What can science do for me? Engaging urban teens in the Chandra Astrophysics Institute

Mark Hartman[1], Irene Porro[1], Fred Baganoff[1], Jeffrey Grove[2]

[1]MIT Kavli Institute for Astrophysics and Space Research (MKI), [2]Lynn Classical High School

Program Summary: The goal of the CAI is to provide an opportunity for students underrepresented in STEM to build the background skills and knowledge necessary to understand how research science is done, by actually doing it. Students practice these abilities during a 5-week summer session at MIT. They then apply these skills to undertake year-long investigative projects involving Chandra data from x-ray targets proposed by MKI Chandra researchers. Students develop their own questions based on their summer experience and preliminary investigation of patterns in their data, and MKI researchers mentor the developing projects with guidance on how to possibly answer those questions.

Is this REAL research? No…but our goal is not to produce "mini-grad students"…

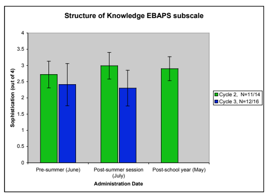
We feel that it is most important for students to be comfortable with and confident of their basic astronomy background and a small set of tools as a result of repeated practice. In this way, they can interpret what they observe about a piece of data that interests them, develop their own connections and ideas, and communicate them to others. This is valuable regardless of who may already have come to a similar conclusion. Indeed, "practice-based mastery of skills" and "the importance of student voice" are cited by Boston teens as an important part of what they desire in an ideal out-of-school time program.

The CAI is funded by NASA through the Chandra Education and Public Outreach Program.

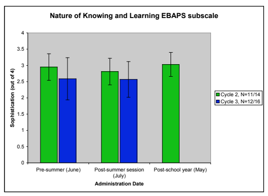
1. Epistemological Beliefs Assessment for Physical Science: Few strong changes.

EBAPS (http://www2.physics.umd.edu/~elby/EBAPS/home.htm) was administered several times to evaluate changes in participants' views of the way science is done and learned. Overall average score did not change significantly for either Cycle 2 or 3, but 3 of 5 subscales directly probe our interest in the above question:

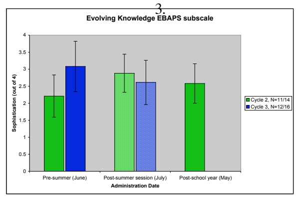
Result: No significant changes



Result: No significant changes



Result: Significant changes, opposite direction for Cycle 2 and 3.



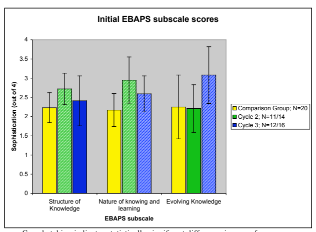
Crosshatching indicates statistically significant difference in mean from pre-summer result (P<0.05 for 2-tailed, paired t-test) Error bars indicate +/- 1 standard deviation in scores

Structure of scientific knowledge. Is physics and chemistry knowledge a bunch of weakly connected pieces without much structure and consisting mainly of facts and formulas? Or is it a coherent, conceptual, highly-structured, unified whole?

Nature of knowing and learning. Does learning science consist mainly of absorbing information? Or, does it rely crucially on constructing one's own understanding by working through the material actively, by relating new material to prior experiences, intuitions, and knowledge, and by reflecting upon and monitoring one's understanding?

Evolving knowledge. This dimension probes the extent to which students navigate between the twin perils of absolutism (thinking all scientific knowledge is set in stone) and extreme relativism (making no distinctions between evidence-based reasoning and mere opinion).

We don't see strong, consistent trends on EBAPS, so we examine a comparison group (= one honors chemistry course, mostly 11th grade students at the school attended by about half of cycle 3 CAI participants). →

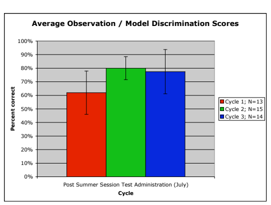


Crosshatching indicates statistically significant difference in mean from comparison group. (P<0.05 for 2-tailed t-test, assuming unequal variance.)

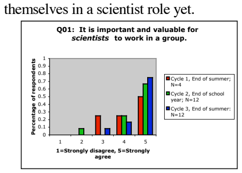
→ Cycle 2 and cycle 3 students initially have significantly different scores from the comparison group, but not always in the same categories.

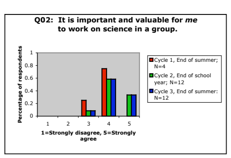
3. Indicators of understanding research science: Encouraging results in spite of initial group differences.

Observation/Model discrimination, Post-Summer: Cycle 2 / 3 have statistically significant (P<0.05) higher mean than Cycle 1, *regardless of their difference in previous science background*. Ability to distinguish observations from models is a prerequisite for understanding how research science is done.



Likert items on collaboration: After their program experience, all groups show a trend to agree more strongly that working in a group is more valuable for scientists than for them. This may indicate that they may not see themselves in a scientist role yet.





What participants value: A shift away from science content knowledge and toward transferable science research skills like communication, collaboration and confidence.

What's the most valuable thing you've gotten (or hope to get) from CAI?	Cycle 1 Pre-summer N=13	Cycle 2 Pre-summer N= 15	Cycle 2 Post-summer N= 15	Cycle 3 Pre-summer N= 16	Cycle 3 Post-summer N= 13
Practical, transferrable skills	23%	7%	73%	25%	77%
Nature of science	31%	7%	7%	13%	23%
Science Knowledge	85%	67%	40%	81%	23%
Career exploration	31%	40%	0%	13%	0%
Access to resources	23%	7%	20%	31%	0%

Our definition of the process of research science:

Our adopted method of science teaching mirrors the development of scientific knowledge and viewpoints in a working science community, with the goal that students will then easily be able to engage in science investigations of their own:

- **Observing** preliminary data helps students generate questions in which they are genuinely interested.
- Using tools to make further observations about the system and discover patterns helps students then make and/or apply **models** about that system which allow them to make predictions or gain a deeper understanding.
- If those **predictions** are inconsistent, models may have to be revised.
- Finally, students get the chance to **present** their own new insights either orally or in writing to be discussed and critiqued with a larger group.

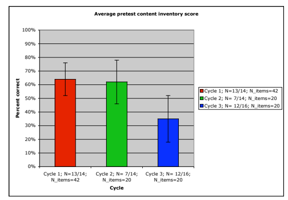
In this poster, we examine data from 3 cycles of the CAI (2005-2006, 2006-2007, and 2007-2008) to answer the following question:

Do participants understand the process of research science?

In other words, do they understand the nature of research science as question-driven, evidence-based, predictive, and a collaborative effort that requires clear communication?

2. Comparison of initial characteristics of groups: Recruitment differences result in different group characteristics.

Initial content knowledge: Seems to reflect difference in previous science background seen in demographics.



Note: Not all content inventories were identical, but generally probed similar content standards, relying heavily on the MOSART Project from Harvard-Smithsonian Center for Astrophysics, Science Education Department (P. Sadler, N. Cook)

Completion Rates: Over time, higher recruitment and completion numbers were obtained. (% female in parentheses)

	Cycle 1 2005-2006	Cycle 2 2006-2007	Cycle 3 2007-2008
# applicants	16 (25%)	16 (31%)	30 (33%)
# accepted	16 (25%)	16 (31%)	23 (43%)
# enrolled	14 (21%)	16 (31%)	17 (59%)
# completed summer session	14 (21%)	15 (27%)	16 (63%)
# completed school year project	4 (75%)	14 (29%)	

Demographics at completion of summer session: Over time, we see a shift to a younger, more diverse group, with less formal physics training.

	Cycle 1 N=14	Cycle 2 N=15	Cycle 3 N=16
Grade at time of application	9: 0% 10: 21% 11: 79%	9: 20% 10: 20% 11: 60%	9: 40% 10: 33% 11: 20%
Taken physics course?	43%	80%	31%
Largest ethnic groups	Hispanic: 36% Multi-group: 21% White: 21%	Asian: 73% White: 13% Hispanic: 7%	Multi-group: 31% Hispanic: 31% Black: 19%

4. Evolution of strategies to recruit our target population, engage them in ways they find meaningful, and pursue our desired outcome for them to develop a working understanding of how research science is done.

How CAI has changed	Cycle 1	Cycle 2	Cycle 3
Recruitment effort: • Spend more direct contact time with students, after gaining educator input and buy-in. • Work directly with as many schools as possible: district-level interaction gives poor results.	• 1 meeting with educators from 4 schools, who also attend summer session • ~2 contact hours/educator • Active recruitment period: Jan. - May • No direct contact with students	• 1-2 meetings with educators from two schools. (Opened recruitment at last minute to 4 additional schools, due to poor recruitment) • ~ 3 contact hours with educators from two school; almost none with other educators • Active recruitment: Mar. - May • 1 - 3 direct meetings with students at each of 2 original schools.	• Cast broad net to all Boston-area schools • 4 meetings with educators from 7 schools, including MIT scientist mentors • ~5 contact hours with educators • ~2 direct meetings (1 hour contact) with students at each of 7 schools. • Average recruitment of ~3 students / school. • Active recruitment period: August - April • TryCAI event at MIT with scientist mentor / educator input as part of application: Students gain a good idea of what CAI is like before they decide to attend. • Strong emphasis on the chance to practice and develop skills that are useful in many fields, including communication, collaboration and building arguments.
Opportunities for independence: • Shift toward more time spent on students' own projects, developing their own questions.	• Small group "expert projects" (done during summer session on a topic of their choice) in 1-2 days, including oral presentation. • Change summer group daily • School-year research projects laid out mostly by scientists.	• "Expert projects" extend over 2 weeks, including oral presentation. • Change summer group daily • School-year research projects and initial direction introduced by scientists; development of final questions by students only in March.	• Expert projects extend over 3 weeks, including written wiki and oral presentation. • Change summer group every 2-3 days, when start a new summer investigation. • School-year research project areas suggested by scientists, but students develop and present their own questions to scientist mentors.
Repeated practice of skills: • Shift away from basic facts toward utilitarian knowledge. (I.e. limit the concepts to that which you actually measure: linear size, distance, motion, luminosity, spectra) • Cast investigations to be more like research projects with respect to data examined and interactions with group: oral/written communication, use of collaboration tools/wikis.	• Use 3-4 image processing tools, practice somewhat segregated from content investigations. • 1/2 summer session day to start year-long research project.	• Use 2 image processing tools; practice integrated with summer astronomical system investigations. • 2 summer session days to start school-year research project. • School-year research project oral presentations follow same outline as summer investigations.	• Use single image processing tool; practice of techniques linked directly to summer investigations. • 3 summer session days, including "group meeting" and informal lunch with mentor to start school-year research project. • School-year research project written presentations/wikis follow same outline as summer investigations. • Initial analysis for school-year investigation involves repeated application of tools and measurements identical to summer investigations.
Scientist mentor involvement: • Students should work *with* real adults from the scientific community, and develop a relationship with them. • Provide effective scaffolding for the goal setting and clear communication necessary for steady progress on school-year research project. • Students should have their own insights/ideas to bring to the table to discuss with mentors, to make the most of limited interaction time.	Worked directly with students during summer investigations, including students' first exposure to some analysis tasks. (3-4 hours student contact/mentor) • 4 scientist mentors for 3 of 4 project areas; 3 projects finished, only 1 with mentor.	• Advised EPO instructor on how to introduce investigation, what data to use. (~1 hour EPO contact/mentor) • Informal summer lunches with scientists (~1 hour student contact/mentor) • 4 scientist mentors for 4 of 4 project areas; 8 projects finished.	• More direct role in revising summer astronomical system investigations (~4 hours EPO contact/mentor) • 3 mentors new to CAI physically present for summer investigation related to the school-year research project they will mentor. • Informal summer lunches AND group meetings (~6 hours student contact / mentor) • 5 scientist mentors for 5 of 5 project areas; 7 projects started. • Mentors physically involved in TryCAI and selection process of students.