# YOUTH ASTRONOMY APPRENTICESHIP

## AN INITIATIVE TO PROMOTE SCIENCE LEARNING AMONG URBAN YOUTH AND THEIR COMMUNITIES

MIT KAVLI INSTITUTE FOR ASTROPHYSICS AND SPACE RESEARCH

SUMMATIVE EVALUATION REPORT OCTOBER 2009

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"I think many youth are attracted to the program because of its multi-cultural aspects. Many different cultures have a connection to the sky and the stars."

Community-Based Organization Staff, YAA After-School Program

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# EXECUTIVE SUMMARY

## INTRODUCTION

The Institute for Learning Innovation was contracted to conduct the summative evaluation of this NSF-funded, three-year project. The research team (Emma Norland, Susan Foutz, and D. Micheal Krabill) worked throughout the final year of the program (October 2008 – September 2009), both on-site and off, utilizing qualitative and quantitative approaches to assess the impact of the program. The team also examined the viability of scale up and broad dissemination as well the potential for successful replication of the program model across diverse settings.

## THE PROGRAM

The Youth Astronomy Apprenticeship (YAA) is an out-of-school time initiative that fosters science learning as an effective way of promoting overall youth development and competitive professional opportunities among urban teenaged youth and their communities. The program is a collaborative effort of the MIT Kavli Institute for Astrophysics and Space Research, the Smithsonian Astrophysical Observatory, and the Timothy Smith Network. There were originally three main components of the youth experience: the after-school program, the summer apprenticeship, and the youth assistant program. As the program developed, a fourth component emerged: the youth intern experience.

During the development of the program, outcomes for the youth participants, the fellows, the CBO staff, and the local community (as represented by outreach event attendees) were identified.

- Youth participants will: develop scientific habits of mind, personal and interpersonal skills, and an appreciation for and personal interest in astronomy and science, increase engagement in STEM learning experiences, gain knowledge of the value of and opportunities for STEM-related careers, advocate for support and ownership of STEM related learning experiences by their communities, and understand what options they have for continuing participation in STEM-related learning opportunities after they complete the program.

- Fellows will develop or increase: confidence in personal ability to teach astronomy and science content through inquiry/project-based activity, ability to engage science learners according to their developmental needs, assets, and personal learning styles, and competence to provide information about STEM learning and career opportunities and pathways to achieve them.

- CBO staff will: learn to identify and promote features of good science learning programs, develop awareness and knowledge of local resources for science education, and take on leadership and advocate roles to promote science-learning opportunities within their communities.

- Members of local urban communities will: perceive and support STEM learning experiences as relevant, effective ways of promoting overall youth development (including autonomy, responsibility, and academic achievement) and recognize the value of STEM education as providing relevant skills for many career paths and express the desire for additional STEM opportunities in their communities.

## METHODOLOGY

The summative evaluation was conducted during the third and final year of the YAA Project. Researchers triangulated data sources and methods in order to answer four evaluation questions:

- To what extent did the program achieve the planned outcomes for each target audience – youth, fellows, CBO staff, and local community?
- What were the unintended outcomes of the program?
- To what extent did the program impact the youth participants?
- What are the transferable elements of the program model and to what extent can each be manipulated during replication, across context, content, and audience?

Methods included: face-to-face and/or telephone interviews with CBO staff, attendees of outreach events, the fellows, and the project team, expert observation of outreach events and CBO staff training meetings, focus groups with youth participants, the fellows, and the project team, and a quantitative survey of youth participants conducted at three points in time across the program year.

Appropriate validity and reliability tests were performed on all instruments. Data collection methods were pilot-tested before use. Data analysis techniques included pattern analysis for qualitative data. For quantitative data, scale development, data reduction, descriptive statistics and multivariate statistical analyses were used. A meta-analysis across all results was conducted to identify the program model's transferable elements and the flexibility of each during replication.

## RESULTS

First and foremost, the results of the summative evaluation determined that the YAA program had multiple impacts on youth participants. Impacts were assessed using a set of quantitative indicators augmented by findings from focus groups. Quantitative data were collected at three points in time across the program year; focus groups were held twice. Results were compared across the program year and across four levels of youth participation (1st year apprentices, 2nd year apprentices, 1st year assistants/interns and 2nd year assistants/interns).

Findings showed that youth developed Scientific Habits of Mind as illustrated by increased scores throughout the program year and higher scores for those participating for multiple years. Measures of six indicators of Personal and Interpersonal Skills suggested an increase across the program year and all youth experiencing gains in some to many skills. Leadership in Science, the strongest indicator for Personal and Interpersonal Skills, had the largest increases in scores for all youth. Youth also experienced gains in Knowledge of Astronomy, Commitment to Science, and Understanding of Science and Astronomy shown by increasing scores across the program year. Although not to the degree to which they experienced most other impacts, all youth became advocates for STEM-related learning in their communities. Their reported advocacy increased throughout the program year as well as across years of participation. The strongest advocates were 2nd year assistants and interns.

Beyond the impact it had on youth, the YAA program contributed to positive changes in other target audiences including the fellows (frontline informal science educators of the program) and the staff of participating Community-based Organizations. Also, many people attending the program's outreach events (general public, scientists, members of the local community, and youths' families and friends) had positive experiences, gained an appreciation of the value for opportunities informal science education for older youth, and had an increased awareness of astronomy and science concepts in general.

In addition to assessing outcomes and impact, the evaluation identified a set of transferable elements for use in replication of the program model. Each of the elements is important to the successful design and implementation of the YAA model and should be included in any replication. A number of the elements appear to be flexible, however, and may be manipulated to fit the unique characteristics of the site, audiences, and resources.

Elements with flexibility include: the nature of organizational partnerships, the science content and associated expertise, methods for community involvement, the type of integrating content used, and the ways in which youth share knowledge and skills with others.

Elements of the YAA model that are fixed include: older youth from under-represented communities as the participants, OST as the type of education, a multi-disciplinary team as informal science educators, and the spiral curriculum of an apprenticeship model.

In addition to these programmatic elements, there must be a focus on youth outcomes [related to the specific field of science (IE. Astronomy), science and STEM, and personal and interpersonal skills] as well as changes in local community's awareness, appreciation, and support for OST science learning for older youth.

In summary, results of the evaluation showed that the YAA program achieved its objectives and had unanticipated positive impacts across target audiences. Also, thirteen transferable elements were identified as key to the successful replication of the YAA program model.

## RECOMMENDATIONS

The results of the evaluation generated two types of recommendations: Questions for Consideration and Recommendations for Model Dissemination.

Questions for consideration clustered around the following issues:

- The Human Dimension (formality of individual and organizational relationships, origination of the program concept, frontline science educator roles, and the increasing responsibilities of youth participants),
- The Apprenticeship Model (definitions, masters, journeymen, youth interns, mentoring relationships, content for apprenticeships, family involvement, and length of time for apprenticeships),
- Community Involvement (definitions, need for masters in community development, methods of and barriers to community engagement, community verses youth development, and effects of locating the program within a physical community), and
- Transferable Elements (inclusion/exclusion, flexibility)

The following recommendations were made regarding dissemination of the program model:

- The YAA Program model is clearly ready to be disseminated and replicated. There are a number of 'lessons learned' from the evaluation that should be shared with those wanting to replicate the model.
- The leadership of the YAA project should consider creating additional dissemination activities that go beyond a broad sweep approach (conferences, journal articles, the YAA dissemination conference and resources).

    - ◊ These additional activities should include closely supporting a few replication sites that have different characteristics from the current YAA program. This manipulation of certain transferable elements during replication will test assumptions about flexibility of elements. In addition to any program evaluation work, a strong research component should be included.
    - ◊ Sites for model replication should be selected based upon: a non-Astronomy science focus and perhaps a non-science (another STEM) focus. In addition, a site should be included where the community is the lead partner with additional organizations brought in to participate. Consider using a site where the partnership does not include a university.
- As a part of dissemination of the results of this project, the project team should seek funding to host a separate conference or workshop for members of the communities and local organizations that were involved.
- During dissemination of the YAA program model, the project team should stress the importance of involving the youths' communities throughout the program.
    - ◊ As a part of this effort, recommend that they begin by defining the word 'community'. It may be different for different organizations and sites. Suggest they enlist the support of experts in community engagement and community development to put a plan together for working with and in local communities.
- During dissemination, the project team should explain the importance of using outreach events to enhance youth outcomes. Include the benefits of varying the location of those outreach events including community locations as well as more formal settings, such as a university campus. Youth need the opportunity to demonstrate their skills and abilities 'at home' as well as for a rigorous and unfamiliar audience on campus.
- Continue to test the Apprenticeship Model and its appropriateness for older youth, by using the Apprenticeship Model in programs beyond the YAA program.
- Continue to follow-up and track YAA graduates. Develop and implement a formal system to gather information on an on-going basis.

# INTRODUCTION

This document contains the summative evaluation report for the *Community Science Learning through Youth Astronomy Apprenticeships* project. The projects' partners included the Massachusetts Institute of Technology Kavli Institute for Astrophysics and Space Research, the Smithsonian Astrophysical Observatory (SAO), and the Timothy Smith Network (TSN). The Institute for Learning Innovation was engaged to conduct both formative and summative evaluations.

The project, a three-year pilot program funded by a National Science Foundation Informal Science Education grant, has had extensive formative evaluation throughout Year One (2006-2007) and Year Two (2007-2008). The summative evaluation took place during the Year Three, from October 2008 through September 2009.

Summative evaluation is conducted when there are questions about a mature program's success in achieving short-term outcomes and longer-term impacts. Usually, a program is well established (4-7 years) before undergoing a summative evaluation, especially when examining secondary, long-term outcomes and impacts. For grant-funded pilot projects and programs, however, there is a tighter timeframe for assessing outcomes and impacts.

Typical questions asked during a summative evaluation are: Did the program achieve its goals/objectives? Should the program be scaled up? Should a large-scale program be continued? Is the program model transferable to other sites, audiences, and content? Do outcomes vary across different sub-groups of the program's audiences? What are the unintended outcomes (and do any positive unintended outcomes outweigh any negative unintended outcomes)?

This report contains a description of the program, the methods used to conduct the summative evaluation, results for each evaluation question (listed below), conclusions, and recommendations.

Target audiences for the project included youth apprentices, youth assistants, and youth interns in the program (primary audience), the local community (secondary audience), and two support audiences: 1) the fellows that facilitated all components of the program and 2) the staff of the community-based organizations that co-facilitated the after-school portion of the program.

The evaluation was guided by four major evaluation questions. The results for questions one, two, and three can be found in the section, 'Results Related to Audience Outcomes'. Question four is addressed in the section, 'Results Related to Transferable Elements of the Program Model'.

***Q1. To what extent did the program achieve the planned outcomes for each target audience?***

***Q2. What were the unintended outcomes of the program?***

***Q3. To what extent did the program have an impact on the youth that participated in the program?***

***Q4. What are the transferable elements of the program model and to what extent can each be manipulated during replication across context, content, and audience?***

# A DESCRIPTION OF THE PROGRAM

## INTRODUCTION

This section contains an overview of the Youth Astronomy Apprentice (YAA) program, the program theory, associated logic models, and a figure illustrating the progression of the program model from Year One through Year Three. Additionally, readers will find a listing of primary, secondary, and support audience outcomes.

## ABOUT THE YAA PROGRAM[1]

The Youth Astronomy Apprenticeship (YAA) is an out-of-school time initiative to foster science learning among urban teenage youth and their communities. The goal of YAA is to broaden the awareness of science learning as an effective way of promoting overall youth development and of leading to competitive professional opportunities.

### *Youth Astronomy Apprenticeship Program*

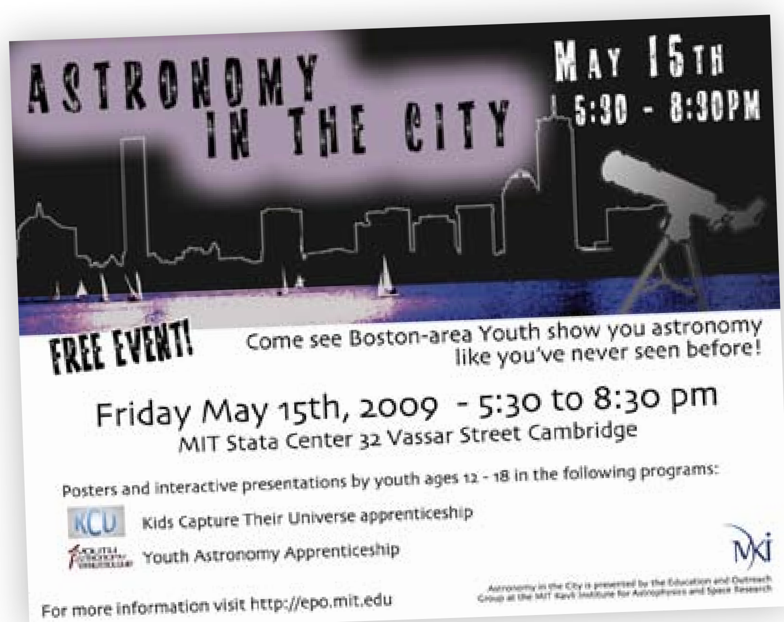
By weaving together science learning and the practice of skills needed in a range of different professions, YAA aims to help youth develop a strong sense of ownership of their work and to make them attentive to and responsible for the quality of the science presentations they offer during their outreach events.

The YAA program progressively develops youth's science knowledge and 21st century employable skills through several stages:

***After-School Program*** - Youth engage in astronomy investigations, take astronomical images using robotic telescopes they can operate via the Internet, learn to use software tools to process astronomical images, and produce reports and presentations about their investigations. The after-school sessions take place at local community-based organizations.

***Summer Apprenticeship Program*** - Youth that complete the after-school program are eligible for a paid position with the YAA apprenticeship program that takes place at MIT. Because the summer program is an actual apprenticeship, YAA is committed to bringing to the program professionals from a variety of fields to train and work with the YAA apprentices. Youth benefits from the expertise provided by:

- Scientists and science educators from MIT and Harvard
- Members of the Underground Railway Theater - a local theater company
- Staff from Jeff Kennedy Associates - a museum exhibition design and planning company




[1] As described in the Program's Fact Sheet, Updated 2009

- The director of ThinkCollaborative - a local marketing and advertising company.

With the support of many local professionals, YAA apprentices:

- Write, produce and perform science/astronomy plays
- Design and facilitate activities to introduce a lay audience to the use of the telescope
- Create components for professional museum exhibits
- Create and run planetarium shows that they perform at various venues using a portable planetarium
- Create a promotional campaign for their community outreach events and to recruit new participants.

***Community Outreach Events: Youth as Science Ambassadors*** **-** By the end of the summer apprenticeship, YAA youth are ready to present their science/astronomy performances at various venues in their communities across the city. In 2007-2008 YAA performances reached out to an estimated 750 people, both at local ("Astronomy in the City" at Hibernian Hall) and national events (AAAS conference).

***Youth Assistant Program: Youth as Agents of Change -*** At the end of the summer apprenticeship some of the youth are willing to take on a major role in the YAA program itself and join MKI staff to work as youth assistants for the YAA after-school programs. With additional training and under the mentorship of YAA staff, youth are gradually empowered to share their learning and passion for science with other youth. As they grow in their roles, youth realize the challenges involved in facilitating somebody else's learning experience. With surprise, they also find themselves being identified as role models: These young ambassadors of science can prove to their peers that – contrary to a widespread teenage urban culture - to engage in science activities - in and outside of the classroom - is actually "OK," and that it can be a rewarding and exhilarating experience.

### *Demographics*

Over three years, the YAA program recruited 178 youth (49% boys and 51% girls) with a retention rate of 54% (52% for boys and 54% for girls). In three years 71 YAA apprentices worked at MIT in the summer, and 17 became YAA assistants: 100% of the assistants returned to the YAA summer apprenticeship the following summer. Of the 178 youth that joined the program so far 95% are from populations historically underrepresented in STEM. The ethnic groups with the largest number of participants so far are: African-American (40%), Hispanic (25%), Cape Verdean (11.5%) and Somali (4%).

## PROGRAM THEORY

A program's theory describes the assumptions made about resources and activities and how they lead (or will lead) to intended outcomes (McLaughlin and Jordan, 2004). In addition to the description of the program's theory, most programs typically have logic models to graphically represent program theory.

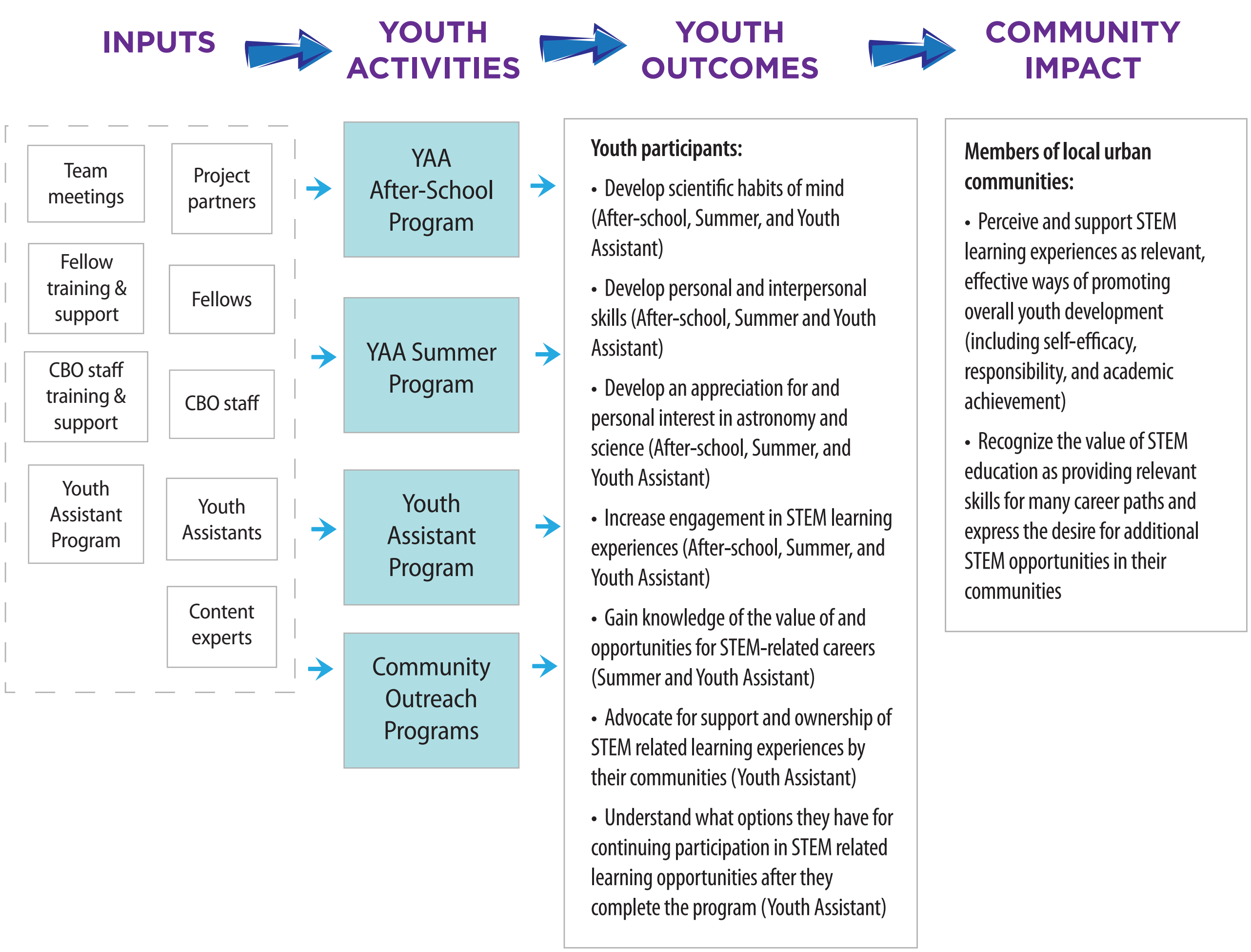
Program logic models are brief diagrams that give a picture of how the program theoretically works to achieve benefits for participants. They clarify the cause-and-effect relationship among program resources, activities and outcomes from key stakeholder perspectives (Love, 2004).

A program's theory of action can be developed before the program is implemented or after the program is under way (Rogers, Petrosino, Huebner, and Hasci, 2000). For this project, a basic program theory was offered in the project proposal. At the beginning of the project, the theory was clarified, using a logic model process, in order to link audiences to specific outcomes.

As the program was implemented and formatively evaluated, sections of the logic model were revised to more accurately represent the program as implemented. At the end of the second year of the project, target outcomes were clarified in preparation for measurement during the summative evaluation. These outcomes, organized by primary, secondary, and support audiences, are provided in this section. They also serve to organize the Findings Related to Outcomes section later in this report.

The Figure below contains the basic logic model illustrating the theory of the YAA Program. Two additional models (presented on the next page) show the hypothesized contributions of the support audiences.

LOGIC MODEL: YAA PROGRAM THEORY OF ACTION, PRIMARY AND SECONDARY AUDIENCES



# LOGIC MODELS: YAA PROGRAM THEORY OF ACTION - SUPPORT AUDIENCES

## FELLOW ACTIVITIES → FELLOW OUTCOMES → INPUTS → YOUTH ACTIVITIES → YOUTH OUTCOMES → COMMUNITY IMPACT

**FELLOW ACTIVITIES**

- Team meetings
- Participation in Program Components
- Fellow training & support

**FELLOW OUTCOMES**

**Fellows develop / increase:**

- Confidence in personal ability to teach astronomy and science content through inquiry/project-based activity
- Ability to engage science learners according to their developmental needs, assets, and personal learning styles
- Competence to provide information about STEM learning and career opportunities and pathways to achieve them.

**INPUTS**

- Fellows

**YOUTH ACTIVITIES**

- YAA After-School Program
- YAA Summer Program
- Youth Assistant Program
- Community Outreach Programs

**YOUTH OUTCOMES**

**Youth participants:**

- Develop scientific habits of mind (After-school, Summer, and Youth Assistant)
- Develop personal and interpersonal skills (After-school, Summer and Youth Assistant)
- Develop an appreciation for and personal interest in astronomy and science (After-school, Summer, and Youth Assistant)
- Increase engagement in STEM learning experiences (After-school, Summer, and Youth Assistant)
- Gain knowledge of the value of and opportunities for STEM-related careers (Summer and Youth Assistant)
- Advocate for support and ownership of STEM related learning experiences by their communities (Youth Assistant)
- Understand what options they have for continuing participation in STEM related learning opportunities after they complete the program (Youth Assistant)

**COMMUNITY IMPACT**

**Members of local urban communities:**

- Perceive and support STEM learning experiences as relevant, effective ways of promoting overall youth development (including self-efficacy, responsibility, and academic achievement)
- Recognize the value of STEM education as providing relevant skills for many career paths and express the desire for additional STEM opportunities in their communities

## CBO STAFF ACTIVITIES → CBO STAFF OUTCOMES → INPUTS → YOUTH ACTIVITIES → YOUTH OUTCOMES → COMMUNITY IMPACT

**CBO STAFF ACTIVITIES**

- Team meetings
- Participation in After-School Program
- CBO staff training & support

**CBO STAFF OUTCOMES**

**CBO staff:**

- Learn to identify and promote features of good science learning programs
- Develop awareness and knowledge of local resources for science education
- Take on leadership and advocate roles to promote science learning opportunities within their communities

**INPUTS**

- CBO Staff

**YOUTH ACTIVITIES**

- YAA After-School Program
- YAA Summer Program
- Youth Assistant Program
- Community Outreach Programs

**YOUTH OUTCOMES**

**Youth participants:**

- Develop scientific habits of mind (After-school, Summer, and Youth Assistant)
- Develop personal and interpersonal skills (After-school, Summer and Youth Assistant)
- Develop an appreciation for and personal interest in astronomy and science (After-school, Summer, and Youth Assistant)
- Increase engagement in STEM learning experiences (After-school, Summer, and Youth Assistant)
- Gain knowledge of the value of and opportunities for STEM-related careers (Summer and Youth Assistant)
- Advocate for support and ownership of STEM related learning experiences by their communities (Youth Assistant)
- Understand what options they have for continuing participation in STEM related learning opportunities after they complete the program (Youth Assistant)

**COMMUNITY IMPACT**

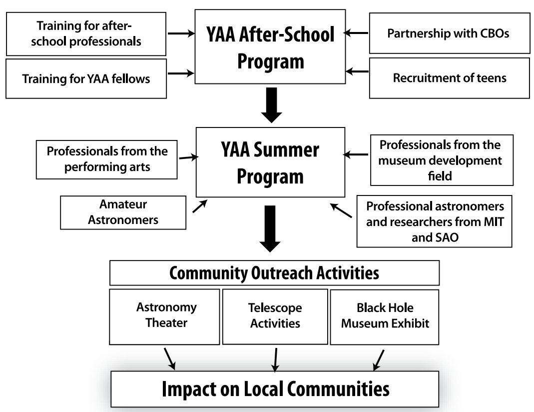
**Members of local urban communities:**

- Perceive and support STEM learning experiences as relevant, effective ways of promoting overall youth development (including self-efficacy, responsibility, and academic achievement)
- Recognize the value of STEM education as providing relevant skills for many career paths and express the desire for additional STEM opportunities in their communities

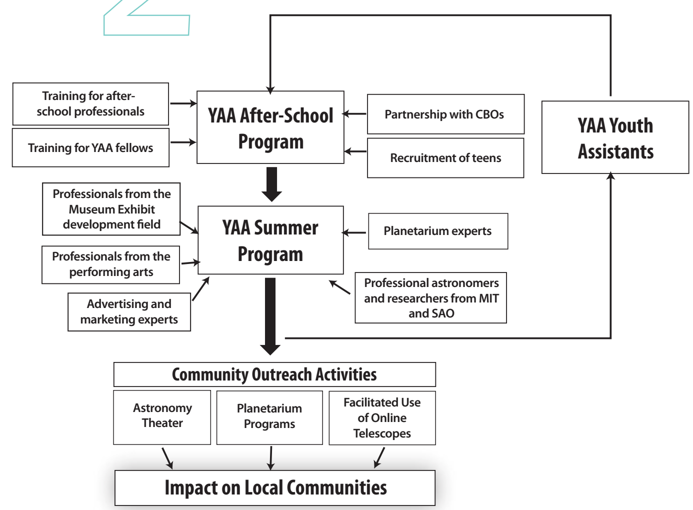
The following Figures provide models of the program that highlight the changes made to the program across the project's three years. These models contain the key components of the program and their relationships to one another.

## EVOLUTION OF YAA PROGRAM MODEL

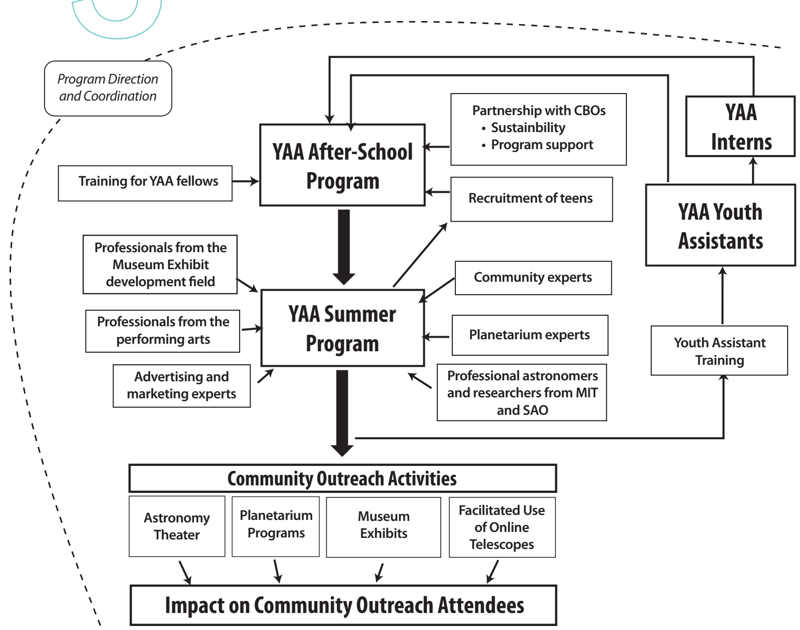
### 1 YEAR ONE




### 2 YEAR TWO




### YEAR THREE 3



## AUDIENCE OUTCOMES

There were four audiences with pre-identified target outcomes: youth apprentices, youth assistants, and youth interns (the primary audience), the local community (the secondary audience), the fellows (a support audience), and the CBO staff (a support audience). The following describes each set of outcomes.

***Outcomes of Youth Apprentices, Youth Assistants, Youth Interns***

- Participants will develop scientific habits of mind (After-school, Summer, and Youth Assistant).
- Participants will develop personal and interpersonal skills (After-school, Summer and Youth Assistant).
- Participants will develop an appreciation for and personal interest in astronomy and science (After-school, Summer, and Youth Assistant).
- Participants will increase engagement in STEM learning experiences (After-school, Summer, and Youth Assistant).
- Participants will gain knowledge of the value of and opportunities for STEM-related careers (Summer and Youth Assistant).
- Participants will advocate for support and ownership of STEM-related learning experiences by their communities (Youth Assistant).
- Participants will understand what options they have for continuing participation in STEM-related learning opportunities after they complete the program (Youth Assistant).

***Outcomes of Outreach Activities with Local Community***

- Members of local urban communities will perceive and support STEM learning experiences as relevant, effective ways of promoting overall youth development (including autonomy, responsibility, and academic achievement).
- Members of local urban communities will recognize the value of STEM education as providing relevant skills for many career paths and express the desire for additional STEM opportunities in their communities.

***Outcomes of Program Fellows' Activities***

- Fellows will develop/increase confidence in personal ability to teach astronomy and science content through inquiry/project-based activity.
- Fellows will develop/increase ability to engage science learners according to their developmental needs, assets, and personal learning styles.
- Fellows will develop/increase competence to provide information about STEM learning and career opportunities and pathways to achieve them.

***Outcomes of Community-based Organization (CBO) Staff Activities***

- Staff will learn to identify and promote features of good science learning programs.
- Staff will develop awareness and knowledge of local resources for science education.
- Staff will take on leadership and advocate roles to promote science-learning opportunities within their communities.

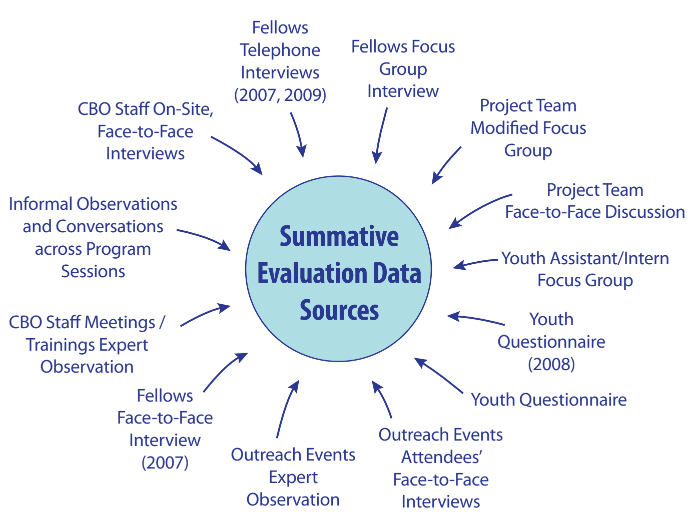
# SUMMATIVE EVALUATION METHODOLOGY

## INTRODUCTION

This section contains a description of the data sources, sampling processes, instrumentation, and data collection methods used during the summative evaluation. The section is organized by data source and methods used with each source.

As shown in the figure below, there were a total of 13 different combinations of data sources and methods. Specifically, the sources used in the study included: 1) the youth apprentices, youth assistants, and youth interns, 2) attendees at outreach events, 3) fellows, 4) core project team, and 5) staff of the community-based organizations.

Data Sources and Methods Used
(Data collected in 2009 unless otherwise noted)




The summative evaluation was conducted during the third year of the project (October 2008 – September 2009) and employed a mixed methods design. Both qualitative and quantitative processes and instruments were used. This approach intentionally involved dual paradigms, each offering a meaningful and legitimate way of knowing and understanding (Green and Caracelli, 1997).

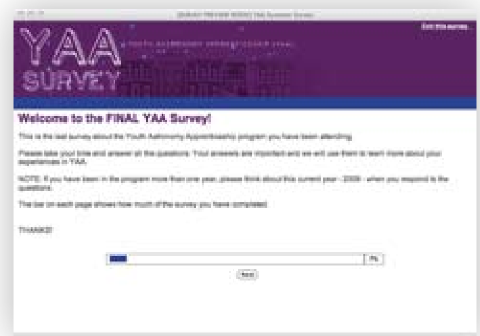
Additionally, using mixed methods provided the breadth and depth of phenomena for maximum interpretation and meaning making and resulted in triangulated evaluation evidence to enhance the reliability and validity of the findings (Chen, 1997; Stufflebeam, 2001).

## METHODOLOGY: YOUTH PARTICIPANTS (YOUTH APPRENTICES, YOUTH ASSISTANTS, AND YOUTH INTERNS)

Two different methods were used to gather data from the youth during 2009: 1) an on-line survey for all youth, and 2) a focus group interview with Youth Assistants and Youth Interns. Instrument development, sampling, and data collection methodology for each are described below. In addition to data gathered using these methods, qualitative data from a 2008 on-line questionnaire were reviewed. The specifics regarding development and use of this questionnaire are included in the Appendix as part of the 2008 Summer Youth Astronomy Apprenticeship Report.

### On-line Survey for All Youth

During the third year of the project, all youth were asked to participate in an on-line survey process. The questionnaire used in this survey was administered at three different points in time during the project year: early in the after-school program (March), early in the summer apprenticeship program (June), and at the end of the summer apprenticeship program (August). The appendix contains each version of the questionnaire.




The questionnaire contained 12 quantitative scales: beliefs about science, attitude toward doing science, beliefs about astronomy, perceived knowledge of astronomy, reported decision-making behavior, reported goal-setting behavior, reported interpersonal communication, reported public speaking behavior, reported leadership behavior, reported teamwork behavior, intentions to participate in science in the future, and intentions to advocate for science in the local neighborhood.

**TABLE 1 - ORIGINAL SCALE DEVELOPMENT**

| SCALE NAME | CORRESPONDING ITEMS (FROM QUESTIONNAIRE 1) | CRONBACH'S ALPHA OF ORIGINAL SCALE (AND RESULTING ALPHA IF ONE ITEM DELETED) |
|---|---|---|
| Beliefs about Science | Question 8 (5 items) | .50 (n=46) (.54 if #5 deleted) |
| Attitude toward Doing Science | Question 9 (4 items) | .55 (n=47) (.63 if #4 deleted) |
| Beliefs about Astronomy | Question 10 (6 items) | .51 (n=48) (.56 if #2 deleted) |
| Perceived Knowledge of Astronomy | Question 11 (5 items) | .77 (n=47) |
| Reported Decision-making Behavior | Question 12 (5 items) | .57 (n=47) |
| Reported Goal-Setting Behavior | Question 13 (5 items) | .32 (n=48) (.56 if #1 deleted) |
| Reported Interpersonal Communication | Question 14 (6 items) | .36 (n=45) (.51 if #3 deleted) |
| Reported Public Speaking Behavior | Question 15 (6 items) | .78 (n=45) |
| Reported Leadership Behavior | Question 16 (8 items) | .10 (n=46) (.54 if #3 deleted) |
| Reported Teamwork Behavior | Question 17 (8 items) | .68 (n=46) (.84 if #5 deleted) |
| Intentions to Participate in Science in the Future | Question 18 (6 items) | .91 (n=46) |
| Intentions to Advocate for Science in the Local Neighborhood | Question 19 (4 items) | .88 (n=49) |

The questionnaire also contained a number of qualitative questions. Each time the questionnaire was administered, the qualitative questions were revised to gather data appropriate for the time and activities in the project year. The quantitative scales, however, remained the same across the three administrations.

Scales were constructed by identifying the constructs of interest and writing items to represent those constructs. Each of the twelve constructs was hypothesized to be an indicator of one or more youth outcomes. For example, reported decision-making behavior, reported goal-setting behavior, reported interpersonal communication, reported public speaking behavior, reported leadership behavior, and reported teamwork behavior, were all hypothesized to be indicators of the youth outcome, personal and interpersonal skills.

Items were written using both positive and negative wording. Each item had a response scale of five points. Reported behavior items used the following anchors: never, rarely, sometimes, most of the time, and always. Beliefs, attitude, and intentions scales were anchored using the following words: strongly disagree, disagree, not sure, agree, and strongly agree. Then the scales were tested for face and content validity and pilot-tested for reliability. Face and content validity were determined through a panel of experts (core project team members and experts in positive youth development and psychometrics) and a field test (using participants from year two). Extensive rewriting of items occurred as a result of these processes. After items were deemed ready for use, the questionnaire was administered for the first time. Internal consistency measures were calculated for each scale using Cronbach's Alpha. The results appear in Table 1 and show that the scales were acceptable for the early stages of instrument development but not all were optimal (Nunnally and Bernstein, 1994). Alphas ranged from .50 to .91.

### *Questionnaire Items and Coding Scheme*

Table 2, on the following page, includes all of the items used in the development of indicators. The items with an asterisk were reverse coded for some analyses.

### *Creating Meaningful Groups by Participation Level*

Because the evaluation occured during the program's third year, there were different time frames within which a youth could have held one or more positions in the program. It was important to capture, from the youths' perspectives, how they would describe their current participation each time the questionnaire was administered. For example, for Questionnaire One, a youth could have been an after-school program participant, a youth assistant helping for their first year, a youth assistant helping for a second year, or a youth not in the after-school program currently but had been either a youth apprentice or youth assistant the year before. Similarly, for Questionnaires Two and Three, there were a number of combinations of roles and years. In addition, position titles changed and a new role had been added.

It was determined that for coding and analysis, the language from Questionnaires Two and Three would be used to describe participation level and the categories from Questionnaire One would be recoded to match. Researchers could not determine if a youth chose the 'correct' participation level, rather that the youth perceived he/she was making the best descriptive choice for that point in time.

The final coding for levels of participation, taken from Questionnaires Two and Three, were:

1=Apprentice

2=Second Year Apprentice

3=Youth Assistant or Intern

4= Second Year Assistant or Intern

5=Fellow=5 (Other)

6=Other=5 (Other)

Questionnaire One responses to participation level were recoded to reflect those categories.

1 (After-school program participant)=1 (Apprentice)

2 (Youth Assistant)=3 (Youth Assistant or Intern)

3 (Second Year Youth Assistant)=4 (Second Year Youth Assistant or Intern)

4 (No participation now but was an apprentice last year)=5 (Other)

5 (No participation now but was a Youth Assistant last year)=5 (Other)

6 (Other)=5 (Other)

There was no number two as a recode for Questionnaire One because there were no second year apprentices in this year's after-school program.

### *Creating a Final Set of Outcome Measures*

To determine if there were alternative underlying factors affecting responses, an exploratory factor analysis was conducted with responses from all questionnaires using Principal Components Analysis extraction with Varimax Rotation (with Kaiser Normalization). Missing data were replaced with item means. A factor solution of 20 factors converged after 35 rotations. Through examination of the Scree Plot and the Rotated Component Matrix, six factors were selected and are presented in the Final Outcome Measures Table (Table 3). These six factors together explained 44% of the variance in the set of scores.

To determine if additional items would contribute to these six factors a second factor analysis was conducted using all items but limiting the number of factors to six. Three of the six factors were interpretable but only factors one and two have been included in the study. The third factor was essentially the same as the original factor one.

A third analysis of the data examined whether there were a few major underlying factors that may have contributed to youth responses. All items were forced into a three-factor solution. The resulting three factors clearly delineated three key themes of the project: a commitment to science, gains in positive youth development, and a greater understanding of science and astronomy. The items and internal consistency of each scale are located in the Final Outcomes Measures table.

One specific outcome measure, scientific habits of mind, was not identified through a factor analysis process. Rather, items deemed to represent the outcome were chosen from the initial scales. Inter-item correlations for these items were examined, and a final selection of items was tested for internal consistency. This final outcome measure is listed along with the others, in the Final Outcomes Measures (Table 3).

### *Data Analysis for Quantitative Measures*

Calculating the mean of the sum of each set of identified items created final outcome measures. Descriptive statistics were computed for: total set of responses, each participation group, each of three administrations of the questionnaire,

**TABLE 2 - QUESTIONS AND ITEMS IN THE ON-LINE YOUTH QUESTIONNAIRE**

NOTE: Negatively worded items (*) were recoded.

**Q8. How much do you agree or disagree with each statement about SCIENCE?**

*1. If one important scientist says an idea is true, all the other scientists will agree with it.

*2. Scientific beliefs really do not change over time.

*3. We can always get answers to our questions by asking a scientist.

4. Two scientists could make the same observations of something and reach different conclusions.

5. People should understand science because it affects their lives everyday.

**Q9. How much do you agree or disagree with the following statements about DOING SCIENCE?**

*1. I personally don't like science very much.

2. I am pretty good at science.

3. I might not make great discoveries but I think working in science would be fun.

*4. Science is difficult.

**Q10. How much do you agree or disagree with each of the following statements about ASTRONOMY?**

1. I think astronomy is interesting.

*2. Astronomy is nice for a hobby but not for someone who is serious about a science career.

3. I see how astronomy is important to my life.

4. It would be fun to share what I know about astronomy with my family/friends.

*5. Astronomy is really only important to someone who wants to be a scientist.

6. Everyone should know the basics of astronomy.

**Q11. How much do you agree or disagree with the following statements about your KNOWLEDGE OF ASTRONOMY?**

1. I can explain the life of a star to someone my age.

2. I understand the basics of how a telescope works.

3. Light is an important key to studying everything in the universe.

4. I can explain what a nebula is.

5. I can explain what it would take to sustain life on a planet other than earth.

**Q12. When faced with MAKING DECISIONS in your everyday life (such as buying a new cell phone, going to a certain party, how much to study for a test, etc.), how often do you...**

1. Look for new information to help understand the situation better.

2. Discuss ideas with family and/or friends.

*3. Just make a decision quickly and move on.

4. Consider many different possibilities before picking one.

5. Think about the decision for a while before acting.

**Q13. In GOAL-SETTING, how often do you...**

*1. Set simple goals so you can reach them easily.

2. Achieve the goals you set.

3. Use feedback, whether positive or negative, to help you reach your goals.

*4. When you don't reach a goal easily, you give up.

5. Stretch yourself by setting challenging but realistic goals.

**Q14. When TALKING with others, how often do you...**

1. Easily see the other person's point of view.

2. Respond to what someone says and not how they say it.

*3. Correct someone when you disagree with their ideas.

*4. Interrupt other people to say your ideas before you forget them.

5. Find it easy to get your point across to others.

6. Think before you speak.

**Q15. When SPEAKING IN FRONT OF A GROUP, how often do you...**

1. Feel comfortable speaking in front of large groups.

*2. Freeze up when you are speaking to a large crowd.

*3. Feel you do not have the preparation to speak in front of a group.

4. Know how to explain your ideas to others.

5. Enjoy sharing what you know with others.

6. Plan HOW to present your message based on the type of group you are talking to.

**Q16. When in a position of LEADERSHIP, how often do you...**

1. Handle disagreements pretty well.

2. Listen to others when they speak.

*3. Instruct others on what to do.

4. Take responsibility for your actions.

*5. Explain why someone is wrong.

6. Show confidence in tough situations.

7. Consider new ways of doing things.

8. Plan for a project, even when you are very familiar with it.

**Q17. When WORKING IN A GROUP, how often do you...**

1. Work comfortably with others in groups.

2. Have a positive influence on other team members.

3. 'Go with the flow'.

4. Learn new skills that will help you in the future.

*5. When there is a disagreement in the group, try to influence the group for the better.

6. Hear others say you are someone they can count on in a work group.

7. Enjoy working with others in a group.

8. Think to yourself that it is important in life to be able to work in a team.

**Q18. How much do you agree or disagree with each of the following statements about your FUTURE IN SCIENCE?**

1. I know of other science activities outside of school I can do.

2. I would consider taking more science classes in high school if I could.

*3. I do not plan to do any more science unless I have to.

4. If I go to college, I will probably major in a science field.

5. I plan to work in a science field as a career.

6. I can see myself maybe getting a graduate degree in a science field.

**Q19. How much do you agree or disagree with the following statements about SCIENCE in your NEIGHBORHOOD?**

1. My neighborhood should try to get more opportunities for people to learn about science.

2. There should be more out-of-school science activities in my neighborhood for kids to participate in.

3. I would support a local campaign for more science-related activities in my neighborhood.

4. I would speak at a local community meeting in support of more science-related activities for my neighborhood.

and each participation group for each of three administrations of the questionnaire. Average scores and standard deviations were examined for trends across time, participation group, and outcome measures.

## Youth Assistant/Intern Focus Group

On May 27, 2009 eight youth assistants from the YAA program participated in a semi-structured focus group. Questions for the focus group were developed by the researchers and reviewed for validity and relevance before use. The focus group lasted approximately 1 hour and 15 minutes and was audio-recorded. Participants in the focus group received a gift certificate for their participation. Participants varied in age, but all had been involved with the YAA program for two or more years. The focus group centered on the nature of the youth assistant position, possible impacts from the program on the participants, and possible impacts on the community. A pattern analysis was performed to identify trends in the data.

**TABLE 3 - FINAL OUTCOME MEASURES**

| FINAL OUTCOME MEASURE NAME | FACTOR ANALYSIS | CORRESPONDING ITEMS (FROM QUESTIONNAIRE 1) | CRONBACH'S ALPHA |
|---|---|---|---|
| Future in Science | Original Exploratory – 20 Factors – Factor 1 | Question 9 (item 1)<br>Question 18 (items 1-6) | .90 (n=98) |
| Advocate for Science in the Community | Original Exploratory – 20 Factors – Factor 2 | Question 19 (items 1-4) | .89 (n=99) |
| Reported Teamwork Behavior | Original Exploratory – 20 Factors – Factor 3 | Question 15 (item 4)<br>Question 17 (items 1, 2, 4, 6-8) | .84 (n=97) |
| Perceived Knowledge of Astronomy | Original Exploratory – 20 Factors – Factor 4 | Question 11 (5 items) | .79 (n=100) |
| Internal/External Focus | Original Exploratory – 20 Factors – Factor 5 | Question 16 (items 5-7)<br>Question 17 (item 5) | .76 (n=97) |
| Self Esteem | Original Exploratory – 20 Factors – Factor 6 | Question 9 (item 2)<br>Question 15 (items 1-2, 4)<br>Question 17 (item 2) | .76 (n=96) |
| Leadership in Science | Forced Six Factor Solution – Factor 1 | Question 13 (items 3, 5)<br>Question 15 (item 5)<br>Question 16 (items 6-7)<br>Question 19 (items 1-4) | .88 (n=95) |
| Communication | Forced Six Factor Solution – Factor 2 | Question 14 (item 5)<br>Question 15 (items 1-4) | .81 (n=95) |
| Commitment to Science | Forced Three Factor Solution – Factor 1 | Question 9 (item 1)<br>Question 10 (item 3)<br>Question 18 (items 1-6)<br>Question 19 (items 1-4) | .90 (n=95) |
| Positive Youth Development | Forced Three Factor Solution – Factor 2 | Question 13 (items 2, 3 5)<br>Question 14 (items 1, 5)<br>Question 15 (items 4-6)<br>Question 16 (items 2, 4, 7)<br>Question 17 (1, 2, 4, 6-8) | .89 (n=92) |
| Understanding of Science and Astronomy | Forced Three Factor Solution – Factor 3 | Question 8 (items 1-3)<br>Question 11 (items 1-5) | .72 (n=97) |
| Scientific Habits of Mind | None | Question 8 (items 2, 4-5)<br>Question 12 (items 1, 4)<br>Question 13 (item 3)<br>Question 15 (item 6)<br>Question 16 (items 7-8) | .72 (n=93) |

**LIST OF QUESTIONNAIRE ITEMS FOR EACH OUTCOME MEASURE**

**FUTURE IN SCIENCE (7 ITEMS)**

Q9-1. I personally don't like science very much.*

Q18-1. I know of other science activities outside of school I can do.

Q18-2. I would consider taking more science classes in high school if I could.

Q18-3. I do not plan to do any more science unless I have to.*

Q18-4. If I go to college, I will probably major in a science field.

Q18-5. I plan to work in a science field as a career.

Q18-6. I can see myself maybe getting a graduate degree in a science field.

**ADVOCATE FOR SCIENCE IN THE COMMUNITY (4 ITEMS)**

Q19-1. My neighborhood should try to get more opportunities for people to learn about science.

Q19-2. There should be more out-of-school science activities in my neighborhood for kids to participate in.

Q19-3. I would support a local campaign for more science-related activities in my neighborhood.

Q19-4. I would speak at a local community meeting in support of more science-related activities for my neighborhood.

**REPORTED TEAMWORK BEHAVIOR (7 ITEMS)**

Q15-4. Know how to explain your ideas to others.

Q17-1. Work comfortably with others in groups.

Q17-2. Have a positive influence on other team members.

Q17-4. Learn new skills that will help you in the future.

Q17-6. Hear other say you are someone they can count on in a work group.

Q17-7. Enjoy working with others in a group.

Q17-8. Think to yourself that it is important in life to be able to work in a team.

**PERCEIVED KNOWLEDGE OF ASTRONOMY (5 ITEMS)**

Q11-1. I can explain the life of a star to someone my age.

Q11-2. I understand the basics of how a telescope works.

Q11-3. Light is an important key to studying everything in the universe.

Q11-4. I can explain what a nebula is.

Q11-5. I can explain what it would take to sustain lie on a plane other than earth.

**INTERNAL/EXTERNAL FOCUS (4 ITEMS)**

Q16-5. Explain why someone is wrong.*

Q16-6. Show confidence in tough situations.

Q16-7. Consider new ways of doing things.

Q17-5. When there is a disagreement in the group, try to influence the group for the better.*

**SELF ESTEEM (5 ITEMS)**

Q9-2. I am pretty good at science.

Q15-1. Easily see the other person's point of view.

Q15-2. Freeze up when you are speaking to a large crowd.*

Q15-4. Know how to explain your ideas to others.

Q17-2. Have a positive influence on other team members.

**LEADERSHIP IN SCIENCE (9 ITEMS)**

Q13-3. Use feedback, whether positive or negative, to help you reach your goals.

Q13-5. Stretch yourself by setting challenging but realistic goals.

Q15-5. Enjoy sharing what you know with others.

Q16-6. Show confidence in tough situations.

Q16-7. Consider new ways of doing things.

Q19-1. My neighborhood should try to get more opportunities for people to learn about science.

Q19-2. There should be more out-of-school science activities in my neighborhood for kids to participate in.

Q19-3. I would support a local campaign for more science-related activities in my neighborhood.

Q19-4. I would speak at a local community meeting in support of more science-related activities for my neighborhood.

**COMMUNICATION (4 ITEMS)**

Q14-5. Find it easy to get your point across to others.

Q15-1. Feel comfortable speaking in front of large groups.

Q15-2. Freeze up when you are speaking to a large crowd.*

Q15-3. Feel you do not have the preparation to speak in front of a group.*

Q15-4. Know how to explain your ideas to others.

Continued on next page >>

**LIST OF QUESTIONNAIRE ITEMS FOR EACH OUTCOME MEASURE, CONTINUED**

**COMMITMENT TO SCIENCE (12 ITEMS)**

Q9-1. I personally don't like science very much.*

Q10-3. I see how astronomy is important to my life.

Q18-1. I know of other science activities outside of school I can do.

Q18-2. I would consider taking more science classes in high school if I could.

Q18-3. I do not plan to do any more science unless I have to.*

Q18-4. If I go to college, I will probably major in a science field.

Q18-5. I plan to work in a science field as a career.

Q18-6. I can see myself maybe getting a graduate degree in a science field.

Q19-1. My neighborhood should try to get more opportunities for people to learn about science.

Q19-2. There should be more out-of-school science activities in my neighborhood for kids to participate in.

Q19-3. I would support a local campaign for more science-related activities in my neighborhood.

Q19-4. I would speak at a local community meeting in support of more science-related activities for my neighborhood.

**POSITIVE YOUTH DEVELOPMENT (17 ITEMS)**

Q13-2. Achieve the goals you set.

Q13-3. Use feedback, whether positive or negative, to help you reach your goals.

Q13-5. Stretch yourself by setting challenging but realistic goals.

Q14-1. Easily see the other person's point of view.

Q14-5. Find it easy to get your point across to others.

Q15-4. Know how to explain your ideas to others.

Q15-5. Enjoy sharing what you know with others.

Q15-6. Plan HOW to present your message based on the type of group you are talking to.

Q16-2. Listen to others when they speak.

Q16-4. Take responsibility for your actions.

Q16-7. Consider new ways of doing things.

Q17-1. Work comfortably with others in groups.

Q17-2. Have a positive influence on other team members..

Q17-4. Learn new skills that will help you in the future.

Q17-6. Hear others say you are someone they can count on in a work group.

Q17-7. Enjoy working with others in a group.

Q17-8. Think to yourself that it is important in life to be able to work in a team.

**UNDERSTANDING OF SCIENCE AND ASTRONOMY (8 ITEMS)**

Q8-1. If one important scientist says an idea is true, all the other scientists will agree with it.*

Q8-2. Scientific beliefs really do not change over time.*

Q8-3. We can always get answers to our questions by asking a scientist.*

Q11-1. I can explain the life of a star to someone my age.

Q11-2. I understand the basics of how a telescope works.

Q11-3. Light is an important key to studying everything in the universe.

Q11-4. I can explain what a nebula is.

Q11-5. I can explain what it would take to sustain lie on a plane other than earth.

**SCIENTIFIC HABITS OF MIND (9 ITEMS)**

Q8-2. Scientific beliefs really do not change over time.*

Q8-4. Two scientists could make the same observations of something and reach different conclusions.

Q8-5. People should understand science because if affects their lives everyday.

Q12-1. Look for new information to help understand the situation better.

Q12-4. Consider many different possibilities before picking one.

Q13-3. Use feedback, whether positive or negative, to help you reach your goals.

Q15-6. Plan HOW to present your message based on the type of group you are talking to.

Q16-7. Consider new ways of doing things.

Q16-8. Plan for a project, event when you are very familiar with it.

## METHODOLOGY: PROJECT TEAM (PRINCIPAL INVESTIGATORS, FELLOWS, AND INTERNS)

### *Face-to-Face Discussions*

Two in-depth group discussions were held with the project team members in order to discuss their thoughts on program sustainability and replication. During these discussions, the project team was asked to reflect on key turning points in the program's life and the changes that were or were not made that had major implications for the program.

Various discussion techniques were used including: designing 'The Program Lifeline", brainstorming transferable elements, employing sentence completion (Dissemination looks like…), nominal group, group questioning, and open discussion. These discussions were recorded using flip charts, individual participants' notes, and researchers' notes. Results from these discussions have been included where applicable, particularly in the results pertaining to transferable elements.

### *Modified Focus Group*

At the end of the final year of the project, team members were assembled to participate in a modified focus group. Using a series of worksheets (in the Appendix), the group was led through a sequenced discussion of topics related to dissemination and replication of the program model. The group worked in pairs to complete each worksheet. Researchers facilitated the process of completing a worksheet, discussing as a large group, and then encouraging the group to come to some agreement on the issues. The discussions were audio-recorded and all worksheets were collected and compiled. The key contribution of this process was identification and understanding of the transferable elements of the program model.

## METHODOLOGY: FELLOWS

Throughout the three years of the YAA program, qualitative data were collected from the fellows. A total of six fellows participated in this portion of the data collection, and at any one time only those fellows who were employed at that time were interviewed. Two of the interviews and a focus group were conducted as part of the formative phase of the evaluation. The final interview with fellows was conducted at the end of the summative evaluation phase.

- Mid-program Year 1: in-person interviewes conducted May 2 and 3, 2007 (n=3); audio recorded, results previously reported in formative phase.
- End of program Year 1: phone interviews conducted September 13-19, 2007 (n=3); audio recorded, results previously reported in formative phase.
- Beginning of program Year 3: focus group conducted December 8, 2008 (n=one focus group with 3 participants); audio recorded, results previously reported in formative phase.
- End of program Year 3: phone interviews conducted September 11-16, 2009 (n=4); not audio recorded.

All interviews and the focus group were semi-structured, consisting of open-ended questions. Some of the data sources were audio-recorded with the permission of the interviewees. Data collectors took notes during all interviews and the focus group. Both the notes and audio recordings were used in the final summative analysis. For the summative phase, a pattern analysis was conducted on all the data with a focus on the outcomes listed in the grant proposal for the fellows. Previously reported formative data from these interviews were not re-analyzed for the summative report.

## METHODOLOGY: CBO STAFF

Data were collected from the staff of the community-based organizations that participated in the after-school component of the program. Researchers traveled to each community site multiple times during the year and conducted face-to-face interviews with staff. In addition to these interviews, training meetings for CBO staff were formally observed and corresponding materials reviewed for relevant content related to targeted outcomes.

During site visit interviews, CBO staff were asked to provide feedback on what they believed were the key elements a program like YAA should have in order to be successful. They were also asked to describe the single most important characteristic of the YAA program as well as the one characteristic YAA does not have that, if added, would make the biggest impact. Other topics included discussion of the ways in which the YAA program has impacted local youth and how the YAA program fits into the overall "portfolio" of programs and activities offered at community centers.

## METHODOLOGY: ATTENDEES OF OUTREACH EVENTS

Initially, a list of specific community impacts was identified and each was to be measured quantitatively as a part of the summative evaluation. Based upon results of formative evaluations suggesting that community impact varied across localities, the process for capturing community impacts was modified. Instead of limiting the types and levels of impacts through a deductive design, a qualitative, inductive approach was used.

Observations and interviews were conducted at YAA public outreach events held in Year 3 of the program. The goals of the observations and interviews were to determine: 1) who attended the outreach events, 2) possible impacts the events had on attendees, 3) attendees' perceptions of the benefits of the program, and 4) types of interactions between youth and the attendees at the events. Observations were conducted using a semi-structured observation protocol. Data collectors took open-ended notes on youth-attendee interactions, categorized evidence

from these interactions into the grant-specified outcomes for community members, and noted details of the event and audience. The data from the observations were analyzed holistically to provide a summary of all the events combined as opposed to single event summaries. The interviews were semi-structured, consisting of open-ended questions focusing on motivation for attending the event, attitudes toward the event, possible benefits for the youth and the community as a result of the program, and demographic information. A total of 12 interviews were conducted. All data from the interviews were entered into an Excel database; the open-ended responses were coded into categories. As with the observations, the interviews analysis looked across all events, and did not focus on the outcomes of one event specifically.

Observations and interviews were conducted at the following YAA outreach events:

- Cambridge Science Festival, Smithsonian Astrophysical Observatory, April 26, 2009
- Astronomy in the City at the Stata Center on the MIT campus on May 15, 2009
- Event at the University of Massachusetts, Boston campus center on July 24, 2009
- Secrets of the Night Sky at the Stata Center on the MIT campus on August 13, 2009

## METHODOLOGY: INFORMAL PROCESSES

Many program activities and team meetings were observed throughout the year. Additionally, informal conversations and discussions took place between the researchers and project participants. Even though these methods did not have protocols, per se, information from the researchers' experiences was useful in interpreting and understanding results.

## LIMITATIONS OF THE STUDY

1. The summative evaluation occurred during the third and last year of the pilot program. Even though the research design created the opportunity to test program impact, the data were limited to only one year. A three-year trend study would be recommended for the future.

2. Youth was the only target group that had both qualitative and quantitative data for use in assessment. Future assessments of the program can add quantitative components created from the results of this study.

3. For the quantitative portion of the youth assessment:

   - While not a limitation, it is important to note that no inferential statistics were used in the quantitative data analysis; the study did not use a random sample of a population but the population itself, there were no inferences made.
   - Some analyses had small numbers for some groups. This did not affect the statistical results but caution should be used when describing groups containing a small number of respondents.
   - For the outcome measure, Knowledge of Astronomy, youths' perceptions were included in the measure.

# RESULTS RELATED TO AUDIENCE OUTCOMES

# YOUTH APPRENTICES, YOUTH ASSISTANTS, YOUTH INTERNS

## INTRODUCTION

This section presents results related to each of the seven youth outcomes. Results from the quantitative research are presented first. Findings from the focus group and any additional methods are then added to provide illustrations for clarity, additional understanding, and/or to support or counter the quantitative data from the questionnaire.

The project hypothesis was that all youth, regardless of their level of participation, would experience gains in the following outcomes: 1) scientific habits of mind, 2) personal and interpersonal skills, 3) appreciation/interest in astronomy and science, 4) engagement in STEM learning experiences, and 5) knowledge of the value of (and opportunities for) STEM-related careers.

Two additional outcomes were proposed for youth assistants and youth interns: 6) advocate for support and ownership of STEM-related learning experiences by their communities, and 7) understand options for continuing participation in STEM-related learning opportunities (after completing the program).

Data Sources Used to Determine Youth Outcomes
(Data collected in 2009 unless otherwise noted)


Before presenting the results for each of the seven outcomes, there is a brief discussion of the results of the three factor analyses, including a table containing the outcome measures that were deemed to represent each of the seven outcomes.

## RESULTS OF FACTOR ANALYSIS

The first step in analyzing the quantitative data was to employ factor analysis. A typical factor analysis is conducted to determine the number and nature of different factors (or constructs) needed to explain the pattern of scores among item responses. In this case, the factor analyses yielded both expected and unexpected results and these factors provided the framework for discussing and interpreting the results across time and participation level.

A total of eleven different factors emerged from the analyses of the data and along with "*Scientific Habits of Mind*" are offered as measures of the youth outcomes. Because the data set was used in three separate analyses, some items from the questionnaire appear in multiple outcome measures (see Final Outcomes Measures table). None of the outcome measures with shared items were used together in any type of variance analysis (correlations, etc.).

The following table matches the seven youth outcomes with the final set of outcome measures.

**TABLE 4 - YOUTH OUTCOMES AND ASSOCIATED MEASURES**

| | **YOUTH OUTCOMES** | | | | | | |
|---|---|---|---|---|---|---|---|
| **OUTCOME MEASURES** | Scientific Habits of Mind | Personal and Interpersonal Skills | Interest in Astronomy / Science | Engage in STEM Learning | Know the Value of / Opportunities for STEM Careers | Science Advocate in the Community | Know Options for Future Participation in STEM |
| Future in Science | | | | • | | | • |
| Advocate for Science | | | | | | • | |
| Teamwork | | • | | | | | |
| Astronomy Knowledge | | | • | | | | |
| Internal / External Focus | | • | | | | | |
| Self Esteem | | • | | | | | |
| Leadership in Science | | • | | | | • | |
| Communication | | • | | | | | |
| Commitment to Science | | | • | • | • | • | |
| Positive Youth Development | | • | | | | | |
| Understanding of Science / Astronomy | • | | • | | | | |
| Scientific Habits of Mind | • | | | | | | |

## DESCRIPTIVE STATISTICS: FINAL OUTCOMES MEASURES

The following tables illustrate the results of the outcome measures in comparison to one another. The first table contains the descriptive statistics for the outcome measures using data points across a year. The next three tables show the descriptive statistics for the outcome measures at each of three points in time. The last four tables are the descriptive statistics for the outcome measures grouped by participant level.

After these eight tables, there are line graphs and tables for each outcome measure illustrating differences across participant groups at three points in time.

**TABLE 5 - DESCRIPTIVE STATISTICS**

| | N | MINIMUM | MAXIMUM | MEAN | STD. DEVIATION |
|---|---|---|---|---|---|
| Teamwork | 101 | 1.67 | 5.00 | 4.01 | 0.66 |
| Astronomy Knowledge | 102 | 2.00 | 5.00 | 3.95 | 0.62 |
| Positive Youth Development | 102 | 1.75 | 4.81 | 3.95 | 0.51 |
| Understanding of Science and Astronomy | 102 | 2.43 | 5.00 | 3.92 | 0.57 |
| Scientific Habits of Mind | 102 | 2.22 | 5.00 | 3.88 | 0.47 |
| Internal External Focus | 101 | 1.50 | 5.00 | 3.85 | 0.68 |
| Leadership in Science | 102 | 1.56 | 5.00 | 3.84 | 0.64 |
| Advocate for Science | 101 | 1.75 | 5.00 | 3.80 | 0.81 |
| Communication | 101 | 1.38 | 5.00 | 3.76 | 0.58 |
| Self Esteem | 102 | 1.00 | 5.00 | 3.70 | 0.71 |
| Commitment to Science | 102 | 1.83 | 5.00 | 3.54 | 0.75 |
| Future in Science | 102 | 1.43 | 5.00 | 3.36 | 0.91 |

**TABLE 6 - DESCRIPTIVE STATISTICS FROM FIRST ADMINISTRATION OF THE YOUTH QUESTIONNAIRE**

| DESCRIPTIVE STATISTICS | | | |
|---|---|---|---|
| | N | MEAN | STD. DEVIATION |
| Teamwork | 49 | 4.02 | 0.78 |
| Positive Youth Development | 49 | 3.91 | 0.61 |
| Internal External Focus | 49 | 3.78 | 0.52 |
| Scientific Habits of Mind | 49 | 3.79 | 0.76 |
| Astronomy Knowledge | 49 | 3.69 | 0.62 |
| Communication | 49 | 3.71 | 0.68 |
| Understanding of Science and Astronomy | 49 | 3.68 | 0.72 |
| Leadership in Science | 49 | 3.68 | 0.60 |
| Self Esteem | 49 | 3.65 | 0.71 |
| Advocate for Science | 49 | 3.56 | 0.88 |
| Commitment to Science | 49 | 3.44 | 0.85 |
| Future in Science | 49 | 3.32 | 1.01 |

**TABLE 7 - DESCRIPTIVE STATISTICS FROM SECOND ADMINISTRATION OF THE YOUTH QUESTIONNAIRE**

| DESCRIPTIVE STATISTICS | | | |
|---|---|---|---|
| | N | MEAN | STD. DEVIATION |
| Astronomy Knowledge | 29 | 4.00 | 0.42 |
| Understanding of Science and Astronomy | 29 | 3.98 | 0.40 |
| Advocate for Science | 28 | 3.92 | 0.67 |
| Scientific Habits of Mind | 29 | 3.89 | 0.67 |
| Teamwork | 28 | 3.88 | 0.40 |
| Positive Youth Development | 29 | 3.90 | 0.37 |
| Leadership in Science | 29 | 3.79 | 0.44 |
| Internal External Focus | 28 | 3.86 | 0.51 |
| Communication | 28 | 3.69 | 0.51 |
| Commitment to Science | 29 | 3.59 | 0.60 |
| Self Esteem | 29 | 3.55 | 0.77 |
| Future in Science | 29 | 3.35 | 0.76 |

**TABLE 8 - DESCRIPTIVE STATISTICS FROM THIRD ADMINISTRATION OF THE YOUTH QUESTIONNAIRE**

| DESCRIPTIVE STATISTICS | | | |
|---|---|---|---|
| | N | MEAN | STD. DEVIATION |
| Astronomy Knowledge | 24 | 4.38 | 0.43 |
| Understanding of Science and Astronomy | 24 | 4.33 | 0.39 |
| Leadership in Science | 24 | 4.14 | 0.67 |
| Advocate for Science | 24 | 4.12 | 0.67 |
| Teamwork | 24 | 4.12 | 0.52 |
| Positive Youth Development | 24 | 4.05 | 0.34 |
| Internal External Focus | 24 | 4.15 | 0.52 |
| Scientific Habits of Mind | 24 | 4.05 | 0.45 |
| Communication | 24 | 3.99 | 0.50 |
| Self Esteem | 24 | 3.97 | 0.55 |
| Commitment to Science | 24 | 3.70 | 0.68 |
| Future in Science | 24 | 3.44 | 0.91 |

**TABLE 9 - DESCRIPTIVE STATISTICS, YOUTH QUESTIONNAIRE - 1ST YEAR APPRENTICES**

| DESCRIPTIVE STATISTICS | | | |
|---|---|---|---|
| | N | MEAN | STD. DEVIATION |
| Teamwork | 64 | 4.10 | 0.68 |
| Positive Youth Development | 64 | 3.99 | 0.50 |
| Scientific Habits of Mind | 64 | 3.84 | 0.43 |
| Communication | 64 | 3.78 | 0.59 |
| Internal External Focus | 64 | 3.77 | 0.73 |
| Astronomy Knowledge | 64 | 3.76 | 0.56 |
| Leadership in Science | 64 | 3.75 | 0.60 |
| Self Esteem | 64 | 3.72 | 0.67 |
| Understanding of Science and Astronomy | 64 | 3.72 | 0.50 |
| Advocate for Science | 64 | 3.63 | 0.78 |
| Commitment to Science | 64 | 3.34 | 0.72 |
| Future in Science | 64 | 3.13 | 0.89 |

**TABLE 10 - DESCRIPTIVE STATISTICS, YOUTH QUESTIONNAIRE - 2ND YEAR APPRENTICES**

| DESCRIPTIVE STATISTICS | | | |
|---|---|---|---|
| | N | MEAN | STD. DEVIATION |
| Astronomy Knowledge | 9 | 4.29 | 0.53 |
| Understanding of Science and Astronomy | 9 | 4.27 | 0.44 |
| Advocate for Science | 8 | 4.09 | 0.52 |
| Internal External Focus | 8 | 4.03 | 0.53 |
| Leadership in Science | 9 | 3.96 | 0.50 |
| Scientific Habits of Mind | 9 | 3.94 | 0.55 |
| Positive Youth Development | 9 | 3.87 | 0.29 |
| Commitment to Science | 9 | 3.87 | 0.47 |
| Teamwork | 8 | 3.81 | 0.43 |
| Communication | 8 | 3.70 | 0.35 |
| Future in Science | 9 | 3.70 | 0.75 |
| Self Esteem | 9 | 3.53 | 1.04 |

**TABLE 11 - DESCRIPTIVE STATISTICS, YOUTH QUESTIONNAIRE - 1ST YEAR YOUTH ASSISTANTS AND INTERNS**

| DESCRIPTIVE STATISTICS | | | |
|---|---|---|---|
| | N | MEAN | STD. DEVIATION |
| Astronomy Knowledge | 13 | 4.09 | 0.79 |
| Understanding of Science and Astronomy | 13 | 4.08 | 0.70 |
| Advocate for Science | 13 | 3.73 | 0.94 |
| Internal External Focus | 13 | 3.72 | 0.69 |
| Teamwork | 13 | 3.67 | 0.86 |
| Positive Youth Development | 13 | 3.67 | 0.75 |
| Leadership in Science | 13 | 3.66 | 0.85 |
| Scientific Habits of Mind | 13 | 3.62 | 0.58 |
| Commitment to Science | 13 | 3.57 | 0.81 |
| Communication | 13 | 3.49 | 0.75 |
| Self Esteem | 13 | 3.46 | 0.81 |
| Future in Science | 13 | 3.43 | 0.99 |

**TABLE 12 - DESCRIPTIVE STATISTICS, YOUTH QUESTIONNAIRE - 2ND YEAR YOUTH ASSISTANTS AND INTERNS**

| DESCRIPTIVE STATISTICS | | | |
|---|---|---|---|
| | N | MEAN | STD. DEVIATION |
| Astronomy Knowledge | 11 | 4.49 | 0.34 |
| Understanding of Science and Astronomy | 11 | 4.47 | 0.26 |
| Advocate for Science | 11 | 4.36 | 0.80 |
| Leadership in Science | 11 | 4.30 | 0.54 |
| Scientific Habits of Mind | 11 | 4.22 | 0.37 |
| Internal External Focus | 11 | 4.18 | 0.42 |
| Positive Youth Development | 11 | 4.09 | 0.26 |
| Commitment to Science | 11 | 4.07 | 0.56 |
| Communication | 11 | 3.97 | 0.34 |
| Self Esteem | 11 | 3.96 | 0.45 |
| Teamwork | 11 | 3.95 | 0.30 |
| Future in Science | 11 | 3.88 | 0.71 |

## DISCUSSION OF RESULTS OF FINAL OUTCOME MEASURES

Note: In the following discussion, average scores for all measures are based on a 5-point scale with 1=lowest or least and 5=greatest or most. The average scores are shown in (parentheses). For this study, because the majority of mean scores fell within a small window (3.5 - 4.0), average scores below 3.5 are considered to be 'lower' than the majority of scores and those above 4.0 are considered to be 'higher' than the majority.

Each standard deviation, a measure for the spread or variance of scores, is also in (parentheses), and is indicated by (sd=). For a 5-point scale, standard deviations below .7 are considered to represent a small spread of scores (respondents score similarly) and those 1.0 or above are described as large (indicating a wide spread of scores around the average score).

Relative rankings were determined by arranging the average scores of the measures in descending order for any particular analysis (ex. 1st year apprentices, 2nd administration of the measure, etc.). The smaller the number or 'rank', the higher the average score, compared to the other measures' average scores.

For this study, the goal for any measure would be to have a high average score on the 1-5 scale (4.5) and a small standard deviation (.4). The optimal situation for any measure is: to have an increase in average score across time and participant level and a decrease in standard deviation. Relative rankings are useful to determine if a desired progression of knowledge and skills is occurring and/or if a curriculum with multiple, ordered components is progressing as planned.

The order of measures is based upon results of the three factor analyses.

***Future in Science***
***(a measure of outcomes four and seven)***

- For the overall set of scores, this measure had the lowest score of all 12 outcome measures in the study (3.4)
  - ◊ Average scores for Future in Science increased slightly from March to August (3.3 to 3.4 to 3.4) but still were the lowest of twelve at each point in time
  - ◊ Scores were fairly wide spread [standard deviations ranged from (sd=.75) to (sd=1.0)] with an average of (sd=.91)
- Across participant groups, this measure was the lowest for three of four participant groups [1st year apprentices (3.3), 1st year assistants/interns (3.4), and 2nd year assistants/interns (3.9)]; for 2nd year apprentices, it was second lowest (3.7)

***Advocate for Science***
***(a measure of outcome six)***

- For the overall set of scores, this measure was eighth out of 12 outcome measures (3.8)
  - ◊ The scores steadily increased from March to August (3.5) to (3.9) to (4.1) as did the ranking (moved from 10th to 3rd to 4th)
  - ◊ The range of scores was unremarkable
- Across participant groups, Advocate for Science was 10th for 1st year apprentices (3.6) but 3rd for the other three groups [2nd year apprentices (4.1), 1st year assistants (3.7), and 2nd year assistants/ interns (4.4)]

***Teamwork***
***(a measure of outcome two)***

- For the overall set of scores, Teamwork was the outcome measure with highest score (4.0)
  - ◊ There was a small decrease in average scores from March to June (4.0) to (3.9) and the ranking moved from 1st to 5th out of 12; the average score increased from June to August (3.9) to (4.1) but remained 5th overall
  - ◊ The range decreased across the program year to a fairly small spread of scores by August (sd=.52)
- Across participant groups, average scores on Teamwork varied greatly, but no particular trend or pattern was identified; teamwork was 1st for 1st year apprentices (4.1), 9th for 2nd year apprentices (3.8), 5th for 1st year assistants/interns (3.9), and 11th for 2nd year assistants/interns (4.0)

***Knowledge of Astronomy***
***(a measure of outcome three)***

- For the overall set of scores, Knowledge of Astronomy was second (3.9)
  - ◊ Scores on this measure increased steadily from March (3.7) to June (4.0) to August (4.4) and moved up in rank from 5th to 1st and stayed 1st through the end of the program
  - ◊ The ranges of scores across the three times of measurement tightened considerably from March (sd=.7) to June and August (sd=.4)
- Across participants groups, Knowledge of Astronomy was the highest score for three of the four groups [2nd year apprentices (4.3), 1st year assistants/interns (4.1), and 2nd year assistants/interns (4.5)]; average scores for 1st year apprentices placed it 6th (3.7)

***Internal/External Focus***
***(a measure of outcome two)***

- For the overall set of scores, this measure ranked 6th (3.9)
    - ◊ In March, this measure's rank was 3rd (3.8), in June, it dropped to 8th but still with an average of (3.8), and in August, moved to 7th and the average score increased to (4.1)
    - ◊ The variability of scores was what would be expected in March (sd=.7) and August (sd=.7); the scores from the June administration of the questionnaire were more clustered with a standard deviation of (sd=.4)
- Across participant groups, 1st year assistants/interns scored lowest (3.7) with this measure placing 4th, for 1st year apprentices it was 5th (3.8), for 2nd year apprentices it was 4th (4.0) with (sd=.5), and, for 2nd year assistants/interns it was 6th but had the highest average score (4.2) with a small standard deviation (sd=.4)

***Self Esteem***
***(a measure of outcome two)***

- For the overall set of scores, Self Esteem was 10th (3.7)
    - ◊ Self esteem was 9th in March (3.7), dropped to 11th in June and dropped in score as well (3.6); moved up slightly to 10th in August but the average score increased (4.0)
    - ◊ The range of the scores was unremarkable
- Across participant groups, the 2nd year assistants/interns had the highest average score on Self Esteem (4.0) and their scores were tightly clustered (sd=.5); the ranking for Self Esteem for these youth, however was 10th out of 12; both 2nd year apprentices and 1st year assistants/interns had the same average scores (3.5) and the ranks were similarly low (12th and 11th respectively); 1st year apprentices' scores placed Self Esteem at a higher relative rank than the other three groups - 8th with an average of (3.7)
    - ◊ On all other measures, 2nd year apprentices scored similarly to one another as indicated by fairly small standard deviations (ranging from .3 to .6), however, for Self Esteem, the standard deviation was larger than expected (sd=1.0)

***Leadership in Science***
***(a measure of outcomes two and six)***

- For the overall set of scores, the average score of Leadership in Science was (3.8) and was 7th out of 12
    - ◊ Across the program year, this measure increased in relative rank and in average score: March (3.7 – 8th), June (3.9 – 7th), and in August (4.2 – 3rd); standard deviations decreased from (sd=.7) to (sd=.5) indicating increasingly more agreement among youth
    - ◊ The range of scores overall was slightly smaller than normally expected (sd=.6)
- Across participant groups, the average scores and relative rankings on Leadership in Science varied but without a noticeable trend or pattern; 1st year apprentices had the measure 7th out of 12 with an average score of (3.8), 2nd year apprentices had it 5th with an average score of (4.0); the average scores for 1st year assistants/interns was the lowest of all four groups (3.7) with a ranking of 7th and 2nd year assistants/interns had the highest average score (4.3) and the highest ranking of the four groups at 4th out of 12

***Communication***
***(a measure of outcome two)***

- For the overall set of scores, the average score for Communication was (3.8) which placed it 9th
  - ◊ Even though its average score increased from (3.7) in March and June to (4.0) in August, its ranking fell from 6th in March to 9th in June and August
  - ◊ The spread of scores was small with a standard deviation of (.58)
- Across participant groups, average scores were (3.5) for the 1st year assistants/interns, (3.7) for 2nd year apprentices, (3.8) for 1st year apprentices, and (4.0) for 2nd year assistants/interns; for both the 2nd year apprentices and the 1st year assistants/interns, the relative ranking for Communication was 10th out of 12; similarly, the average score for 2nd year assistants/interns placed it 9th; for 1st year apprentices, however, Communication had a much higher relative rank at 4th; the sets of scores for all but 1st year assistants/interns (sd=.8) clustered closely together (sd=.6), (sd=.4), and (sd=.3) respectively;

***Commitment to Science***
***(a measure of outcomes three, four, five, and six)***

- For the overall set of scores, Commitment to Science was 11th (3.5) (sd=.7)
  - ◊ The average score increased from (3.4) in March to (3.6) in June to (3.7) in August; however, its relative ranking within the 12 measures remained fairly consistent (11th in March, 10th in June, and 11th in August)
  - ◊ The ranges of scores across all three measurement times were unremarkable
- Across the participant groups, average scores were (3.3) for the 1st year assistants/interns, (3.9) for 2nd year apprentices, (3.6) for 1st year apprentices, and (4.1) for 2nd year assistants/interns; the relative rankings were 11th, 8th, 9th, and 8th respectively; standard deviations were unremarkable for three of the four groups; 2nd year apprentices, however, had a narrower spread of scores (sd=.5)

***Positive Youth Development***
***(a measure of outcome two)***

- For the overall set of scores, PYD was 3rd with an average score of 4.0
  - ◊ Even though the average score increased from (3.9) in March and June to (4.1) in August, the relative ranking fell from 2nd in March to 6th in June and August
  - ◊ The range of scores for the overall set of scores was small (sd=.5); furthermore, the spread decreased at each administration of the questionnaire: March (sd=.6), June (sd=.4), and August (sd=.3)
- Across participant groups, average scores were (4.0) for 1st year apprentices, (3.9) for 2nd year apprentices, (3.7) for 1st year assistants/interns, and (4.1) for 2nd year assistants/interns; relative rankings for PYD were similar for three out of four groups [7th for 2nd year apprentices and 2nd year assistants/interns and 6th for 1st year assistants/interns]; for 1st year apprentices, however, the relative ranking for PYD was 2nd; standard deviations were very small (sd=.5), (sd=.3), (sd=.3) for all but 1st year assistants/interns (sd=.8)

***Understanding of Science and Astronomy***
***(a measure of outcomes one and three)***

- For the overall set of scores, Understanding had an average score of (3.9) and a relative ranking of 4th
  - ◊ Both the average scores and relative rankings improved across time: 7th in March (3.7) to 2nd in June (4.0), and

stayed 2nd in August (4.3)

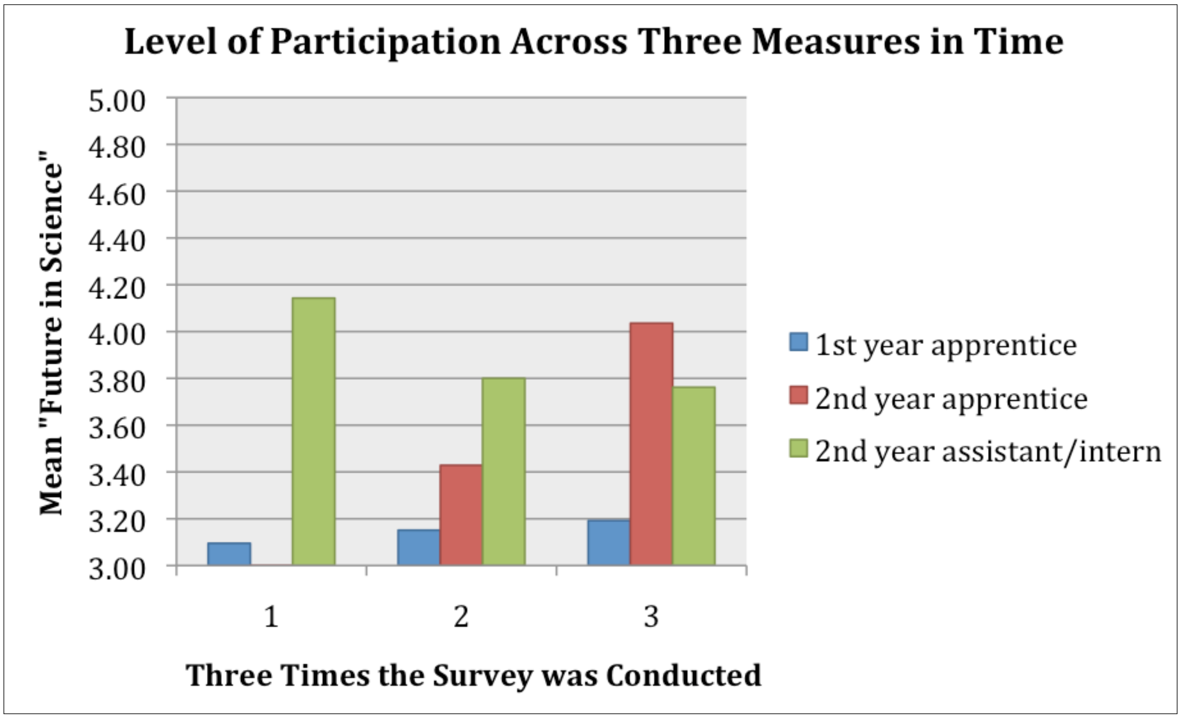
  - ◊ All standard deviations were small [total group (sd=.6), March (sd=.6), June (sd=.4), and August (sd=.4)

- Across participant groups, for three of the four groups, the relative ranking was 2nd and the average scores were high [2nd year apprentices (4.3), 1st year assistants/interns (4.1), and 2nd year assistants/interns (4.5)]; for 1st year apprentices, however, the average score was (3.7) which placed this measure 9th out of 12; the standard deviations were small (sd=.5), (sd=.4), and (sd=.3) for all but 1st year assistants/interns (sd=.7)

***Scientific Habits of Mind (a measure of outcome one)***

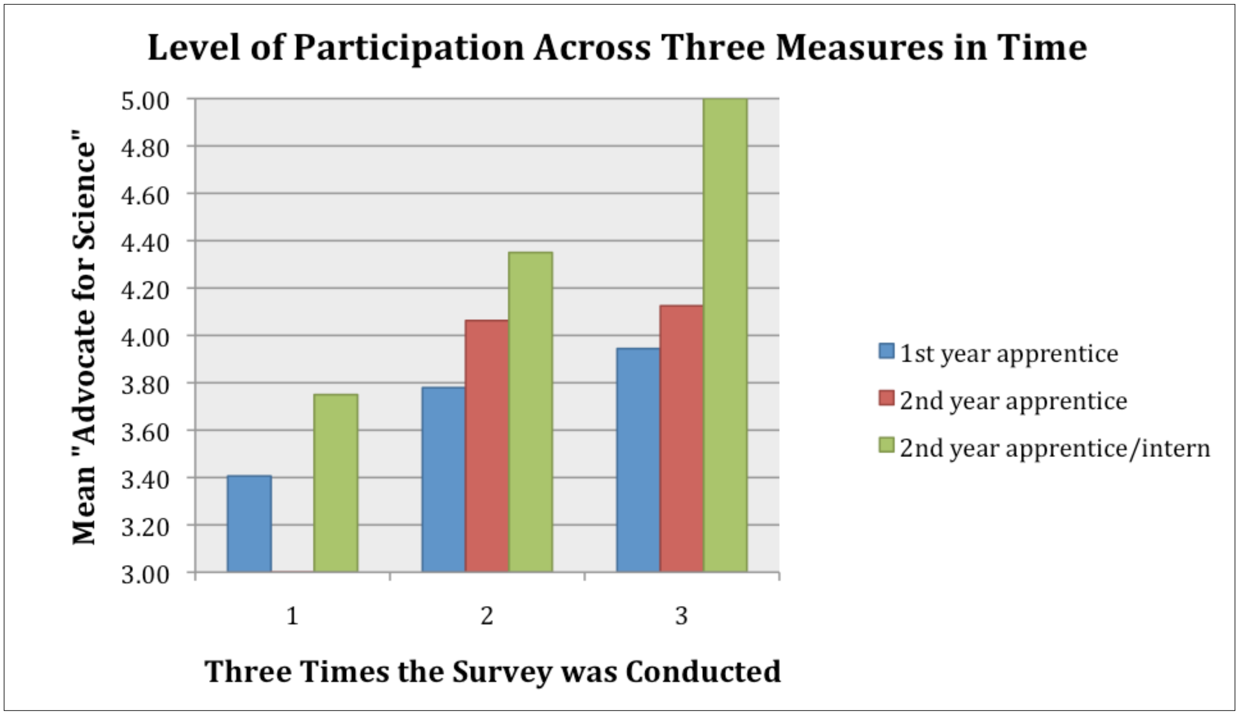
- For the overall set of scores, the average score was (3.9) which placed Habits 5th
  - ◊ The average score progressed from (3.8) in March to (3.9) in June to (4.0) in August; however, the relative ranking fell from 4th in March and June to 8th in August
  - ◊ The spread of scores was narrow for all administrations [overall set of scores (sd=.5), March (sd=.5), June (sd=.4) and August (sd=.5)]
- Across participant groups, the average scores and relative rankings varied but without a noticeable trend or pattern; average scores along with their relative rankings were: 1st year apprentices (3.8) and 3rd, 2nd year apprentices (3.9) and 6th, 1st year assistants/interns (3.6) and 8th, and 2nd year assistants/interns (4.2) and 5th; standard deviations were small (sd=.4), (sd=.6), (sd=.6), and (sd=.4) respectively

## TRENDS IN OUTCOME MEASURES: **FUTURE IN SCIENCE**



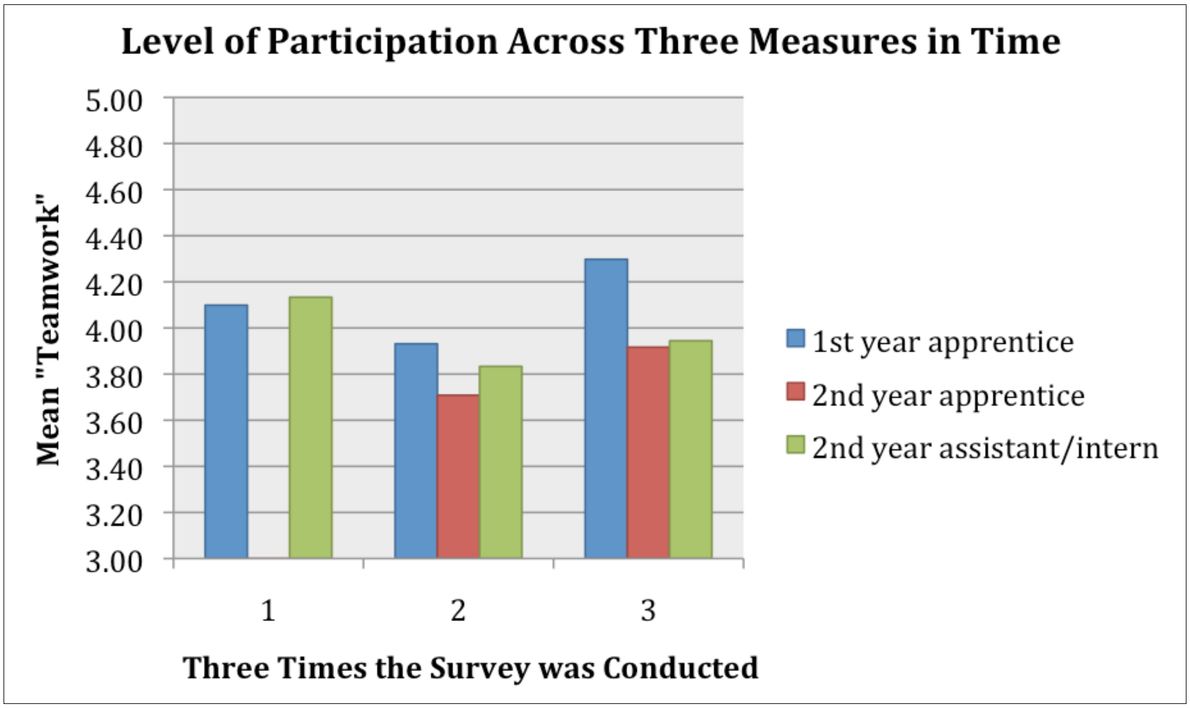

| FUTURE IN SCIENCE | | | | |
|---|---|---|---|---|
| Participation Level - Four Groups | | N | MEAN | SD |
| 1st Year Apprentice | First | 32 | 3.10 | 0.98 |
| | Second | 17 | 3.15 | 0.75 |
| | Third | 15 | 3.19 | 0.91 |
| 2nd Year Apprentice | First | 0 | 0.00 | 0.00 |
| | Second | 5 | 3.43 | 0.62 |
| | Third | 4 | 4.04 | 0.84 |
| 1st Year Assistant/Intern | First | 9 | 3.32 | 1.04 |
| | Second | 2 | 3.79 | 1.31 |
| | Third | 2 | 3.57 | 1.01 |
| 2nd Year Assistant/Intern | First | 3 | 4.14 | 0.80 |
| | Second | 5 | 3.80 | 0.65 |
| | Third | 3 | 3.76 | 0.95 |

## TRENDS IN OUTCOME MEASURES: **ADVOCATE FOR SCIENCE**



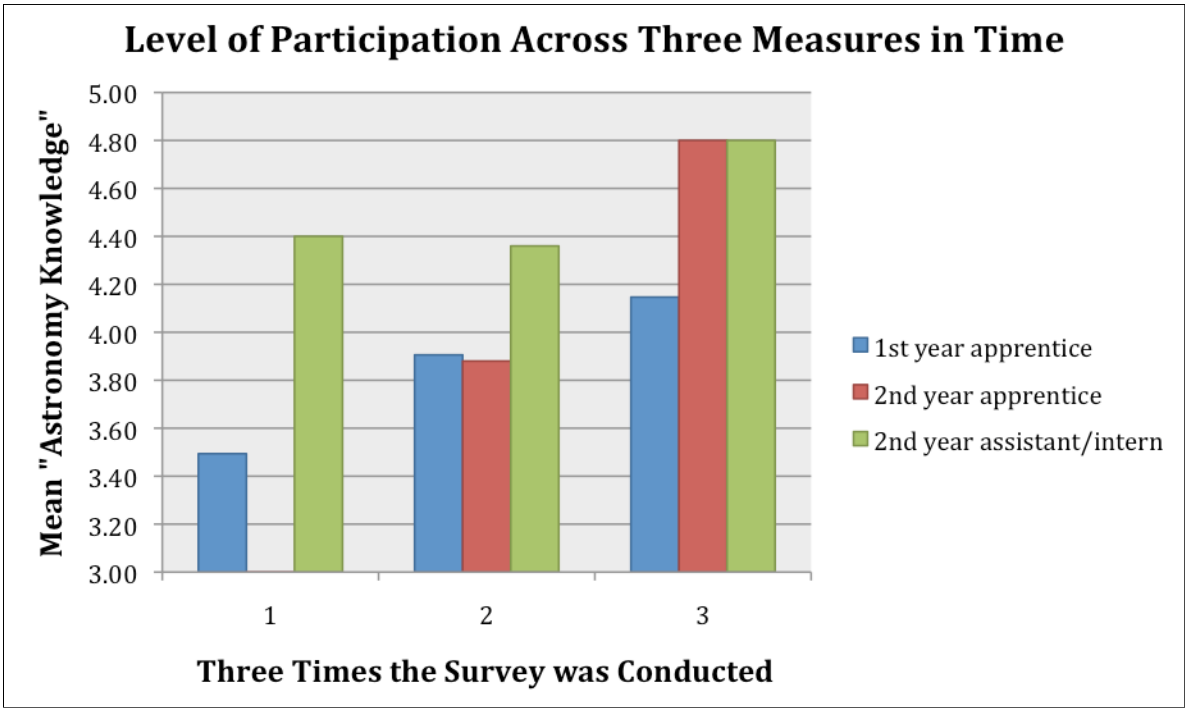

| ADVOCATE FOR SCIENCE | | | | |
|---|---|---|---|---|
| Participation Level - Four Groups | | N | MEAN | SD |
| 1st Year Apprentice | First | 32 | 3.41 | 0.79 |
| | Second | 17 | 3.78 | 0.75 |
| | Third | 15 | 3.94 | 0.68 |
| 2nd Year Apprentice | First | 0 | 0.00 | 0.00 |
| | Second | 4 | 4.06 | 0.52 |
| | Third | 4 | 4.13 | 0.60 |
| 1st Year Assistant/Intern | First | 9 | 3.58 | 1.09 |
| | Second | 2 | 3.75 | 0.35 |
| | Third | 2 | 4.38 | 0.18 |
| 2nd Year Assistant/Intern | First | 3 | 3.75 | 1.25 |
| | Second | 5 | 4.35 | 0.49 |
| | Third | 3 | 5.00 | 0.00 |

## TRENDS IN OUTCOME MEASURES: **TEAMWORK**



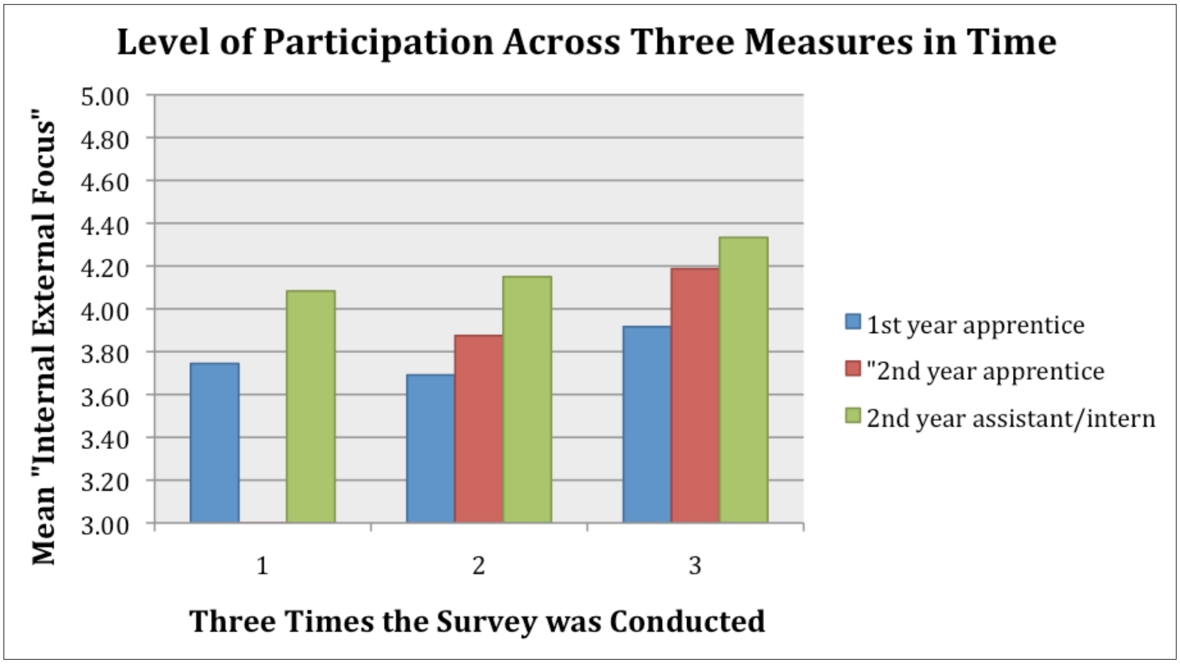

| TEAMWORK | | | | |
|---|---|---|---|---|
| **Participation Level - Four Groups** | | **N** | **MEAN** | **SD** |
| 1st Year Apprentice | First | 32 | 4.10 | 0.65 |
| | Second | 17 | 3.93 | 0.82 |
| | Third | 15 | 4.30 | 0.54 |
| 2nd Year Apprentice | First | 0 | 0.00 | 0.00 |
| | Second | 4 | 3.71 | 0.55 |
| | Third | 4 | 3.92 | 0.32 |
| 1st Year Assistant/Intern | First | 9 | 3.61 | 1.01 |
| | Second | 2 | 4.08 | 0.35 |
| | Third | 2 | 3.50 | 0.24 |
| 2nd Year Assistant/Intern | First | 3 | 4.13 | 0.28 |
| | Second | 5 | 3.83 | 0.24 |
| | Third | 3 | 3.94 | 0.42 |

## TRENDS IN OUTCOME MEASURES: **ASTRONOMY KNOWLEDGE**



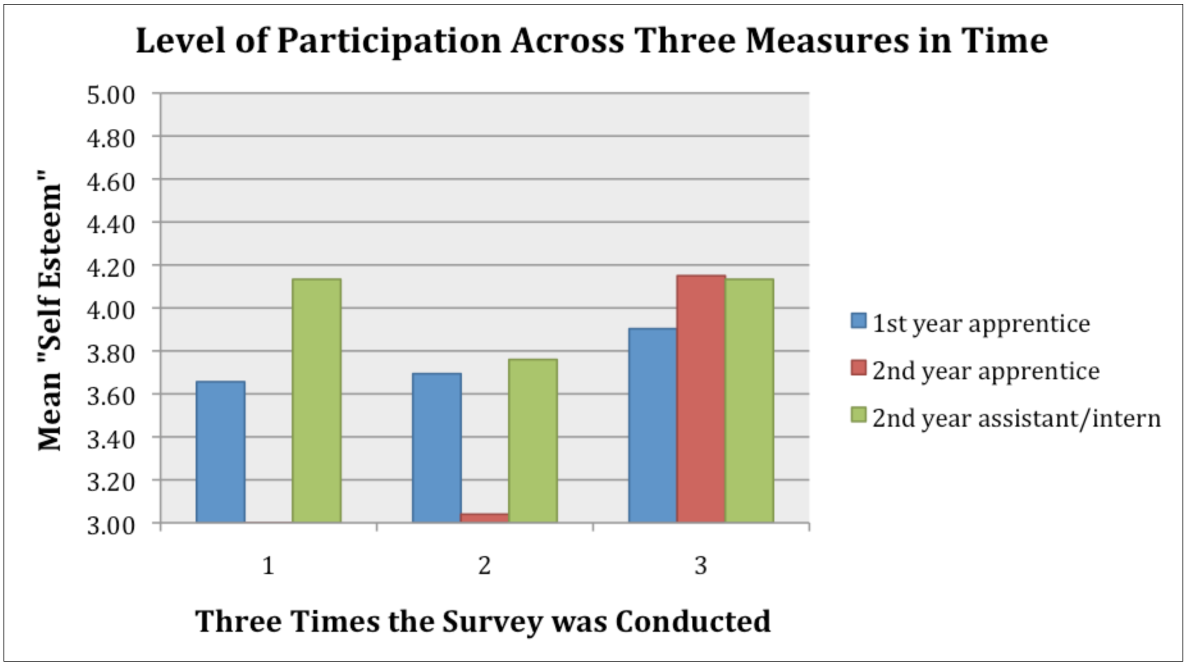

| ASTRONOMY KNOWLEDGE | | | | |
|---|---|---|---|---|
| Participation Level - Four Groups | | N | MEAN | SD |
| 1st Year Apprentice | First | 32 | 3.49 | 0.56 |
| | Second | 17 | 3.91 | 0.42 |
| | Third | 15 | 4.15 | 0.37 |
| 2nd Year Apprentice | First | 0 | 0.00 | 0.00 |
| | Second | 5 | 3.88 | 0.27 |
| | Third | 4 | 4.80 | 0.16 |
| 1st Year Assistant/Intern | First | 9 | 3.93 | 0.88 |
| | Second | 2 | 4.20 | 0.57 |
| | Third | 2 | 4.70 | 0.14 |
| 2nd Year Assistant/Intern | First | 3 | 4.40 | 0.35 |
| | Second | 5 | 4.36 | 0.33 |
| | Third | 3 | 4.80 | 0.20 |

## TRENDS IN OUTCOME MEASURES: **INTERNAL / EXTERNAL FOCUS**



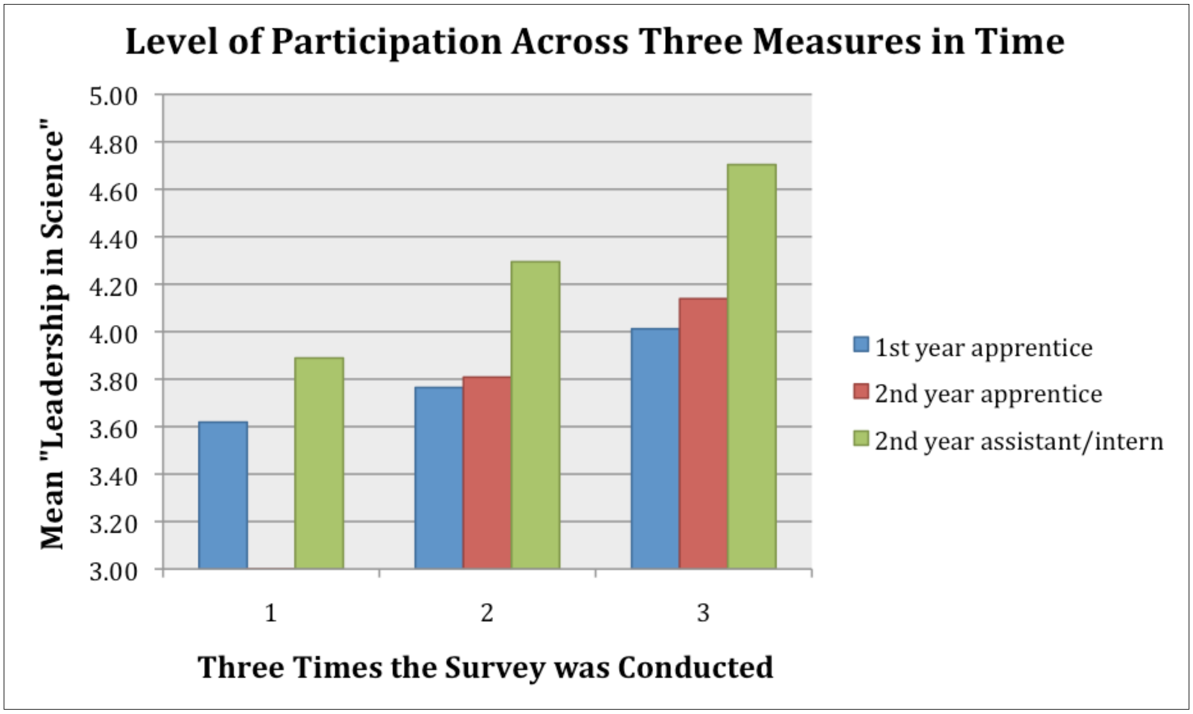

| INTERNAL EXTERNAL FOCUS | | | | |
|---|---|---|---|---|
| **Participation Level - Four Groups** | | **N** | **MEAN** | **SD** |
| 1st Year Apprentice | First | 32 | 3.74 | 0.81 |
| | Second | 17 | 3.69 | 0.44 |
| | Third | 15 | 3.92 | 0.83 |
| 2nd Year Apprentice | First | 0 | 0.00 | 0.00 |
| | Second | 4 | 3.88 | 0.52 |
| | Third | 4 | 4.19 | 0.55 |
| 1st Year Assistant/Intern | First | 9 | 3.60 | 0.74 |
| | Second | 2 | 3.63 | 0.53 |
| | Third | 2 | 4.38 | 0.18 |
| 2nd Year Assistant/Intern | First | 3 | 4.08 | 0.58 |
| | Second | 5 | 4.15 | 0.22 |
| | Third | 3 | 4.33 | 0.63 |

## TRENDS IN OUTCOME MEASURES: **SELF ESTEEM**



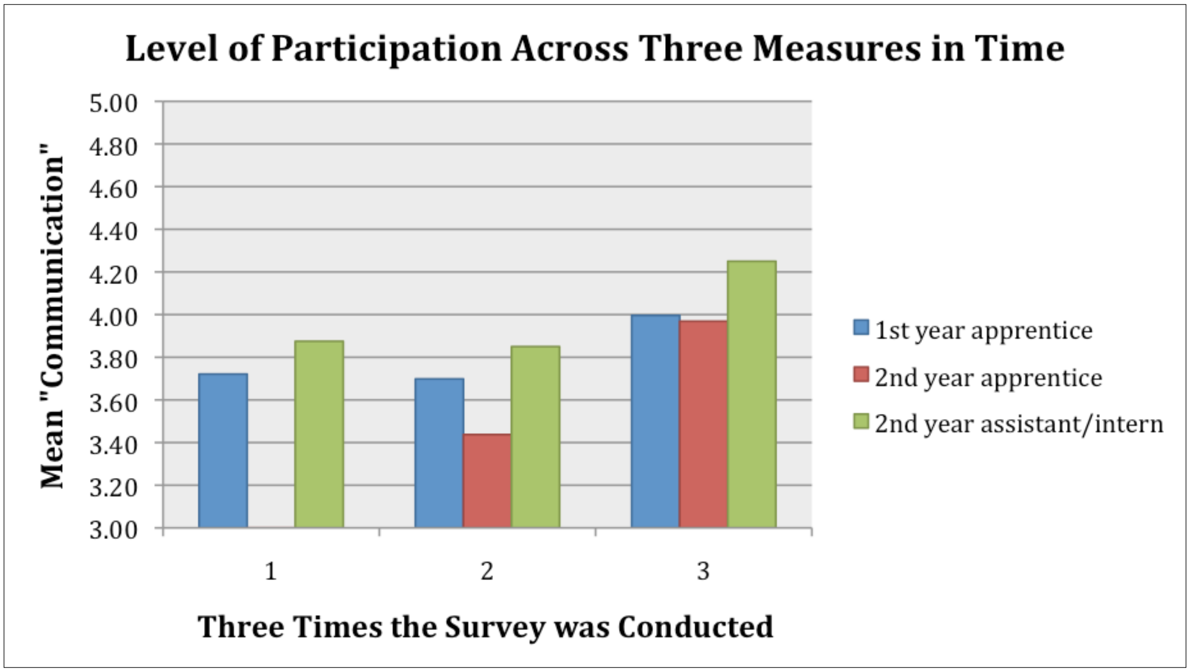

| SELF ESTEEM | | | | |
|---|---|---|---|---|
| Participation Level - Four Groups | | N | MEAN | SD |
| 1st Year Apprentice | First | 32 | 3.66 | 0.65 |
| | Second | 17 | 3.69 | 0.70 |
| | Third | 15 | 3.90 | 0.68 |
| 2nd Year Apprentice | First | 0 | 0.00 | 0.00 |
| | Second | 5 | 3.04 | 1.19 |
| | Third | 4 | 4.15 | 0.30 |
| 1st Year Assistant/Intern | First | 9 | 3.44 | 0.94 |
| | Second | 2 | 3.10 | 0.14 |
| | Third | 2 | 3.90 | 0.14 |
| 2nd Year Assistant/Intern | First | 3 | 4.13 | 0.61 |
| | Second | 5 | 3.76 | 0.43 |
| | Third | 3 | 4.13 | 0.23 |

## TRENDS IN OUTCOME MEASURES: **LEADERSHIP IN SCIENCE**



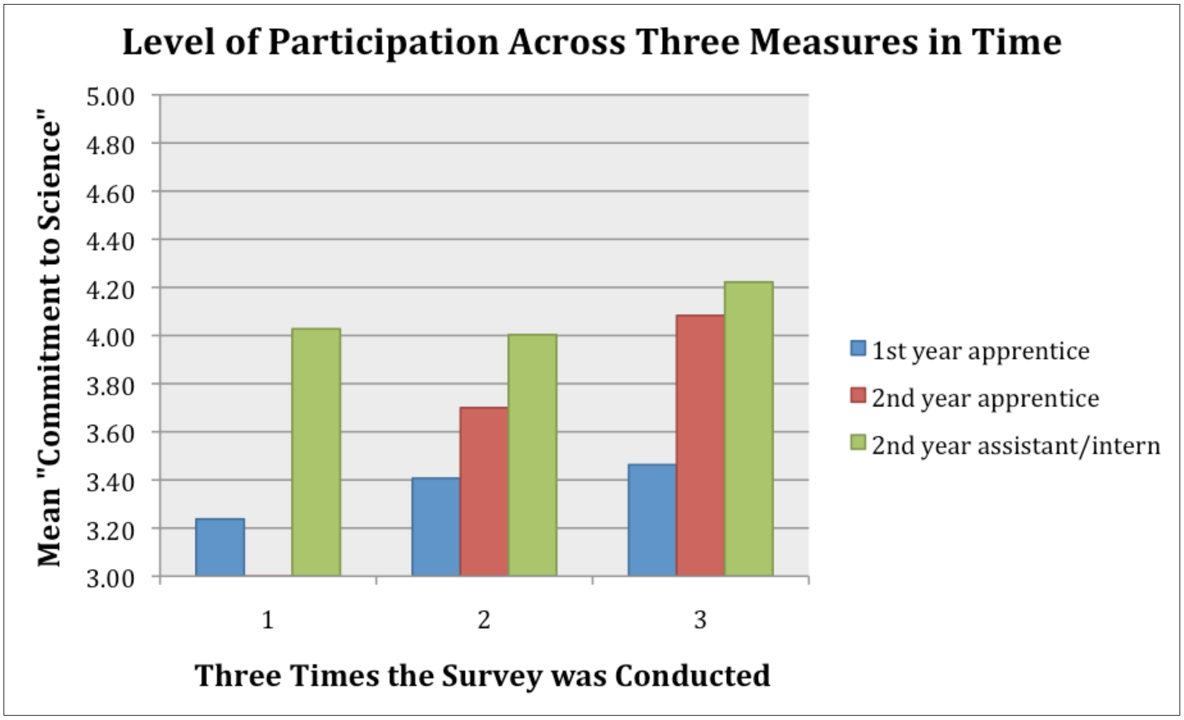

| LEADERSHIP IN SCIENCE | | | | |
|---|---|---|---|---|
| Participation Level - Four Groups | | N | MEAN | SD |
| 1st Year Apprentice | First | 32 | 3.62 | 0.63 |
| | Second | 17 | 3.76 | 0.59 |
| | Third | 15 | 4.01 | 0.50 |
| 2nd Year Apprentice | First | 0 | 0.00 | 0.00 |
| | Second | 5 | 3.81 | 0.33 |
| | Third | 4 | 4.14 | 0.66 |
| 1st Year Assistant/Intern | First | 9 | 3.51 | 0.97 |
| | Second | 2 | 3.67 | 0.31 |
| | Third | 2 | 4.33 | 0.16 |
| 2nd Year Assistant/Intern | First | 3 | 3.89 | 0.91 |
| | Second | 5 | 4.29 | 0.18 |
| | Third | 3 | 4.70 | 0.26 |

## TRENDS IN OUTCOME MEASURES: **COMMUNICATION**



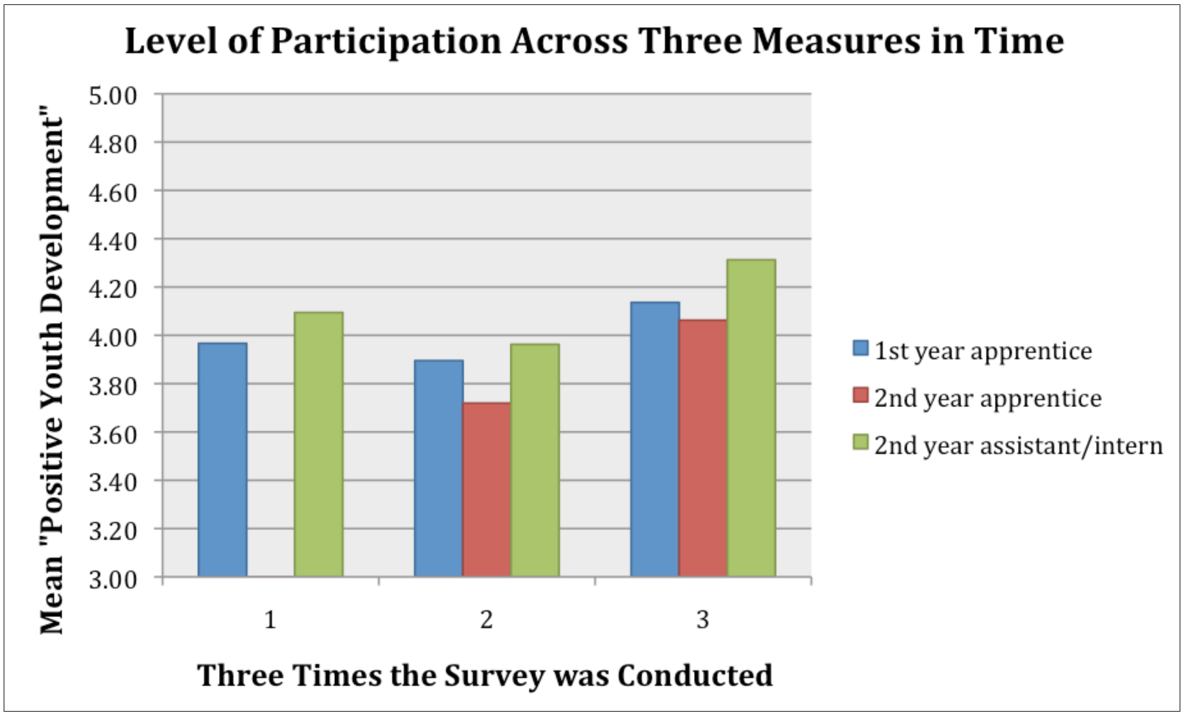

| COMMUNICATION | | | | |
|---|---|---|---|---|
| Participation Level - Four Groups | | N | MEAN | SD |
| 1st Year Apprentice | First | 32 | 3.72 | 0.56 |
| | Second | 17 | 3.70 | 0.63 |
| | Third | 15 | 4.00 | 0.60 |
| 2nd Year Apprentice | First | 0 | 0.00 | 0.00 |
| | Second | 4 | 3.44 | 0.26 |
| | Third | 4 | 3.97 | 0.19 |
| 1st Year Assistant/Intern | First | 9 | 3.42 | 0.91 |
| | Second | 2 | 3.69 | 0.09 |
| | Third | 2 | 3.63 | 0.00 |
| 2nd Year Assistant/Intern | First | 3 | 3.88 | 0.57 |
| | Second | 5 | 3.85 | 0.14 |
| | Third | 3 | 4.25 | 0.22 |

## TRENDS IN OUTCOME MEASURES: **COMMITMENT TO SCIENCE**



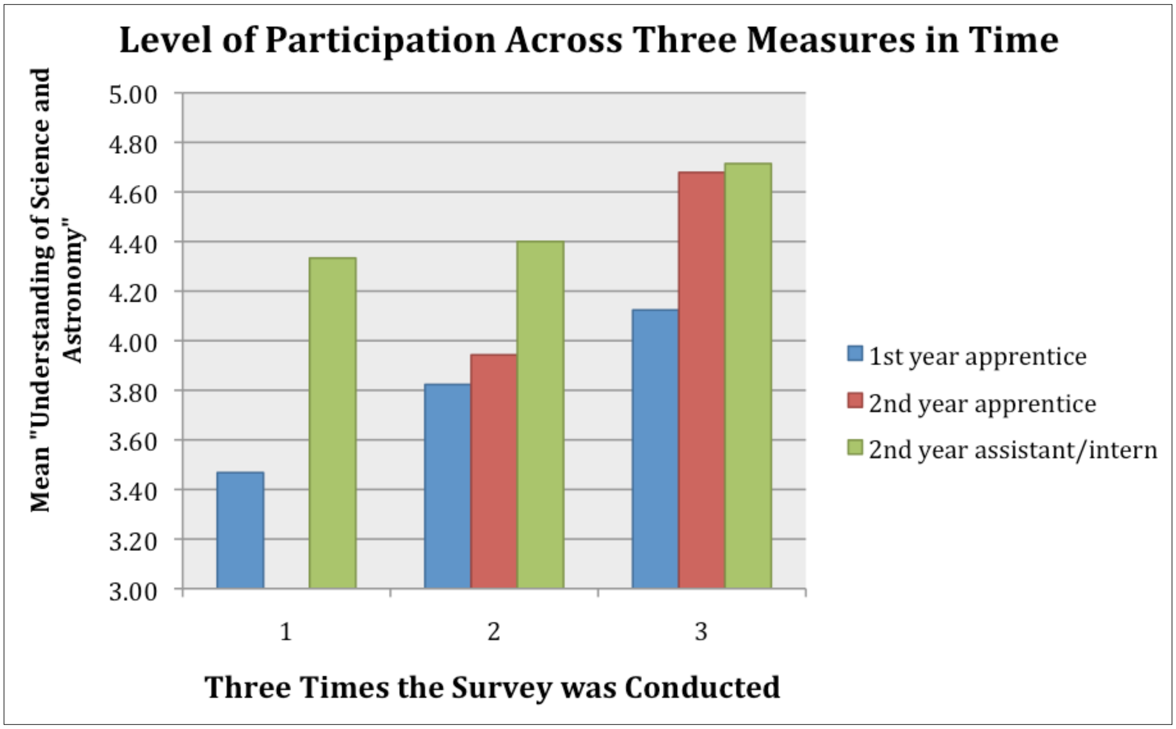

| COMMITMENT TO SCIENCE | | | | |
|---|---|---|---|---|
| Participation Level - Four Groups | | N | MEAN | SD |
| 1st Year Apprentice | First | 32 | 3.24 | 0.78 |
| | Second | 17 | 3.41 | 0.63 |
| | Third | 15 | 3.46 | 0.68 |
| 2nd Year Apprentice | First | 0 | 0.00 | 0.00 |
| | Second | 5 | 3.70 | 0.33 |
| | Third | 4 | 4.08 | 0.59 |
| 1st Year Assistant/Intern | First | 9 | 3.44 | 0.89 |
| | Second | 2 | 3.79 | 0.88 |
| | Third | 2 | 3.92 | 0.47 |
| 2nd Year Assistant/Intern | First | 3 | 4.03 | 0.92 |
| | Second | 5 | 4.00 | 0.45 |
| | Third | 3 | 4.22 | 0.53 |

## TRENDS IN OUTCOME MEASURES: **POSITIVE YOUTH DEVELOPMENT**




| POSITIVE YOUTH DEVELOPMENT | | | | |
|---|---|---|---|---|
| Participation Level - Four Groups | | N | MEAN | SD |
| 1st Year Apprentice | First | 32 | 3.97 | 0.54 |
| | Second | 17 | 3.90 | 0.50 |
| | Third | 15 | 4.14 | 0.37 |
| 2nd Year Apprentice | First | 0 | 0.00 | 0.00 |
| | Second | 5 | 3.72 | 0.16 |
| | Third | 4 | 4.06 | 0.33 |
| 1st Year Assistant/Intern | First | 9 | 3.58 | 0.90 |
| | Second | 2 | 3.94 | 0.35 |
| | Third | 2 | 3.78 | 0.04 |
| 2nd Year Assistant/Intern | First | 3 | 4.09 | 0.40 |
| | Second | 5 | 3.96 | 0.16 |
| | Third | 3 | 4.31 | 0.11 |

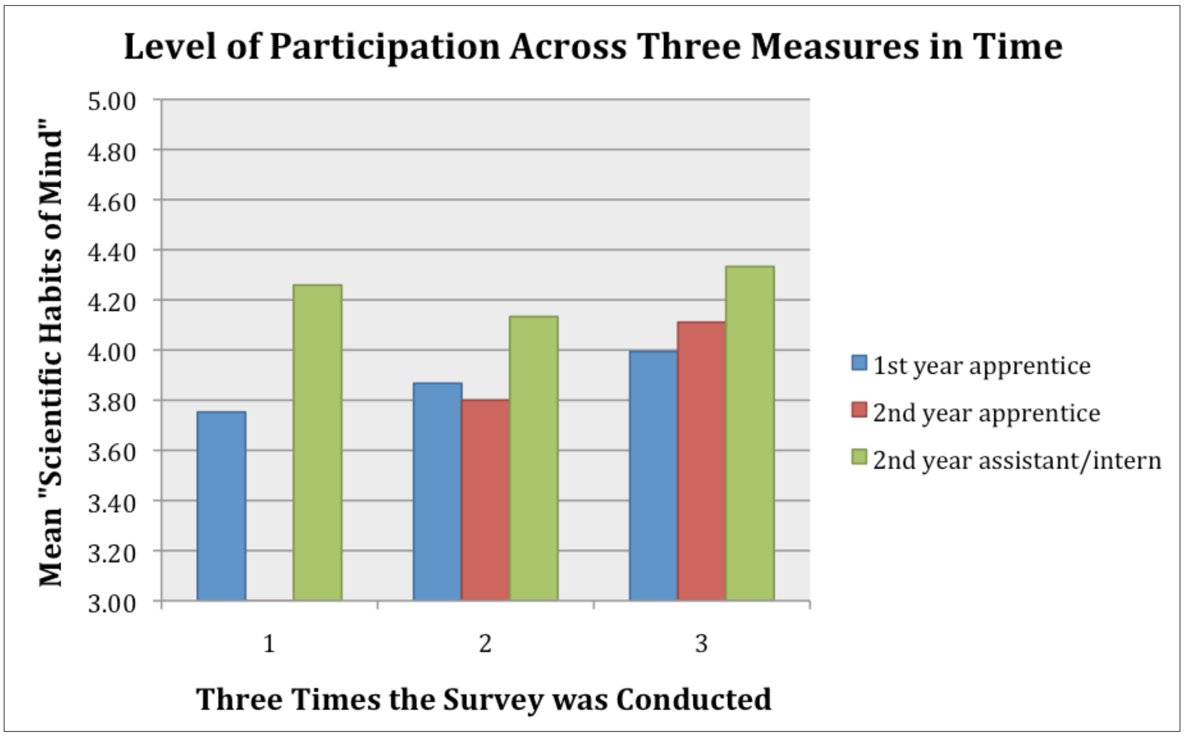
## TRENDS IN OUTCOME MEASURES: **UNDERSTANDING OF SCIENCE AND ASTRONOMY**




| UNDERSTANDING OF SCIENCE AND ASTRONOMY | | | | |
|---|---|---|---|---|
| Participation Level - Four Groups | | N | MEAN | SD |
| 1st Year Apprentice | First | 32 | 3.47 | 0.50 |
| | Second | 17 | 3.82 | 0.37 |
| | Third | 15 | 4.12 | 0.31 |
| 2nd Year Apprentice | First | 0 | 0.00 | 0.00 |
| | Second | 5 | 3.94 | 0.22 |
| | Third | 4 | 4.68 | 0.24 |
| 1st Year Assistant/Intern | First | 9 | 3.89 | 0.75 |
| | Second | 2 | 4.36 | 0.51 |
| | Third | 2 | 4.64 | 0.10 |
| 2nd Year Assistant/Intern | First | 3 | 4.33 | 0.08 |
| | Second | 5 | 4.40 | 0.23 |
| | Third | 3 | 4.71 | 0.29 |

## TRENDS IN OUTCOME MEASURES: **SCIENTIFIC HABITS OF MIND**

Scientific Habits of Mind was measured by one outcome measure of the same name. This measure was created by selecting items from multiple sections of the questionnaire including: beliefs about science, decision-making behavior, goal-setting behavior, leadership behavior, and communication. The item content included planning, seeing all sides of an issue, gathering new information to address a problem, employing new ways to accomplish a task, seeing all sides of an issue, understanding that science is ever-changing, believing that science is important in daily life, knowing that there are multiple perspectives in science and that answers can be found across many diverse sources.




| SCIENTIFIC HABITS OF MIND | | | | |
|---|---|---|---|---|
| Participation Level - Four Groups | | N | MEAN | SD |
| 1st Year Apprentice | First | 32 | 3.75 | 0.44 |
| | Second | 17 | 3.87 | 0.38 |
| | Third | 15 | 3.99 | 0.44 |
| 2nd Year Apprentice | First | 0 | 0.00 | 0.00 |
| | Second | 5 | 3.80 | 0.46 |
| | Third | 4 | 4.11 | 0.67 |
| 1st Year Assistant/Intern | First | 9 | 3.52 | 0.67 |
| | Second | 2 | 3.78 | 0.16 |
| | Third | 2 | 3.94 | 0.24 |
| 2nd Year Assistant/Intern | First | 3 | 4.26 | 0.68 |
| | Second | 5 | 4.13 | 0.23 |
| | Third | 3 | 4.33 | 0.29 |

## FINDINGS, PRESENTED BY OUTCOME

### Participants will develop scientific habits of mind (After-school, Summer, and Youth Assistant).

For the quantitative study, this outcome was assessed using two measures: Understanding of Science and Astronomy and Scientific Habits of Mind. As can be seen from the preceding tables, graphs, and discussion, both of these outcome measures had average scores that increased over time during the project year. Both placed in the upper half of the set of outcome measures (relative rankings were 4th and 5th respectively). And, both measures had narrow ranges of scores around their average scores as indicated by the small standard deviations suggesting that the average scores were representative of the complete group of scores. Relative rankings for Understanding of Science and Astronomy increased over time (7th to 2nd) but rankings for Scientific Habits of Mind fell from 4th to 8th.

The line graphs for both of these measures show that average scores for each participation level went up across the three administrations of the questionnaire but for one exception. The group of 2nd year youth apprentices/interns had a slight dip in its average score for Scientific Habits of Mind in June (from 4.25 to 4.13 and then up slightly to 4.33) but still ending higher than the three other groups. In fact, this 'senior YAA' group began in March with an average score on this measure that was higher than the other three groups ended with in August.

For Understanding of Science and Astronomy, the new apprentices scored lowest throughout the year. The three other groups (2nd year apprentices and both years of youth assistants/ interns) all started at different levels in March but all ended up at about the same level (4.6-4.7) in August.

In summary, the quantitative data clearly show that youth developed 'Scientific Habits of Mind' throughout the program year and throughout the years of the program.

Results from the focus group provided additional insights. A few youth assistants reported programmatic impacts on their scientific habits of mind. For those who did report such an impact, they thought YAA had helped to change the way they approach problems or questions. One participant described how the process of answering questions is similar across scientific disciplines:

> *Science raises a lot of [questions], and being able to learn more science, you are able to answer more questions appropriately… If you learn a way to answer a question in astronomy, you are going to go about [it] the same way in biology, even though it's not the same subject. It's like we're going to do this experiment and find out*


> *what happens…you learn something [in YAA] that's going to help in all the other disciplines, I guess. (YAA Youth Assistant)*

This youth understood that aspects of doing science are consistent regardless of the discipline in question; being in YAA helped him to understand the underlying process of science. Other youth in the focus group generally agreed that this was an impact of program participation for them as well.

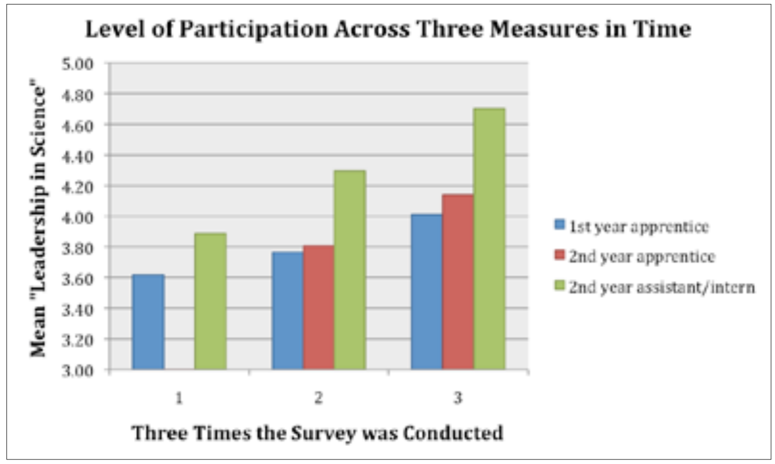
Another youth assistant expressed an understanding of a different aspect of the process of science: answering one question will usually generate additional questions. "A big part of answering questions is coming up with more questions," he replied. "It's a never-ending thing; you are answering a question in order to move on." This demonstrated a larger understanding of the process used by science professionals to advance research in their fields. Other youth mentioned taking more time when approaching a question, looking at a problem from different points of view, and the use of modeling in science.

### Participants will develop personal and interpersonal skills (After-school, Summer and Youth Assistant).

This outcome was assessed using six measures: Teamwork, Internal/External Focus, Self Esteem, Leadership in Science, Communication, and Positive Youth Development.

Teamwork had the highest average score of all outcome measures and the average score increased from March (4.0) to August (4.1) but with a slight dip in June (3.9). Its relative ranking however moved from 1st in March to 5th in June and remained 5th in August.

Internal/External Focus had a relative ranking of 6th [average score of (3.9)] and the average score progressed from (3.8) in March and June to (4.1) in August. Its relative ranking, however fell from 3rd in March to 8th in June and 7th in August. The variability of scores for March and August were at the expected level; June's scores were clustered very tightly suggesting that, even though the average score did not increase from March to June, (3.8) was a more representative measure for the entire group in June than in March.




Self Esteem had a low relative rank of 10th out of 12 measures. The average score was (3.7) and fluctuated across the program year (3.7) to (3.6) to (4.1). Standard deviations were similar for the three sets of scores. Even though the average score increased from March to August, the relative ranking across time stayed fairly low (9th to 11th to 10th).

Leadership in Science, with an overall average of (3.8) and rank of 7th, increased in average score and improved its relative ranking across the program year. Beginning at (3.7) and 8th, this measure increased to (3.9) in June (relative rank moving to 7th), and in August, its average score of (4.2) moved it to 3rd overall. The range of scores decreased as the average increased.

Communication, with an overall average score of (3.8) increased from an average of (3.7) in March and June to over (4.0) in August. Its relative ranking dropped from 6th to 9th, which was its overall ranking. Standard deviations were small.

Positive Youth Development had an overall average score of (4.0) and a relative ranking of 3rd. Scores increased from (3.9) in March and June to (4.1) in August but the relative ranking dropped from 2nd to 6th in June and August. Standard deviations were small and decreased throughout the year.

Generally, the average scores of these six measures increased across the program year. The greatest gains were in Leadership in Science.

As illustrated in the line graphs preceding this section, Leadership in Science was the only measure of six that increased in average score across the program year for all four participant groups. The following is a description of trends in scores across the program year for each participant group.

- 1st year apprentices had a 'U' shaped line for Teamwork, Internal/External Focus, Communication, and Positive Youth Development. The average score for Self Esteem improved across time.
- 2nd year apprentices (with only two measurements, June and August) increased their average scores for all six measures.
- 1st year assistants/interns (with an 'n' of two) had a 'U' shaped curve for Self Esteem. Teamwork, Communication, and Positive Youth Development had an average score across that dropped from June to August.

- 2nd year assistants/interns had average scores that held steady or increased from March to August on Internal/External Focus and Communication. They had a 'U' shaped curve for Teamwork, Self Esteem, and Positive Youth Development.

In summary, based on these six measures, youth across all participation levels experienced some to many gains in Personal and Interpersonal Skills. The measure with gains across time and group was Leadership in Science.

During the focus group, all youth assistants were able to give examples of how the program has supported their personal and interpersonal growth. Throughout the focus group they kept coming back to this impact, describing more ways the program has impacted them personally.

Youth reflected on the personal skills they acquired or improved through the program. These included aspects of communication (public speaking, expressing oneself, practicing English as a second language), employment skills (being on time, coming prepared to work, experience with computers, working with professionals), commitment and follow-through (time management, will power to stick with something, taking initiative), and academics (interest in and ability to improving their grades). The following quotations from the focus group provide examples of youths' reflections on public speaking and improving their grades through the program:

> *[YAA gives you] confidence…to do things that before you couldn't possibly do, like be in a play or present things to a big number of people. And it gives you confidence and it gets you ready for when you're older. Because if you never had this experience and you go to college, after college, out to work. And you want to work where you have to be out in front of a crowd, but you don't have any experience you'd be shaking when you are there. But if you have this experience, where you did it a lot and you are like good at it, then you are really ready. (Youth Assistant)*

And another participant shared...

> *So like MIT, every time you hear that you think about a big school, prestige and all that. So working here my sister is like, "Oh, you are going to MIT? Where are you going to go after graduating [high school]? … But your grades are low." I was like, "But I can bring that up anytime I want." But now they have increased a lot, and I hope I can go to this school or if I don't go into this school, there are other technical schools. (Youth Assistant)*

In both of these quotations, youth demonstrated self-efficacy, knowing that they have the ability to do the task at hand. The first youth expressed how the confidence to speak in front of a crowd comes from repeated practice. YAA gave her the practice she needed so that in a similar situation, she would be confident, knowing she had the ability to give a good presentation. The second youth knew he could improve his grades but was not motivated to do so until he had a goal in mind (e.g. going to MIT or a similar school). The YAA program had interested him in going on to higher education and motivated him to improve his grade so that he could be admitted to a school of his choice.

Youth were also able to reflect on the interpersonal skills they gained through the program. When considering how they learned to interact with others in YAA, youth mentioned learning to work in teams, learning the norms of collaboration and a work environment, and improving their social skills. One youth assistant admitted, "I was never that good at being that social so the program helped me a lot. I still have a long way to go... [towards] becoming more social." For him, YAA was one step in a journey, but YAA started him on the journey by requiring him to interact with others. As both a participant and even more so as a youth assistant, the youth learned that working with others is required. As one assistant summarized, "you are not going to like everyone but you also need to get over it. Because it will … [distract] from what really matters, which is work."

Youth assistants in the focus group thought progressing though the program from an unpaid participant to their current job had allowed them to practice the life skills they have learned in greater depth (e.g., public speaking, expressing themselves, time management), learn more astronomy than new participants do, and gain real employment experience (e.g., being on time, working with others in a professional environment).

Overall, the youth assistants felt the YAA program supported them as individuals. They described the core project team and environment at supportive or "somewhere to come to feel like home." One said the program provided the "constant ability to improve yourself" and another that with YAA you can "move forward with confidence" in your other pursuits. Youth also talked about how YAA was different from other places teens typically work, where "they just want the work to get done." They viewed YAA as providing support on both a personal and professional level, which was not the case in other places they had worked.

Parents of youth participants in YAA noticed changes in their youth as a result of the program. As reported by the fellows, parents have given the fellows feedback on how their child had matured through the course of program participation. Fellows said parents had commented on their child's growing confidence and how they were "opening-up" at home. This was particularly true for an autistic youth in the program; the youth's mother reported to a fellow that the youth had made gains in confidence and being more outgoing with strangers.

The growth of Positive Youth Development (PYD) skills in youth was apparent at the events which took place periodically through out the year. The researchers observed that youth participating in the outreach events conducted themselves professionally as they interacted with the public. Their initial nervousness before each event quickly disappeared once the event began. Youth, who only a few days before were too shy or reticent to explain their models at a practice session, introduced themselves to strangers and launched into explanations of their projects at events. Youths' descriptions of their projects also improved from event to event, becoming more polished and enriched with science content throughout the year.

The fellows also noted the importance of the events for the development of the youth. The events gave the youth something to work towards, reported the fellows. In the process of preparing for the events, the youth learned to meet deadlines and to "break down a project into smaller steps." Presenting at the events "validated" the work that they did, giving them a sense of accomplishment. One fellow thought the youth did not get a sense of their own growth until the events. Another fellow echoed this idea, saying that youth were proud of their work when others give them feedback.

### Participants will develop an appreciation for and personal interest in astronomy and science (After-school, Summer, and Youth Assistant).

For the quantitative portion of the study, this outcome was assessed using three measures: Knowledge of Astronomy, Commitment to Science, and Understanding of Science and Astronomy. As can be seen from the preceding tables, graphs, and discussion, there is much support for the achievement of this outcome.

Knowledge of Astronomy, with an overall average score of (3.9) had a relative ranking of 2nd, just under Teamwork. The average score increased across time, as did the relative ranking. In March, the average score was (3.7) which placed it 5th overall. In June, the average score increased to (4.0) and the ranking went to 1st. In August, the average score increased to (4.4), which was again the top measure (1st).

The distribution of scores tightened from March (sd=.7) to August (sd=.4). Given this small standard deviation, the average score of (4.4) in August is representative of all the youth.

Knowledge of Astronomy was the measure with the highest average score for three of four participant groups (with a relative rank of 1st). Only 1st year apprentices had an average score that produced a relative ranking lower than 1st; it was 6th for that group. When examining the August average scores for each participant group, 1st year apprentices ended the year with an average score of (4.1). The other three groups' August scores were very high (4.7 – 4.8).

As illustrated in the preceding line graphs, the average score on Knowledge of Astronomy increased across the program year for every participant group. This was also the case for Commitment to Science and Understanding of Science and Astronomy.

Commitment to Science had a much lower overall average score and relative ranking than did the other two measures. Its average score (3.5) placed its relative rank at 11th out of 12 measures. But, as did the other two measures, average scores increased across the program year, (3.4) to (3.6) to (3.7). The relative ranking however did not change much (11th to 10th to 11th). The spread of scores around the means (average score) were in the normal range.

Within participant groups, the average score increased during the program year but relative rankings remained low. When examining average scores at the three points in time across participant groups, Commitment to Science was lowest for 1st year apprentices at each point in time and highest for 2nd year assistants/interns at each point in time thus average scores were directly connected to level of participant so that clear trends of impact were observed.

Understanding of Science and Astronomy, as described in outcome one above, had an overall average score of (3.9) with a relative rank of 4th. The average score increased over time during the project year and had narrow ranges of scores around the average scores as indicated by the small standard deviations. Relative rankings for Understanding of Science and Astronomy improved over time (7th to 2nd).

The new apprentices scored lowest throughout the year on this measure. The three other groups (2nd year apprentices and both years of youth assistants/interns) all started at different levels in March but ended up at about the same level (4.6-4.7) in August.

In summary, these three measures increased across time and for the most part, across the levels of participation indicating program impact on this outcome.

Again, results of the focus group confirmed that participating in the program led to a greater understanding of, appreciation for, and interest in astronomy. When asked if they think differently about astronomy as a result of participating in YAA, youth assistants generally agreed that they now find astronomy interesting. "[It's] way more interesting than I thought," replied one assistant. Others agreed and were able to give examples of instances that led to this increased interest. "My interest came from seeing how big the universe is and how small we are," said one assistant, reflecting on her first view of Saturn's rings.

The youth assistants talked about learning astronomy and sharing their knowledge in ways that were closely related. As teachers of youth participating in the after-school program, youth assistants saw teaching as a way to apply what they had learned when they were in the after-school program. Youth also recognized that they were uniquely suited to teach other teens because they were closer in age and because they knew what concepts were difficult for them to learn. They felt they had the ability to translate the difficult concepts into something other teens would understand. Some youth also reflected on being knowledgeable about a subject that other are not. These youth liked having knowledge that was unique or unusual from their family and friends. For them, this was connected to sharing their knowledge with others.

Youth assistants did not think that their participation in the program led to greater appreciation of and interest in science. For example, one assistant put it bluntly, "I still hate science in general, but I am interested in astronomy." Others agreed that they did not think of science differently in terms of being more interested. However, they did seem to appreciate that all sciences are interconnected. Knowing one science discipline in-depth was seen by some as helping in other science classes, but this was not an opinion that all focus group participants voiced. Others talked about how all sciences are interconnected or even how religion and politics are connected to science. For example, one youth assistant thought that when learning about a topic like exoplanets, "you need to understand these other sciences" like chemistry, biology, physics, and math. Another expressed how political concerns "like where our energy comes from" can be impacted by science. Overall, while youth assistants may not have been more interested in science as a whole, the YAA program did seem to help them make connections between science disciplines and between science and social issues.

### Participants will increase engagement in STEM learning experiences (After-school, Summer, and Youth Assistant).

In the quantitative component of this study, this outcome was assessed using two measures: Future in Science and Commitment to Science. These measures had the lowest overall average scores (3.4) and (3.5) placing them 12th and 11th among the 12 measures in this study. Note: Commitment to Science was described in outcome three above; refer to that discussion for details of the results for that measure.

Even though both measures had low average scores, the average score for each did increase across the program year. The spread of scores for Commitment to Science was comparatively normal but those for Future in Science tended to be on the large side compared to others in this study (sd=.8) to (sd=1.0).

When examining average scores for Future in Science across the program year for the four participant groups, the trend looked different for each participant group. For the 1st year apprentice group, the average score began low (3.1) and climbed very little (3.2). The average score for 2nd year apprentices jumped sharply (3.4) to (4.0). For 1st year assistants/interns, the average score began fairly low (3.3), improved (3.8) and then dropped (3.6). And, for 2nd year assistants/interns, the average score dropped steadily (4.1) to (3.8) to (3.7).

Completely opposite from Future in Science with a lack of trends across participant groups, Commitment to Science was lowest for 1st year apprentices at each point in time, next lowest for 2nd year apprentices, higher for 1st year assistants/interns, and highest for 2nd year assistants/interns at each point in time. These trends suggest that average scores were directly connected to level of participant so that program impact by participant level was observed.

In summary, taken together, results suggest the program made an impact on this outcome across the program year and across the years in the program.

The focus group provided some specifics regarding the youths' participation in STEM. For example, one assistant joined the local amateur astronomy club. Another decided while in YAA to pursue a biology major in college. Two assistants placed very high in the state science fair and had focused on astronomy topics for their projects. However, the data from the focus group were somewhat inconclusive as to whether their engagement was increased.

### Participants will gain knowledge of the value of and opportunities for STEM-related careers (Summer and Youth Assistant).

For the quantitative portion of the study, this outcome was assessed using the measure Commitment to Science. As already described previously, even though this measure had an average score and ranking that were relatively low, the average score did improve across the program year. The spread of scores was normal. And, trends on this measure across time by participant group showed a steady progression across the program year and across the years of the program.

These results suggest that the program had a positive impact on this outcome for all youth.

Youth assistants, through their participation in the program, did seem to gain an awareness of different types of science careers and what it takes to pursue a science career. At its most basic level, YAA exposed youth to STEM career options. One assistant spoke generally about how YAA could impact teens: "[It gives you a different picture on what you want to become. Cause some people [could be] like 'I want to be a lawyer.' But when they do this project they can be like 'That seems cool,' and it broadens their choices."

Throughout the program, youth met scientists, the core project team, and "experts" who helped with the projects during the summer program. In the focus group, the youth assistants were able to talk about some of the qualities needed to pursue a science career or work in the sciences. This included pursuing higher education if doing research is one's goal, becoming highly specialized, having a passion for the work, making the necessary time commitments, being willing to make mistakes, developing patience, letting go of an idea when it is a dead end, and working on grant-funded projects. There were some indications that program participation had "humanized" scientists for the youth. One youth assistant reflected that one does not have to be Einstein to be a scientist: "being a scientist or an engineer is making a simple contribution."

When asked about the value of knowing about science careers even if they themselves were not going to pursue a career in science, youth assistants had some insightful answers. They thought knowing how scientists work, especially the peer review process and feedback loops in science, would be helpful in any profession. They also appreciated knowing that other people were doing the scientific research. For example, one youth was comforted in knowing that there are astronomers watching out for things like asteroids that could impact the earth.

The fellows were asked to reflect on the ways in which the YAA program included the opportunity for youth to learn about STEM careers and how to pursue them. The four fellows agreed that informing youth about careers was not done in a formal way. There was no session in the program that explicitly talked about what STEM careers are available or pathways for pursuing them. Rather, the fellows felt that guidance and learning about STEM careers happened: 1) as part of other program activities, and 2) through informal, one-on-one conversations. Program activities in both the summer and after-school portions of YAA were recalled by the fellows as including references to science careers. McLaughlin (2000) calls this "embedded curriculum" or an activity that achieves multiple goals, some of which are not directly related to the project on which the youth are working (2000). For example, when talking about making observations and collecting images in the after-school program, fellows would relate the exercise to what professional astronomers do in their work. During the summer program, professional astronomers worked with the youth as content experts. Through these interactions, fellows thought the youth gained a sense of the breadth of possible careers in astronomy, although again this was not an explicit or primary focus of the interaction. Fellows also explained that by meeting working astronomers, the youth were able to overcome some of their stereotypes about scientists, concluding that a scientist "wasn't just a nerd" but a normal person.

One-on-one conversations with youth participants about STEM careers also occurred in the program. According to the fellows, these conversations would be initiated by either the youth or the

core project team. Sometimes youth would ask the fellows about their college major or career path. Youth also came to the fellows and program director for letters of reference for their college application; one fellow said this request would spark further conversation about what the youth hoped to major in or pursue as a career. Fellows reported starting conversations with youth about possible careers when they noted a particular interest in a topic.

However, the fellows generally felt that the impact the program had on youths' awareness of career options was limited. This was in part because not all youth were interested in STEM careers and some already knew of their options. Overall, fellows felt that those who were involved in YAA longer or who were more interested in STEM careers to begin with benefited most from the embedded discussions and one-on-one conversations about career possibilities.

### Participants will advocate for support and ownership of STEM-related learning experiences by their communities (Youth Assistant).

For the quantitative portion of this study, this outcome was assessed using three measures: Advocate for Science in the Community, Leadership in Science, and Commitment to Science. The results for both Leadership in Science and Commitment to Science have been described previously. Additional information as to how they relate to this outcome, each other, and the measure, Advocate for Science in the Community is provided below.

The measure, Advocate for Science in the Community, had an overall average score of (3.8) that placed it 8th in the set of 12 outcome measures. The overall average score steadily increased from March (3.5) to June (3.9) to August (4.1). Relative rankings had a similar pattern: March – 10th, June – 3rd and August – 4th. The ranges for scores on each measure in time were considered to be in the normal range. When examining average scores and relative rankings for the four participant groups, this measure had a relative ranking of 3rd for all but 1st year apprentices. That group's average score (3.6) placed it as 10th. Average scores for the three other groups were (4.1), (3.7), and (4.4) respectively.

The measure, Leadership in Science, had a similar average score and ranking to those for Advocate for Science in the Community. Progress across the program year was also similar in that average scores steadily progressed from March to August. Standard deviations, however, were considered to be small for Leadership in Science and in fact, they decreased across the program year.

One difference between these two outcome measures was the trend across participant groups when viewing the overall average scores. While Advocate for Science in the Community had an expected and interpretable trend (lower levels of participation scoring lower/higher participation scoring higher), Leadership in Science did not. But, when examining the trend in average score across three measures in time within each participant group (as illustrated in the line graphs), both measures increased from March to June to August for all four groups.

When viewing the results of the measure, Commitment to Science, with those of the two other measures, there are a number of differences. Commitment to Science had a much lower average score (3.5) and relative ranking (11th). However, the average score did improve across the program year. The spread of scores was normal. And, trends on this measure across time by participant group showed a steady progression across the program year and across the years of the program.

In summary, given the results of these three measures, the program had an obvious impact on youth at all levels.

In the end-of-summer questionnaire, youth participants of the summer program were asked to give three examples of things they could "do in the next few months to help others in your own community understand the value of science programs like YAA." As seen in Table 13, youth participants had many ideas for promoting STEM learning in their communities. Youth, overall, suggested more informal ways of interacting with community members (e.g., individual conversations) than formal ways (e.g., events or programs). The full range of youth responses to this question is contained in the Appendix.

**TABLE 13 - YOUTHS' SUGGESTIONS FOR ADVOCATING FOR SCIENCE PROGRAMMING IN THEIR COMMUNITY (N=25)**

| SUGGESTIONS | PERCENT OF RESPONSES |
|---|---|
| Share my experience, talk to people about the program | 40% |
| Teach people astronomy | 17% |
| Do an event or encourage people to attend events | 17% |
| Tell people about the importance of science to their daily lives | 8% |
| Advertise YAA (flyers, announcements) | 7% |
| Nothing/don't know | 7% |
| Other | 7% |

The most common response to the question about promoting STEM in their communities was to share their own personal experience in the program or talk to others about the program (40% of all youth responses). For example, some youth would share practical aspects of the program: "I could tell friends of mine that are looking for jobs about the program and tell them that they can get paid to come here, and make them want to come and understand more about YAA." Others would share how they were impacted by the program, such as the youth who wrote, "Let people know how it has changed my life." Youth also indicated that they would share their astronomy knowledge with people (17%) and participate in events or encourage people to attend events (17%). Some youth thought more broadly and indicated they would share with others the connection between science and daily life (8% of all responses). Youth responses in this area included: "I would help them understand that science does have to do with everyday life…" and "Tell them science holds the answer to most of questions."

Youth assistants were asked what specifically they had done to advocate for STEM opportunities in their communities. Only one youth assistant had a specific example of an action he had taken to bring more STEM learning experiences to his community. This youth had made arrangements with the library in his neighborhood to host a YAA event. While the event was not highly attended, he felt that the people who did come appreciated it. As indicated by the responses of all youth who took the end-of-summer questionnaire, it is likely that many have taken more informal actions, such as sharing their experience with others. Formal actions such as the event organized by the youth assistant were uncommon. This is likely because youth need support of the larger YAA community to accomplish a formal dissemination activity, while informal ones can happen on an individual basis.

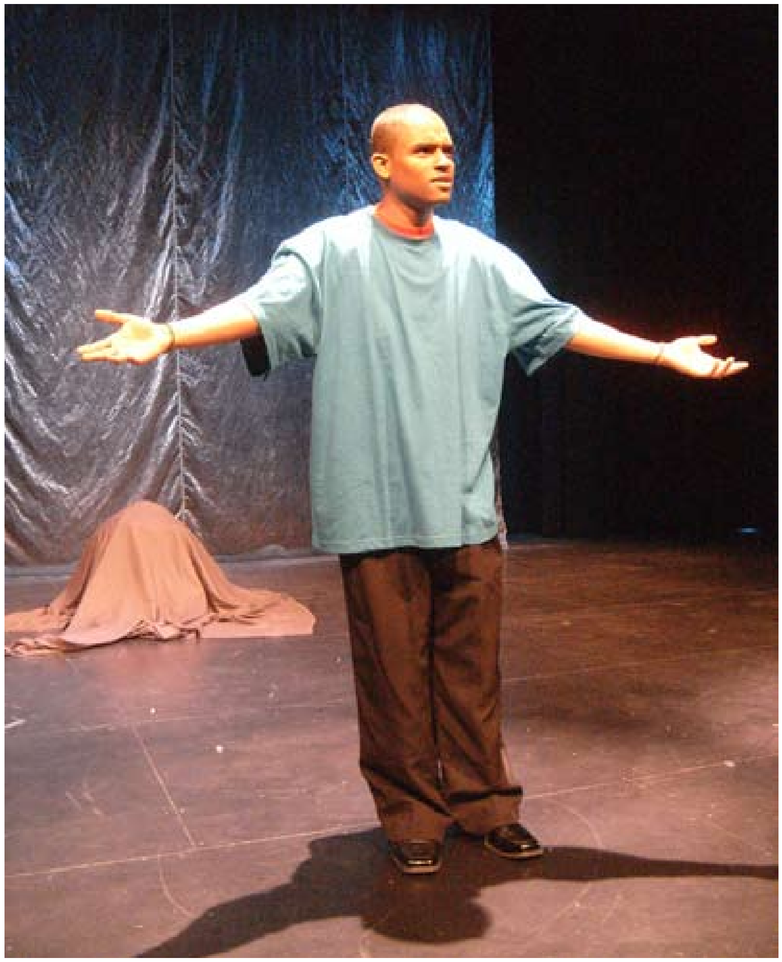
### Participants will understand what options they have for continuing participation in STEM-related learning opportunities after they complete the program (Youth Assistant).

For the quantitative results, this outcome was assessed using one measure: Future in Science.

Previously described in outcome four, the measure Future in Science had the lowest overall average score (3.4), which placed its relative rank as 12th. The overall average score did increase across the program year; however slight, there was improvement (3.3) to (3.4). There were wide variations in average scores across each of the analyses and standard deviations ranged from (sd=.8) to (sd=1.0). And, in fact, the standard deviation for the overall average was (sd=.9).

By examining average scores for Future in Science across the program year for the four participant groups, the trend looked different for each participant group, as illustrated in the line graph. For the 1st year apprentice group, the average score began low (3.1) and climbed very little (3.2). The average score for 2nd year apprentices jumped sharply (3.4) to (4.0). For 1st year assistants/interns, the average score began fairly low (3.3), improved (3.8) and then dropped (3.6). And, for 2nd year assistants/interns, the average score dropped steadily (4.1) to (3.8) to (3.7).

When examining average scores across the participant groups at the end of the program in August, 1st year apprentices had the lowest score (3.2), 2nd year apprentices had the highest score (4.0) and both groups increased in average score across the program year.



In summary, these results are less conclusive than those for outcomes one through six. However, there was a slight increase in the average score across the program year.

The majority of the participants in the youth assistant focus group (6 out of 8) indicated that they would continue to participate in STEM learning opportunities after leaving the program. Many were interested in pursuing STEM-related majors in college.

## SUMMARY

The results of the summative evaluation determined that the YAA program had multiple impacts on youth participants. Findings showed that youth developed Scientific Habits of Mind as illustrated by increased scores throughout the program year and higher scores for those participating for multiple years. Measures of six indicators of Personal and Interpersonal Skills suggested an increase across the program year and all youth experiencing gains in some to many skills. Leadership in Science, the strongest indicator for Personal and Interpersonal Skills, had the largest increases in scores for all youth. Youth also experienced gains in Knowledge of Astronomy, Commitment to Science, and Understanding of Science and Astronomy shown by increasing scores across the program year. Although not to the degree to which they experienced most other impacts, all youth became advocates for STEM-related learning in their communities. Their reported advocacy increased throughout the program year as well as across years of participation. The strongest advocates were 2nd year assistants and interns.

# LOCAL COMMUNITY (THROUGH OUTREACH EVENTS)

Data Sources Used to Determine Local Community Outcomes
(Data collected in 2009 unless otherwise noted)


## INTRODUCTION

In order to understand what impacts the YAA program may have had on the local community, the "community" needed to be defined. The grant proposal stated and the YAA fellows agreed that the community was the neighborhoods where the youth lived, and consisted of friends, family, people at the community sites they go to (not including the site staff), youth at their schools, and neighbors. Once the community was defined, the next step was to determine if these groups were being impacted, and if so, what were the impacts.

According to the program model, outreach events were the means by which the local community would be impacted. Examining who came to these events and the potential impacts on the attendees partially addressed the community impacts as described by the model. This was done by observing the events and interviewing attendees. The other methods by which the YAA program could have impacted the local community were more informal, namely through the youth participants themselves and the interactions they had with community members outside of the outreach events. This type of impact was not part of the program model, and therefore is discussed in the unintended impacts section below. The potential impact of youths' informal interactions with the community was not measured through data collection with the community members. Instead, it was measured indirectly through data collected from the youth (focus groups and questionnaires), and the fellows (interviews).

In observing the events, attendance of community members was less than the program evaluators expected. While some community site staff members and some parents of participants typically attended all the events, the overall attendance of youths' families were very low (as few as two or three families per event). With the exception of the event at the University of Massachusetts, events did not attract teens or community members not related to the youth. Based on the low attendance of the intended audience, we conclude that the impact of the outreach events on the community members was minimal.

To further investigate local community attendance, youth participants were asked to complete a questionnaire at the end of the summer program (August 2009). In response to the question about whether members of their family, friends, or other community members had attended outreach events, 60% of youth reported that someone from their YAA after-school site had attended an outreach event. This is consistent with observations. Slightly more than half (52%) of all youth also reported that school friends had attended events. This is not consistent with observations, but it is likely that youth were thinking of events that occurred in Years 1 and 2 of the program which were not observed. Likewise, 40% of youth reported that a parent or guardian had attended an event. While not particularly high, this percentage indicates that some parents did attend events, even if they did so only once over the course of their child's participation.

**TABLE 14 - YOUTH'S REPORTING OF WHETHER PEOPLE THEY KNEW HAD ATTENDED YAA OUTREACH EVENTS (N=25)**

| POSSIBLE ATTENDEES | PERCENT OF YOUTH RESPONDENTS | |
|---|---|---|
| | YES, HAD ATTENDED | CATEGORY DOES NOT APPLY TO ME |
| Someone from my YAA after-school community center | 60% | 12% |
| My school friends (not involved in YAA) | 52% | 4% |
| My brother/sister | 46% | 4% |
| My other friends (not involved in YAA) | 44% | 4% |
| My parent/guardian | 40% | 0% |
| Members of my extended family | 33% | 4% |
| People I know from my neighborhood | 32% | 4% |
| An adult from my school | 30% | 0% |
| My grandparents/aunts/uncles | 20% | 4% |
| Someone from my church or other community organization | 16% | 4% |
| Other | 4% | n/a |

Youth participants in the program also were asked why their family and friends may not have been able to attend outreach events. The youth responses indicated that a variety of factors may be involved, but the primary reasons they gave for their friends or family not attending were: day or time of the event (64%), and work conflicts (64%). Youth also provided specific suggestions for increasing the attendance of their family, friends, and community members as well as ways to improve the outreach events in general. These are included in the Appendix.

There may be additional reasons why the events were not well attended by members of the youth's community:

- Events were held in locations outside of the community: Many of the events in Year 3 were held in Cambridge and on college or university campuses. Given that the youths resided in Boston neighborhoods such as Dorchester, Roxbury, and Jamaica Plain, Cambridge was well outside of these communities. This could make factors such as the accessibility of the event location, transportation to the event, and the time spent in getting to the event location barriers to community attendance. Another possible factor was that must events were held on college campuses which may have been unfamiliar and intimidating to the members of the community.

There were advantages and disadvantages to holding the events on a university campus. One obvious disadvantage was that youth family, parents, and community members most likely had to travel some distance to the event, and the event itself had to be heavily advertised where the youth participants lived. The advantages relate to the youths' experiences of public outreach events in university facilities

on university campuses. There is a higher probability that university faculty and students would attend the event if located on a campus. The campus venue provided the youth with an opportunity to engage with scientists – to actually be questioned about their exhibits by astronomy professionals. The choice of venue depends upon what outcomes (youth or community) are being sought.

- Youth often did not want their family to attend: According to the fellows, when youth first started in the program they did not want their family members to attend events. Fellows conjectured that some possible reasons included: thinking the event was unimportant and not wanting family members to have to make special arrangements (e.g., getting off of work, finding childcare) in order to attend. It took a while, said one fellow, for the youth to start inviting their family; they typically started to encourage their family members to attend once they felt proud of their accomplishments or wanted to show what time and hard work they had put into their projects.

- Building community support took time: It may also be that the program was just reaching the "tipping point" of building the sort of community support that translates into attendance at events. For example, the CBO staff did not come to outreach events in the first year of the program, but by Year 3 a core group of site staff attended outreach events. They also tended to bring other members of the community with them (friends, family, and co-workers). The fellows viewed this growing commitment as a success.

This does not mean that the outreach events were not of high quality or had no impacts on those who did attend. Attendees at the events found the activities enjoyable and were able to talk about the benefits of YAA for youth and the community (See the "Overall Reaction to Outreach Events" and the "Findings Presented by Outcomes" sections below).

The overall reactions to the outreach events, drawing on observational data, attendee interviews and youth questionnaire data, are reported below to provide context for the impact findings. The intended impacts on the local community were based on the data from the observations and


interviews conducted at the events. The impacts of the youths' informal contact with community members were based on interviews with the fellows and youth participants. These data are reported below for each impact proposed in the grant and unintended impacts.

## OVERALL REACTIONS TO THE OUTREACH EVENTS

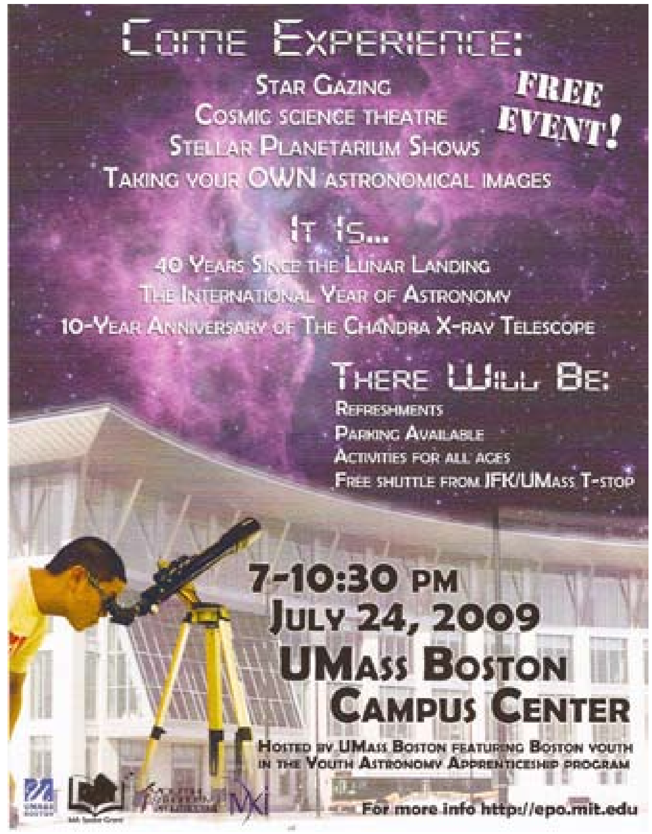
Attendees of the events generally found them to be enjoyable. When asked what they enjoyed the most about the event they attended, responses included the planetarium shows (5 respondents), the theater shows (3 respondents), the opportunity for youth to learn and demonstrate their skills (2 respondents), the posters/exhibits (1 respondent) and the Cambridge Science Festival event non-YAA activities (5 respondents). When asked what was most surprising about the event, attendees said they were most surprised by the event logistics, organization, and participation (4 respondents); variety of activities (3 respondents); and the number or age of youth participating (2 respondents).

Youth participants in the summer program were asked to what degree a variety of event outcomes occurred. Outcomes that were most likely to occur at events, according to youth, included youth sharing their knowledge with others, attendees learning about science and astronomy, youth meeting science professionals, and attendees learning what youth can do. The Appendix contains a table of this data.

## FINDINGS, PRESENTED BY OUTCOME

**Members of local urban communities will perceive and support STEM learning experiences as relevant, effective ways of promoting overall youth development (including autonomy, responsibility, and academic achievement).**

There is evidence that this outcome was achieved by the YAA project, at least for those who attended the events. Given the small number of community members who attended the events, this impact may not have been far reaching. Attendees of the outreach events were asked to what extent opportunities like YAA were important for youth and in what ways could youth benefit. All of those interviewed indicated that a program like YAA was very important for youth. "They are critical," replied one woman, while another felt these opportunities were "wonderful" for youth. A man who previously did not know about YAA replied that it "is tremendously important to expose kids to science, especially on a campus like MIT."


When asked in an open-ended question why these opportunities were important and how youth benefited, attendees tended to focus on the PYD and science learning that occur through program participation. Half of all respondents (6 of 12) highlighted aspects of youth participation that could be categorized as PYD. Some attendees focused on how programs like YAA gave youth something positive to do; "anything to keep them off the streets" as one woman put it. Others had specific ideas about skills the youth were gaining such as public speaking, working with the public, and giving and receiving feedback." Nearly half of all respondents (5 of 12) talked about learning science as a positive outcome for youth who are involved in the program. For these attendees, learning the astronomy content was a key program benefit to youth. One mother of a YAA participant saw space as something that is "new and unexplored" making learning about it attractive (and beneficial) to youth. Another attendee thought it was important for youth to learn more about astronomy, allowing them to make the distinction between science and astrology.

Other benefits for youth named by event attendees included exposure to new topics or situations (3 out of 12 respondents), gaining experiences or knowledge that are not part of school (3 out of 12 respondents), and learning about careers in the sciences (1 respondent). For example, one woman who worked at Harvard University commented that "You don't know [what's out there] when you are a kid. You need to be exposed to things." She said she drew on her own background of growing up in an underprivileged family when considering the benefits of the program. A male attendee thought it was important for youth to gain out-of-school experiences, saying that a topic can "seem so dry" if you only learn about it in school.

**4:00 - 6:00 PLANETARIUM SHOWS RM 124**

THE WONDERS OF THE NIGHT SKY ARE OFTEN CONCEALED BY THE BRIGHT CITY LIGHTS. THE STARLAB WILL INTRODUCE YOU TO THE BEAUTIFUL NIGHT SKY THROUGH VARIOUS SHOWS CREATED BY THE YAA APPRENTICES

4:00 PM MID-SUMMER NIGHTS' GALAXIES
*PRESENTED BY LUCILLE GERNAIN AND ALONZO PAUL*

4:30 PM YOUR OWN SECRETS OF THE NIGHT SKY
*PRESENTED BY PHILLIP ERILUS*

5:00 PM LIVING AND DYING IN THE NIGHT SKY
*PRESENTED BY STEPHON FORTE AND ABDI MOHAMMED*

5:30 PM THE ADVENTURE OF THE URSA MAJOR CONSTELLATION
*PRESENTED BY DANIELLE SPRUILL AND LISETTE ZAYAS*

***TO ATTEND A PLANETARIUM SHOW VISITORS NEED FIRST TO OBTAIN A TICKET FROM THE WELCOME DESK.***

**4:00 - 6:00 SCIENCE THEATER RM 144**

ARTS AND SCIENCE COME TOGETHER TO CREATE INTRIGUING THEATER PERFORMANCES. YOUTH WILL READ WORKS THEY CREATED WITH COACHING FROM ARTISTS FROM THE UNDERGROUND RAILWAY THEATER.

4:00 PM A SHARPER EYE: LOOKING INTO THE PAST *WRITTEN BY IHAB MOHAMED*
SPACE HUNTER *WRITTEN BY ARTUR RODRIGUES*

4:30 PM HOW TO GET RID OF SKY *WRITTEN BY NAIR FERREIRA*
TROPIC SPACE ISLAND *WRITTEN BY ARNALDO PIRES*
THE BOOK *WRITTEN BY EDWARD HAWLEY*

5:00 PM WE'RE NOT SO BIG *WRITTEN BY CLEITON COSTLY*
WHO TO BELIEVE? *WRITTEN BY RONNY BELMONTES*
ONE OF BILLIONS *WRITTEN BY NEREYDA SANTOS*

5:30 PM BIG BANG EXPANSION *WRITTEN BY JOSHUA DONALD*
A JOURNEY THROUGH THE UNIVERSE *WRITTEN BY ANDREA BELMONTES*

**4:00 - 6:00 CHANDRA EXHIBIT THE ATRIUM**

LEARN MORE ABOUT THE CHANDRA X-RAY TELESCOPE THROUGH AN INTERACTIVE EXHIBIT: VIEW BEAUTIFUL IMAGES CHANDRA HAS TAKEN, LEARN ABOUT BLACK HOLES AND THE SPECIAL TECHNOLOGY THAT HAS BEEN DEVELOPED FOR THIS GREAT TELESCOPE. EXHIBITS INCLUDE:

★ SPACE X-RAYS VS. EARTH X-RAYS
*CREATED BY KANEKO GREGORY*

★ ABOVE AND BEYOND: THE EGG SHAPED ORBIT
*CREATED BY AMER FADELESAID AND VENESSA HILL*

★ EUREKA! QUALITY X-RAY IMAGING
*CREATED BY: KENNETH COTTRELL AND HELENO DEPINA*

★ CAN YOU SEE WHAT I SEE?
*CREATED BY JUAN ANTONIO ROJAS*

★ A CAMERA LIKE NO OTHER!
*CREATED BY AMER FADELESAID*

★ STEPHAN'S QUINTET
*CREATED BY CANDICE FILKINS*

★ A JOURNEY THROUGH THE DISK OF A BLACK HOLE
*CREATED BY CHRISTIAN MANUEL, BENJI PHAM AND KHADIJA MBOUP*

**4:00 - 6:00 TAKE YOUR OWN IMAGES THE ATRIUM**

USE THE MICROOBSERVATORY NETWORK OF TELESCOPES TO TAKE IMAGES OF ASTRONOMICAL OBJECTS, SUCH AS GALAXIES, NEBULAE AND STAR CLUSTERS.

★ LEARN HOW TO CREATE COLOR IMAGES OF ASTRONOMICAL OBJECTS.
★ LEARN HOW TO FIGURE OUT THE DISTANCE TO FAR AWAY GALAXIES FROM IMAGES YOU TOOK.

**6:15 CLOSING REMARKS RM 141**

JOIN US AS WE CONCLUDE THE YAA SUMMER PROGRAM, TO ACKNOWLEDGE THE WORK THE APPRENTICES HAVE DONE AND TO THANK OUR VOLUNTEERS AND COLLABORATORS.

### Members of local urban communities will recognize the value of STEM education as providing relevant skills for many career paths and express the desire for additional STEM opportunities in their communities.

There is little evidence that this outcome was achieved through the outreach events of the YAA project. As reported above, only one attendee at the events mentioned anything about careers, and this was in the context of youth learning about careers. Attendees did find the outreach events to be beneficial to the community by providing positive examples of what youth can do, and creating learning opportunities  and enjoyable activities. When the fellows were asked to provide examples related to how the program might have impacted community members' value of STEM as careers, they could not provide specific examples. They felt the program could impact the way community members viewed careers but did not know if it had.

There was also little evidence that community members felt differently about ensuring that STEM opportunities were available in the community as a result of the outreach events. The fellows gave examples of how community site staff showed interest in providing more STEM opportunities, but did not have examples of other community members asking for such opportunities.

## SUMMARY

Taken as a whole, there is little evidence that the program made an impact on the local community through the outreach events on outcomes identified in the program model. While those who came to the events may have felt that the program was an effective avenue for both STEM learning and PYD, the local community did not attend events in large numbers. It is therefore difficult to say that the events impacted a broad section of the local community in this way. The events also did not seem to make an impact on the manner in which community members viewed or advocated for STEM learning.

It appears that the program did have a set of unintended outcomes on those who attended events, local community members who interacted with youth outside of events, and groups other than the local community. It is likely that the greatest impact was on friends and family of program participants through their daily interactions with the youth. This included an increasing awareness and knowledge of astronomy, and for some teens who knew program participants, increasing their own interest in joining the YAA program itself. These outcomes are focused on a narrower segment of people (i.e., friends and family of the youth as opposed to the youths' community) and are more easily achievable than the intended outcomes outlined in the grant proposal. It could be, however, that these outcomes of interest, awareness, and knowledge with a more targeted audience serve as the first step toward attaining the intended outcomes. With more time, it is possible that the YAA program could achieve its intended outcomes for the local community through events or other avenues.

# PROJECT FELLOWS

## INTRODUCTION

In the YAA program, the fellows were the core project team members who had the most daily contact with the youth participants. Throughout the program, the fellows were asked to reflect on their role within the program and their expectations for the role they played. The job position of "fellow" was seen as multifaceted by the fellows themselves. When describing their roles, the fellows tended to emphasize the "many hats" they wore. One fellow described his role in the summer program in the following way: "I think my primary role is one of, sort of, mentor and guide and facilitator in making all of these things happen." Another saw himself as mentor, teaching, and supervisor. The fellows as a whole agreed that the type of work they did was quite variable. They alternated between different kinds of work (office-based versus on-site) and different kinds of programs (after-school and summer), leading one fellow to call the job a "Swiss-army knife." "I was just kind of the glue to hold it all together," reflected another fellow.

The fellows also talked about the differences between themselves and the other fellows and their own individual strengths and weaknesses. This was especially apparent in Year 1 of the program when the fellows had very diverse life experience and backgrounds; this diversity continued to be a theme for the Year 2 and 3 fellows as well. Fellows came into the program with varying degrees experiences )teaching, urban community involvement, and youth programming) and knowledge (astronomy). As a result, some fellows had different training needs and more room to grow or progress in gaining certain skills or experience. This variability can be seen in the results of the intended outcomes for fellows.

## FINDINGS, PRESENTED BY OUTCOME

### Fellows will develop/increase confidence in personal ability to teach astronomy and science content through inquiry/project-based activity.

By the end of their program participation, fellows did feel confident in teaching astronomy content using the inquiry method and project-based activities. Whether each fellow increased his or her confidence depended on their incoming experience. For example, one fellow was a former teacher with a Master's degree in education and an undergraduate degree in astronomy. For her, both teaching and the content to be taught were already familiar. Other fellows entered into the program with astronomy knowledge but more limited teaching experience, while still other fellows had experience working with youth but very limited astronomy knowledge.

Data Sources Used to Determine Fellow Outcomes
(Data collected in 2009 unless otherwise noted)

For fellows who did need to increase their astronomy knowledge, they felt they definitely had grown in this area. At the end of his first year in the program, one fellow thought it was surprising, "how much science content and astronomy knowledge I now have…even watching TV its like there is nothing new." For these fellows, the training activities and materials were very valuable. For example, a fellow new to astronomy appreciated the book Origins: Fourteen Billion Years of Cosmic Evolution by Neil de Grasse Tyson and Donald Goldsmith because it presented current debates and theories in astronomy: "It was good to just at least boost your confidence as far as feeling like you know and are up-to-date on a lot of these things, in case down the line, kids ask about it.  At least you can say something about the topic." Going over the curriculum in advance of the after-school program was also helpful in learning the science behind the concepts. Some fellows also felt they learned from the experts who came

to the summer program to work with the youth, including one who said, "When the students are talking to a professional astronomer I'm there too. And it's always interesting to hear them speak, and a lot of the time it's new for me as well."

The YAA program also helped some fellows feel more comfortable teaching and working with youth. For example, one fellow with existing astronomy knowledge replied:

> *I gained a lot of knowledge then [in training] and during the program learned more how to deliver it in a way that is effective. So, in that sense I've learned how to deliver science content more effectively, but I didn't learn more content so to speak.*

For him, his growth came in conveying his content knowledge to youth. Another fellow said that fellows as a whole are "constantly improving our baseline level of teaching abilities…With ASAP [the after-school program] and prior teaching experience I feel like I'm constantly improving by trying it out." Fellows who wanted or needed more knowledge about teaching were able to take college-level education courses to improve their teaching.

In terms of learning how to use the inquiry method and project-based learning as avenues for engaging youth, many fellows gained skills in these areas a well. In the first year of the program, fellows attended a workshop on project-based learning, which was intended to provide a good preview of what working with youth in the summer program was like. Of course, first-hand experience with project-based learning also allowed fellows to increase their confidence:

> *So at this point…whatever sort of maybe project-based learning kind of thing, I feel I could definitely implement. Especially since the task of the play was such a monumental one in bringing together so many different people and resources and art and science and this and that. So I feel a lot of other things would be a lot easier to me now having gone through that.*

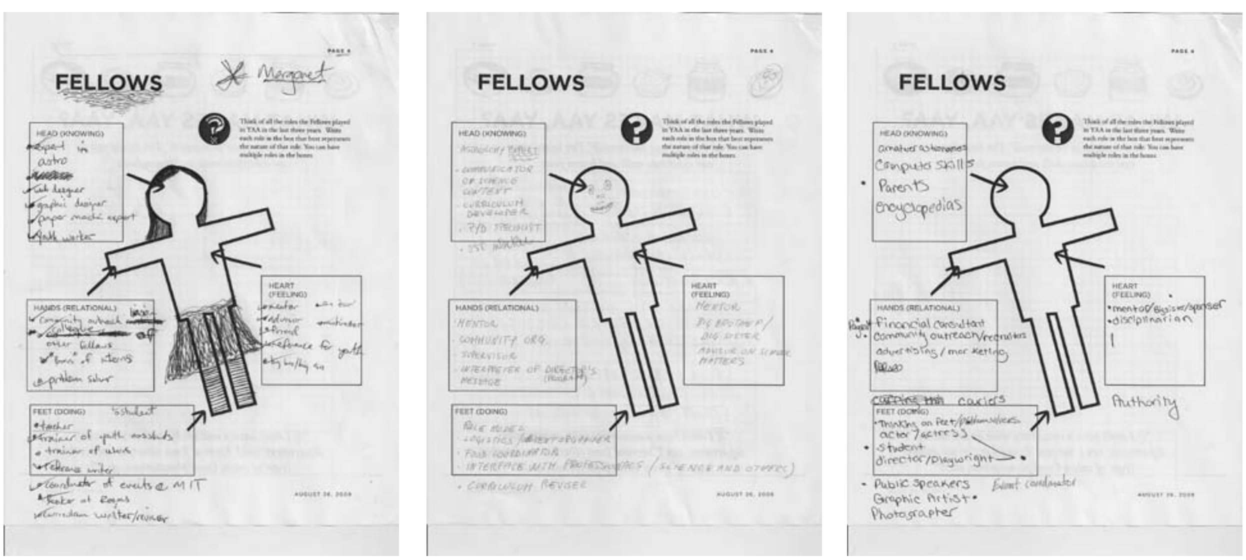
For this fellow, the experience of having used project-based learning in the summer program and having a successful result was a boost to his confidence. Likewise, fellows with no prior experience with inquiry-based learning thought learning about the approach during training and practicing it with youth were helpful in mastering the approach.

### Fellows will develop/increase ability to engage science learners according to their developmental needs, assets, and personal learning styles.

Fellows said they were generally able to engage the youth on an individual level according to their developmental needs, assets, and personal learning styles. For most of the fellows, participating in YAA allowed them to attain new skills in this area and refine existing skills. Some fellows were able to take courses or seminars on working with youth or teaching that they felt were particularly helpful. For example, one fellow took an education course that focused on techniques such as classroom management. Another fellow found a seminar on working with youth helped him to learn some best practices for empowering youth. Working with youth on an almost daily basis allowed fellows to practice these skills. "I could apply the learning [from my course] right away" said one fellow. Some fellows also thought that the YAA staff meetings helped them to learn more about working with youth. In these meetings, they would discuss issues that arose during the week and as a group they debriefed on various approaches to the issue. This group support and feedback helped these fellows find new ways to work with youth.

At the same time, most fellows said they had entered into YAA with many of the skills needed to work with youth on an individual level. For example, one fellow had taken college courses on

**CORE PROJECT TEAM EXERCISE - "DISECTING" THE ROLES AND RESPONSIBILITIES OF A YAA FELLOW**



developmental psychology and felt this was helpful in meeting youth in a manner that addressed their developmental needs. Other fellows had worked with youth in previous jobs and felt this incoming experience was what they drew on the most when assessing and working with individual youth's assets and learning styles.

A few fellows felt they would benefit from additional training on working with youth especially in the area of assessing youth developmental needs and learning styles. As one fellow said, the more you learn the more you realize you still have to learn about a topic. However, most fellows thought that on-the-job-learning, observing youth, talking with them, and helping to meet their needs was also a valuable part of the learning process. One fellow described this as a "gut feeling" he has when interacting with youth; often youth will not discuss their problem out loud but it is "plain as day eventually" through interacting with them.

### Fellows will develop/increase competence to provide information about STEM learning and career opportunities and pathways to achieve them.

There is little evidence that the YAA program increased fellows' competence or ability to provide youth with information or guidance on STEM learning pathways or careers. Most fellows reported that they used their incoming knowledge about STEM careers and learning pathways to speak with youth about their opportunities. These fellows did not draw on any YAA training or experience in their conversations with youth. For example, one fellow used her prior knowledge from teaching and having friends who are in the sciences to inform youth about possible options. Only one fellow thought that she had broadened her knowledge about possible options for STEM learning, and this came from becoming more aware herself of opportunities for STEM learning in the Boston-area. All fellows did report making youth aware of STEM learning pathways and career opportunities regardless of the original of their initial familiarity with the topic.

## SUMMARY

The degree to which the YAA program achieved its intended outcomes for fellows varied greatly for each fellow. The fellows came into the program with varying levels of skills, experiences and knowledge. As a whole, the YAA program did increase fellows' confidence and ability to deliver astronomy content using project-based learning and inquiry approaches. Participation in the program also increased the overall ability of fellows to engage youth based upon their individual needs, assets, and learning styles. YAA did not appear to have an impact on fellows' ability to inform youth about STEM learning or career options. The degree to which each fellow was impacted by the program was very individualized. Overall, those employed as YAA fellows seemed to have come to the positions with strengths in many areas, and the program helped them to acquire the new skills or knowledge they needed.

# COMMUNITY-BASED ORGANIZATION (CBO) STAFF

## INTRODUCTION

Community-based organizations and their staff play vital roles in the YAA program model. They serve as the point of entry for the youth who participate – helping to recruit youth into the YAA program. They host the after-school program in the forms of facilities, computer equipment, and support staff. Table 15 lists the community-based organizations served as after-school sites and participated in the YAA program in 2009.

**TABLE 15 - YAA 2009 AFTER-SCHOOL SITES**

| |
|---|
| Tobin/Mission Hill Community Center<br>1481 Tremont Street Roxbury, MA 02120 |
| Roxbury Community College Upward Bound Program<br>1234 Columbus Ave. Roxbury, MA 02120 |
| Roxbury Multi-Service Center's John D. O'Bryant Youth Community Center<br>434 Warren Street Dorchester, MA 02121 |
| Vine Street Community Center<br>339 Dudley Street Roxbury, MA 02119 |
| IBA<br>100 W. Dedham St. Boston, MA |
| Hispanic Office of Planning and Evaluation<br>165 Brookside Avenue Extension Jamaica Plain, MA 02130 |

Data Sources Used to Determine CBO Staff Outcomes
(Data collected in 2009 unless otherwise noted)


## FINDINGS, PRESENTED BY OUTCOME

### Staff will learn to identify and promote features of good science learning programs.

Common themes that emerged over the course of observations, group meetings and individual discussions with community center staff are presented below. They are described within the context of the YAA program; specifically, the positive attributes of the program that made YAA beneficial for the youth and community centers.

1) YAA is rigorous – this is a quality CBO staff both loved and (at times) loathed about the YAA program.

2) YAA is genuine and accessible – program delivery (led by fellows, young people in their 20s and 30s; supported by community center site staff at places near their neighborhoods and homes); and, its astronomy science content

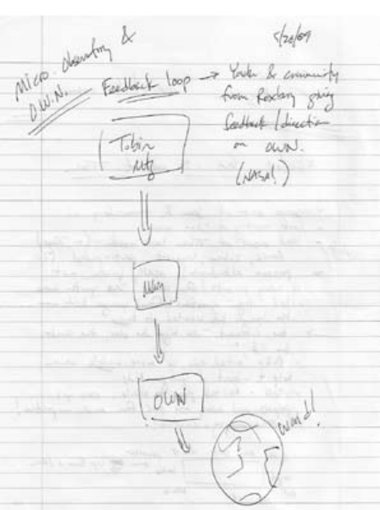
3) YAA is timely – site staff shared

that quality programs such as YAA are desperately needed in order to help teach job and leadership skills to young people

4) YAA provides exposure – CBO staff indicated that participating in programs such as YAA allow youth to be able to imagine themselves in fields (science) and in places (MIT, Harvard) that they did not before think possible

5) YAA meets immediate needs – CBO staff noted the importance of the paid apprenticeship component. In their view, this had significant benefit for youth for two reasons: it provided an incentive for youth to commit to and complete the initial phases of the program; a paying job helped the youth (and in some cases, their families) meet real economic needs.

Agenda items / topics of discussion at the meetings between CBO staff and the core project team have centered on elements of effective science learning programs. At the meeting in March 2009, CBO staff participated in an exercise in which they worked in small groups to create their own lists of characteristics of good science programs. These lists were then compared to known best practices. There was much overlap between those listed by the CBO staff and the known and documented best practices.




CBO staff participated in the feedback loop for the redesign of the user interface of MicroObservatory, the primary web-based technology that was used in the YAA Program. In response to being asked to provide feedback on the redesign of this tool, the feedback they provided was evidence of the value of their collective opinion and knowledge base about elements of good science programming.

## Staff will develop awareness and knowledge of local resources for science education.

- A listing of available science resources was assembled by the core project team and shared with CBO staff at one of their regular joint meetings. This resource information has also been posted to the Program's web site.

- It was evident through meeting conversations that the CBO staff saw the core project team and the project fellows in particular as accessible sources for content and answers to technical questions.

- Participating site staff also indicated the Timothy Smith Network as a "go-to" resource for science-related programs and activities.

- MicroObservatory. During the after-school portion of the program, youth used a web-based tool, MicroObservatory, to "engage in astronomy investigations, take astronomical images using the MicroObservatory online telescope network, learn to process astronomical images, and produce reports and presentations about their investigations." Independent of the science content benefits of the tool, MicroObservatory was described as an effective, hands-on way for youth to develop and improve computer skills in general. Both CBO site staff and core project team members attributed the availability of this tool to the overall success of the YAA program.

**A SAMPLING OF DISCUSSION TOPICS AND RESOURCES DISTRIBUTED DURING 2009 MEETINGS OF THE YAA CORE PROJECT TEAM AND CBO STAFF**

### ELEMENTS TO LOOK FOR IN A SCIENCE AFTER-SCHOOL PROGRAM

**In general:**

- Create opportunities for youth to view science as a part of their daily lives.
- Include hands-on and project-based activities: fun because it is rigorous (like professionals do)
- Reinforce literacy and communication skills
- Convey positive message to youth about who can do science (everyone!)
- Have high standards, expect the best!
- Involve adults as mentors (science mentors but not only)

**For younger kids**

- Involve parents and other family members in science activities they can do with their children.

**For older youth**

- Incorporate youth-voices in decision making
- Included training and preparation focused on employable skills
- Introduce youth to the world outside their local neighborhood
- Focus on positive youth development
- Provide expertise and specific knowledge of subject matter (partner with local science experts)
- Provide internship opportunities, paid positions or help in securing paying jobs.

References:

- ***Back to the Future: Engaging Older Youth***, 2007, National Institute of Out-of-school Time
- ***Meeting the High School Challenge: Making After-School Work for Older Students***, 2007, The After-School Corporation

### WHY SCIENCE IN OUT-OF-SCHOOL TIME

- 80% of future careers will demand knowledge of science and technology
  - If children think science and technology is not for them they will find themselves left out of most careers.
- Being interested in science may be more important than being good at science
  - Interest in science among 8th graders is proven to be a better indicator than test scores for predicting career choices
- Schools alone cannot create future scientists and engineers
  - Children need time to explore and discover on their own
- Availability of resources
  - Resources abound but communities must take the lead in using such resources in ways that are appropriate locally

Coalition for Science After School

### ROLE OF ADULTS

- 59% of parents think that an advanced degree beyond a college bachelor's degree is necessary to have a job in science and engineering (false!)
- 64% of parents were surprised to learn that working in science or engineering today hav degree.
- After being introduced to what science and are about, 88% of parents realize that scien offer realistic job opportunities for their chi

### WHAT IS NEEDED TO SUCCEED IN THE WORKPLACE?

- At the high school level, more than 50% of graduating seniors will not be prepared in the most important skills needed to be successful in the workplace:
  - Oral and Written communication
  - Professionalism/Work Ethic
  - Critical thinking/Problem Solving
- NOTE: college graduates of 4 year colleges are better prepared but only 25% score "excellent" AND 25% are not prepared in Written Communication

*Reference: Are They Really Ready To Work? Employers' Perspectives on the Basic Knowledge and Applied Skills of New Entrants to the 21st Century U.S. Workforce* – The Conference Board, 2006

"This gives us something to offer the youth besides basketball."

**Staff will take on leadership and advocate roles to promote science-learning opportunities within their communities.**

This outcome was not measured using the above techniques. However, there is evidence that science-learning was starting to gain a foothold among participating community centers in Boston:

- Three of the six community sites that participated in the YAA program have participated in an additional science-learning program implemented by MKI, "Kids Capture their Universe."

- Core project team members reported that there has been an increase within and across the after-school sites in terms of interest and demand for science-learning programs. They indicated the increase was a direct result of the YAA program.

### SUMMARY

During Years Two and Three, the project team worked diligently to build relationships with individual CBO staff that will result in a sustainable program at the current CBO's. Without a solid partnership that involves these organizations in multiple aspects of the program, it will be difficult to reach and impact the local community. As the data show, members of the youths' local communities are not well represented at the outreach events. That said, those members of the community who did attend the outreach programs were positively impacted.

## UNINTENDED OUTCOMES

### INTRODUCTION

Program models are developed in order to describe how a program is to function and how it is to be evaluated. However, even when the literature is thoroughly reviewed in advance of developing a program model, even when stakeholders and funders are involved in developing a model for a program, and even with the best logic model, it is not at all uncommon for programs, upon their evaluation, to have unintended outcomes.

Unintended outcomes are program effects that could not have been foreseen. These outcomes often have positive and unforeseen effects on a program and in some cases the unintended outcomes are deleterious to the program goals. Unintended outcomes may be the result of extraneous variables not previously reported in the literature related to the program of interest or they may simply be the result of random events and actions. In either case, unintended outcomes are important to program staff and evaluators alike. Program staff should find the unintended outcomes to be of use in designing future, similar programs; program evaluators should consider incorporating this new knowledge about possible program outcomes when assisting staff in the development of a program.

In YAA, unintended outcomes did occur and are reported here in order to provide the most complete picture possible of what occurred as a result of the YAA Program.

## YOUTH APPRENTICES, YOUTH ASSISTANTS, YOUTH INTERNS

In the first exploratory factor analysis, two factors emerged that were not anticipated. Discovery of new factors is not unusual in an exploratory analysis where data are free to cluster based solely on the shared variance among items rather than forced, by the researcher, into predetermined categories. These two factors, however, provided additional understanding of youth behavior across both time and participation level.

The first factor appeared to represent a type of *self-esteem* that can develop in youth that have *positive learning experiences* in a new and in depth area of inquiry. The perception of self as related to the new experience is not necessarily based upon the amount of skills or knowledge gained, but in the mere experience of learning. This factor was based upon items such as: I am pretty good at science. I feel comfortable speaking in front of large groups. I know how to explain my ideas to others. I have a positive influence on other team members.

The second factor represented only four items from the initial leadership and teamwork scales. The combination of these four items suggested a type of control exhibited when faced with difficult situations or decisions. Two items represented reaching within one's self: I show confidence in tough situations; I consider new ways of doing things. In contrast, the other two items represent youth that react to a difficult situation by trying to control it: I explain why someone [else] is wrong; When there is a disagreement in the group, I try to influence the group for the better.

In each of the factor analyses, the items meant to represent 'advocate for science in the community' emerged intact as a single factor or part of a larger factor.

In two factor analyses, items representing 'knowledge of astronomy' emerged, intact as a single factor or as part of a larger factor.

Youth responses to the majority of items created to capture: 1) attitude toward doing science, 2) beliefs about astronomy, 3) decision-making behavior, and 4) interpersonal communication behavior could not be explained through any of the factor analyses. Furthermore, the original sets of items created to measure each of these four did not have strong internal consistency, thus, were not used as intact sets. Some of these items, however, were used in various outcome measures (as represented in the table, Final Outcome Measures).

The YAA program includes a progression of roles, responsibilities, and activities for youth. As youth move through the program, they are able to progress from being an after-school participant to an employee. There are also multiple employee levels within the program, allowing youth to continue to move up the career ladder within the program. In their estimation, youth assistants felt that this progression had allowed them to grow in areas whose groundwork was laid in the after-school program (life skills, astronomy content knowledge).

## LOCAL COMMUNITY (THROUGH OUTREACH EVENTS)

Three areas of unintended outcomes have been identified: 1) unintended outcomes on outreach event attendees, 2) unintended outcomes on local audiences through informal interactions with youth, and 3) unintended outcomes for groups other than the local community. Each of these areas is detailed below.

***Unintended outcomes on outreach event attendees:***

Although difficult to quantify given the methods used, it is likely that the greatest impacts of the outreach events were not those specified by the program model. Rather, impacts such as exposure to astronomy topics, enjoyment of YAA events, and gaining insight into youths' interests were much more likely to occur. Multiple sources of data (interviews with event attendees, the youth assistant focus group, and fellow interviews) emphasized these impacts on attendees.

Youth assistants in the focus group felt the public programming that they did through YAA exposed people to astronomy and could spark their curiosity in it. If the opinion that people have is that STEM careers are boring, the outreach activities showed that there are "fun ways to do your work and to be able to have a career in it that is fun." Star parties, especially, were thought to have a great impact. Youth participants, on the questionnaire collected at the end of the summer program, also reflected on the power of the outreach events of attendees. "Most of the time after our events," wrote one youth, "people from my community will tell me how much they enjoy our work and how much more they are interested."

The fellows thought that family members and friends of the YAA youth were impacted by the program through their attendance at events. Fellows thought these impacts included learning more about astronomy, but more importantly, gaining insight into what the youth participants were spending their time on and were "passionate" about. One fellow said that attendees to events are often "amazed at what youth can do…impressed at what is possible." While these potential event-based impacts on family members and friends of participants were notable, as reported above, the overall attendance at events by these groups was small.

***Unintended outcomes on local audiences through informal interactions with youth:***

It is more likely that the greatest impacts of YAA on the local community were achieved through day-to-day interactions with YAA participants. Given their closeness to participants, this outcome may be strongest among family members and friends of youth participants. The opportunity for informal conversations about the program between youth and their friends and family would arise daily, as opposed to events which were held occasionally. As one fellow put it, events were a "one-shot deal" for attendees, implying the impacts gained from attending one event would likely be small. Youth assistants in the focus group reported these types of casual conversations with friends. For example, one assistant related a conversation that had begun with her family when they were "just hanging out on the front porch looking at stars." She had been able to answer some of the questions that were raised by the group. Similarly, a fellow related that one participant's play was based on conversations the youth had with her father about the nature of the universe. No doubt, casual conversations about astronomy were more likely in these families because of YAA.

Some youth assistants in the focus group reported either recruiting their friends or siblings into YAA or having been recruited themselves by a friend. There is some evidence, therefore, that demonstrates that friends of youth participants did join the program. This would cause them to be impacted in similar ways as the rest of the youth participants. What is less clear is how the program might have impacted friends of youth participants who did not join the program. Some youth were also able to report specific instances of impacts on others, friends and family excluded. One assistant, for example, knew of a teacher who was using his success in the science fair to motivate her students.

Youth in the program had mixed opinions on whether YAA had made an impact in their community. When asked if the program had increased the community's value and support of science, 50% of youth in the summer program indicated that it had not and 50% that it had achieved this goal. Those who thought this outcome was met tended to focus their explanation on: 1) general willingness of community members to talk about the program or astronomy, 2) how the program had changed them and their standing in the community, and 3) the effectiveness of the outreach events. This first explanation is the informal impact on the community through youth interaction. Some youth indicated that as a result of their interest, they shared astronomy information with people they know. This included their friends and family members. For example, one youth told his brother about black holes and reflected that "I think that from me telling him, he got something different out of it than if [he] had gotten the information anywhere else." Thinking more broadly, another youth wrote, "I don't really remember people saying science learning isn't the way to go but [they] seem to have more willingness to talk about it with me, or at least me to them."

For those youth who felt the program had not increased the community's value and support of science, their reasoning focused on: 1) people from the community do not know about the program, 2) community members do not attend events, and 3) people in the community, in general, and their friends, specifically, were not interested in science or astronomy. For example, a youth wrote, "People in the community I live in don't care about science and I think that it didn't increase because every time I talk about science to my friends they never wanna listen to me." Another youth echoed this idea: "I don't think that has happened much in my community because if I mention the program…members of the community look at me like I lost it. They think that a girl like me should be into music and dancing, not science." For the full range of youth responses on the degree of community impact, see the Appendix.

***Unintended outcomes for groups other than the local community:***

It is also likely that other communities beyond the youths' were impacted by the YAA program. Possible additional communities that were impacted included those whose residents included: staff at MIT that attended outreach events, the scientists and professionals who served as experts for the summer program, and exhibition staff at the Museum of Science who worked with youth to create the exhibit, "Black Holes: Space Warps & Time Twists," in Year 1 of the program. Reports from the core project team and project PIs indicated that these groups were impacted through their interactions with youth. Future studies of the program could investigate the impact of YAA on these and other communities not targeted in the original model and its intended outcomes.

## FELLOWS

When reflecting on their positions, fellows thought they had grown personally as a result of their experience. Over the course of a program year, the fellows were required to use a variety of different skills, and the summer experience, especially, required the fellows to synthesize many different skills. According to one fellow, program participation "required technical knowledge, people skills, project management of course. It was really a combination of skills, which I hope I've developed in the last several years but trying it out in the real world was very useful for me." For this fellow, YAA allowed him to practice and refine existing skills.

To some extent, the fellows described their learning in ways similar to the youth. The fellows felt they were learning content knowledge and project-based skills, as did the youth. The fellows themselves saw this connection:

> *I think like it's given the students confidence to do a multitude of things. I feel its done the same for me…and also its just the combination of so many different elements [of project content] and science and education and mentoring, coaching, managing different personalities…I've grown personally and just the personal sense of satisfaction and accomplishment of going through this whole process. (Another fellow)*

The YAA program created a learning environment for the fellows as well as for the youth and allowed them to feel a growing sense of confidence and accomplishment.

The fellows felt that YAA was organized in a way that allowed them to focus on the needs of each youth as an individual. There were multiple factors that supported their abilities to work with youth one-on-one, including the low ratio of youth to adults in the after-school program, the presence of the youth assistants (who both benefited themselves from the individualized attention and allowed th fellows to spend more time with youth who needed extra help), and the 'open door' policy of the program and staff.

## COMMUNITY-BASED ORGANIZATION (CBO) SITE STAFF

The staff of the CBO's shared a number of program qualities that provided a different perspective on the benefits of the YAA program.

They included:

- Exposes at-risk youth to opportunities (science and others) that they otherwise would not be introduced to
- Unique nature of YAA program adds diversity to typical offerings at some community sites (i.e., something to offer to the youth other than baseball)
- Relevance – the multi-cultural aspects of the program – many different cultures have a connection to the sky and stars
- "Meeting youth halfway" – being sensitive to the immediate needs and challenges of the youth; take care of basic needs first, then push them to grow via YAA
- Gets youth onto the "MIT / collegiate pipeline / pathway"
- Teaches youth very important and necessary information technology / computer skills

## OTHER UNINTENDED OUTCOMES

Non-science experts working with youth on their own content (i.e. theatre) experienced increasing fluency in astronomy and science in general as they learned on the job.

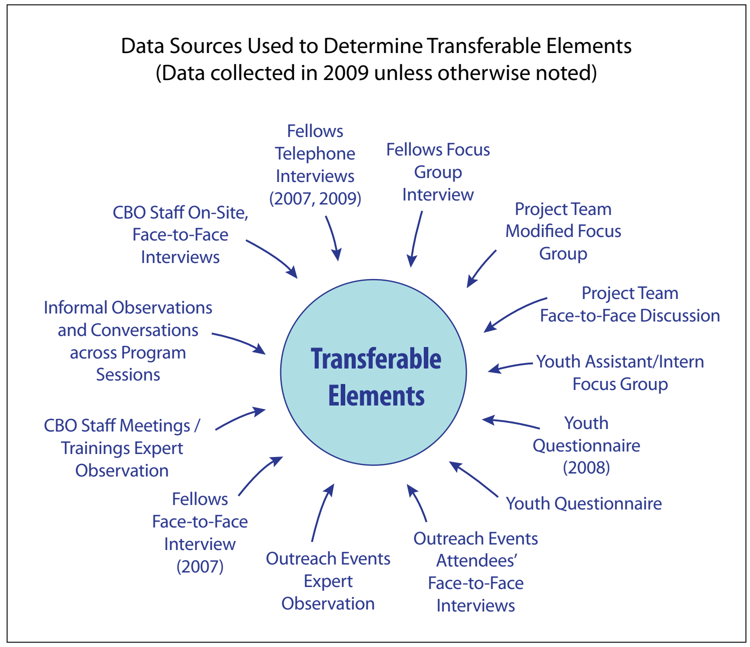
# RESULTS RELATED TO TRANSFERABLE ELEMENTS OF THE PROGRAM MODEL

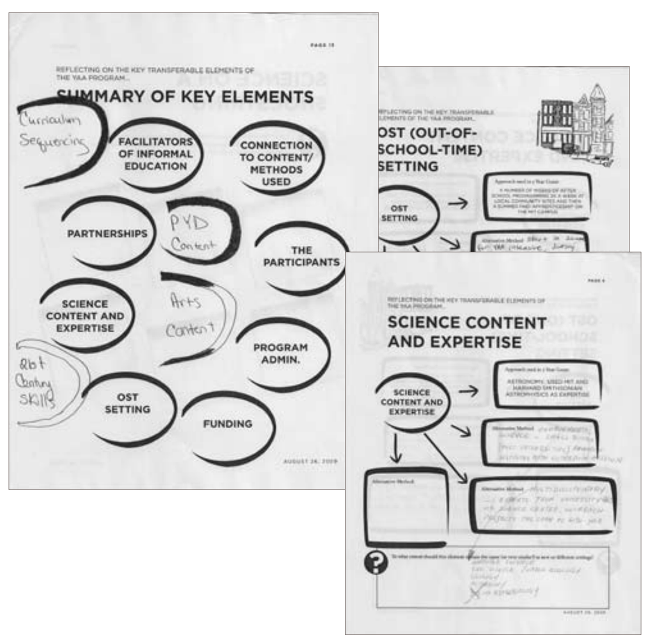
## INTRODUCTION TO THE TRANSFERABLE ELEMENTS

Transferable elements permeate a program's structure but emanate from the program's philosophy. These elements must be considered by those replicating the program but are malleable enough to allow the new program o employ its unique assets. Several sources were used to identify the YAA model's transferable elements.

The following is a listing of the key transferable elements identified as part of the summative evaluation process.

- Program Participants
- Type of Education
- Organizational Partnerships
- Informal Science Educators (Frontline)
- "Content" Expertise
- Involvement of Youths' Communities in All Phases of the Program
- Opportunities for Youth to Share Knowledge and Skills with Others
- Spiral Curriculum in an Apprenticeship Model
- Processes, Products, and Integrating Content
- Youth Outcomes: Specific Field of Science
- Youth Outcomes: Other Science and STEM-related Outcomes
- Youth Outcomes: Personal and Interpersonal Skills
- Community Outcomes: Attitudes, Knowledge, Skills, Intentions and Behavior

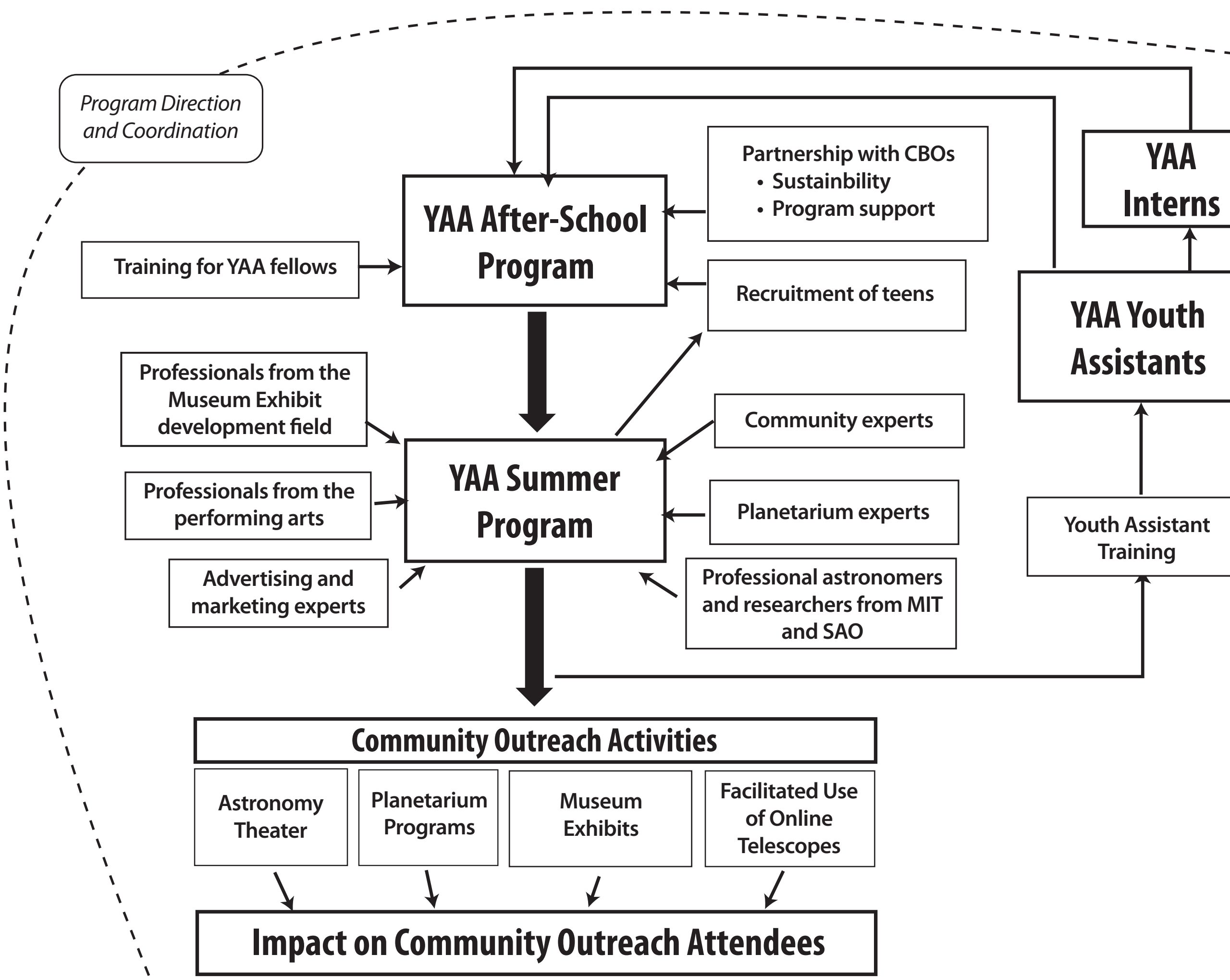



Data were collected to inform the use of each transferable element in five broad categories.

- Brief Description of Element
- Element in the YAA Program Model
- Rationale for Element
- Flexibility of Element
- Considerations

YAA PROGRAM MODEL, YEAR THREE



ANALYSIS AND DISCUSSION OF TRANSFERABLE ELEMENTS

## PROGRAM PARTICIPANTS

Older youth from urban, under-represented communities

### *Element in the YAA Program Model*

- HS-aged youth (ages 14-19);
- From inner-city Boston, MA;
- Most youth were members of under-represented / underserved communities (Latino and/or African-American);

### *Flexibility of Element*

- Very little flexibility on age (14-19 years);
- Success of program is not dependent upon which of the various under-represented communities participate, just that they are considered to be under-represented in science opportunities and professions;

### *Rationale for Element*

- Few informal science education programs are for older youth;
- Minority populations are still under-represented in science professions;
- Youth from under-represented communities are still underserved in formal and informal science education programming;

### *Considerations*

- The target audience must be clearly defined: the word 'community' has a multitude of definitions as does 'under-represented' which, in this case, referred to under-representation of cultural/ ethnic groups in science-related experiences and professions;
- The nature of minority cultural/ ethnic communities tends to be socio-geographic, thus urban was included in the definition of target audiences;
- Older youth tend to be more difficult to recruit and retain in voluntary, out-of-school programs because they/their friends drive and have multiple, external demands including sports and jobs;

ANALYSIS AND DISCUSSION OF TRANSFERABLE ELEMENTS

# ORGANIZATIONAL PARTNERSHIPS

A high level of complexity in a program suggests that there should be multiple organizations working together to develop and implement it.

The success of any partnership is based on factors related to the environment, membership characteristics, process and structure, communication, purpose, and resources. (Fieldstone Alliance, 2001).

### *Element in the YAA Program Model*

- The organizations involved in the project included two universities and a non-profit foundation;
- The CBO's hosting the after-school program were not initially involved as partners;
- MIT was the initiating partner and had control of the funds and human and other resources for the program;
- The other partner organizations (Smithsonian Astrophysical Observatory and the Timothy Smith Network) had much smaller but critical roles in the project;

### *Rationale for Element*

- In most informal science education programs, partnerships are key to covering all 'the bases' whether it is content, resources, planning and coordination, or other issues that arise; Multiple perspectives are crucial when addressing problems and making decisions;

### *Flexibility of Element*

- The number and types of organizations involved can be flexible;
- What is not flexible is the pre-planning and on-going communication needed to implement a program with multiple partners;
- Partnerships can be categorized into three major types: cooperation, coordination, or collaboration and there is flexibility in which type(s) of partnerships are developed;

### *Considerations*

- This project considered the community sites to be partners with identified target outcomes; but, the type of partnership that developed did not support achievement of those outcomes;
- There was a mismatch between the nature of the partnership and what could have occurred as a result of it;
- The Timothy Smith Network represented the community sites in the development of the program; but, the sites themselves were the actual participating partners and were minimally engaged before program implementation; by the time the program was launched, it was too late to involve the sites in ways that would have enhanced the partnerships and experiences of those involved;

ANALYSIS AND DISCUSSION OF TRANSFERABLE ELEMENTS

## INFORMAL SCIENCE EDUCATORS (FRONTLINE)

Mature individuals with knowledge and skills in informal science education (philosophy, approach, methods), specific science content, understanding of youth development (i.e., Positive Youth Development), skills in program planning / managing, community relations skills

### *Element in the YAA Program Model*

- Fellow position;
- Paid position with MIT;
- When viewed as a group (there were 4 per year), the fellows had all the knowledge, skills, and experiences needed but as individuals, no;
- Had multiple roles beyond informal science educators;
- Provided consistency across the components of the project year;
- Served as youth mentors;
- Critical to the Apprenticeship Model as the 'journeyman';

### *Rationale for Element*

- For the Apprenticeship Model, as a journeyman, the individuals hired as frontline informal science educators needed to be learners as well as teachers – they had to be comfortable with both roles;
- For the universities participating in the project, the concept of a fellow was familiar;
- The science content, program context, youth audience, and informal science education approach were all complex – requiring the position (and those in it) to feel comfortable in the academic setting as well as the informal science education settings;

### *Flexibility of Element*

- The program model must have individuals that work day-to-day, are consistent throughout the program year, and regularly interact with the youth;
- The Apprenticeship Model must have individuals at the Journeyman level to both mentor and teach the apprentices and be guided by and learn from 'the Masters' (their learning provides a model for the apprentices);
- This element (informal science educators) appears to work best when one position (in this case, the fellow) combines both the consistency with the journeyman's skills and knowledge;

### *Considerations*

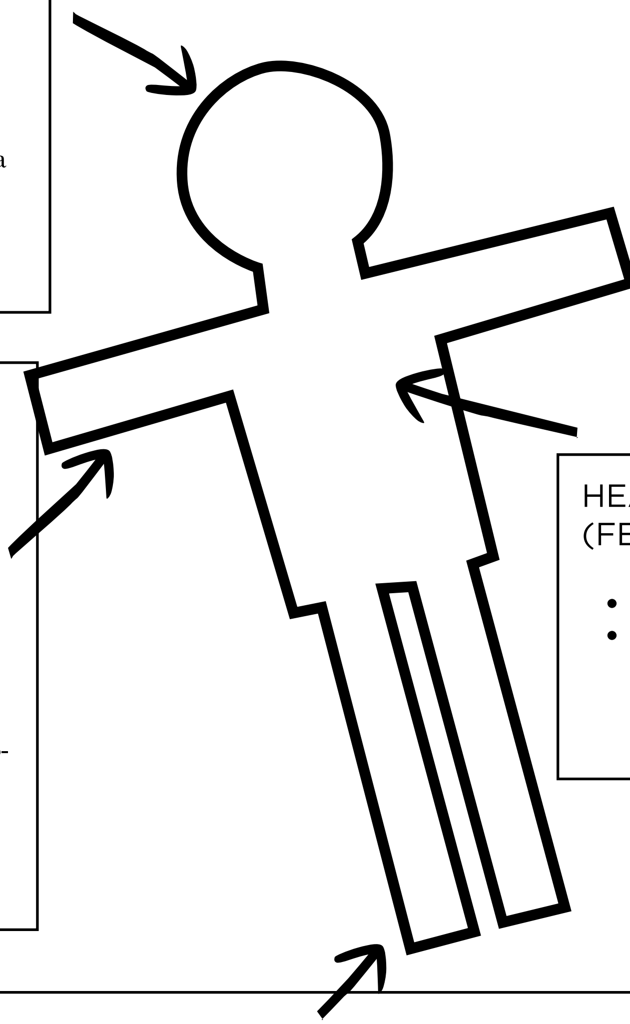
- The fellows took on many different roles; during a 15-minute discussion, 61 different roles were identified by the project team, interns, and fellows; (see next page)
- All these roles were not necessarily assigned and different fellows took on different roles based upon their interest and skills;
- Programs may want to identify the roles that only the fellows can / must play, focus on those and, either eliminate the need for the others or assign them to another existing position or create new positions;

# FELLOWS

Think of all the roles the Fellows played in YAA in the last three years. Write each role in the box that best represents the nature of that role. You can have multiple roles in the boxes.

## HEAD (KNOWING)

- PYD specialist
- Expert in appropriate science content
- Expert in technology
- Technology expert (activities/ methods)
- Accountant/ payroll
- Crafts expert
- OST professional
- ISE professional
- Amateur astronomer
- Computer expert
- Encyclopedia
- Visionary



## HANDS (RELATIONAL)

- Big brother/ sister
- Nagging Mom/ Dad – buddy
- Interface with experts
- Friend
- Motivator
- Supervisor/boss
- Good cop/bad cop
- School counselor/ academic advisor
- Interpersonal relations with youth
- Employee
- Community liaison
- Taskmaster/ disciplinarian
- Mentor
- Colleague of co-workers
- Leader
- Role model
- Coach

## HEART (FEELING)

- Shoulder for crying on
- Available as an empathetic party

## FEET (DOING)

- Logistics associates
- Graphic artist
- Curriculum reviser/developer
- Flexible in changing circumstances
- Problem-solver
- Trainer of Youth Assistants
- Messenger/ communicator
- Student/lifelong learner
- Reference writer
- Public speaker
- Web designer
- Event planner
- Decorator
- Coordinator
- Interpreter of director/ program
- Office assistant
- Photographer
- Advertiser
- Teacher
- Artist
- Scientist
- Archivist
- Janitor
- Paradigm shifter
- Magician
- Traveler
- Hauler
- Actor/director/ playwright (Gong-ringer)
- Photographer
- Tutor

## ANALYSIS AND DISCUSSION OF TRANSFERABLE ELEMENTS
## "CONTENT" EXPERTISE

Using the concept of ***Master*** in the Apprenticeship Model, content expertise is provided by a number of recognized experts in different content areas.

### *Element in the YAA Program Model*

- Experts in astronomy included members of the project team and their institutions;
- Experts in successful approaches to informal science education provided training and support for fellows and project team members;
- Experts in disciplines used as integrating content, providing alternative processes and 'products' for apprentices to work on (theatre, telescopes, museum exhibit design, planetarium design and use) came from well-known practitioners;

### *Flexibility of Element*

- In an Apprenticeship Model, content expertise should come from the people working in that field of content;
- They should be recognized by peers as 'experts' (Masters of their trade);
- The type of content expertise should be in at least five areas: 1) science / the specific science, 2) the integrating content (such as theatre), 3) informal science education, 4) philosophy for working with youth, and 5) community engagement;

### *Rationale for Element*

- The Apprenticeship Model calls for apprentices to work, hands-on, side-by-side with Journeymen and the Masters in the development of some end product;
- There was not the type and level of expertise in some areas of content within the existing core project team – and certainly the core project team were not recognized expert practitioners in all areas of content;

### *Considerations*

- There was one area of expertise that was lacking: community engagement / development;
- Experts varied in their interest and ability to work with youth;
- The expertise regarding informal science education came from organizations recognized in OST and was provided at a few points in the development of the program – this left gaps in this expertise when specific issues arose;

ANALYSIS AND DISCUSSION OF TRANSFERABLE ELEMENTS

# INVOLVEMENT OF YOUTHS' COMMUNITIES IN ALL PHASES OF THE PROGRAM

Include members of the community in program identification, planning and delivery; ask members of and organizations in the local community to support and host programming in the local community; use members of local community as advisors to the program and to share their expertise about the community and the youth

### *Element in the YAA Program Model*

- Partnered with a local foundation, the Timothy Smith Network, to identify community sites with interest and appropriate facilities for the after-school component of the program (TSN-funded computer labs);
- Little community involvement in identifying community needs, designing the program, and providing expertise about the nature of the communities to be involved;
- No community members were advisors to any component of the program and none were asked to provide expertise;
- However, CBO staff (that may or may not have been from the community) participated in the after-school component;

### *Rationale for Element*

- The long-term impact of the program was identified as community change;
- Involvement creates buy-in and generally better programming;

### *Flexibility of Element*

- Ways to involve the community are flexible;
- The roles of community members in the design and implementation of the program are flexible;
- Choosing whether or not to involve the community in various ways throughout the program is not flexible;

### *Considerations*

- The project team never really focused on defining just who the community was;
- Urban geography approaches and low-or-no cost mapping tools as well as community liasion can be used to support this element;
- Involving organizations in the community, beyond the community sites hosting the after-school program, could have provided additional contacts within the community;

ANALYSIS AND DISCUSSION OF TRANSFERABLE ELEMENTS

## TYPE OF EDUCATION

Out-of-School time (OST) programming; informal science education

### *Element in the YAA Program Model*

- Entire program took place out-of-school;
- After-school component was conducted in youths' local communities at community-based organizations such as recreation centers, social services agencies, community colleges, etc.;
- Summer component was conducted on the MIT university campus;
- Follow-up activities for youth interns were also held on the MIT campus;
- Outreach events were primarily held on university campuses although some were held in youth neighborhoods;

### *Rationale for Element*

- Choice of the OST / informal science education approach was influenced by prior success of project team with similar programs with younger youth;
- Informal science education is being recognized as a valuable and complimentary partner for formal education;
- Apprenticeship Model comes from the world of work and fits best within an informal education approach where initial and continued participation is voluntary;

### *Flexibility of Element*

- Program model must embrace OST / informal science education and occur out-of-school time and away from a formal school;
- There is flexibility in timing and locations of program components;
- The choice to use the community-based organizations and a university campus as OST sites is flexible;

### *Considerations*

- Many scholars and practitioners of OST and informal education ascribe to different theories (from those used in formal education) in order to understand behavior, its precursors, and appropriate methods for various audiences;
- A true apprentice would work on-site - the choice of locations for implementing the program needs to be made carefully – in order to provide an authentic and effective experience;
- There were both positive and negative consequences connected with both OST sites for this project;

ANALYSIS AND DISCUSSION OF TRANSFERABLE ELEMENTS

## SPIRAL CURRICULUM IN AN APPRENTICESHIP MODEL

Content, activities, experiences, challenges, responsibilities, achievements, and rewards increase as youth move up the spiral.

The Apprenticeship Model mirrors its namesake (from the world of professional craftsmen and tradesmen) in a number of ways including multiple levels of skilled youth and adults helping and mentoring those in the skills levels below themselves. Another important characteristic of this model is guided, hands-on learning, using skills leading to an end product.

### *Element in the YAA Program Model*

- Youth begin in a voluntary, (three afternoons a week) after-school program (March – May) held at a community-based organization. This program resembles a typical after-school program focused on learning about astronomy but youth work on a project they can share at an annual outreach event: Astronomy in the City;
- Next, youth can apply for a full-time, paid summer apprenticeship (June – August). The transition from a less structured after-school program to a summer job is key;
- Community outreach events are a part of both;
- Youth can return a second year in a Youth Assistant role in the after-school program;
- Summer Youth Internships are available for a small group of Youth Apprentices;
- Interns continue as staff members into the next program year;
- All but the after-school youth are paid positions;

### *Rationale for Element*

- Research in informal and formal science education supports multiple, sequenced learning activities and content as beneficial to learning and retention;
- The Apprenticeship Model, even though few informal science education programs are employing it, is based upon models that are successful in other arenas: crafts and trades guilds and higher education are two that have used it for centuries;
- The model employs a number of characteristics from successful mentoring models and programs in work and education settings;

### *Flexibility of Element*

- The entire program is based upon the Apprenticeship Model – this element is not flexible;
- What is flexible is the way in which the various components are designed and implemented, the roles of various persons, and the closeness with which the apprenticeship concept is followed;

### *Considerations*

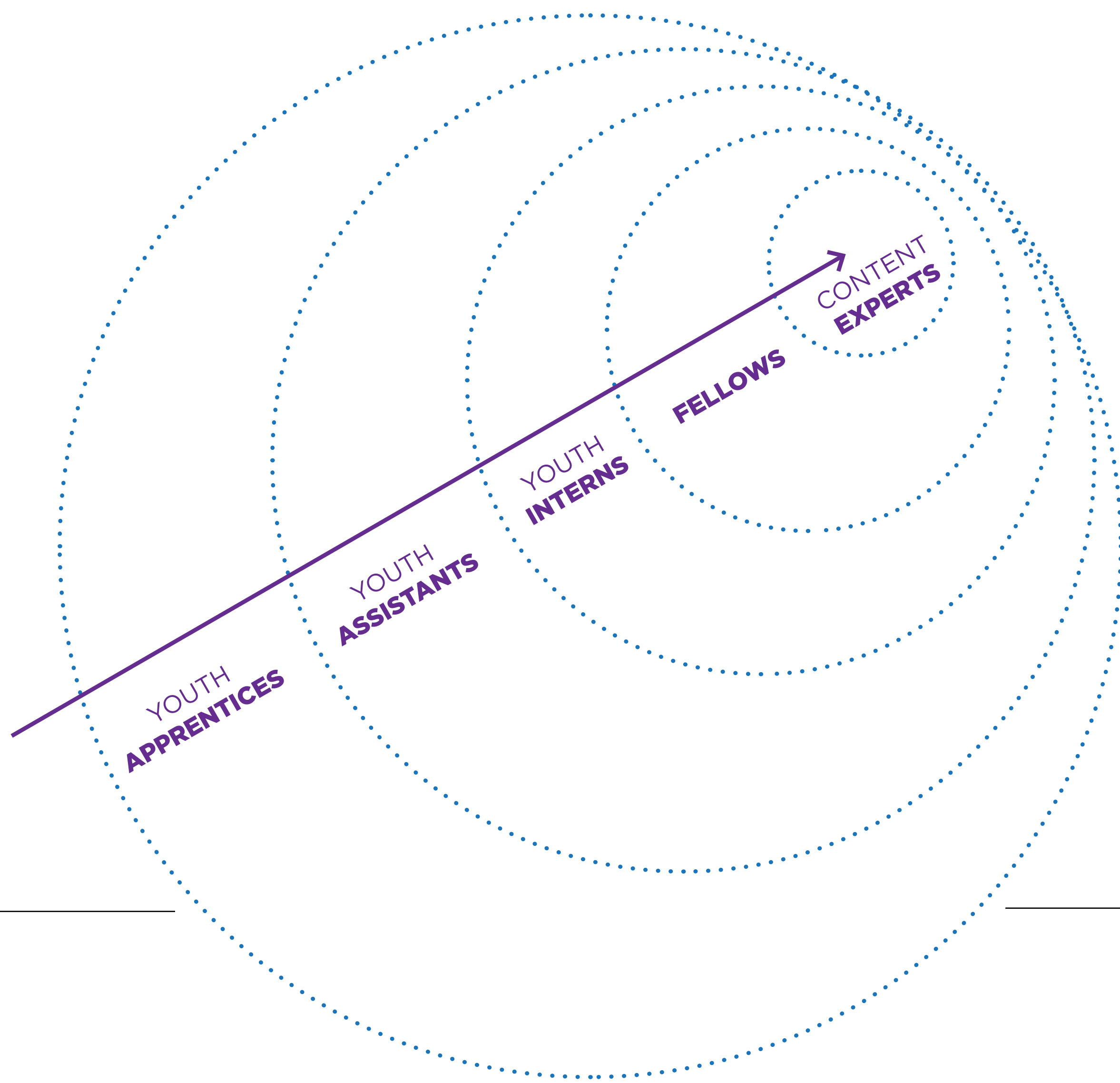
- The Apprentice Model should be clearly defined and communicated at the beginning of the program. Use similar concepts such as trade guilds and higher education models as well as mentoring programs in job training and employment when explaining the how's and why's of the approach both internally to staff and externally to stakeholders and other interested parties including potential funders;
- When issues arise in the program, refer to apprenticeship literature for additional theory and practice information;

## THE APPRENTICESHIP MODEL

The program is based upon a traditional Apprenticeship Model, common in crafts and trades guilds as well as in higher education. An individual who wants to be considered 'a master' in a trade, profession, field of study, or body of knowledge begins as an apprentice, working along side a master practitioner. As the apprentice gains in skills and knowledge and can illustrate a certain level of mastery, he/she moves to a higher level, customarily called a journeyman. The learning process continues until the individual can prove that he/she has 'mastered the craft' by creating, what is judged by the top practitioners, to be 'a masterpiece'.

As illustrated in the figure, below, of the various participants in the YAA program, youth apprentices, youth assistants, and youth interns represent various levels an apprentice. The fellows are the journeymen and the content experts are the masters.

Many of the results of the summative evaluation reinforce this model by the progression of scores on outcome measures, from a beginning apprentice through the youth assistant, to the youth intern. These findings can be seen in the previous results section.



ANALYSIS AND DISCUSSION OF TRANSFERABLE ELEMENTS

## PROCESSES, PRODUCTS, AND INTEGRATING CONTENT

In the Apprenticeship Model, it is not enough to learn (in this case) science and astronomy. The goal for an apprentice is to create a product that meaningfully illustrates the acquired knowledge and skill and then to share it with peers and others.

Non-science content and processes (referred to as 'integrating') play a critical role as the vehicle for product creation. It is the product that allows progress from apprentice to journeyman and to master. The product created and shared illustrates movement toward mastery and is referred to as the 'masterpiece'.

### *Element in the YAA Program Model*

- The focus for youth in both the after-school program and the summer apprenticeship was creating and sharing a product;
- Multiple processes and extensive content from a variety of non-science disciplines were used by the youth as they worked toward finishing a product and preparing to share it publicly;
- These disciplines offered the integrating content and processes that provided a set of authentic experiences and alternative meanings to science learning;
- The integrating content for YAA included theatre (script-writing and performance), museum exhibit (design and creation), optics (learning about optical devices and sharing knowledge with others), photography (with the Micro Observatory), development of arts, crafts, and games (for use with children attending outreach events), communication and marketing (for display of images and information and for creating flyers), and StarLab portable planetarium (the care, maintenance, use of StarLab as well as content / "show" development and performance);

### *Rationale for Element*

- Integrating content is critical for providing the opportunity to use new and different process and content to create and share an end product;
- The choice of what particular non-science content and processes would be used was informed by the flexibility, the resulting adaptation, its uniqueness and interest by the youth, and whether there were recognized 'masters' available;

### *Flexibility of Element*

- Very flexible but must provide complimentary content and processes for the science;

### *Considerations*

- Selecting integrating content and process from other disciplines takes 'outside-the-box' thinking;
- Finding experts that will contribute their time is difficult if they are truly experts;
- It may be difficult to find experts that are skilled in working with youth in an informal, less structured and less controlled education setting;

ANALYSIS AND DISCUSSION OF TRANSFERABLE ELEMENTS

## OPPORTUNITIES FOR YOUTH TO SHARE KNOWLEDGE AND SKILLS WITH OTHERS

Reinforces science content learning by providing the opportunity to 'share with and teach' others, to show expertise in a content area that not many other people have; Provides opportunities to develop confidence, practice and become comfortable with public speaking, hone skills in interpersonal communication, planning, and teamwork; Youth appreciate and value the opportunities to give back to the community.

### *Element in the YAA Program Model*

- Community outreach events held on university campuses and in the youths' neighborhoods;
- Occurred throughout the program;
- Youth planned the events, developed the educational displays and activities, shared their displays with others, conducted activities with attendees, and wrote and performed theatre plays about astronomy;

### *Rationale for Element*

- Outreach events were designed to reach multiple program objectives including community outreach (addressed in another element) and learning opportunities for the youth;
- Closes the loop for the youth learning process;
- Fits well with Apprenticeship Model providing a vehicle to work toward and share an end product;
- Supports the development of personal and interpersonal skills;
- Provides the opportunity for youth to interact with scientists;

### *Flexibility of Element*

- A program must have this element but how it takes place is flexible;
- Venues should have some formality to them and be accessible for multiple audiences to attend;

### *Considerations*

- It became clear very quickly that the community outreach events were more successful in achieving youth outcomes than those of the community;
- This element turned out to be critical in the youths' positive experiences with the program;
- The outreach events moved quickly toward being a capstone event for the youth in the program;

## ANALYSIS AND DISCUSSION OF TRANSFERABLE ELEMENTS

# YOUTH OUTCOMES: SPECIFIC FIELD OF SCIENCE

Outcome goals related to the specific field of science used as the major science content of the program (physical setting, living world, science and technology as a human endeavor)

### *Element in the YAA Program Model*

- Astronomy – knowledge of, attitudes toward, interest in, and beliefs about astronomy;
- Fits into the Physical Setting category;

### *Flexibility of Element*

- It is unclear whether the science of astronomy holds some special draw, thus the choice of science is flexible;

### *Rationale for Element*

- The program is nested in the education category of informal science education, thus some type of specific science content must be the major focus;
- Astronomy was selected for a number of reasons: 1) the major partners of the project are focused on astrophysics and have direct access to many hard to find resources, 2) astronomy is not addressed by many informal science education programs, 3) The concepts and objects of astronomy are present everyday in all persons' lives but few people know much about it, 4) most people are interested in it as it has a mystical aura and a spiritual connection for many cultures, and 5) the science is perceived to be difficult but in reality, is no more difficult than other areas so the youth are attracted to learning something that is perceived to be difficult and will set them apart from their peers and adults;

### *Considerations*

- Because astronomy is the only specific science content that was used with this program, the curriculum is specific to astronomy;
- Another consideration relates to a major technology used in the program that appears to have worked as a recruitment and retention tool for the after-school program: the MicroObservatory;


| | | understand size and scale of universe | familiar with main characters of universe | describe key difference between characters BASED on evidence | understanding of light | understand analyzing light is only way to study universe | understanding of reflecting telescope | meaning and use of exposure time | meaning and use of filters | formulate Qs and find evidence | understand how digital image is produced | understand how digital image is processed | value organizing own observing work | create powerpoint presentations | importance of and need to improve personal oral and written | gain confidence in giving oral presentations | ask meaningful and clear questions | address science (and other) Qs from audience | lead group discussion | work as a team | provide feedback to each other | receive feedback and use it | teach others |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Science Content Objectives | | | | | | | | | Computer/Technology Objectives | | | | Positive Youth Development Objectives | | | | | | | | |
| Hands-On Activities | Astronomy in the Marketplace | | x | | | | | | | | | | | | | | | | | | | | |
| | Youth Generate Rules | | | | | | | | | | | | | | | | | | | x | | | |
| | Modeling the Universe Activity | x | x | | | | | | | x | | | | | | | x | | | x | | | |
| | Cosmic Cast of Characters | x | x | x | | | | | | | | | | | | x | | | | x | | | x |
| | From Starlight to Image | | | | x | x | | | x | | x | | | | | | | | | | | | |
| | Cosmic Survey | x | x | | | | | | | x | | | | | | | | | | x | | | |
| | Modeling the Earth-Moon System | x | x | | | | | | | x | | | | | | | | | | x | | | |
| | Moon Phases Activity | | | | | | | | | x | | | | | | | | | | | | | x |
| | Toilet Paper Solar System | x | x | x | | | | | | x | | | | | | | | | | x | | | |
| | Group Portrait of the Solar System: Taking Images | | x | | | | x | x | x | | x | | | | | | | | | | | | |
| | Group Portrait of the Solar System: Making Sense of Images | x | x | x | | | | | | x | | | | | | | x | | | | | | |
| | Telescopes and Light | | | | x | x | x | x | x | | x | | | | | | x | | | x | | | |
| | Tour of the Universe | x | x | x | | x | | | | | | | | | | | | | | x | | | |
| | A Journey through the Universe: Presentation | | | | x | | | | | x | | | | | | | | | | | | | |
| | Group Portrait of the Universe: Taking Images | | x | | | | | x | | | | | | | | | | | | | | | |
| | Group Portrait of the Universe: Making Sense of Images | | x | x | | | | | | x | | | | | | | x | | | | | | |
| | Light, Color and Astronomy | | | | x | x | | | | | | | | | | | | | | x | | | |
| | Filters Puzzler | | | | x | x | | | x | | x | | | | | | | | | | | | |
| | Introduction to Models | x | x | | x | x | | | | x | | | | | x | x | x | x | x | x | | | |
| Computer Activities | MicroObservatory Guest Portal | | | | | x | | x | | | | | | | | | | | | | | | |
| | Introduction to MicroObservatory | | | | | | x | x | x | | x | | x | | | | | | | | | | |
| | Image Processing and Contrast | | | | | | | | | | x | x | x | | | | | | | | | | |
| | Images as Data | | | | | | | | | | x | x | | | | | | | | | | | |
| | Investigation of Jupiter and Its Moons: Taking Images | | x | | | | x | x | x | | x | | | | | | | | | | | | |
| | Investigation of Jupiter and Its Moons: Making a Movie/Making Sense of Images | x | x | x | | x | | x | | | x | x | x | | | | | | | | | | |
| | Advanced Image Processing | | | | x | | | x | x | | x | x | x | | | | | | | | | | |
| | Group Portrait of the Universe in Color: Taking Images | | x | | x | x | | x | x | | | | | | | | | | | | | | |
| | Creating Color Images | | | | x | | | | x | | x | x | x | | | | | | | | | | |
| Observing Activities | **Observing Project #1** | | x | x | | x | | | | x | | | x | x | x | x | x | | | | x | | x |
| | Did You Notice? | | | | | | | | | x | | | | | | | | | | | | | |
| | Observation or Inference? | | | | | | | | | x | | | | | | | | | | | | | |
| | Sharing & Publishing | | | | | | | | | | | | | | x | | | | | | | | |
| | **Observing Project #2** | | x | x | | x | | | | x | | | x | x | x | | x | | | x | x | x | x |
| | Introduction & Planning | | | | | | | | | x | | | | | | | x | | | x | | | |
| | What does your data mean? | | | | | | | | | x | | | | | x | | x | | | | | | |
| | Giving Feedback | | | | | | | | | | | | | | | | x | | | | x | x | |
| | **Observing Project #3** | | x | x | | x | | | | x | | | x | x | x | x | x | x | | | x | x | x |

ANALYSIS AND DISCUSSION OF TRANSFERABLE ELEMENTS

## YOUTH OUTCOMES: OTHER SCIENCE AND STEM-RELATED OUTCOMES

Outcome goals related to other STEM content, continued science learning; becoming advocates for science; knowing about future science-related opportunities (informal and formal education, careers); understanding what science is and why it is important to daily living; understanding 'scientific habits of mind' and being able to employ these habits in thinking and acting; understanding the nature of science (the scientific view, scientific inquiry, scientific enterprise)

### *Element in the YAA Program Model*

- Additional STEM content was related to (T) technology including technology directly supporting astronomy (Ex. On-line Micro-Observatory) as well as information gathering and analysis technologies, graphics and fine arts-related technologies, presentation technologies, and instructional technologies;
- Scientific habits of mind (problem-solving, reasoning, communication, making connections);
- Current engagement in science learning;
- Understanding the value of and opportunities for science-related careers;
- Being an advocate for science and astronomy in the local community;
- Understanding options for future participation in science;

### *Rationale for Element*

- The goals for all science education programs typically go beyond knowledge, skills, and attitudes connected to the specific science content;
- They include creating a more scientifically literate citizenry and workforce;
- The programs influence participants so that they understand the value of and employ scientific habits of mind in daily living;
- Science education programs build in content and activities that illustrate the nature of scientific inquiry and the scientific enterprise;

### *Flexibility of Element*

- For an informal science education program to achieve excellence, it must include a focus on achieving science outcomes beyond the specific science content (in this case astronomy);
- There is much flexibility in approach, less flexibility in the content and skills sought;
- Incorporating this content, related skills, and ways of thinking into information and activities of the key science discipline (astronomy) is a natural approach;
- Incorporating some additional STEM-related content into an informal science education program almost happens routinely;
- There is flexibility in which, if any additional STEM content is included;

### *Considerations*

- Many educators use terminology (such as 'scientific habits of mind') but are not completely familiar with its meaning or what it would look like in their specific audience and science – settle on clear definitions and ways to measure before designing program activities that are meant to address them;
- If the program is designed to address additional STEM content, that would suggest a completely new topic – beyond science – with different standards, methods, objectives, measures, etc.;
- If technology, engineering, and/or math are used in the program to support program objectives, then the STEM content objectives are focused on science;

ANALYSIS AND DISCUSSION OF TRANSFERABLE ELEMENTS

## YOUTH OUTCOMES: PERSONAL AND INTERPERSONAL SKILLS

Outcomes related to personal growth and development and knowledge, skills, attitudes, and behavior leading to successful lifelong participation in society are sometimes viewed as an invisible achievement and certainly difficult to measure but are often included as major target outcomes for informal science education programs

### *Element in the YAA Program Model*

- Teamwork;
- Positive Youth Development (PYD);
- Communication;
- Internal verses external focus (when problem-solving and decision-making);
- Leadership;
- Self-esteem;
- The type of people selected for fellows and content experts supports the atmosphere needed for youth to experience personal growth and development;

### *Rationale for Element*

- The program uses a PYD approach and emphasizes learning activities that go beyond science and astronomy knowledge, attitudes, and skills to those that contribute to youth becoming successful citizens and employees;

### *Flexibility of Element*

- Constructing a program to maximize opportunities for youth to achieve outcomes related to their personal growth and development is an important element in the model and not flexible;
- However, there is a wealth of methods, approaches, and models in the literature that one could use in lieu of Positive Youth Development;

### *Considerations*

- These are more than just outcomes; PYD and similar constructs are ways of thinking, acting, organizing, planning, and implementing informal education programming;
- This is an educational philosophy or paradigm – and very difficult to 'do' if not valued, understood, or embraced;

ANALYSIS AND DISCUSSION OF TRANSFERABLE ELEMENTS

## COMMUNITY OUTCOMES: ATTITUDES, KNOWLEDGE, SKILLS, INTENTIONS AND BEHAVIOR

Most informal science education programs have long term outcomes that include various changes and/or impact in the local community. These types of outcomes typically take years of consistent, multiple efforts by many diverse organizations. Very seldom are community outcomes, even when they occur and can be measured, attributable to a specific program or organization.

### *Element in the YAA Program Model*

- Two specific community outcomes were identified: 1) Members of local urban communities will perceive and support STEM learning experiences as relevant, effective ways of promoting overall youth development (including autonomy, responsibility, and academic achievement); and 2) Members of local urban communities will recognize the value of STEM education as providing relevant skills for many career paths and express the desire for additional STEM opportunities in their communities;
- Methods for reaching the community included community outreach events, holding the after-school programming in community organizations, and expecting youth participants to influence friends, neighbors, and family;

### *Rationale for Element*

- The program's theory of action had long term results occurring in the local communities;
- Most youth programs aim to have direct impacts on youth with the hope that youth will be able to impact friends, neighbors, and family (the trickle-down effect);
- Including community outcomes as long term targets for a program provides information to others about the program's context and staff understanding of the opportunity for longer term and greater impacts;

### *Flexibility of Element*

- Great flexibility in whether the community has clearly identified target outcomes, when those outcomes are expected, and the ways in which those outcomes will be approached;

### *Considerations*

- Identifying and achieving community outcomes has a number of issues to address;
- What is the definition of 'community'?
- How long will it take to involve the community in ways that should produce the outcomes?
- What methods work best?
- Does informal science education have theories of community change or are there other fields that should be consulted?
- Should youth be expected to change the community?

# CONCLUSIONS

This section contains conclusions for the Summative Evaluation. Conclusions are organized by the four evaluation questions.

## 1. TO WHAT EXTENT DID THE PROGRAM ACHIEVE THE PLANNED OUTCOMES FOR EACH TARGET AUDIENCE?

### YOUTH PARTICIPANTS (YOUTH APPRENTICES, YOUTH ASSISTANTS, AND YOUTH INTERNS IN THE PROGRAM)

All seven of the proposed outcomes for youth were achieved.

### THE LOCAL COMMUNITY

Community outcomes typically take much longer to achieve and assess than the length of time this program was in place. Therefore, the summative evaluation examined the achievement of these objectives by using a limited approach and sample.

***1) Members of local urban communities perceive and support STEM learning experiences as relevant, effective ways of promoting overall youth development (including autonomy, responsibility, and academic achievement)***

There was evidence that this outcome was achieved, particularly when defining the attendees at outreach events as representing this target audience for the purposes of the summative evaluation.

***2) Members of local urban communities recognize the value of STEM education as providing relevant skills for many career paths and express the desire for additional STEM opportunities in their communities***

There was less support from the formal evaluation data to support the achievement of this outcome. However, informal methods provided some anecdotal information for consideration when this program continues to work toward community outcomes and impact.

### THE PROGRAM FELLOWS

***1) Fellows develop/increase confidence in personal ability to teach astronomy and science content through inquiry/project-based activity***

This outcome was achieved.

***2) Fellows develop/increase ability to engage science learners according to their developmental needs, assets, and personal learning styles***

This outcome was achieved.

***3) Fellows develop/increase competence to provide information about STEM learning and career opportunities and pathways to achieve them.***

There was less evidence to support the achievement of this outcome.

THE STAFF OF PARTICIPATING COMMUNITY-BASED ORGANIZATIONS

***1) Staff learn to identify and promote features of good science learning programs***

This outcome was achieved.

***2) Staff develop awareness and knowledge of local resources for science education***

This outcome was achieved.

***3) Staff take on leadership and advocate roles to promote science learning opportunities within their communities***

Similarly to community outcomes, this third outcome will take longer to achieve than the time allotted. This is a behavioral goal with many extraneous issues that will affect the potential for achievement. A major issue is the time based upon the multiple roles and responsibilities that staff have as employees of the community site. Helping with YAA was just a small part of their overall responsibilities.

There was some anecdotal evidence that CBO staff were moving in the direction of more participation in YAA and even establishing other science-based programming for their sites.

## Q2. WHAT WERE THE UNINTENDED OUTCOMES OF THE PROGRAM?

All of the target audiences experienced changes in knowledge, attitudes, skills, intentions, and/or behavior that were not planned for nor expected and have been described in a previous section of the report. A few of these unintended outcomes will be highlighted in this section. Note that a number of these 'unintended outcomes' occurred earlier in the project (years one and two). Researchers, during their formative evaluation work, discovered and shared the information with the project team. The project team considered and acted upon this new information by making changes to the program in order to support the positive outcomes (or diminish the negative ones).

An unintended outcome of the best type was the enthusiasm of youth to continue in the program beyond their first program year and to become youth assistants for the second year (which had been clearly included in the initial program model). But, some of those youth wanted to stay with the program a third year – thus the project team had to develop a new position with additional challenges and responsibilities. These youth became interns.

Some youth became very attached to the physical location housing the project team (Kavli Institute for Astrophysics on the MIT campus). This location should have been an intimidating place for these youth but in fact, it was not intimidating but inviting and comfortable. It was not unusual for the researchers, when visiting the project, to see youth sitting in offices, eating lunch with staff, and doing school homework in the lounge area.

One unintended outcome relates to the rapid and intense connection some youth made with science and astronomy. One youth entered and won the Massachusetts State Science Fair after his first year as a youth apprentice. Another youth placed quite high in the same science fair. These achievements were never planned as outcomes for a first year youth apprentice. They were, however, heartily embraced and supported by project staff.

Another unintended outcome related to the fellows and the ways in which participating in the program had a profound effect on their immediate and future life and career choices. Similarly, a content expert, a master, from the first year became a fellow in the second and third years.

Again, specific unintended outcomes for each audience have been described in a previous section. Critical to the discovering of unintended outcomes is acting upon them in a timely yet measured way so that they become outcomes that are expected and planned for (if positive) or they disappear (if negative).

## Q3. TO WHAT EXTENT DID THE PROGRAM HAVE AN IMPACT ON THE YOUTH THAT PARTICIPATED IN THE PROGRAM?

All of the seven outcomes for youth were achieved. The research design and methods support the statement that not only did the program achieve the target outcomes but also the program had multiple impacts on youth.

## Q4. WHAT ARE THE TRANSFERABLE ELEMENTS OF THE PROGRAM MODEL AND TO WHAT EXTENT CAN EACH BE MANIPULATED DURING REPLICATION ACROSS CONTEXT, CONTENT, AND AUDIENCE?

Various representations of the program model can be found throughout this report including an illustration of the evolution of the model across the three years of the project and the model's 'Theory in Action' logic models.

In order to determine the key components of the program model, the researchers began with these basic models. Then, by employing many different data sources and methods, the researchers built a knowledge base that contained the critical components and characteristics of the program. It was hypothesized that these 'transferable elements' must be included, in some form, in order for the model to be replicable. An important part of the process of identification of transferable elements was to consider each element as part of an authentic Youth Apprenticeship Model Program as well as part of an informal science education program.

There were a total of thirteen elements identified as critical to the replication and overall success of the program model. They clustered into three basic categories: Inputs, Program, and Outcomes.

## INPUTS

- Program Participants – This element is not flexible. The target audience for YAA was high school-aged youth or 'older youth'. More specifically, the youth were members of under-represented communities in the urban Boston area. This program model is built on the developmental, personological, socio-geographic, and cultural characteristics of the audience. In replication, age and status of underrepresentation are not flexible. The geographic location is certainly flexible. The type of underrepresented community the youth belong to is also flexible.

- Organizational Partnerships –This element is flexible. Multiple organizations will most likely be involved, to some extent, in the program. The program is complex and requires many different types of expertise, resources, and on-going support. The number and types of organizations involved in partnering is flexible. The types of partnerships (cooperation, coordination, or collaboration) are flexible but must be defined and agreed upon by participating organizations. The roles of and relationships between organizations can differ within the partnership structure.

- Informal Science Educators (Frontline) – There must be frontline informal science educators. The success of the program depends upon frontline individuals that play one of (or both of) two specific roles. One role is to provide the day-to-day contact with the youth, being consistent across the program year, and regularly interacting with youth in a variety of ways. The second role, specifically associated with the apprenticeship model, is that of the journeyman. The journeyman both mentors and teaches the youth and continues learning from the masters. These roles can be and were played by the same individuals – the program fellows. Both of these roles must be implemented to have a successful program – this is not flexible. How the program provides each of them is.

- Content Expertise – If the program is following the apprenticeship model, masters must provide content expertise. The concept of a 'master' is an important one for an apprenticeship model. Masters are experts practicing in their area of expertise. They need to be recognized by their peers as practicing leaders in the field. For this program model, there are masters in five areas: 1) STEM and the specific content (in this case, astronomy), 2) the integrating content (i.e., theatre or museum exhibit design), 3) informal science education theory and methods, 4) philosophy for working with youth – Positive Youth Development, and 5) outreach and community engagement.

  There must be masters involved for this program model to succeed. The number and areas of expertise is somewhat flexible and should match the goals of the new program.

- Involvement of Youths' Communities in All Phases of the Program – This element must be included in the model. This element has been included not because it was successfully implemented in the YAA model. Rather, it is offered as a transferable element, because it was only minimally employed in the program. Literature strongly suggests that local stakeholder involvement increases buy-in, adds resources, creates a program that is suited to the community, and enhances chances of program success in achieving long-term outcomes and sustainability. This element is not flexible. How it is employed is.

## THE PROGRAM

- Type of Education – The type of education is not flexible. This program model represents several areas of education, the broadest being informal (as opposed to formal) education. In addition, it is informal science or STEM, education. It could also be referred to as OST (out-of-school time) or after-school youth education. It may also be referred to as outreach education or community-based education. The program is not meant to be adapted to an in-school program or be school-based.

- Spiral Curriculum in an Apprenticeship Model – The YAA program is based upon an Apprenticeship Model – this element is foundational. However, there are various ways to implement an apprenticeship model in OST programs for older youth. Two important characteristics to consider include a mentoring relationship between youth and content experts and the creation and sharing of content-related products by the youth. In addition, youth should have the opportunity to progress through a hierarchy of learning experiences, changing roles, and increased responsibility. The nature of the apprenticeship model not only assumes an in depth, authentic experience but one that occurs systematically and over time.

- Processes, Products, and Integrating Content – In most cases, there must be integrating content to provide processes and products for implementation of an Apprenticeship Model. The Apprenticeship Model follows a structure that provides learning experiences and content mastery through a series of process aimed toward producing a product. The integrating content, in the case of YAA, varied from theatre, to telescope construction, to developing programs for use in a planetarium, to museum exhibit design. The type of integrating content can vary but must have: 1) recognized masters willing to participate, 2) content that can relate to the science content, and 3) processes that lead to clearly identified products.

- Opportunities for Youth to Share Knowledge and Skills with Others – The program model must have this element but it is very flexible in how, when, where, and why it occurs.

## OUTCOMES OF THE PROGRAM

The program model must be based upon a set of clearly defined, achievable, and measurable outcomes for one or more audiences. YAA had four audiences: Fellows, CBO Staff, Youth Participants, and Community Outreach Event Attendees, but the primary target audience was the youth. There were three categories of youth outcomes: 1) knowledge of astronomy as the specific field of science, 2) other science –related outcomes and other STEM-related outcomes, and 3) personal and interpersonal skills. There were two outcomes identified for the community


(attendees of community outreach events).

- It is unclear to what extent astronomy is a better science for this model than other fields of science. In addition to the specific science content related to astronomy, there were other science outcomes that must be included as outcomes for an informal science education program. Also, the program was informal science education (the 'S' of STEM) but the model is judged to be appropriate for informal technology, engineering, and mathematics education as well.

- There is flexibility in choice of science content or even in choice of STEM area. However, for programs using science as a focus, additional science outcomes must be included (e.g., scientific habits of mind, the scientific view, scientific inquiry). There is flexibility in approach but less so in the types of outcomes sought.

- Beyond STEM-related outcomes, a major focus of youth programs is personal growth and development toward being a happy, healthy, contributing member of society. One framework suggests that a curriculum should focus on the knowledge, skills, and expertise youth should master to succeed in work and life in the 21st century. Positive Youth Development is another paradigm found in informal youth education that focuses on developing confidence, being part of a community, and other outcomes. Identifying, defining, and planning for these outcomes is crucial to the program model. There is much flexibility, however, in the approaches and methods utilized.

- Community Outcomes: Attitudes, Knowledge, Skills, Intentions and Behavior – This program model has as its long-term outcomes, changes within the youths' local community. These are long-term outcomes, most likely not realized in the first three to five years of a program. However, if they are to be achieved, they must be identified, defined, planned for, and measured.

In summary, the thirteen transferable elements are important if not crucial to include in any replication of this program model. However, with most, there is flexibility in approach, timing, amount, type, extent of focus or incorporation, and many other options for crafting a model that suits the particular needs and context of the replication site.

# RECOMMENDATIONS

This section includes two types of recommendations:

***Questions for Consideration, and***

***Recommendations for Model Dissemination.***

## QUESTIONS FOR CONSIDERATION

Many times, an evaluation produces more questions than answers. In the case of this summative evaluation, there were a number of questions that emerged from the results. The project team may want to consider these questions as their own YAA program continues and is replicated by others.

### The Human Dimension

1. This program model is built on relationships; among people and among organizations; both formal and informal. To what extent should the formal relationships be structured based upon the desired outcomes for each partner as well as for the participants of the program?

   This program had target outcomes for community site staff that were more likely to be achieved if their partnerships with project team had been more collaborative. The structure of the partnerships was similar to that of a cooperative agreement. Cooperative agreements would have supported different but still meaningful and achievable outcomes. The Collaboration Handbook, Creating, Sustaining, and Enjoying the Journey, published by Fieldstone Alliance, can provide information on various partnership structures and associated benefits for participating organizations (Winer and Ray, 1994).

2. When a program requires the participation of diverse organizations for it to be fully successful, how important is it for the original concept for the program to originate and develop from within the collaboration of organizations verses just one or a subset of organizations? What effect does initial ownership of the program's concept and design have on program success with recruitment and retention of participants, expansion and sustainability of the program, and attainment of outcomes?

3. It appeared that the fellows had too many roles, responsibilities, jobs, and tasks to maximize their effectiveness. What role(s) and responsibilities are best addressed by the fellow? How can the other tasks be completed?

4. Results from the youth questionnaires showed, for the most part, that outcomes across participation levels increased steadily from level to level. However, 1st year assistants and interns scored lowest of all four groups on Teamwork, Internal/External Focus, Leadership in Science, Communication, Positive Youth Development, and Scientific Habits of Mind. Were these low scores unique to the specific group of individuals or do youth beginning this new role with increased responsibility need additional orientation and support?

### The Apprenticeship Model

1. The definition and characteristics of the Apprenticeship Model used in YAA should be more clearly articulated. How closely does YAA adhere to the crafts/trades

apprenticeship model? What specific characteristics (of a traditional Apprenticeship Model) should be included in the YAA model? Are there any issues connected with the traditional Apprenticeship Model that should be examined and enhanced or excluded?

2. The content experts for YAA are the Masters in this model. In what ways should their roles be more similar to that of a Master in the traditional Apprenticeship Model?
3. If the fellows are Journeymen, then their role includes producing and submitting products of their own for 'judging'. What is their 'trade' and should it vary across fellows? What are their products? How and by whom are the products judged?
4. How does the Youth Intern position differ from the Youth Assistant position? Where do 2nd year Apprentices fit in the 'apprentice' lineage? What do the current Youth Interns do next? At what point do they become Journeymen?
5. Should the relationships, responsibilities, and mentoring roles among the various positions within the Apprenticeship Model be formalized?
6. To what extent should the content (craft/ trade) of each Apprentice be clearly identified? When, in the apprenticeship process (Apprentice, Youth Assistant, or Youth Intern) should each Apprentice choose a specific track and begin to work more closely with the appropriate fellows and Masters?
7. What are the potential tracks for the YAA program model? Astronomy, science, informal education, world of work, one of the areas of integrating content, community development, community outreach, technology, life-long learner, other? What type of Master would a program need for each of these?
8. But for a few exceptions, youths' families were only peripherally involved in the program. Parental and family involvement has been shown to be important to the success of some youth programs.

   This program model however, has a built-in support and mentoring system and is based upon transitioning into the world of work, further education, and careers. A question regarding family support still remains and that is, would youths' outcomes have been different if families had been more involved? Does the nature of the Apprenticeship Model, when used in programs for older youth, reduce the need for family involvement?
9. Programs using an Apprenticeship Model occur over an extended length of time in order to maximize the benefits of mentoring by Journeymen, learning from the Masters, and then creating their own masterpieces along the way. In the YAA model, there are sequenced experiences throughout the program year and multiple years of increased responsibilities and learning opportunities. How long is a reasonable period of time for a program using an Apprenticeship Model to begin experiencing long-term outcomes? Are there techniques that could be used to 'speed up' the process of achieving long-term (community) outcomes?

## Community

1. What is the operational definition of community? From what disciplines is/can/ should it be drawn? Is it reliant on geography, culture, or other?
2. Should one of the 'trades' be community engagement? From what disciplines would the Masters be drawn? Can the roles of Master and Community Liaison be incorporated into the responsibilities of one person?
3. What are the tested methods for engaging [youths'] communities in informal education programs? What are the barriers for

community participation? How have those barriers been overcome by other successful programs?

4. What are tested channels for entry into a community? Which of these would be appropriate for the YAA model?
5. Is YAA mostly a community change program or mostly a youth development program? What are the professional fields and associated theory that would differ depending upon the program focus and the desired long-term outcomes?

   To illustrate:

   > *One youth said this about his community: "You don't live in [my community] because you want to; you live in [my community] because you have to."*
   >
   > *One type of response would be to encourage him to leave the community now, make the most of his life, and hope that someday, he will return to the community to help other youth.*
   >
   > *Another type of response would be, well, let's help make your community a place you'll want to stay.*

6. To what extent does the fact that the program is physically located at a community center within the community make an impression and impact on that community? There were some data to suggest that because the YAA program took place at local community centers, it did have a proximal effect on interest in science.

### Other

1. How important, to the overall success of the program, is each type of technology used in this program? Specifically, to what extent did the use of the Micro Observatory enhance recruitment and retention of youth? To what extent were outcomes impacted by the various technologies? Is it important for a program replicating the model, to have technologies as sophisticated and unique as the Micro Observatory?
2. There were thirteen transferable elements of the YAA model. Some were found to be fairly flexible; others were quite rigid. What is the relative importance of including or excluding, each element? What issues might arise if a program makes changes to an inflexible element?

## DISSEMINATION OF THE PROGRAM MODEL

1. The YAA Program model is clearly ready to be disseminated and replicated. There are a number of 'lessons learned' throughout this document and should be shared with those wanting to replicate the model.
2. The leadership of the YAA project should consider creating additional dissemination activities that go beyond a broad sweep approach (conferences, journal articles, the YAA dissemination conference and resources).

   These additional activities should include closely supporting a few replication sites that have different characteristics from the current YAA program. This manipulation of certain transferable elements during replication will test assumptions about flexibility of elements. In addition to any program evaluation work, a strong research component should be included.

   Sites for model replication should be selected based upon: a non-Astronomy science focus and perhaps a non-science (another STEM) focus. In addition, a site should be included where the community is the lead partner with additional organizations brought in to participate. Consider using a site where the partnership does not include a university.

3. As a part of dissemination of the results of this project, the project team should seek funding to host a separate conference or workshop for members of the communities and local organizations that were involved. See Bruyere, (2009) for successful examples.
4. During dissemination of the YAA program model, the project team should stress the importance of involving the youths' communities throughout the program. As a part of this effort, recommend that they begin by defining the word 'community'. It may be different for different organizations and sites. Suggest they enlist the support of experts in community engagement and community development to put a plan together for working with and in local communities.
5. Explain the importance of using outreach events to enhance youth outcomes. Include the benefits of varying the location of those outreach events including community locations as well as more formal settings, such as a university campus. Youth need the opportunity to demonstrate their skills and abilities 'at home' as well as for a rigorous and unfamiliar audience on campus.
6. Continue to test the Apprenticeship Model and its appropriateness for older youth, by using the Apprenticeship Model in programs beyond the YAA program model.
7. Continue to follow-up and track YAA graduates. Develop and implement a formal system to gather information on an on-going basis.

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