduate and graduate students were asked if they had plans to continue their pursuit of a graduate degree. 100% of students indicated their intentions to pursue a graduate degree were *moderately true* or *definitely true*. Students were less sure about their plans to pursue a career related to astrophysics, with 47% of students indicating plans to pursue a career were *definitely true*. The remainder of students indicated their plans to pursue an astrophysics career were *moderately true* (35%) and *somewhat true* (12%).

International Graduate and Postdoctoral Internship Program

Satisfaction

- Overall students described internship experiences favorably, especially in regards to its meaningfulness and intellectual growth.
- Interns also indicated they "felt like their contributions made a difference," which they also identified as being of high importance to them during their internship.
- Students qualitatively described the travel component of the internship one of the most satisfying internship components.

Effectiveness

- A majority of students (75%) stated they *strongly agreed* they felt adequately prepared for this experience. Specifically, a majority of students (75%) found all support from their home institutions to be very or extremely useful and a majority of students (85%) found all support from their visiting institutions to be very or extremely useful.
- Participants were most polarized on an item asking if they felt "part of a community," with 50% of participants indicating they *strongly agreed* and 25% indicating they *disagreed*. Two of the three focus group students indicated they felt isolated. They suggested it would be helpful to become better integrated with their mentor's existing graduate students, as this would help to facilitate feelings of support, combat feelings of isolation.
- Two of the three focus group students said it would be helpful to receive more clarity regarding internships expectations (both expectations of GROWTH and those of internship mentors).

Impact

- Overall, a majority (94%) of students found internships "*met their expectations*," "*met their needs*," "*was a rewarding experience*," and "*was valuable to their academic and professional growth."*
- One student indicated potential value in having all internships connect post-internships to talk about experiences and learnings.

AY3- Automated Discovery of the Universe Course Evaluation

Effectiveness

- Students (86%) *agreed* or *strongly agreed* about the seminar's overall effectiveness.

Impact

- Students (100%) strongly agreed the seminar "increased [their] knowledge of present day time domain astronomy (e.g. current and upcoming optical surveys ZTF, Gaia, Kepler)," "increased student hands-on experience with time series astronomical data (e.g. light curves periods)," and "increased student ability to apply software tools (Matlab and Python programming) to analyze astronomical data sets from modern day optical observatories (PFT)."

Goal 3: Capacity Building (partnerships and sustainability)

International collaborations

- Participants were asked how often they collaborate within their institution and outside (both within and outside their country). Participants generally rated their frequency of activities highest among their own institutions, then between institutions in their own country, and last, between institutions outside their country. This is to be expected at project's commencement, but as the project advances, it is hoped frequencies of interinstitutional collaborations will increase.

International research collaboration capacity

- In assessing collaborative capacity (i.e. how skilled they are to perform collaborative work), 73% of project members stated they had previously participated in research collaborations with scientists from other countries. The most polarizing item was whether participants had received training to prepare them to participate in interdisciplinary and/or international research collaborations, with 36% of participants saying this was *definitely true*, and 20% saying this was *not true*.

Project sustainability capacity

- In assessing the project's sustainability capacity, project leadership rated *funding from multiples sources* highest. Project leads rated the project's *integration into partner institutions* lowest. No qualitative responses were offered by project leadership to help clarify these responses.

Recommendations

Progress made towards broader impacts

Goal 1: Research/Knowledge

Knowledge attainment

- Examine ways to further increase current participant (and new participant) knowledge about project goals. It is assumed as research collaborations grow, participant knowledge should grow in participant's areas of concentration and across research themes.

Project impact on participant work and research

- Brainstorm concrete strategies for individual researchers to connect their research to GROWTH's research.

Discoveries and dissemination of findings

- Target high impact publications (as defined by Eigenfactor analysis) to publish research.

Goal 2: Education and workforce development

Education and career trajectory

- Education leads should meet regularly to discuss plans for implementation of the project courses.
- Educate students about the GROWTH project (and its research areas) and how it relates to the course material.
- Develop plans for scaling up the course in other partner institutions, both within the US and internationally.

International Graduate and Postdoctoral Internship Program

Satisfaction

- Connect mentors and mentees prior to the trip (via Skype). This will support mentors and mentees in solidifying internship expectations (e.g. frequency of meetings, connection to the lab) and research project specifics. This pre-internship call could also include a few of the mentor's graduate students who could speak to what to expect working in the lab, cultural norms, as well as tips for socializing during the internship.
- Brainstorm strategies to support role clarity to students entering internships; this includes: GROWTH expectations and mentor expectations. Ideas for communicating roles and expectations could include: a promotional video, a flyer, or email to internship students.

Effectiveness

- Create and disseminate documents to provide greater clarity to interns on logistical aspects of trip (transportation from airport, specifics of housing accommodations (e.g. what to bring, what is provided, etc.).
- Consider encouraging (or requiring) mentors to involve one or several of their graduate students in the mentee's internship experience. This would help to alleviate the time demand placed on faculty and also help mentees to feel better integrated and supported by their visiting institution.
- Consider revising the internship's final deliverable. A format where all interns can share their (e.g. in-person or virtual presentation) may be more impactful in sharing internship experiences and research.

Impact

- Communicate (e.g. at annual meetings, hosting a virtual meeting, or circulate a flyer or PowerPoint presentation) the connection between internships and larger project so student interns understand how their role as an intern fits within larger project vision.
- Communicate (e.g. at annual meetings, hosting a virtual meeting) the connection between intern's research and GROWTH research, so student interns understanding how their internship research is aligned.
- Ensure intern research is aligned with GROWTH research and attempt to strategically allocate internships based on student interest, how an institution can accommodate an intern area of interest or intern needs of intuitions.
- Consider having student intern's do presentations at annual meetings as a method for students to: a) gain presentation skills, b) share their work, and c) also better illustrate how intern research relates to GROWTH research.
- Consider expanding internships to also include teaching components (if feasible). This could help expand GROWTH's influence on astronomy/astrophysics education and career pipelines, impacting not just research careers, but also teaching-centric careers.
- Establish GROWTH trajectories/pipelines for student interns to transition to post-internship (e.g. mentors to future student interns, paired with GROWTH faculty mentors, teaching assistants, annual attendance at GROWTH conference, a community of practice for all student intern cohorts). This will ensure internships are not a 'one-off' activity, but rather one method within the project to engage students in astrology and astrophysics.

AY3- Automated Discovery of the Universe Course Evaluation

Effectiveness

- Target seminar outreach and recruitment to existing astronomy/astrophysics majors, to ensure the seminar is impacting educational trajectory of students, as findings indicate the seminar in isolation is not likely to impact non-astronomy/astrophysics majors' educational trajectories.

Impact

- Continue to facilitate the seminar in its current format, as results indicated the seminar is conducive to student learning. All students indicated the seminar course increased their knowledge of astronomy.
- Integrate guest lectures into the seminar to speak to their astronomy/astrophysics education and career trajectories, as a method of informing students of education and career options in this field. This could be 20-40 mins of one lecture within a semester.

- Circulate or present astronomy/astrophysics resources (e.g. conference opportunities, research opportunities, internship opportunities) to seminar students. This could represent 20-40 mins of one lecture within a semester.

Goal 3: Capacity Building (partnerships and sustainability)

International collaborations

- Encourage more interinstitutional collaborations (i.e. internships, educational collaborations) both within and outside of participant's country of origin, through incentivizing collaborative participation of this kind.

International research collaboration capacity

- Consider providing collaborative training to project participants (including project management tools that support collaboration), as 20% participants indicated they haven't received training to prepare them to participate in interdisciplinary and/or international research collaborations.

Project sustainability capacity

- Brainstorm strategies to integrate the project into its project membership's institutions, as awareness of the project will help to garner institutional support. Some examples include: having institutions support GROWTH interns and having institutions introduce new courses in astronomy/astrophysics, and ensuring GROWTH is promoted within each of the former.
- Consider greater collaborative decision-making around the GROWTH budget to enhance feelings of transparency and empowerment around the project's budget, as some project participants indicated they felt human and other resources were not managed effectively, and others indicated they felt the project did not have adequate resources in place to manage the goals of the project. Collaborative conversations regarding the project's budget can help to alleviate some of these concerns.

Appendix A: GROWTH Baseline Survey

Dear GROWTH Participants,

As a requirement of your involvement in the National Science Foundation (NSF) GROWTH project, we at SmartStart (www.smartstart-er.com), the external evaluator assigned to this project, are asking that you complete this survey.

This survey will take approximately 15 minutes to complete. As you work through the survey, responses on each page are saved when you click the "*next*" button. If you exit the survey while it is partially complete you can return to complete it later by clicking on the link from this email invitation. You will be returned to the page from which you exited.

SmartStart will administer this survey on an annual basis to assess the achievement of project goals over the course of this project. The information will support project improvements each year and support the project in reporting its impact to the NSF. **Comprehensively reporting project impact increases the possibility for future NSF funding to be secured.**

Individual survey responses will not be shared. Survey results will be reported as a project-wide aggregate, in which all identifying information will be removed.

By clicking "next", you consent to participate in this evaluation. If you have any questions, please feel free to contact me by sending me an email to the address listed below.

Sincerely,
Tyler Johnson
Project Evaluator
tjohnson@smartstart-er.com

The following are the three goals for the project, as detailed in the NSF proposal. Each of the goals has a particular focus for national and international impact.

- ***Goal 1: Research****: Advance knowledge and research in identified areas of astrophysics*
- ***Goal 2: Education and Workforce Development****: Contribute to education, training and development of the STEM workforce.*
- ***Goal 3: Capacity Building (Partnerships & Sustainability):*** *Create a strong collaborative network of scientists and facilities that catalyze educational and scientific achievements in the field of astronomy and astrophysics.*

Demographics

Completion of this section provides basic information to capture the demographics of project participants. This information strengthens future applications for funding, ultimately providing research project sustainability and growth.

What is your country of citizenship?

( ) United States ( ) Japan ( ) Taiwan ( ) Germany
( ) Sweden ( ) Israel ( ) India ( ) Other, please specify: _____

Where are you currently working/studying?

( ) United States ( ) Japan ( ) Taiwan ( ) Germany
( ) Sweden ( ) Israel ( ) India ( ) Other, please specify: _____

With which gender do you identify?

( ) Male ( ) Female ( ) Prefer not to answer ( ) Other (please specify): _____

With which ethnic background do you most closely identify?

( ) Hispanic or Latino ( ) Not Hispanic or Latino ( ) Prefer not to answer ( ) Other (please specify): _____

With which racial background do you most closely identify.

( ) Asian or Asian American ( ) Hispanic or Latino ( ) Do not wish to specify
( ) Black or African American ( ) American Indian or Alaskan Native ( ) Other, please specify: _____
( ) Caucasian or White (non-Hispanic) ( ) Pacific Islander or Native Hawaiian

With which organization are you most closely affiliated?

( ) California Institute of Technology ( ) Pomona College ( ) San Diego State University
( ) Los Alamos National Laboratory ( ) University of Maryland, College Park ( ) University of Wisconsin, Milwaukee
( ) Tokyo Tech University ( ) National Central University, Taiwan ( ) Indian Institute of Astrophysics
( ) Inter University Center for Astronomy and Astrophysics ( ) Weizmann Institute of Science
( ) Oskar Klein Center, Stockholm University ( ) Humboldt University

How many years have you participated in astronomy/astrophysics-related studies and/or research?

( ) 0-1 ( ) 1-5 ( ) 6-10 ( ) 11-15 ( ) 16-20 ( ) 21-25 ( ) 26+

What role do you play in the GROWTH project?

( ) Faculty/University researcher ( ) Industry researcher ( ) Postdoctoral fellow
( ) Graduate student ( ) Undergraduate student ( ) Professional staff
( ) Policy maker/politician ( ) Governmental agency employee ( ) Technician
( ) Other, please specify: _____

Are you a <u>first generation college student</u> <u>(An individual both of whose parents or guardians did not complete a baccalaureate degree; OR in the case of an individual who regularly resided with and received support from only one parent or guardian, an individual whose only parent or guardian did not complete a baccalaureate degree</u>)?

( ) Yes ( ) No ( ) I'm not certain ( ) Not sure/Prefer not to answer

Goal 1: Research: *Advance knowledge and research in identified areas of astrophysics*

The following section will ask you about your involvement in and knowledge of the various research areas of the project.

In which of the research objective areas will most of your work and research be conducted?

( ) Research Theme 1: Electromagnetic follow up of gravitational wave sources
( ) Research Theme 2: Supernovae studies
( ) Research Theme 3: Study of near-earth asteroids

Rate your current level of knowledge for the following GROWTH research objectives, using the following 5-point scale, where 1= *not at all knowledgeable* and 5= *extremely knowledgeable.*
<u>Only undergraduate and graduate students:</u> Additionally, identify ('yes'/'no') whether this knowledge came as a result of your involvement in this project.

							Identify ('yes'/'no') whether this knowledge came primarily as a result of your involvement in this project?	
	Not at all knowledgeable	Slightly knowledgeable	Somewhat knowledgeable	Moderately knowledgeable	Extremely knowledgeable	N/A	Yes, primarily as a result of my involvement in this project	No, primarily outside of my involvement in this project
Research Theme 1: Electromagnetic follow up of gravitational wave sources	( )	( )	( )	( )	( )	( )	( )	( )
Research Theme 2: Supernovae studies	( )	( )	( )	( )	( )	( )	( )	( )
Research Theme 3: Study of near-earth asteroids	( )	( )	( )	( )	( )	( )	( )	( )

Answer the following questions using the following 5-points scale, where 1= *not at all* and 5= *extremely.*

	Not at all	Slightly	Somewhat	Moderately	Extremely	N/A
How much has the knowledge you have obtained through this project impacted your work and research?	( )	( )	( )	( )	( )	( )

In what ways have your work and research been influenced by knowledge obtained from the project? _____

Contributions to the Scientific Community

Please rate the following statements about discoveries you have made, using the following 5-point scale.

	Not true	A little true	Somewhat true	Moderately true	Definitely true
I have made scientific discoveries in the field of astronomy/astrophysics.	( )	( )	( )	( )	( )

I have shared my findings with individuals, institutions, and/or industry by writing a paper or presenting at a conference.	( )	( )	( )	( )	( )
My findings are being used by individuals, institutions, and/or industry to make positive impacts in my field. (an example of a metric will be the # of citations on scientific publications)	( )	( )	( )	( )	( )

Goal 2: Education and Workforce Development: *Contribute to education, training and development of the STEM workforce.*

The following section will ask about your involvement in the educational and workforce development activities of the project. If you are an undergraduate, graduate, or postdoctoral fellow, you will be asked questions about your future educational and professional plans.

PI Only

Please answer the following question using the following 5-point scale.

I have recruited the following participant populations into STEM:	Not at all	Slightly	Somewhat	Moderately	Extremely	Not relevant to my role
Undergraduate students	( )	( )	( )	( )	( )	( )
Graduate student and postdocs	( )	( )	( )	( )	( )	( )

If rating above *somewhat* or below: Please describe any barriers you have to implementing strategies for college student participants. _____

If rating above *somewhat* or below: Please describe any barriers you have to implementing strategies for graduate student participants. _____

UNDERGRADUATES

Please rate your likelihood of pursuing the following, using the 5-point scale below.

	Not likely at all	A little likely	Somewhat likely	Very likely	Extremely likely
I plan to take more courses in astronomy/astrophysics.	( )	( )	( )	( )	( )
I am or plan to major in a field closely related to astrophysics (physics, math, engineering, computer science).	( )	( )	( )	( )	( )
Only shown to students studying abroad: I would enjoy participating in a research experience in the field of astronomy for undergraduates in the USA.	( )	( )	( )	( )	( )
I would enjoy participating in a research abroad experience in the field of astronomy/astrophysics.	( )	( )	( )	( )	( )
I plan to pursue a graduate degree in an area related to STEM.	( )	( )	( )	( )	( )
I plan to pursue a graduate degree in an area related to astronomy/astrophysics.	( )	( )	( )	( )	( )
I plan to pursue a career related to STEM.	( )	( )	( )	( )	( )
I plan to pursue a career related to astronomy/astrophysics.	( )	( )	( )	( )	( )

I would know where to look for career opportunities in astronomy/astrophysics?	( )	( )	( )	( )	( )

Indicate which of the following you have participated in.

	Yes	No
I attended at least one seminar/lecture conducted by professionals who work in the field of astrophysics (professors, researchers, senior lecturers, etc)	( )	( )
I participated in at least one competition related to astrophysics held by an academic and/or governmental organization.	( )	( )
I attended at least one career-related presentation or career fair in a STEM area.	( )	( )
I attended a conference/workshop organized by the GROWTH project.	( )	( )
I attended an international conference focused on research themes related to GROWTH	( )	( )

GRADUATE Students

Please rate your likelihood of pursuing the following, using the 5-point scale below.

	Not likely at all	A little likely	Somewhat likely	Very likely	Extremely likely
I plan to continue my pursuit of a graduate degree in an area related to astrophysics.	( )	( )	( )	( )	( )
I plan to pursue a career related to astrophysics.	( )	( )	( )	( )	( )
I would enjoy participating in a research abroad experience in astrophysics.	( )	( )	( )	( )	( )

Indicate which of the following you have participated in.

	Yes	No
I attended at least one seminar/lecture conducted by professionals who work in the field of astrophysics (professors, researchers, senior lecturers, etc)	( )	( )
I participated in at least one competition related to astrophysics held by an academic and/or governmental organization.	( )	( )
I attended at least one career-related presentation or career fair in a STEM area.	( )	( )
I attended a conference/workshop organized by the GROWTH project.	( )	( )
I attended an international conference focused on research themes related to GROWTH	( )	( )

	Yes	No
Do you know where to look for career opportunities in astrophysics?	( )	( )
Do you know who to contact to pursue a job in a field related to astrophysics?	( )	( )

POSTDOCS

Please rate your likelihood of pursuing the following, using the 5-point scale below.

	Not likely at all	A little likely	Somewhat likely	Very likely	Extremely likely
I plan to pursue a career related to astrophysics	( )	( )	( )	( )	( )
I would enjoy participating in a research abroad experience in astrophysics.	( )	( )	( )	( )	( )

Indicate which of the following you have participated in.

	Yes	No
I attended at least one seminar/lecture conducted by professionals who work in the field of astrophysics (professors, researchers, senior lecturers, etc)	( )	( )
I participated in at least one competition related to astrophysics held by an academic and/or governmental organization.	( )	( )
I attended at least one career-related presentation or career fair in a STEM area.	( )	( )
I attended a conference/workshop organized by the GROWTH project.	( )	( )
I attended an international conference focused on research themes related to GROWTH	( )	( )

	Yes	No
Do you know where to look for career opportunities in astrophysics?	( )	( )
Do you know who to contact to pursue a job in a field related to astrophysics?	( )	( )

Goal 3: Capacity Building (Partnerships & Sustainability): *Create a strong collaborative network of scientists and facilities that catalyze educational and scientific achievements in the field of astronomy and astrophysics.*

The following section will ask you about building capacity for the project, which includes infrastructural partnerships (i.e. telescopes) and scientific partnerships with other researchers, and plans related to the long-term sustainment of the former and latter.

Partnerships

Indicate the frequency of which you are performing the following *collaborative activities* as part of the GROWTH project, using the following 5-point scale below. You will be asked to identify the frequency of the collaborate activities performed within your institution, within your country, and internationally.

	My Institution					Interinstitutional (*within my country*)					Interinstitutional (*outside my country*)				
	Never	Rarely	Sometimes	Often	Very often	Never	Rarely	Sometimes	Often	Very often	Never	Rarely	Sometimes	Often	Very often
I share resources (e.g. datasets, telescope facilities) with other researchers.	( )	( )	( )	( )	( )	( )	( )	( )	( )	( )	( )	( )	( )	( )	( )
I work with scientists, researchers, and students on research projects.	( )	( )	( )	( )	( )	( )	( )	( )	( )	( )	( )	( )	( )	( )	( )

I communicate with colleagues about my research.	( )	( )	( )	( )	( )	( )	( )	( )	( )	( )	( )	( )	( )	( )	( )
My scientific knowledge has improved through collaborations with other researchers.	( )	( )	( )	( )	( )	( )	( )	( )	( )	( )	( )	( )	( )	( )	( )
I obtain new insights into my own research through discussion with others.	( )	( )	( )	( )	( )	( )	( )	( )	( )	( )	( )	( )	( )	( )	( )
My ability to further scientific discoveries has improved through collaborations with other researchers.	( )	( )	( )	( )	( )	( )	( )	( )	( )	( )	( )	( )	( )	( )	( )

Please rate the following statements on a scale from *not true* to *definitely true.*

	Not true	A little true	Somewhat true	Moderately true	Definitely true
I have participated in previous research collaborations with scientists from other countries	( )	( )	( )	( )	( )
I have received training (attended conferences, workshops, meetings, etc.) to prepare me to participate in interdisciplinary and/or international research collaboration.	( )	( )	( )	( )	( )
I am knowledgeable of international team efforts to solving problems in astrophysics.	( )	( )	( )	( )	( )
I am aware of the challenges of collaborating on research projects with scientists from other countries.	( )	( )	( )	( )	( )
I am familiar with cultural norms of non-English speaking countries other than my own.	( )	( )	( )	( )	( )

Only for project leadership: Sustainability

The following sections assess the sustainability capacity of the project, with the assumption that the project's sustainability should grow in capacity as the project matures. Please answer the following questions based on the following 7-point scale where 1 =Little or no extent and 7 = very great extent.

Funding Stability: Establishing a consistent financial base for your project

	Little or no extent (1)	(2)	(3)	Some extent (4)	(5)	(6)	Very great extent (7)	Not able to answer
The project management ensures sustained and flexible funding through a variety of sources	( )	( )	( )	( )	( )	( )	( )	( )

Organizational Capacity: Having the internal support and resources needed to effectively manage your project and its activities

	Little or no extent (1)	(2)	(3)	Some extent (4)	(5)	(6)	Very great extent (7)	Not able to answer
The vision of the project is clearly articulated to team members and external parties	( )	( )	( )	( )	( )	( )	( )	( )

The project is well integrated into the operations of the partner institutions	( )	( )	( )	( )	( )	( )	( )	( )
Human and other resources are effectively managed by the GROWTH council	( )	( )	( )	( )	( )	( )	( )	( )
The project has adequate staff to complete the project's goals	( )	( )	( )	( )	( )	( )	( )	( )

Project Adaptation: Taking actions that adapt your project to ensure its ongoing effectiveness

	Little or no extent (1)	**(2)**	**(3)**	**Some extent (4)**	**(5)**	**(6)**	**Very great extent (7)**	**Not able to answer**
The project adapts to new science.	( )	( )	( )	( )	( )	( )	( )	( )
The project regularly re-evaluates and adapts its strategies to changes in the environment (scientific, political, social)	( )	( )	( )	( )	( )	( )	( )	( )

Appendix B: 2016 International Graduate and Postdoctoral Internship Program Evaluation

Please participate in this survey related to your support and experiences in your most recent **internship** for the **GROWTH project** at **Caltech**.

In a continued effort to improve this program, we are conducting a follow-up survey with all internship participants. Your responses are very important. The information you provide will help to make the internship experience more valuable for future student and faculty participants.

Completion of this survey should take approximately 10-15 minutes. Please answer each question honestly and thoroughly. All responses will be kept confidential.

If you have any questions or concerns, please contact me at the following e-mail: tjohnson@smartstart-er.com

Thank you,
Tyler Johnson
Project Evaluator

Internship support

Home institution support

In reflecting on the support services offered to you *before* your internship, please rate how *useful* the following services were in preparing for your time abroad.

	Not at all useful	Slightly useful	Somewhat useful	Very useful	Extremely useful	N/A
Information provided by my host about the internship.	( )	( )	( )	( )	( )	( )
Assistance with getting to your new location (booking the flight) and daily living issues such as accommodations, transportation at your new location, maps, food information, etc.	( )	( )	( )	( )	( )	( )
Assistance from the GROWTH project.	( )	( )	( )	( )	( )	( )
Academic preparation provided by my host such as learning specific software, hardware, calculations, understanding concepts, etc.	( )	( )	( )	( )	( )	( )
My international experience assignments were relevant to my interests.	( )	( )	( )	( )	( )	( )

What other information and/or assistance were you provided that proved useful? Please detail this information and/or assistance and explain why it was important to you. _____

Thinking back, what additional information and/or assistance would have been beneficial to help you better prepare for the internship? _____

Visiting institution support

In reflecting on the support services offered to you *during* your internship, please rate how *useful* the following services were to your time aboard.

	Not at all useful	Slightly useful	Somewhat useful	Very useful	Extremely useful	N/A
Informational/welcome meeting with my host at my visiting institution.	( )	( )	( )	( )	( )	( )
Assistance with daily living issues, such as accommodations, transportation at your new location, computer/internet use, maps, tour, lab information, etc.	( )	( )	( )	( )	( )	( )
Response to my questions, requests, and needs from my visiting institution.	( )	( )	( )	( )	( )	( )
Academic preparation provided by my host such as learning specific software, hardware, calculations, understanding concepts, etc.	( )	( )	( )	( )	( )	( )
Social activities and events.	( )	( )	( )	( )	( )	( )

What other information and/or assistance were you provided that proved useful to you? Please detail this information and/or assistance and explain why it was important to you. _____

Thinking back, what additional information and/or assistance would have been beneficial to help you during your internship? _____

Please rate your level of *agreement* with the following statements about your internship.

	Strongly disagree	Disagree	Neither disagree/agree	Agree	Strongly agree
I felt my internship was an appropriate length of time.	( )	( )	( )	( )	( )
I felt adequately prepared for this experience.	( )	( )	( )	( )	( )
My host provided me with adequate supervision and guidance.	( )	( )	( )	( )	( )
My host provided me with ongoing and valuable feedback.	( )	( )	( )	( )	( )
My host was a good match with my academic interests.	( )	( )	( )	( )	( )
I had meaningful experience working with my host.	( )	( )	( )	( )	( )
I felt a part of a community.	( )	( )	( )	( )	( )

Impact of your internship

In reflecting on the impacts of your internship, rate your level of *agreement* with the following statements. For each statement, please also rate the level of *importance* each of these items is to your internship experience.

	Level of agreement					Importance to you				
	Strongly disagree	Disagree	Neither agree/disagree	Agree	Strongly agree	Not important	Slightly important	Somewhat important	Important	Extremely important
I was assigned tasks that were meaningful to	( )	( )	( )	( )	( )	( )	( )	( )	( )	( )

me.										
I assumed additional responsibility as my experience increased.	( )	( )	( )	( )	( )	( )	( )	( )	( )	( )
I had opportunities to work with like-minded people.	( )	( )	( )	( )	( )	( )	( )	( )	( )	( )
I learned new ways of approaching my work that were specific to the culture I was visiting.	( )	( )	( )	( )	( )	( )	( )	( )	( )	( )
I gained confidence in doing research in this field.	( )	( )	( )	( )	( )	( )	( )	( )	( )	( )
I gained a passion for doing research in this field.	( )	( )	( )	( )	( )	( )	( )	( )	( )	( )
I learned how to conduct scientific research with international collaborators.	( )	( )	( )	( )	( )	( )	( )	( )	( )	( )
I was exposed to new ideas.	( )	( )	( )	( )	( )	( )	( )	( )	( )	( )
I was intellectually challenged.	( )	( )	( )	( )	( )	( )	( )	( )	( )	( )
I had ample opportunities to use my existing skills in practice.	( )	( )	( )	( )	( )	( )	( )	( )	( )	( )
I feel like my contributions made a difference.	( )	( )	( )	( )	( )	( )	( )	( )	( )	( )
I gained a global awareness;	( )	( )	( )	( )	( )	( )	( )	( )	( )	( )

expanding my worldview.										
My personal awareness improved.	( )	( )	( )	( )	( )	( )	( )	( )	( )	( )
I felt engaged in the local community.	( )	( )	( )	( )	( )	( )	( )	( )	( )	( )
I had ample opportunities for networking.	( )	( )	( )	( )	( )	( )	( )	( )	( )	( )

As a result of your internship, please rate your level of *agreement* with the following statements related to your beliefs, confidence and motivations to engage in scientific collaborations.
Since my internship,

	Strongly disagree	**Disagree**	**Neither disagree/agree**	**Agree**	**Strongly agree**
I believe collaborating on a research project with researchers from another discipline and/or country is beneficial for me.	( )	( )	( )	( )	( )
I am confident in my ability to develop a successful research collaboration with astrophysics researchers from another country.	( )	( )	( )	( )	( )
I am motivated to collaborate on scientific projects related to astronomy/astrophysics with researchers from another area of expertise and/or country.	( )	( )	( )	( )	( )

Please select which of the research themes your research project falls under.
( ) My understanding of r-process nucleosynthesis (creation of heavy elements)
( ) My understanding of newborn supernovae
( ) My understanding of the detection and follow-up of small near earth asteroids and their orbits

How much has your understanding of the research you identified above increased after your internship?
( ) Not at all ( ) Slightly ( ) Somewhat ( ) A great deal ( ) Extensively

Please rate your level of *agreement* with the following statements, in reflecting on *before* and *after* your internship experience.
As a result of my internship experience,

	Before					After				
	Not knowledgeable	**Slightly knowledgeable**	**Somewhat knowledgeable**	**Knowledgeable**	**Very knowledgeable**	**Not knowledgeable**	**Slightly knowledgeable**	**Somewhat knowledgeable**	**Knowledgeable**	**Very knowledgeable**
I enhanced my exposure to peer research.	( )	( )	( )	( )	( )	( )	( )	( )	( )	( )
I feel better equipped to identify possible research projects.	( )	( )	( )	( )	( )	( )	( )	( )	( )	( )
I enhanced my understanding of how to collaborate on a project with researchers from another country.	( )	( )	( )	( )	( )	( )	( )	( )	( )	( )
I strengthen my personal network of researchers from other countries.	( )	( )	( )	( )	( )	( )	( )	( )	( )	( )
I have a stronger commitment to develop and maintain international scientific partnerships and collaborations.	( )	( )	( )	( )	( )	( )	( )	( )	( )	( )

I have greater knowledge of careers that are available in astronomy and astrophysics.	( )	( )	( )	( )	( )	( )	( )	( )	( )	( )
I have greater interest in pursuing a career in astronomy or astrophysics.	( )	( )	( )	( )	( )	( )	( )	( )	( )	( )
I feel better prepared for a career in astronomy and astrophysics.	( )	( )	( )	( )	( )	( )	( )	( )	( )	( )

Final Thoughts

In reflecting on your overall experience, please rate the following items from *strongly disagree* to *strongly agree*.

My internship,

	Strongly disagree	Disagree	Neither disagree/agree	Agree	Strongly agree
Met my expectations.	( )	( )	( )	( )	( )
Met my needs.	( )	( )	( )	( )	( )
Was a rewarding experience.	( )	( )	( )	( )	( )
Was valuable for my academic and professional growth.	( )	( )	( )	( )	( )

What was most satisfying about your internship? _____

What was least satisfying about your internship? _____

What suggestions do you have for improving the overall program? _____

What impacts do you believe participating in this internship has had on you? Has it affected you personally? Has it changed your education or career paths? Please explain. _____

What advice would you provide to future students participating in this internship program? What do you wish you had known? _____

Any final thoughts you would like to share about your internship experience? _____

Demographics

What academic year did you participate in an internship?

( ) 2014-15 ( ) 2015-16 ( ) 2016-17 ( ) 2017-18 ( ) 2018-19 ( ) 2019-20

With which gender do you most closely identify

( ) Male ( ) Female

With which ethnic background do you most closely identify?

( ) Hispanic or Latino ( ) Not Hispanic or Latino ( ) Prefer not to answer

With which racial background do you most identify?

( ) Asian ( ) American Indian or Alaska Native ( ) Black or African American
( ) Native Hawaiian or Pacific Islander ( ) Hispanic or Latino ( ) White
( ) Prefer not to answer ( ) Other, please specify: _____

What is your current student status?

( ) Graduate Student ( ) Postdoc

How many internships have you participated in, including the one that you just completed?

( ) 1 ( ) 2 ( ) 3 ( ) 4 ( ) 5+

Are you a first generation college student?

( ) Yes ( ) No ( ) I am not sure ( ) Prefer not to answer

Appendix C: Focus Group Protocol Guide

Home institution support

- Thinking back, what additional information and/or assistance would have been beneficial to help you better prepare for the internship?

Visiting institution support

- Thinking back, what additional information and/or assistance would have been beneficial to help you during your internship?
- What was most **satisfying** about your internship?
- What was least **satisfying** about your internship?
- What impacts do you believe participating in this internship has had on you? Has it affected you personally? Has it changed your education or career paths? Please explain.
- What advice would you provide to future students participating in this internship program? What do you wish you had known?
- Any final thoughts you would like to share about your internship experience?

Appendix D: AY3 – Automated Discovery of the Universe Course Assessment

Please participate in this survey related to your support and experiences in the Freshman Seminar: Automated Discovery of the Universe. To continuously help the project improve, we are asking all students in the seminar to participate in this survey. Your responses are very important to the project.

In this survey you will be asked about your participation in the Freshman Seminar and how it has impacted you, your academic career, and future plans. In particular, you will be asked about seminar content, research skills, and future plans.

Please answer these questions as honestly as possible. All responses will be kept anonymous and names will not be reported to the project administration or funders. If you have any questions about the survey, please contact Tyler Johnson at tjohnson@smartstartecs.com.

Seminar Usefulness and Effectiveness

Please rate your level of *agreement* with the following aspects of the seminar.

	Strongly disagree	Disagree	Neither disagree or agree	Agree	Strongly agree
Lecture information was presented in a logical, step-by-step order	( )	( )	( )	( )	( )
Examinations effectively evaluated seminar material and coverage	( )	( )	( )	( )	( )
Instructor handled student questions well	( )	( )	( )	( )	( )
Instructor understood when class did not understand information	( )	( )	( )	( )	( )
Instructor was available during office hours and offered assistance as needed	( )	( )	( )	( )	( )
Instructor demonstrated enthusiasm in the subject matter	( )	( )	( )	( )	( )
Instructor had a strong command of the subject matter	( )	( )	( )	( )	( )
The seminar raised challenging questions	( )	( )	( )	( )	( )
The seminar stimulated interest and deeper thinking about the subject	( )	( )	( )	( )	( )

Seminar Impact

Achievement of course objectives

Please rate your *agreement* with the following statements:

This seminar,	Strongly disagree	Disagree	Neither disagree or agree	Agree	Strongly agree
Increased my knowledge of fundamental principles in time domain astronomy.	( )	( )	( )	( )	( )
Increased my knowledge of present day time domain astronomy (e.g. current and upcoming optical surveys ZTF, Gaia, Kepler).	( )	( )	( )	( )	( )
Increased my hands-on experience with time series astronomical data (e.g. light curves periods).	( )	( )	( )	( )	( )

Increased my ability to apply software tools (Matlab and Python programming) to analyze astronomical data sets from modern day optical observatories (PFT).	( )	( )	( )	( )	( )
Ignited my excitement/passion for astronomy	( )	( )	( )	( )	( )
Increased my overall knowledge of astronomy	( )	( )	( )	( )	( )

Impact on Educational and Career Trajectories

What is your current major? _____

Do you plan on staying in this major?

( ) Yes ( ) No

If no, do you have any plans on changing to another major?

( ) Yes ( ) No

If yes, what major? _____

Has your participation in the seminar impacted your decision in selecting a major related to astronomy or astrophysics?

If yes, in what ways? _____

If no, please explain _____

Do you plan to attend graduate school or professional school?

( ) Yes ( ) No ( ) Undecided

If yes, what degree? _____

Do you believe that participating in this seminar has affected your interest in pursuing post-secondary education, professional opportunities, and/or a career?

If yes, in what ways? _____

If not, please explain? _____

What did this seminar do *well* in affecting your interest in pursuing post-secondary education, professional opportunities, and/or career? _____

How could this seminar improve to affect your interest in pursuing post-secondary education, professional opportunities, and/or career? _____

Demographics

With which gender do you most closely identify?

( ) Male ( ) Female ( ) Prefer not to answer

With which ethnic background do you most closely identify?

( ) Hispanic or Latino ( ) Not Hispanic or Latino ( ) Prefer not to answer

With which racial background do you most identify?

( ) Asian ( ) American Indian/Alaska Native ( ) Black/African American

( ) Native Hawaiian/Pacific Islander ( ) Hispanic or Latino ( ) White

( ) Multiracial ( ) Prefer not to answer ( ) Other, please specify: _____

What is your current grade level?

( ) College Freshman (13th) ( ) College Sophomore (14th) ( ) College Junior (15th) ( ) College Senior (16th)

Are you a first generation college student?

( ) Yes ( ) No

Appendix E: PIRE Publication Titles

1. Radio follow-up of gravitational wave triggers during Advanced LIGO O1
2. Intermediate Palomar Transient Factory: Realtime Image Subtraction Pipeline
3. iPTF15dtg: a double-peaked Type Ic Supernova from a massive progenitor
4. The peculiar Type Ia supernova iPTF14atg: Chandrasekhar-mass explosion or violent merger?
5. Common Envelope ejection for a Luminous Red Nova in M101
6. Localization and Broadband Follow-up of the Gravitational-wave Transient GW150914
7. Time-varying sodium absorption in the Type Ia supernova 2013gh Decay
8. SN2002es-like Supernovae From Different Viewing Angles
9. iPTF Search for an Optical Counterpart to Gravitational-wave Transient GW150914
10. PTF13efv—An Outburst 500 Days Prior to the SNHunt 275 Explosion and Its Radiative Efficiency
11. Absence of Fast-moving Iron in an Intermediate Type Ia Supernova between Normal and Super-Chandrasekhar
12. The bolometric light curves and physical parameters of stripped-envelope supernovae
13. PS1-14bj: A Hydrogen-Poor Superluminous Supernova With a Long Rise and Slow Decay
14. Galaxy Strategy for LIGO-Virgo Gravitational Wave Counterpart Searches
15. Going the Distance: Mapping Host Galaxies of LIGO and Virgo Sources in Three Dimensions Using Local Cosmography and Targeted Follow-up
16. Type II Supernova Energetics and Comparison of Light Curves to Shock-cooling Models
17. Optical and Near-infrared Observations of SN 2013dx Associated with GRB 130702A
18. Flash Spectroscopy: Emission Lines from the Ionized Circumstellar Material around <10-day-old Type II Supernovae
19. Long-rising Type II supernovae from PTF and CCCP
20. Radio observations of a sample of broad-lined type Ic supernovae discovered by PTF/iPTF: A search for relativistic explosions
21. Detection of Broad Hα Emission Lines in the Late-time Spectra of a Hydrogen-poor Superluminous Supernova