The Impact of an Authentic Science Experience on STEM Identity:

A Preliminary Analysis of YouthAstroNet and MicroObservatory Telescope Network Participant Data

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Synopsis

In this astronomy education program featuring robotic telescopes, pre-post changes in youth participants' science affinity, STEM identity, and STEM career interest are modeled to measure impact of core program elements. These elements are designed to support authentic inquiry*: e.g. requesting images with robotic telescopes; using image processing software to enhance and make measurements of images; asking questions; connecting science to everyday life*.

Introduction

Encouraging students to pursue careers in science, technology, engineering, and mathematics (STEM) is a high priority for national K-12 education improvement initiatives in the United States. From both equity and workforce demand perspectives, the fact that females and students of color continue to be underrepresented in STEM pursuits is particularly worrisome.

Authentic Inquiry

Many educators have claimed that a promising strategy for nurturing early student interest in STEM is to engage them in authentic inquiry experiences.[1,2,3,4] "Authentic" refers to investigations in which the questions are of genuine interest and importance to students, and the inquiry more closely resembles the way real science is done.

The **YouthAstroNet** program is designed to put this theory into action.

YouthAstroNet Project Goals & Program Design

- Create and study a nationwide online learning community and program that features the remotely-controlled, online MicroObservatory telescopes of the Harvard Smithsonian Center for Astrophysics
- Increase the interest and positive dispositions of middle school youth, especially girls and underrepresented youth, toward STEM and information technology careers

Fig 1. MicroObservatory

Essential Program Design Elements:

- Online community supporting interactions among students, educators (PD), project staff, and STEM professionals
- Personalized access to robotic telescopes, online workspace
- Use of professional image analysis tools and techniques to pursue projects of interest
- Adaptable hands-on activities focusing on concepts in astronomy, digital imaging, light & color, etc.

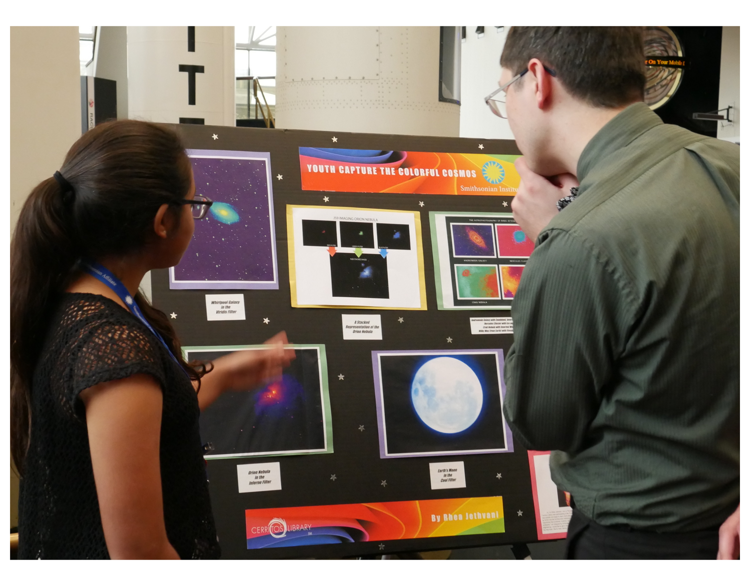


Fig 2. Student demonstrating project during capstone event.

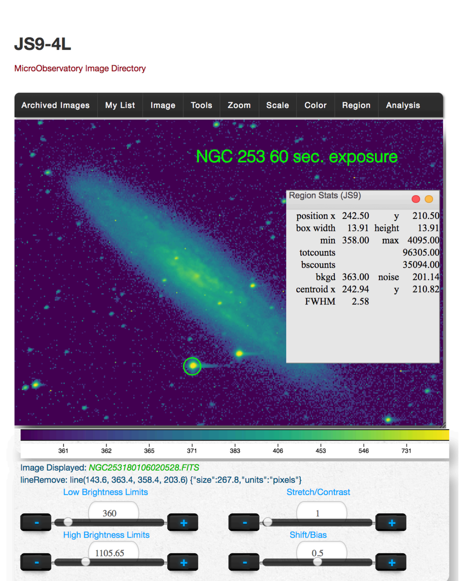


Fig 3. Browser-based image software: JS9 For Learners

Methods and Study Group

Development of pre/post survey instruments: Through pilot-testing and factor analysis of an initial research-based instrument, we identified items that measured 6 hypothesized underlying factors that might be affected by student STEM learning experiences, or have an influence on student outcomes including STEM career interest.[5,6,7]

	Sci Affinity D1	Good Student D2	Fixed/Growth Mindset D3	Math/Compu Identity D4	I like Science D5	STEM Identity D6
Q1a. Science is something I get excited about	0.584	0.219	0.307	0.203	0.111	0.225
Q1d. I am curious to learn more about science, computers, or technology	0.520	0.105	0.222	0.470	0.149	0.022
Q1e. I want to understand science (for example, to know how computers work, how rain forms, or how airplanes fly)	0.408	0.224	0.236	0.388	0.186	-0.193
Q1h. I am curious to learn more about cars that run on electricity	0.423	0.115	0.056	0.314	0.230	-0.079
Q1i. I would like to have a science or computer job in the future	0.565	0.058	-0.119	0.403	0.239	0.118
Q2a. I feel I belong in science	0.657	0.251	0.188	0.178	0.108	0.172
Q2c. I talk with my family and friends about science	0.418	0.144	0.155	0.117	0.320	0.139
Q2f. Learning science is useful to me	0.508	0.270	0.337	0.038	0.196	0.141
Q4a, I would consider taking more science courses in high school if I could	0.623	0.248	0.126	0.228	0.142	0.171
Q4b. If I go to college, I will probably major in a science or technology field	0.665	0.092	-0.008	0.197	0.174	0.089
Q4c. I do not plan to do any more science unless I have to	-0.605	-0.160	0.028	0.000	-0.052	-0.029
Q4d. I would like to do other science activities outside of school	0.527	0.085	0.066	-0.139	0.350	0.208
Q6a. Yourself	0.623	0.170	0.051	0.126	0.248	0.433
Q7a. I am interested in science and science-related things.	0.735	0.228	0.106	0.121	0.211	0.261
Q7f. I feel confident in my ability to learn science	0.491	0.594	-0.020	0.089	0.168	0.152
Q3e. I like challenging projects that I have to work hard to complete	0.274	0.447	0.304	0.131	0.187	0.302
Q3g. When I have to work hard at something, it makes me feel like I'm not very smart	-0.130	-0.404	0.231	-0.072	0.033	0.046
Q7d. I understand the science I have studied in school	0.152	0.726	0.026	0.053	0.187	0.097
Q7e. I can do well on science tests	0.095	0.687	0.021	0.094	0.102	0.155
Q7g. I feel confident in my ability to learn math	-0.013	0.465	-0.060	0.191	0.070	-0.043
Q1b. I like to participate in science projects	0.181	0.387	0.438	0.099	0.014	0.187
Q3b. It's more important to me to learn new things than to get the best grades	0.204	-0.077	0.442	0.036	0.161	-0.074
Q3c. You can learn new things, but you can't really change your basic intelligence	-0.038	-0.090	0.505	-0.021	-0.018	0.046
Q2e. I like writing code on computers	0.234	0.125	0.177	0.477	0.354	0.129
Q2h. I am pretty good at using computers	0.114	0.079	0.028	0.568	0.105	0.193
Q7h. I feel confident in my ability to use computers	0.104	0.239	-0.117	0.656	0.001	0.224
Q7i. I know about many different kinds of science and computer-related jobs	0.377	0.284	0.047	0.417	0.291	0.255
Q2g. I do science activities out of school because I want to	0.382	0.081	0.167	0.038	0.520	0.176
Q2i. I know a lot about some science topics	0.273	0.394	0.106	0.164	0.406	0.209
Q2j. I know a scientist or engineer personally	0.028	0.047	0.001	0.182	0.482	-0.007
Q7b. I am interested in astronomy	0.378	0.140	-0.127	0.148	0.529	-0.005
Q7c. I participate in science activities outside of school.	0.302	-0.042	0.121	0.034	0.491	0.263
Q6b. Parents/Family	0.276	0.080	-0.120	0.130	0.206	0.596
Q6c. Friends	0.268	0.075	0.158	0.143	0.315	0.489
Q6d. Teachers	0.107	-0.014	0.136	0.237	-0.019	0.476

Fig 4. Factor analysis of pilot items.

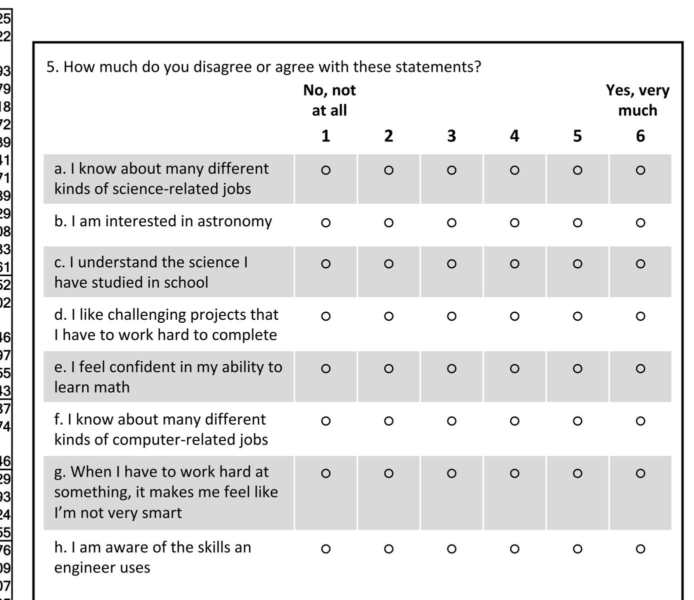


Fig 5. Sample items from final survey.

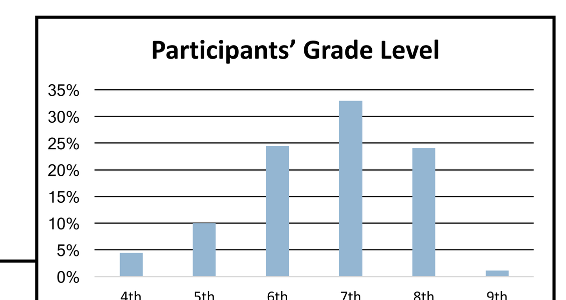
The final pre-post surveys were constructed from a subset of items within these factors, plus demographics. The post-test instrument also included an extensive set of questions that asked about the kinds of instruction and learning activities that students experienced as part of their program.

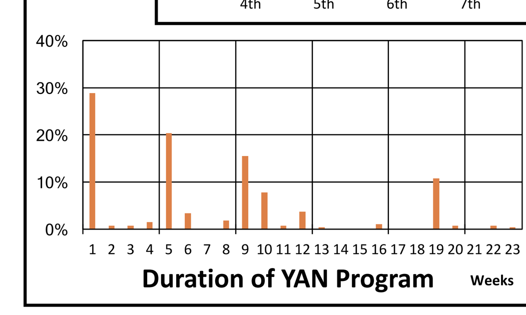
Study Group Demographics:

20 Program settings, 30 Groups

261 subjects with matched Pre/Post & consent:

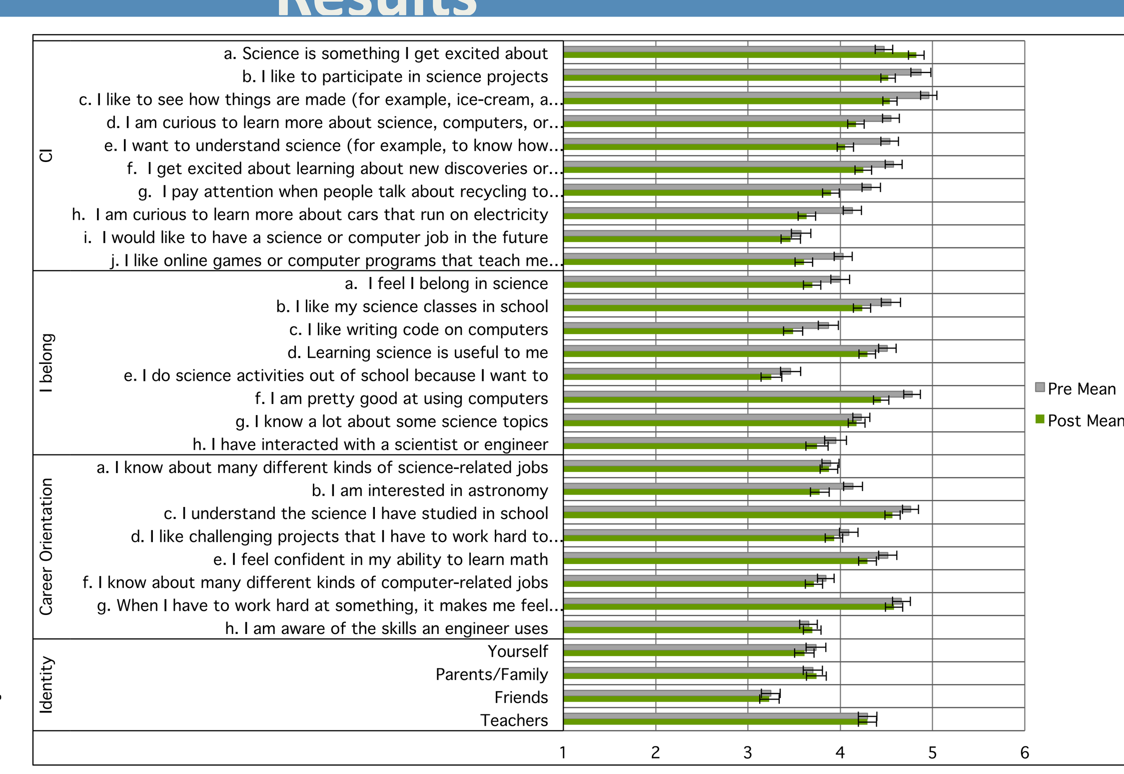
- 57% Female
- 63% White
- 21% Black or African American
- 13% Asian
- 10% American Indian or Alaskan Native
- 3% Native Hawaiian or other Pacific Islander





Results

A simple analysis of pre-post changes in STEM affinity and interest overall revealed very little significant change, and for those items where a small pre-post effect was observed, the average change was most often negative.



Results, Continued

However, after accounting for students' different program treatment experiences and for their prior attitudes and interests via regression models, a predictor of significant student gains in Affinity, STEM Identity, Computer/Math Identity, and STEM Career Interest could be identified. This was the degree to which students reported using and experiencing the primary "authentic" learning activities of the YouthAstroNet program (Table 1). These core activities—which included requesting robotic telescope images, using image processing software to enhance and make measurements of images, asking questions, and connecting science to everyday life—emerged together as one of three correlated groups of treatment variables in a factor analysis of student responses regarding their experience of 34 different potential program instructional strategies.

Dependent Variables		Affinity (Common Instrument+)	STEM Identity	Computers/ Eng/Math	STEM Career Interest	Astronomy Knowledge
Independent Variables						
	Intercept	-0.32(0.04)***	-0.07(0.04)*	-0.20(0.04)***	-0.15(0.05)**	0.07(0.05)
Pretest	Affinity (Common Instrument+)	0.47(0.07)***	-0.11(0.07)	-0.04(0.08)	-0.06(0.11)	0.11(0.09)
	STEM Identity	0.18(0.07)**	0.71(0.07)***	0.06(0.07)	0.23(0.10)*	0.01(0.09)
	Computers/Eng/Math	0.07(0.07)	0.06(0.07)	0.64(0.07)***	-0.04(0.10)	0.01(0.09)
	STEM Career Interest	0.09(0.04)*	0.08(0.04)	0.08(0.05)	0.54(0.06)***	-0.05(0.05)
	Astronomy Knowledge	0.01(0.04)	0.04(0.04)	0.07(0.04)	-0.01(0.06)	0.64(0.05)***
Treatment	Other STEM Activities	0.07(0.04)	0.02(0.04)	0.04(0.04)	0.07(0.05)	-0.07(0.05)
	Core AstroNet Activities	**0.27(0.04)*** **	**0.23(0.04)*** **	**0.20(0.05)*** **	**0.16(0.06)***	**-0.03(0.06)**
	Guests and Field Trips	-0.03(0.04)	-0.03(0.04)	-0.02(0.04)	-0.05(0.06)	-0.12(0.05)***
R^2		69.0%	67.5%	61.6%	40.3%	44.4%

Table 1. Results of regression main effects models predicting pre-post changes in student STEM attitudes and astronomy knowledge.

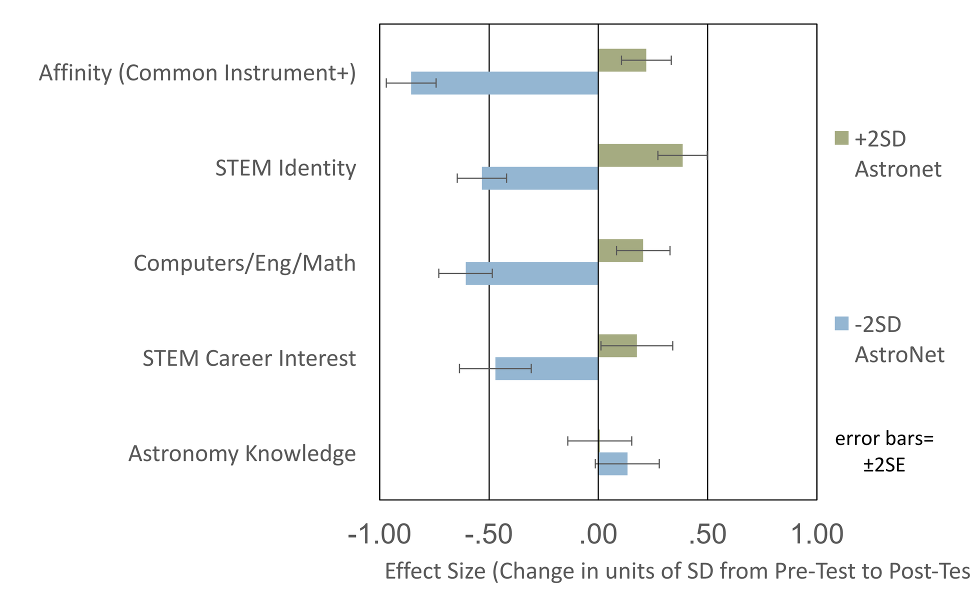


Chart 1. Pre-Post change in standardized measures comparing students reporting plus or minus 2 standard deviations from the mean value of "Core YouthAstroNet Instruction."

Implications and Future Analysis

Most of the educators of the students in this analysis were brand new adopters of the YouthAstroNet program model and first-time users of the MicroObservatory telescopes and image-analysis procedures. These preliminary results may suggest that the degree to which educators can integrate the primary authentic inquiry innovations of the project into their instruction can have a direct and positive effect on student outcomes.

The preliminary analysis is limited because many potential factors and project data sources have yet to be incorporated. These include an exploration of educators' pre/post survey data including their professional development and implementation experiences; an analysis to determine if there is a differential impact on specific demographic groups; and hierarchical linear modeling to examine specific program characteristics, such as duration, in- or out-of-school settings, single vs. mixed gender groups; and analyses that incorporate embedded analytics of participants' online participation.

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