FINAL EVALUATION REPORT

Teacher Renewal for Urban Science Teachers
(TRUST 2003 – 2007)

A Collaborative Project of the American Museum of Natural History
Brooklyn College and Lehman College of the
City University of New York (CUNY)

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Teacher Renewal for Urban Science Teachers

This report provides summative evaluation evidence on the Teacher Renewal for Urban Science Teachers (TRUST) project. TRUST was a four-year (2003-2007) National Science Foundation (NSF) funded grant of a collaborative project between the American Museum of Natural History in New York City and Brooklyn and Lehman Colleges of the City University of New York designed to increase the number of certified Earth Science teachers in New York City, and to establish a collaborative model of formal-informal urban science teacher education.

The TRUST Principal Investigators (PIs) developed a formal-informal partnership model using a problem-based approach to the urban teacher shortage by focusing on the knowledge base required for Earth science teacher certification, and the need for instructional approaches that lead to improved student performance. Key features of the model included new college-based Earth system courses; a two-week museum-based summer institute focused on Earth systems science, continued year-long professional development opportunities at AMNH, and introduction of participants into national informal and formal science professional organizations such as National Science Teachers Association, American Geophysics Union, American Educational Research Association, and American Associations of Museums (AAM).

Figure 1, on the next page, describes the TRUST model. Evidence from the multi-year evaluation indicated:

- Project staff had been successful in designing courses strong in content knowledge, and the delivery of these courses reflected sound pedagogical practices.
- The two-week summer institutes expanded and deepened the teachers' content knowledge, introduced them to the variety of resources of the museum, and provided the foundational structures

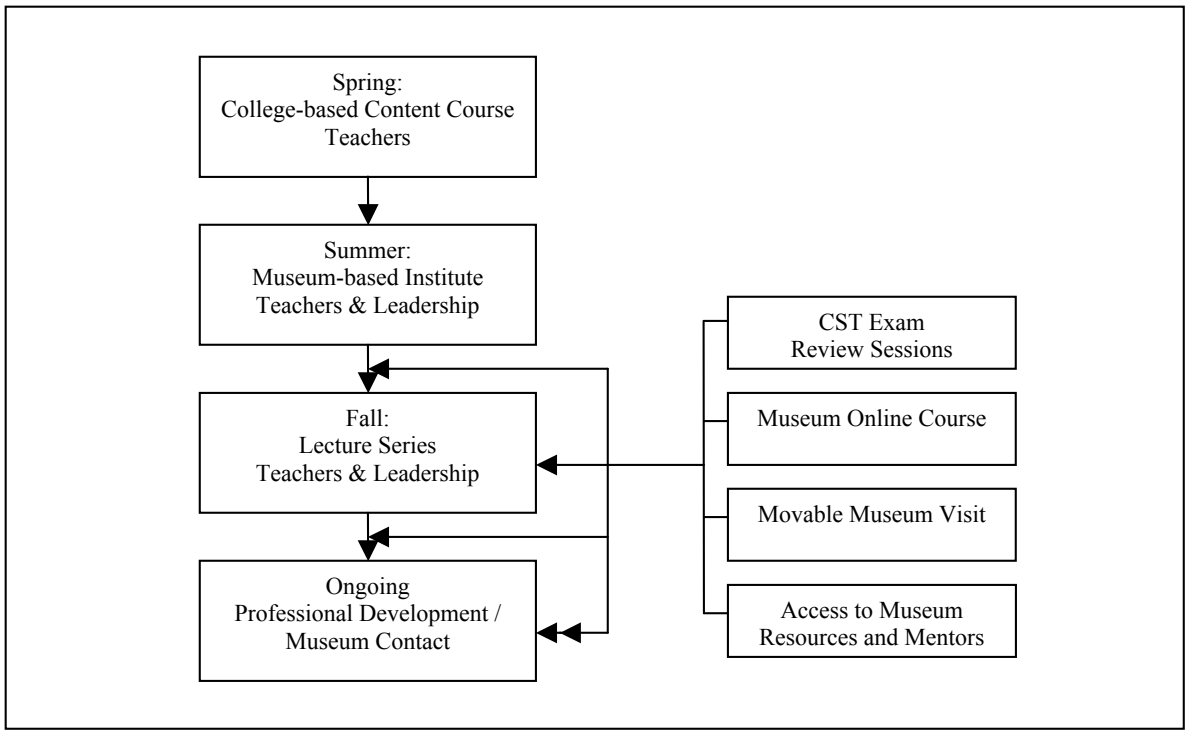


Figure 1: Schematic of TRUST Model components

to assist teachers on the use of informal education resources in increasing their own content knowledge, and improving their classroom instruction.

- Evidence from the end-of-institute questionnaire indicated the institute helped participants discover ways to improve their own classroom instruction and to use the museum.
- Over 8 out of 10 of the participants reported that the most meaningful learning experience in the summer institute was the lectures and content, and over 90% reported that the lectures and presentation were the most intellectually satisfying aspects of the institutes.
- TRUST had a significant impact on Earth Science teacher shortages in NYC by achieving the project goal of improving the preparation of 90 teachers and 30 leadership administrators.
- Analysis of retention statistics indicated that 82% of all teacher participants and 91% of all leadership participants continue to be active in the NYCED school system.

- Teachers report significant impacts of the project on themselves, their teaching, and their schools.
- The impacts were substantial in the first year and continued to be sustained, and in many cases, enhanced over years 2 or 3.
- Over 50% of the TRUST participants reported they brought their students to AMNH to use the museum as a setting for Earth science instruction, over 64% of the leadership group participants indicated they brought students on instructional trips to AMNH and over 25% brought teachers for field trips and/or professional development.
- Eight out of ten supervisors reported they had more confidence in their ability to provide their colleagues science professional development, all of the supervisors believe they have become a better resource to their science teachers, and 90%+ believe their science programs have improved because of their involvement in the TRUST program.
- Significant institutional and cultural changes have taken place over the course of the project.
- TRUST participants have proven to be an excellent candidate pool for leadership roles in other AMNH professional development programs.
- Museum scientists also report the program has improved their thinking, teaching and behavior.
- The Earth science summer institute has been institutionalized by the museum.
- The TRUST program provided the foundation for securing new grant funds to expand the TRUST model to Life science.

In summary, the evaluation evidence clearly indicates that the TRUST program has been effective. Many factors have contributed to the success of TRUST, including a focus on increasing teachers' content knowledge, developing ongoing professional development activities for teachers, and building continuing learning communities among teachers, and the teachers

with the museum scientists. But it is the judgment of this external evaluator that it is the problem-centered approach, in contrast to the typical institutional-centered approach, that was taken in this project that is a significant key to the success of the project. In addition to curriculum and logistical planning, the one-year design period was also used to develop a strong documentation and evaluation component, a feature typically lacking in many formal-informal partnerships prior to TRUST.

The new approach required development of acceptance and integration at each of the partnership institutions. The planning period allowed for multiple meetings between the partnership personnel, which included college faculty, museum educators, museum scientists, school principals and experienced teachers, all of whom were focused on increasing the number of certified and highly qualified Earth science teachers and improving Earth science instruction in NYC schools. The PI and co-PIs worked together and within their respective institutions to determine how best to integrate informal science education at the museum with formal teacher education programs and college policies. Ultimately, each partner took on the role it played best, but did so within the construct of the partnership; the Museum maintained its role as content provider by identifying and involving museum scientists and by presenting research on learning in museums to enhance participants' experiences with scientists, objects, exhibitions, visualizations, and a variety of technologies. The colleges played their established role as accredited degree granting institutions with state-approved teacher certification programs focusing on science education in formal settings. Cross-over of personnel between formal and informal institutions existed in both directions: AMNH educators were reviewed, approved and hired as CUNY adjunct professors so that credit-bearing courses offered by the colleges could be taught at the museum by museum instructors. Lehman and Brooklyn College faculty involved in the project were museum research associates in various disciplines, having been approved by the AMNH senate. Cross-over between the natural sciences and education also existed within institutions: the Lehman College

co-PI is a geoscientist who at the time was a faculty member in the Division of Education and the director of the science education program; one of the Brooklyn College co-PIs, a geoscientist with formal training in science education, is a faculty member of a geosciences department and has a history of close collaboration with the Brooklyn College School of Education; the other Brooklyn College co-PI is a science educator and faculty member in the School of Education who originally studied and worked as a biologist; the AMNH PI, director of AMNH professional development at the time, has extensive experience in urban teacher education and research.

Based on the evaluation evidence, and an analysis of the project impacts, the external evaluator would offer three recommendations. First, AMNH and CUNY institutions should continue to address the NYC ongoing recruitment and retention problem by expanding the TRUST model to other content and teacher shortage areas. Second, the TRUST partners should develop proactive dissemination activities. Third, the TRUST partners should develop and implement a longitudinal research agenda for determining the short and long-term impacts of a TRUST-like program on teachers' classroom practices, student learning, leadership in local and national science networks, and the profession at large.

FINAL EVALUATION REPORT

Teacher Renewal for Urban Science Teachers

David L. Silvernail University of Southern Maine

INTRODUCTION

This report provides summative evaluation evidence on the Teacher Renewal for Urban Science Teachers (TRUST) project. TRUST was a four-year (2003-2007) National Science Foundation (NSF) funded grant of a collaborative project between the American Museum of Natural History in New York City and Brooklyn and Lehman Colleges of the City University of New York. As stated in the funded proposal:

> "The major goal [of the project] will be to respond to two specific needs of schools in New York City at the beginning of the twenty-first century:
>
> 1. Shortage of certified Earth science educators; and
> 2. Low academic performance of students in districts with the highest population of new immigrants.
>
> The objective of this four-year project is to create, evaluate, and institutionalize articulated courses and summer educators' institutes for the preparation of certified Master level Earth science teachers and for the enhancement of educators." (p.1)

Thus, TRUST at its core was a project designed to respond to a specific need in New York City. As part of the new standards based state education program, all students are required to demonstrate knowledge and skills in Earth science. However, there is a severe shortage of certified Earth science teachers in the City. This project was designed to respond to this need.

But TRUST also had a secondary, but critically important goal. As stated in the funded proposal, "…TRUST aims at establishing a collaborative model of formal-informal urban science teacher education." (p.1) Nationally, many projects and programs exist for the initial and continued preparation of science teachers. But the institutions of TRUST and the location of these institutions placed it in a unique position to create a collaborative partnership between formal and informal institutions, content-rich institutions and sites, research and

academic teaching institutions, and scientists, teacher educators, and teachers and supervisors, for addressing the Earth science teacher shortage in New York City.

The TRUST Principal Investigators (PIs) developed a formal-informal partnership model using a problem-based approach to the urban teacher shortage by focusing on the knowledge base required for Earth science teacher certification, and the need for instructional approaches that lead to improved student performance. Key features of the model included new college-based Earth system courses; a two-week museum-based summer institute focused on Earth systems science, continued year-long professional development opportunities at AMNH, and introduction of participants into national informal and formal science professional organizations such as National Science Teachers Association, American Geophysics Union, American Educational Research Association, and American Associations of Museums (AAM).

The project contracted with Dr. David L. Silvernail, Director of the Center for Education Policy, Applied Research and Evaluation at the University of Southern Maine to conduct the evaluation of the project. Dr. Silvernail worked with the PIs to collect formative evaluation information for use in refining the implementation of the collaborative model over the four-year grant period, and collected summative evaluation information for assessing the effectiveness and impact of the project. This report provides the summative evaluation.

PROGRAM NEED

The New York State Education Department (NYSED) statistics available as this project was conceived in 2002 indicated that of the 474 people teaching Earth science in NYC schools, only 10 had Earth science certification (NYCED, 2002). In addition, the situation was compounded by the overall shortage of qualified teachers. Of the 3,953 science teachers teaching in New York City, 24% were over 55 and eligible for retirement. It was estimated that approximately 70% of temporarily licensed and retiring science teachers would have to be replaced by fall 2004 to meet new state certification regulations

(NYSED, 2003). During the three years prior to 2002, the local board of education had attempted to alleviate teacher shortages by recruiting recent graduates, career changers, and teachers from other countries. Most of these recruits lacked teaching experience, but were placed directly into classrooms prior to receiving formal teacher preparation.

The scarcity of adequately prepared science teachers was particularly severe in the Bronx and Brooklyn, the regions served by Lehman and Brooklyn Colleges, with the worst shortages in schools located in higher poverty neighborhoods. According to the 2000 Census, the Bronx has the highest proportion of children, 29.82%, of all the counties in the state. Only 7.12% of these children were identified as non-Hispanic White (Bosworth, 2000). Brooklyn is the largest borough in the city with a population of nearly 2.5 million. Children constitute 26% of its population, with 27% of them identified as non-Hispanic White. In addition, by fall 2002, 12 high schools and 8 middle schools in these boroughs had been classified as "Schools under Review" by the Office of the Chancellor for Education as a result of poor academic achievement (NYCED, 2002). The need for better science instruction in Brooklyn and the Bronx was further evidenced by data from the state-wide tests in 2000 and 2001, which showed poor performance by students in Earth Science relative to Biology, Chemistry, and Physics. NYSED reports also indicated that fewer students were taking the Earth Science exam in order to fulfill graduation requirements.

OVERVIEW OF THE PROGRAM MODEL

Figure 2 on the next page describes the TRUST model. The first year of the four-year grant-funded period was focused on planning and partnership development. Although the project proposal contained the foundations of the model structure, it remained for the project staff to finalize the details of logistical and curricular planning during the first year. New graduate level geology content courses for educators at each of the colleges were designed to be articulated with a 60-hour summer institute at the AMNH, followed by an

additional 10 hours of AMNH lecture and activity series. TRUST participants received a stipend which was disbursed upon completion of each of the project

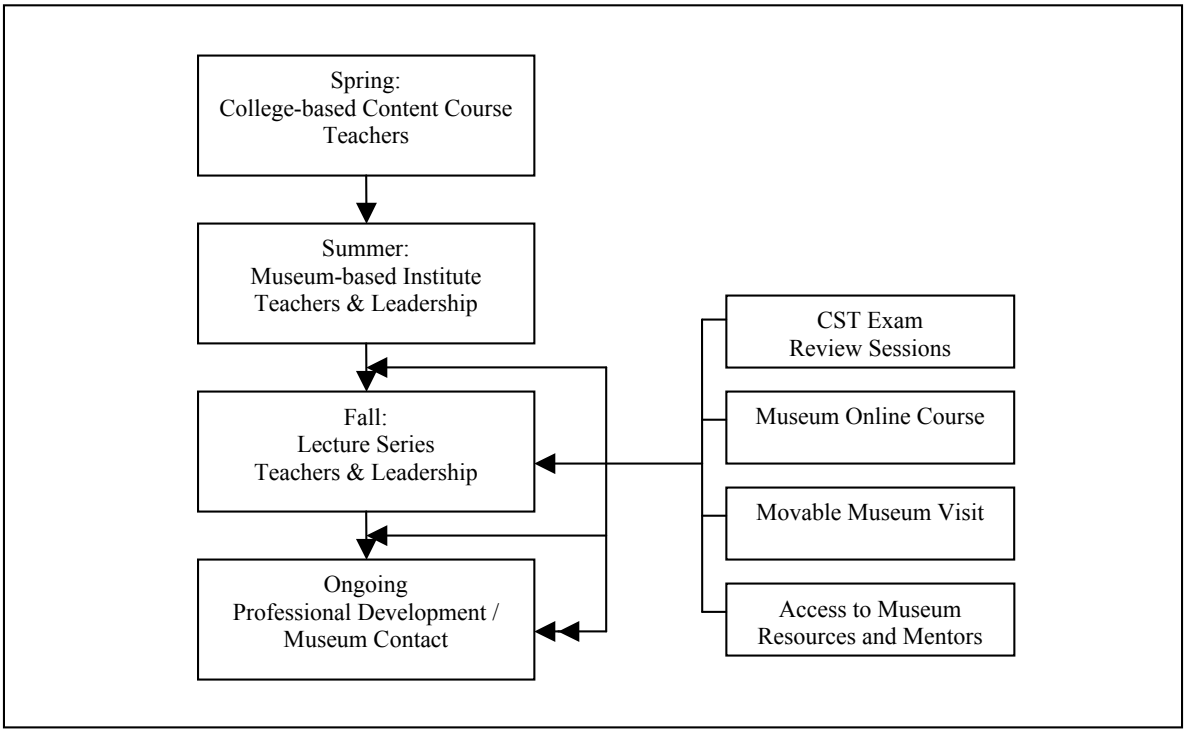


Figure 2: Schematic of TRUST Model components

component requirements. This basic structure was supplemented by additional resources from the Museum: certification Content Specialty Test review sessions, Movable Museum visits to participants' schools, online learning seminars and resources, participants' access to a variety of AMNH resources and to the museum itself, and inclusion in a growing TRUST network of Earth science educators.

The project was designed to provide these programs and activities to 40 participants each of three years, 30 teachers and 10 supervisors each year. Thus, by the end of the project the goal was to have significantly impacted the shortage of qualified Earth science K-12 educators in the city of New York.

EXTERNAL EVALUATION PLAN

The external evaluation of TRUST was guided by a plan which was designed to collect evidence and provide answers to seven core questions which were related to the two project goals. These questions were:

1. To what extent do the new geosciences courses enhance teachers' and supervisors' understanding of science, and how they learn and teach using informal resources?
2. To what extent does the museum program affect how supervisors understand and guide science teachers, and support and assess science instruction in their schools?
3. How does the museum program contribute to local urban needs for highly qualified teachers and administrators with rich and deep science knowledge and pedagogy?
4. What is the impact of TRUST on teacher-education faculty, on their instruction, and how they use resources in curriculum development?
5. To what extent does a museum-infused science teacher preparation program prepare new teachers to teach science in a variety of urban settings? How does research-rich informal education contribute to formal preparation programs?
6. What is the impact of the TRUST program on participating research scientists, on their understanding of education, and their role in its improvement?
7. How does the collaboration between formal and informal institutions on behalf of teachers affect the institutional education and science structures?

To guide the evaluation a logic model was developed for the project, and this model appears in Figure 3 on the next page.

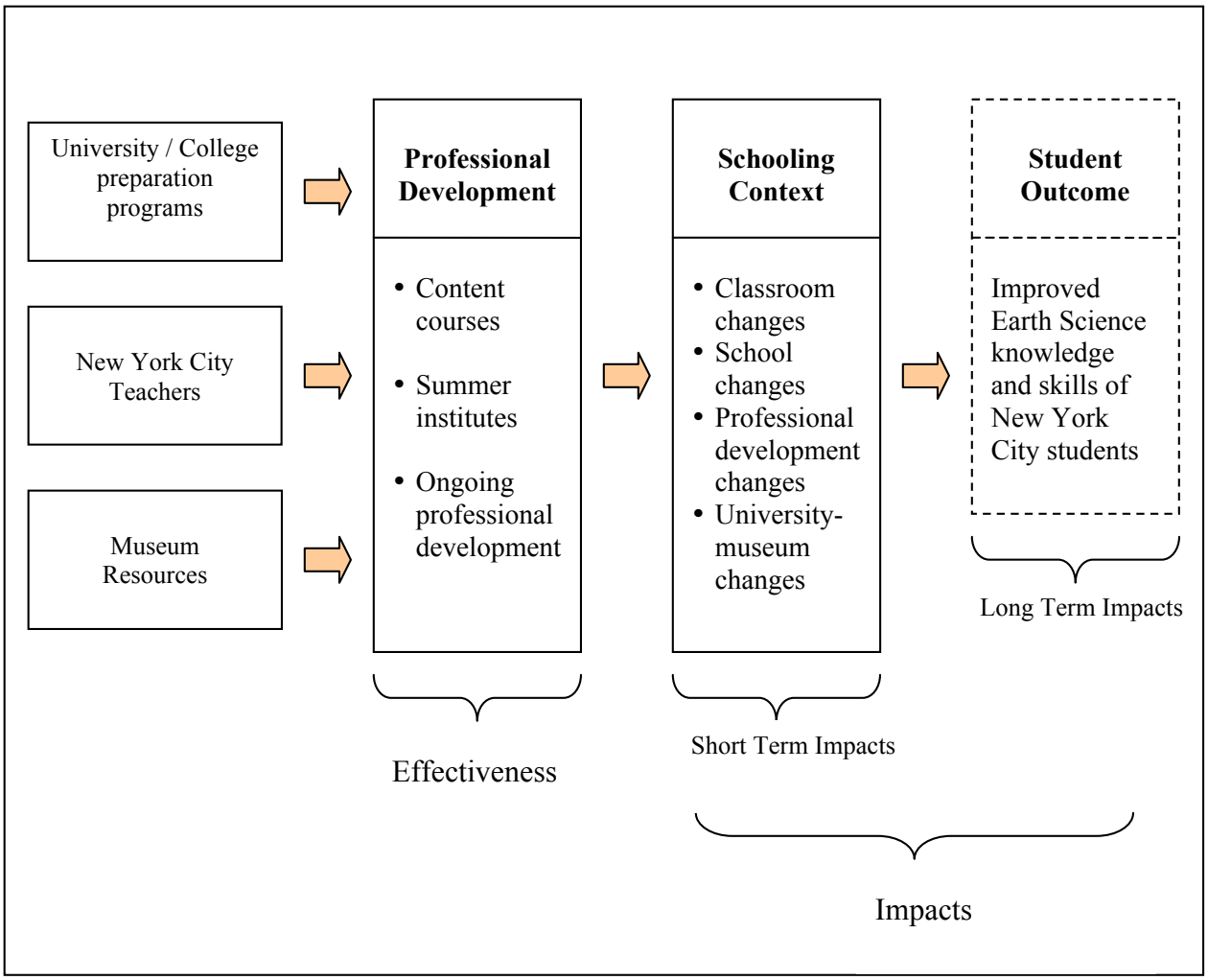


Figure 3: Project Logic Model

As may be seen from the logic model, the overarching focus of the evaluation was to determine the Effectiveness and Short Term Impacts of the project. The Long Term Impacts were beyond the scope of the project, but the logic model reflects the assumption that effectiveness and short term impacts are prerequisite for achieving long term impacts.

To provide a comprehensive framework for the triangulation of evidence, and to increase the validity, reliability, and generalizability of findings, the evaluator used multiple methods and varied sources of data. Methods that were used over the course of the project included;

1. Surveys: Surveys were used throughout the project to assess the breadth of the effectiveness and impact of the various program

components and activities. All teachers and administrators participating in the project were surveyed after initial interventions (e.g., courses, summer institutes, lecture-series, etc.), and one year (post) and two years (delayed post) – after interventions.

2. Structured Interviews: Structured interviews (pre, post, and delayed-post) were conducted with a stratified purposive sample of new teachers, administrators, education faculty, Museum personnel, and project personnel. These interviews augmented the survey evidence, and provided greater depth and understanding of how the project and its various components affected participants.
3. Observations: Observations of project activities (e.g. summer institutes, courses, participant action projects) were used in assessing program effectiveness.
4. Document Analysis: Documents produced by the project staff were reviewed for their contribution to program effectiveness.
5. Focus Groups with Leadership Group: Meetings with members of the leadership team to assess their evolution as leaders in Earth Science knowledge and instruction in their schools.

The remainder of this report presents the evaluation evidence, a summary assessment, and recommendations for future actions.

EFFECTIVENESS EVIDENCE

The effectiveness evidence was focused on three key professional development activities: (1) college-based courses; (2) summer AMNH institutes; and (3) ongoing professional development opportunities.

College-based Courses

Two of the college co-PIs developed new graduate level geology and Earth systems science courses at their respective colleges, submitting them for evaluation and approval following the colleges and state standard protocols for new courses. The courses were designed specifically for teachers, with a focus on pedagogy and modeled instructional practices that teachers could emulate

in their classrooms. Modeling of pedagogic practices was integrated into content teaching at multiple levels in order to establish a well-defined pedagogical content knowledge model of instruction. In addition to these two core content courses, new variable-credit graduate level independent study courses in geology were created at each college through which students could receive credit for the TRUST Summer Institute for Earth and Space Science and Fall Lecture Series.

Each of these courses was approved by the CUNY Board of Trustees and the NYS Board of Regents. Course titles, brief descriptions, and the essential questions upon which the courses were based were as follows:

- Brooklyn College GEOL 613: Earth Science in the NYC Urban Environment (3 crs)
    - An overview of geological features of the NYC area and how they have influenced the city's history, growth and development.
        - On what is the city built?
        - Of what is the city built?
        - Why did the city develop here?
        - What environmental hazards does NYC face?
        - How has the NYC environment changed?

- Brooklyn College GEOL 690T Seminars in Geology (3 crs)
    - Series of seven selected topics in geology offered in public lectures in venues within New York City. Classroom-based discussion of each topic in the week following the lecture.

- Lehman College GEO 601: Earth Systems Science for Educators (4 crs)
    - Earth systems science coupled with pedagogic approaches and applications to the geology of New York City framed by the following questions:
        - The Earth System: What are its components and structure?
        - Solid Earth Dynamics: How and why do the processes of plate tectonics, volcanism, and earthquakes occur?
        - Oceans and Atmosphere: What creates climate and climate change?
        - Biosphere and Biogeochemical Cycles: What makes Earth habitable?
        - Fieldwork: How do we apply Earth systems science learning in NYC?

- Lehman College GEO 697: Independent Study (1-3 crs)
        - Independent study of selected topics in geology under the guidance of a faculty member. This course may be repeated with advisor approval for up to 6 credits.

A review of the course syllabi, course materials, interviews and a limited number of classroom observations indicate the instructors were successful in

developing these strong content-based courses which included sound pedagogy and informal education activities. Each college course included 3-5 field trips to New York City sites (e.g. Gateway National Recreation Area, Central Park, New York Botanical Gardens, Inwood Hill Park, etc.) and knowledgeable guest speakers from NYC colleges, departments and AMNH.

An analysis of course assignments indicated that the instructors were assessing students' content knowledge development and their ability to translate the content into meaningful instruction. For example, part of one course assignment was:

> Educational personnel from the National Park Service will lead a learning module called "Sentinels of Our Shores". This session will focus on the defense of New York Harbor. You will either act as participants or observers depending on the number of children that attend. In either role your task will be to objectively critique the learning experience, both in terms of content and pedagogy. Remember that you should be paying particular attention to connections with the Earth sciences. Your report should include:
>
> - A summary of the program that was delivered, in particular, noting the interplay of geology in the defense of NY Harbor.
> - Identify the three greatest strengths of the program, and support your choices.
> - Identify three aspects of the learning module that could be improved, explain why you chose these, and suggest ways that the deficiency could be improved.
> - Suggest at least one change that could increase the earth-science content of the learning module. Describe the change and added content in detail. (Geology 613)

Many assessment strategies used in the courses also are reflective of good instruction practices. Scoring rubrics were used and known by students as they prepared their assignments, and in the Geo 601 course the instructor provided students with exemplary assessment responses, a practice known to be highly successful in helping students document their learning.

In addition to providing sound content, both instructors modeled effective instruction strategies. For example, an excerpt from a classroom observation in one of the college courses included the following:

> "The instructor asked many thought-provoking questions and made it a point not to answer them directly. She/he referred the question to other students and

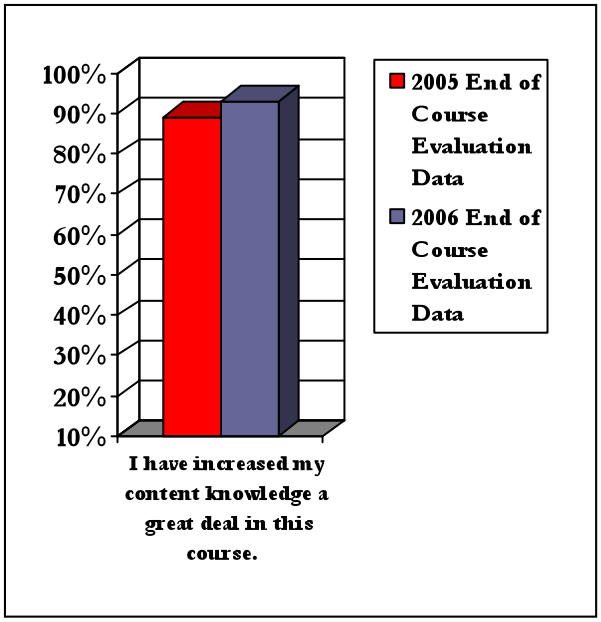
> allowed them to discuss/debate the answers or she/he would refer to a prior diagram/graph or article to help them ascertain the answers. As students interjected questions or new ideas about a topic, she/he pointed out related hypotheses and studies that were underway today. This generated much excitement and more discussion. She/he made students an important resource in the classroom. She/he exhibited a well developed questioning technique that enabled students to become active thinkers and responders throughout the lesson."

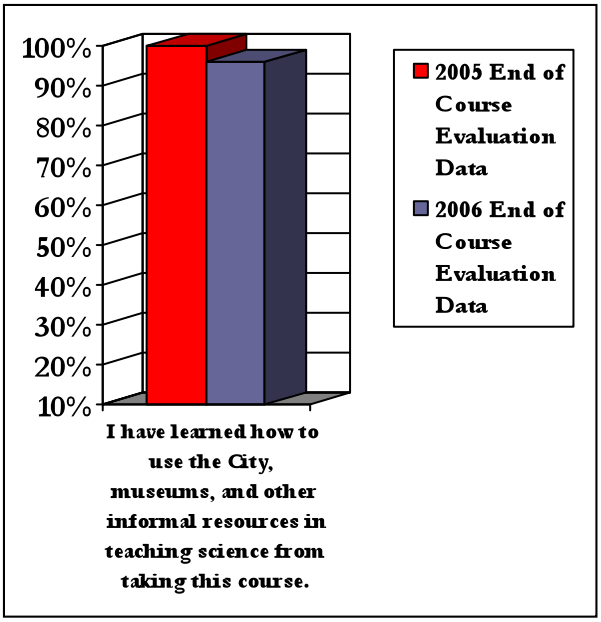
Observation notes from the second college course included these notes:

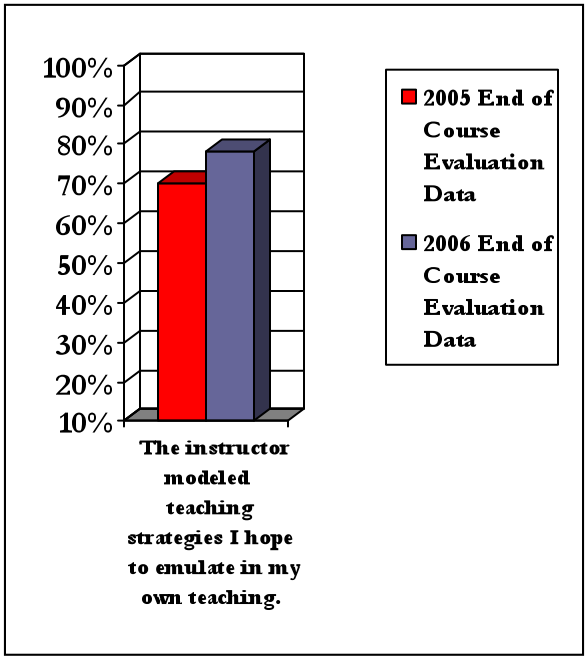
> "She/he used the story and demonstrations to focus her/his students' attention on the class topic: *Human Intervention in Geology*. She/he summarized the lessons from the past few weeks and connected them to the lesson for the day. She/he asked the class, 'How has the city's geology and geography been altered?' Answers were solicited from the class and she/he wrote their responses on the board. As more responses were written, she/he began to categorize them and show how the categories were related to each other. The answers she/he solicited and categorized from the class were used and referred to throughout the lesson and her/his summary. She/he was observed as the resource person. She/he guided the flow of instruction and knowledge very carefully. She/he masterfully incorporated student responses and comments into the lesson and their connection to past topics learned."

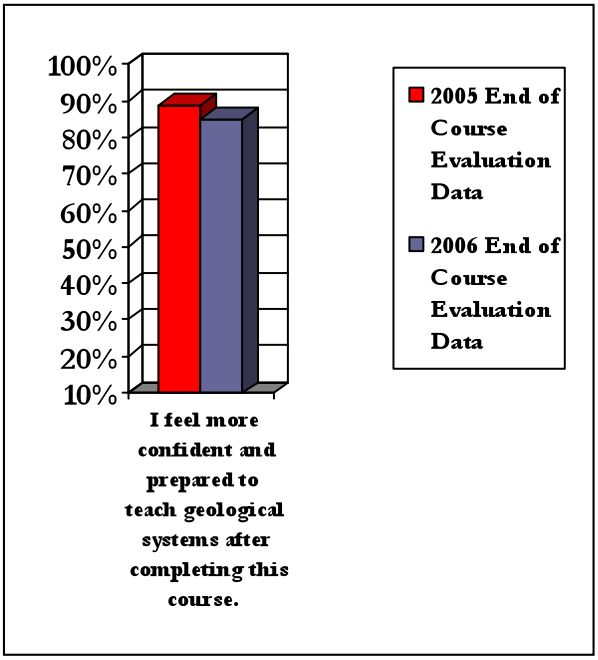
Beginning in the second year the college-based courses were offered, students completed an end-of-course evaluation of the courses. A copy of the course evaluation form appears in Appendix A, and a summary of responses to all items appears in Appendix B.

Figures 4 and 5 on the next page, report the two year evidence for key characteristics of the courses. As may be seen from the evidence in the charts, the courses were given high marks by the students. Between 90-100% of the students reported that they had substantially increased their content knowledge and learned how to use informal institutions and resources in teaching Earth science. Additionally, they reported their instructors' modeled good teaching pedagogy. Consequently, they report more confidence in teaching Earth science. And it is noteworthy that these student assessments were maintained, and in some cases, improved over the two years of course evaluations.









Thus, it was concluded from the course development evidence that the project staff had been successful in designing courses strong in content knowledge. Additionally, the delivery of these courses reflected sound pedagogical practices.

Museum-based Summer Institutes

A second key component of the model was the summer institute. The AMNH Summer Institute for Earth and Space Science provided 60 hours of museum-based instruction over a period of 2 weeks for each of the three TRUST cohorts. The summer institute was designed as a structured blending of content and pedagogy utilizing and modeling research-based best practice for learning in informal museum settings. The content and structure of curriculum design were anchored to the five content areas required by the NYS Content Specialty Test in Earth science (NYSED, 2003), the National Science Education Standards (National Research Council, 1996), and NYS learning standards (NYSED, 1996): that is, the five content areas of foundations of scientific inquiry, space systems, atmospheric systems, geological systems, and water systems. AMNH instructors for the institute included six curators and a team of four science educators. Together with college faculty and several members of the Advisory Board, the instructors developed ten essential questions to engage participants in the range of content required for Earth science teacher certification. These questions were:

Space Science Questions:

- What is Earth?
- How old is Earth?
- Where is Earth?
- Why is Earth warm?
- How does Earth move?

Earth Science Questions:

- How has Earth evolved? How do we know?
- What is the nature of the inner/solid Earth?
- Why does the Earth's surface look the way it does?
- What causes climate and climate change?
- What makes a planetary body habitable?

The first week of the summer institute focused on Space science and the second on Earth science with a different essential question addressed each day. Scientists and teacher educators at AMNH worked closely in collaboration to provide a balanced blend of lectures, classroom activities, behind the scenes laboratory and collections explorations, field expeditions, exhibition tours and in-depth exhibition explorations. Teacher participants were grouped by age and the grade levels they taught and assigned a grade level specific museum

educator mentor. These mentors remained accessible to teachers throughout the following school year and beyond.

In addition, a variety of media and interactive resources made remotely available through the AMNH website were integrated throughout the institute. AMNH scientists and educators joined participants for meals and other informal meetings in order to facilitate continued interaction. This practice was a direct outcome of formative evaluation processes designed to provide feedback for remediation mostly between years 1 and 2. Participants kept journals and regular reflection meetings were scheduled to monitor comprehension and ensure integration of content as they progressed throughout the two weeks. The supervisors participated as a leadership group in the summer institute with the teachers' group in the mornings in order to solidify Earth science content knowledge and create community. In the afternoon they attended a seminar dealing with leadership topics such as program evaluation, national and local science policy; and grant writing. The key museum exhibitions used for instruction were the Rose Center for Earth and Space, the Gottesman Hall of Planet Earth, the Hall of Meteorites, and the Millstein Hall of Ocean Life.

At the end of each of the two weeks of the institute, students submitted their journals and completed end-of-week institute evaluations. This evidence was used in assessing the effectiveness of the summer institute. The evidence indicated that the institute was successful on several fronts. It expanded and deepened the teachers' content knowledge, it introduced them to the variety of resources of the museum, and provided the foundational structures to assist teachers on the use of informal education resources in increasing their own content knowledge, and improving their classroom instruction.

One indicator of the effectiveness of the museum program with the participants was the impact of the institute's scientific presentation on the teachers. Table 1 on the next page presents a tally of journal references to different components of one of the two-week summer institutes. Twenty-six logs were reviewed using a content assessment protocol. In many cases a

Table 1:
Tally of References Made by Participants in Each Session in Journal Logs

Date	SP #1*	SP #2	WS	ICS	ATC
Day 1	9=35%	5=19%	3=12%	5=19%	6=23%
Day 2	13=50%	7=27%	14=54%	8=31%	15=58%
Day 3	19=73%	7=27%	7=27%	10=38%	13=50%
Day 4	15=58%	8=31%	9=35%	11=42%	6=23%
Day 5	9=35%	5=19%	1=4%	2=8%	5=19%
Day 6	19=73%	4=15%	2=8%	14=54%	11=42%
Day 7	19=73%	10=38%	11=42%	13=50%	14=54%
Day 8	9=35%	5=19%	6=23%	2=8%	4=15%
Day 9	15=58%	9=35%	8=31%	14=54%	5=19%

single log entry included multiple components, and consequently was coded for several categories. Responses were not tallied based on positive (most) or negative (few) comments, although there were many positive comments and only very few negative ones. The table is useful in determining which sessions stood out most in each participant's mind at the end of the day. And as may be seen from the table, the participants devoted considerable portions of their reflections to the scientific presentations. Journal entries typical of comments made by many participants included:

> "The moveable museum will be a great asset for me to use in the Fall because I teach astronomy in the early part of the year. I had no idea that it was free and this should be taken advantage of by all the NYC public schools. I am learning a lot of information – at times it is almost overwhelming. But at other times it is clarifying things I am familiar with but had no real depth of knowledge on it."

Another remarked:

> "Days one and two have broadened my knowledge of the science I thought I already knew and understood. For example, yesterday [one of the museum scientists] took us around AMNH to view how the water cycle influences or is influenced by New York and the larger system of Earth. I assumed too much prior to this AMNH workshop. I figured how much more can there be to evaporation, condensation, and precipitation? As it turns out – a lot. Water is an unusual and unique substance!"

One participant remarked on the end-of-the-institute questionnaire that the most academically satisfying aspect of the institute was the scientific presentations. He wrote:

> "The lectures provided me with additional insight into the content and built upon ideas that were incomplete in my own interpretation."

Evidence from the end-of-institute questionnaire also indicated the institute helped participants discover ways to improve their own classroom instruction and to use the museum. Typical responses from participants included the following:

> "My teaching of science will never be the same, for I have learned to rearrange all the knowledge I had about earth sciences, include the Earth as a smaller structure of the much larger universe/cosmos, and include the integration of non traditional sources (museum, parks, beaches etc.) into my curriculum. In summary, I will be changing the way I teach, I will be using a more modern way to teach science. Yes, I will be stepping out of my little whole (classroom) and actually teach my students in a place where science is actually happening."

> "In the past I was hesitant to consider a class trip to the museum, but I am much more apt to do this in the future. By providing background information before attending the trip I will be able to initiate certain concepts and theories and then support these when visiting exhibitions."

> "The moveable museum will be a great asset for me to use in the fall because I teach astronomy in the early part of the year. I had no idea that it was free and this should be taken advantage of by all the NYC public schools."

> "I must say that even though I've done a few classes/institutes at the museum, none have been as rewarding and useful as this one. This institute has focused on Earth/Space science and the teaching of it in NYC schools. For me it has been a dream come true to interact with real, live scientists. This might sound corny but I share with my students a wonder of meeting a real scientist, for this is an opportunity of a lifetime. Interacting with scientists and museum curators brings the whole concept of science being real in everyday life to my personal experience."

> "It's only 2 days and I have an impressive list of laboratory activities and demonstrations for use in the classroom. These are ideas shared with us from the staff and many which have been sparked in my brain as I observe the lectures, demonstrations, and exhibits. It has been both interesting and productive thus far."

> "I learned so much about the processes of the Earth and Universe (background info that I am interested in). I learned how to use the information I acquired to enhance my students' knowledge. I also discovered new ways of using the halls to teach my kids. "

The evidence is clear that the summer institutes were effective. And a key to its success was that it provided the opportunity for participants to increase their content knowledge. Over 8 out of 10 of the participants reported that the most meaningful learning experience was the lectures and content, and over 90% reported that the lectures and presentations were the most intellectually satisfying aspects of the institutes. Typical comments included:

> "My time at AMNH/TRUST has been extremely helpful. The content has been excellent and the level of instruction has been excellent."
>
> "I never learned so much in one week as I did in the TRUST institute. I joined AAAS and read the articles in Science Magazine that I can understand and I understand more of them because of the institute. I would do it again."
>
> "More lectures would be great. I like learning from what other scientists are doing."
>
> "I would love to hear more about the museum scientists' research. This would help me be in touch with current earth/space science."
>
> "I would like to continue to learn and "do science" with scientists at the museum, particularly in other areas of science."

Thus, in terms of effectiveness, the accumulated summative evaluation evidence indicated the project staff was very successful in developing and delivering effective professional development activities to the project participants. Participants reported they had increased their content knowledge, both from the college courses and summer institute, and experienced modeling of good instructional practices and the use of informal venues in providing classroom instruction.

IMPACT EVIDENCE

The information provided above indicates there is substantial evidence that the project staff were effective in designing and implementing programs and activities that substantially increased the content knowledge and pedagogical knowledge of the participants. Given these findings the second major foci of the evaluation was to determine the Short Term impacts of the program and activities. These are described and discussed below, beginning

with an examination of the impacts on the participant teachers and supervisors and their professional work.

Impacts on Teacher Shortage

To have an impact on Earth Science teacher shortages in NYC the project needed to achieve its participant target levels and for these participants to continue working in NYC schools and/or settings. The evidence indicates the program achieved substantial success on both fronts. Over the course of the funded project grant period and the additional year of a no-cost extension 90 teachers and 30 leadership/administration participants completed the TRUST program, and consequently the project had a 100% success rate in reaching this project goal.

Teacher retention is also a key indicator of the impacts of the project. Analysis of retention statistics indicated that 82% of all teacher participants and 91% of all leadership participants continue to be active in the NYCED school system. Some TRUST teachers have left the city, but continue to teach, while others left teaching altogether. Reasons given for leaving were generally personal and/or typical of urban settings, such as higher salaries offered in suburban districts or in other professions, and access to affordable housing. Those who left NYC to teach elsewhere in NYS, continue to teach Earth science. Others (7%), although they are no longer in NYC public school classrooms, have remained educators, becoming faculty members in teacher education programs at local colleges, including Brooklyn College School of Education and Teachers College, Columbia University. Retention rates for another NYC program, Teaching Fellows, a NYCED sponsored alternative route to certification program, reveals a 65% retention rate. The retention rate for the TRUST program was substantially higher. The TRUST retention rate for the 2004 cohort, the only cohort with a three year record since inception of the program, was 78%. It can be suggested that this type of program with extensive institutional and mentoring connections beyond the years of preparation may serve as a model for teacher induction and in support of retention.

Another goal of the TRUST program was to address the shortage of certified Earth science teachers. Of the 23 member 2004 TRUST cohort, 44% are now certified in Earth science; all of them received this certification after participating in TRUST. The 2005 teacher cohort numbered 25, of whom 47% are now certified in Earth science (six members of this cohort were certified prior to entering TRUST). The evidence for the 2006 teacher cohort was not yet available as this report was being written. Of those in the leadership group, 11% of the 2004 cohort has attained Earth science subject area certification, 18% of the 2005 cohort, and so far 9% of the 2006 cohort. Those teachers who have remained active in the NYCED system, who have not yet attained Earth science teacher certification, are certified in other subjects including biology, chemistry, general science, childhood and early childhood education.

Evidence was also collected on the impact of the TRUST program and activities on participants' teaching and professional development, and their schools. At the end of each school year after completing the college courses, summer institute, and ongoing professional development activities, teachers were asked to report on impacts. And teachers continued to be asked to report impacts two-three years after their initial participation year in the project.

Although the evidence of impacts were limited to self-reported assessments, teachers report significant impacts on themselves, their teaching, and their schools. A complete report of participant responses to all the survey items appears in Appendix C of this report. Suffice it to say here that 90+% of the teachers reported they were more confident teaching Earth science and content relevant to NYC tests and assessments, and an equal percent of teachers reported they now know how to use the city and museum in their teaching.

What is particularly noteworthy is the sustained impacts the TRUST program has had on teachers. Table 2 on the next page reports some of these sustained impacts. Typically, an intervention program, such as TRUST, has a substantial impact in the first year, followed by a decline in impacts in subsequent years. However, in this case, the impacts were substantial in the

first year and continued to be sustained, and in many cases, enhanced in years 2 or 3. Interviews with participants suggest these impacts continued because of the quality of the courses and summer institute, but also were directly attributable to the TRUST program partners providing ongoing professional development opportunities for participants.

Table 2:
Sustained Teaching Impacts

Schooling Context survey items	Strongly Agree/Agree		
	2005	2006	2007
After TRUST I feel more confident to teach Space Systems to my students.	95%	100%	100%
I feel confident teaching geological systems.	91%	100%	100%
My TRUST experience prepared me to teach content relevant to NYC tests and assessments.	78%	88%	93%
I have been able to find ways to share the summer experiences with students in my school.	79%	100%	100%
I use essential questions as ways to organize my teaching units.	78%	98%	93%
I know how to use the City and Museum to help my students learn.	96%	100%	100%
I have taken my students outside the classroom for instruction this year.	88%	89%	87%
I have been able to be a better resource to other science teachers after my TRUST experience.	100%	94%	100%
My involvement in TRUST has improved the science program in my school.	63%	72%	88%

Participant Use of the Museum as an Instructional Setting

Among the objectives of the TRUST project was to encourage use of informal science learning institutions as instructional settings. Of those participants who have continued to teach, over 50% reported they brought their students to AMNH to use the museum as a setting for Earth science instruction. And over 64% of the leadership group participants indicated they brought students on instructional trips to AMNH and over 25% brought teachers for field trips and/or professional development. It should be noted these figures reflect the instructional use of AMNH only and do not take into account participant instructional use of other informal settings such as parks, zoos, or other museums.

The project also had significant impacts on supervisors' leadership development. Table 3 reports some of these impacts. Eight out of ten supervisors reported they had more confidence in their ability to provide their

Table 3:
Impacts on Supervisors' Leadership Development

Survey Items	Strongly Agree/Agree
I have been able to be a better resource to other science teachers after my TRUST experience.	100%
I think it makes a big difference in my professional options to be certified in Earth science.	76.9%
I am prepared to share some of my work in school this year in professional development sessions with other science teachers.	92.3%
My involvement in TRUST has improved the science program in my school.	92.6%
I have felt more confident to do professional development sessions for my school or region after TRUST.	81.5%

teachers science professional development, all of the supervisors believe they have become a better resource to their science teachers, and 90%+ believe their science programs have improved because of their involvement in the TRUST program. Additionally, several members of the leadership group have continued their professional development by enrolling in advanced degrees. Three have enrolled in science education doctoral programs at Teachers College, Columbia University and the Graduate Center, CUNY. One TRUST participant, a 2007 graduate of CUNY Urban Education doctoral program, was recently hired as a faculty member of Teachers College. Two participants have become assistant principals whose schools use the museum extensively as an instructional setting and for teacher professional development. One participant who entered the TRUST program as an assistant principal has moved on to become Science Instructional Supervisor for NYCED.

Impact on the Museum and College Institutions

In addition to increasing the number and quality of Earth science Teachers of New York City, the TRUST project has demonstrated impacts on the collaborating institutions. First, in the case of the two colleges, and as

reported earlier, both colleges have developed and institutionalized new Earth science courses. Currently, these courses are offered once every two years as part of the colleges' scheduled curriculum and course offering cycles.

Additional other significant institutional and cultural changes have occurred. Examples include the following:

1. One of the TRUST PIs was selected by his peers as chair of a science department, thereby providing new opportunities to embed the TRUST collaborative partnership in the science department curriculum.
2. Two TRUST participants are teaching general life science and education courses within the college, using both formal and informal resources in their institution.
3. One TRUST participant is co-teaching with a college-based scientist, assisting in incorporating informal institutions and resources into course labs and assignments.
4. One TRUST PI has been invited to become a research associate in a museum science department.
5. One TRUST PI submitted a NSF grant proposal to use informal institutions and resources in providing a research immersion experience for teachers, and the grant was awarded funding.
6. Some museum scientists have requested debriefings and assistance in further developing their pedagogical skills.
7. The TRUST program is being used as a model in creating formal informal institutional partnerships in other departments within the colleges.
8. Within the Museum, the Education and Scientific divisions have become stronger collaborators in supporting certification efforts in the City.

The TRUST program has also had some significant impacts on the museum and the museum scientists. TRUST participants have proven to be an excellent candidate pool for leadership roles in other AMNH professional development programs. One such program is Urban Advantage, a collaborative partnership led by AMNH that integrates the resources and expertise of eight of NYC's cultural institutions, for which 45% of the 2005 and 2006 TRUST leadership participants were selected. These former TRUST participants are

acting as Lead Teachers within the Urban Advantage program, providing professional development in Earth science to middle school teachers. Five of these Lead Teachers have made significant impacts on science instruction at their schools, transforming them into Urban Advantage Demonstration sites.

Museum scientists also report the program has improved their thinking, teaching and behavior. Although all scientists interviewed indicated that preparing scientific lectures for a wide range of teacher and supervisor participants was challenging, all indicated new insights into K-12 science teaching. For example, one scientist said:

> "I think it's having a natural impact for sure. Earth scientists do arrange a kind of activity. Usually they teach at the graduate level in their discipline. That's the most typical thing for scientists to do here. They teach at Columbia, at NYU, and some CUNY courses occasionally. You might collaborate with the education department and arrange a thing that might be anywhere from an hour long lecture to part of a weekend institute where you are vaguely aware that you are talking to teachers but you're not learning anything in particular to prepare yourself for that. I think that is pretty typical. But, in the case of the TRUST program, when we got together to talk we were confronted with what the teachers needed. We really looked at what teachers needed to know. I remember teachers needed to know a lot. I think that impressed all the scientists."

And when reflecting on the summer institute, this scientist remarked:

> "Talking with teachers reminds me of how important content knowledge is to teachers – it sounds funny – but scientific research is really about the answer. Even though we worked hard to place the content we were disseminating at the institute into the context of overarching questions [and I think it was really an important and strong approach] ultimately the important goal seems to be to develop content expertise – which makes sense since it's hard to be comfortable with questions if one is on shaky ground with one's own understanding."

And when asked to describe the longer-term impacts on themselves, scientists repeatedly mentioned four impacts:

- Became knowledgeable of NY State and City Earth Science teaching content and licensing requirements.
- Improved their teaching by incorporating more active learning into their lectures.

- All found the Institute rewarding, particularly the opportunities to share their research with teachers.
- All indicated they would like to participate in more TRUST-like institutes and programs.

In terms of impacts on the museum, the TRUST program has provided a model for continuing to collaborate with degree granting formal institutions and contribute to future preparation of scientists. To that end, two impacts are particularly noteworthy. First, the Earth science summer institute has been institutionalized by the museum. In conjunction with offering the college courses, the Museum is scheduled to offer the institute every other summer as part of its ongoing professional development activities that support formal education and certification of science teachers. Having institutes that carry credits will, in all likelihood, increase enrollment from other college students preparing to teach Earth Science in other places around the state.

Second, the TRUST program provided the foundation for securing new grant funds to expand the TRUST model to Life science. In this program the Museum is again collaborating with two CUNY colleges, in this case, Brooklyn College and Hunter College in developing, implementing, and documenting a yearlong program of the summer institute and online courses for New York City teachers. Early evidence from the 2007 summer institute indicates the new institute is equally effective to the original TRUST summer institute. Once again providing evidence of the replicability of this model.

EVALUATION DISCUSSION

In summary, the evaluation evidence clearly indicates that the TRUST program has been effective. In reflecting back on the seven core questions the evaluation plan was designed to address, there is substantial, and in many cases triangulated; evidence that TRUST has significantly increased the number and quality of Earth science teachers in New York City. In so doing TRUST provided a testbed for the collaboration of formal and informal institutions in providing initial and ongoing professional development for urban

teachers. And the collaborative approach has had some lasting positive impacts on both the formal and informal institutions.

Within the partnership institutions a number of attitudinal, structural, and political changes have been accomplished in the course of building the TRUST model as a sustainable feature of each institution. The four college-based courses are fully established and are scheduled to continue to be offered. The museum has made a commitment to continued offerings of the summer institute, and requirements for completion of degree programs at the colleges now include museum-based courses taught by museum instructors. College and museum administrators have committed resources and continue to support the ongoing partnership. Museum educators and scientists report a deeper knowledge of the requirements for teacher certification and a better understanding of how to identify relevant resources at informal science-rich community institutions such as museums, parks and zoos. Scientists involved in the summer institute report a better understanding of what teachers need to know and be able to do as well as developing a greater appreciation and enthusiasm for science education.

Why was TRUST successful? Many factors have contributed to the success of TRUST, including a focus on increasing teachers' content knowledge, developing ongoing professional development activities for teachers, and building continuing learning communities among teachers, and the teachers with the museum scientists. But it is the judgment of this external evaluator that it is the problem-centered approach, in contrast to the typical institutional-centered approach, that was taken in this project that is a significant key to the success of the project.

The planning year of the project focused on two core questions: What, in exact terms, is the problem? What can each of the collaborating institutions bring to the solution? This was a significant departure from the usual manner in which the various partnership institutions respond to teacher preparation needs. Typically, the partnership institutions, like most institutions involved in the pre- and in-service teacher education, take an institution-centered

approach to addressing the problem; that is, they attempt to solve the shortage of highly qualified teachers by developing new content courses that are designed almost exclusively by academic content specialists. Although well intentioned, these courses many times become surveys of a discipline, and are not particularly responsive to teacher needs in providing standards-based classroom instruction.

TRUST used a different approach to addressing this problem. The project staff began the program design by answering a different set of programmatic questions. These were: (1) What do NYC students need to know about Earth science to meet state standards; (2) What do teachers need a deeper knowledge of in order to help students meet the state standards; and (3) How can the partnership design a program that increases teacher depth of Earth science content knowledge and pedagogical knowledge?

In addition to curriculum and logistical planning, the one-year design period was also used to develop a strong documentation and evaluation component, a feature typically lacking in many formal-informal partnerships prior to TRUST. Another of the first organizational steps taken was the creation of an Advisory Board that was made up of stakeholders: members of the NYCED, deans from colleges, and in particular experienced teachers. The Advisory Board met at intervals throughout the project to hear of its progress and evolution, to offer feedback and to suggest future directions. A subgroup of the Advisory Board along with the PI, co-PIs and the external evaluator carried out detailed design of the summer institute. The college co-PIs were responsible for design of the courses at their respective institutions.

The new approach required development of acceptance and integration at each of the partnership institutions. The planning period allowed for multiple meetings between the partnership personnel, which included college faculty, museum educators, museum scientists, school principals and experienced teachers, all of whom were focused on increasing the number of certified and highly qualified Earth science teachers and improving Earth science instruction in NYC schools. The PI and co-PIs worked together and within their

respective institutions to determine how best to integrate informal science education at the museum with formal teacher education programs and college policies. Ultimately, each partner took on the role it played best, but did so within the construct of the partnership; the Museum maintained its role as content provider by identifying and involving museum scientists and by presenting research on learning in museums to enhance participants' experiences with scientists, objects, exhibitions, visualizations, and a variety of technologies. The colleges played their established role as accredited degree granting institutions with state-approved teacher certification programs focusing on science education in formal settings. Cross-over of personnel between formal and informal institutions existed in both directions: AMNH educators were reviewed, approved and hired as CUNY adjunct professors so that credit-bearing courses offered by the colleges could be taught at the museum by museum instructors. Lehman and Brooklyn College faculty involved in the project were museum research associates in various disciplines, having been approved by the AMNH senate. Cross-over between the natural sciences and education also existed within institutions: the Lehman College co-PI is a geoscientist who at the time was a faculty member in the Division of Education and the director of the science education program; one of the Brooklyn College co-PIs, a geoscientist with formal training in science education, is a faculty member of a geosciences department and has a history of close collaboration with the Brooklyn College School of Education; the other Brooklyn College co-PI is a science educator and faculty member in the School of Education who originally studied and worked as a biologist; the AMNH PI, director of AMNH professional development at the time, has extensive experience in urban teacher education and research.

Logistical coordination between the partner institutions was also required. At the museum, PI and co-PIs and scientific staff worked on redesigning the focus and scheduling of lectures to meet college and teacher schedules, created opportunities and found funding for TRUST participants to be included in other museum professional development opportunities, provided

college faculty with museum access, and reassigned museum staff time for museum-based support and mentoring of teachers and their students. At the colleges, co-PIs completed program redesign and submission for state and NCATE accreditation, shepherded new course curricula through a typically complex approval process, and oversaw programming and scheduling of new courses.

All these activities, initiatives, and collaborative experiences were designed with one purpose in mind; how to address effectively the need for more, and more highly qualified, teachers in NYC. Essential to the project's success was the support and long-term commitments of key individuals at the museum, the colleges and the NYCED. For example, the college administrators from the provosts and deans to the department chairs and program directors supported the initiative by serving on steering committees, attending discussion sessions, promoting the initiative on their respective campuses, and supporting tuition waiver requests for participants. At the museum, the vice-president for education, a team of scientist, and the directors of professional development and online instruction strongly believed in the concept and their ability to institutionalize the museum dimension of the program. Development of the initiative within and between partner institutions evolved into a combination of two separate but complementary teacher development cultures that expanded teachers' opportunities to learn and teach Earth science in and outside formal programs and curriculum.

Based on the evaluation evidence, and an analysis of the project impacts, the external evaluator would offer three recommendations. First, AMNH and CUNY institutions should continue to address the NYC ongoing recruitment and retention problem by expanding the TRUST model to other content and teacher shortage areas. Additionally, replication could be aimed at teachers seeking second subject area certification. These teachers would benefit not only by acquiring the required credits and experience for a second certification, but also by fulfilling the professional development requirement to maintain their existing certification status, currently 175 hours every five years in NYS.

Second, the TRUST partners should develop proactive dissemination activities. It is the conclusion of this external evaluator that the TRUST model is replicable by partnerships prepared to take a problem-solving approach and to entertain policy change that challenge status quo practices in order to solve instructional, recruitment, and retention problems. The model can also be used within institutions that wish to encourage collaboration between the natural sciences and education. Such collaboration is greatly enhanced when cross-pollination of personnel occurs. In the case of TRUST cross-over of personnel already existed at the outset of the project, but willing faculty and engaged administrators could easily create similar structures in other institutions and settings.

Third, the TRUST partners should develop and implement a research strategy for determining the short and long-term impacts of a TRUST-like program on teachers' classroom practices and student learning. Such a research strategy should be evidence-based and use an experimental or quasi-experimental research design to provide empirical evidence of impacts. In so doing, the TRUST partners would not only be able to more definitively assess the impacts of the TRUST program on teachers and student learning, but also provide more generalizable evidence for the teaching profession; research strategies the TRUST collaborative are well positioned to undertake. In so doing the TRUST collaborative may serve as a future model for addressing teacher shortage problems across the nation.

Appendices

Appendix A: TRUST End-of-Course Evaluation Form

The Teacher Renewal for Urban Science Teachers (TRUST) is a four-year National Science Foundation (NSF) funded grant designed to respond to a specific need in New York City for certified Earth science teachers. Part of the grant program includes this course. As part of the evaluation of the program we are asking you to take a few minutes to complete this end-of-course evaluation form. All responses will be kept completely confidential.

Course Title: _____ Date: _____

A. Please indicate your agreement level to the following statements.	**Strongly Agree**	**Agree**	**Not Sure**	**Disagree**	**Strongly Disagree**
1. The instructor was well prepared for classes.	O	O	O	O	O
2. The course objectives were clearly described by the instructor.	O	O	O	O	O
3. The instructor presented ideas and theories clearly.	O	O	O	O	O
4. I was encouraged to think for myself in this course.	O	O	O	O	O
5. The instructor was open to other viewpoints.	O	O	O	O	O
6. The instructor inspired confidence in his/her knowledge of the subject matter.	O	O	O	O	O
7. I have learned new ways of teaching science from taking this course.	O	O	O	O	O
8. The instructor showed respect for the questions and opinions of students.	O	O	O	O	O
9. I felt the instructor was genuinely concerned with my progress in the course.	O	O	O	O	O
10. The instructor modeled teaching strategies I hope to emulate in my own teaching.	O	O	O	O	O
11. I have learned how to use the City, museums, and other informal resources in teaching science from taking this course.	O	O	O	O	O
12. Class meetings were profitable and worth attending.	O	O	O	O	O
13. The assignments in this course were helpful for me to demonstrate what I have learned.	O	O	O	O	O
14. The tests and assessments in this course were helpful for me to demonstrate what I have learned.	O	O	O	O	O
15. I feel more confident and prepared to teach geological systems after completing this course.	O	O	O	O	O

Appendix A: TRUST End-of-Course Evaluation Form

A. Please indicate your agreement level to the following statements.	**Strongly Agree**	**Agree**	**Not Sure**	**Disagree**	**Strongly Disagree**
16. Overall I would give this course high ratings.	O	O	O	O	O
17. I have increased my content knowledge a great deal in this course.	O	O	O	O	O
18. I would recommend other students take this course.	O	O	O	O	O

B. Please provide your assessments in items 19-22.

19. What was the most academically challenging part of the course?

_____

_____

_____

20. What was the most interesting part of the course?

_____

_____

_____

21. What suggestions, if any, would you make to improve this course in the future?

_____

_____

_____

22. Any other comments you would like to make?

_____

_____

_____

_____

_____

_____

_____

_____

Thank you for your assistance. It is much appreciated.

Appendix B: Summary of Course Evaluation Responses

Instructor Approach

Please indicate your agreement level to the following statements.	Strongly Agree	Agree	Not Sure	Disagree	Strongly Disagree
1. The instructor was well prepared for classes.	**67% (24)**	31% (11)	3% (1)	0% (0)	0% (0)
2. The instructor presented ideas and theories clearly.	**53% (19)**	42% (15)	6% (2)	0% (0)	0% (0)
3. The instructor inspired confidence in his/her knowledge of the subject matter.	**61% (22)**	31% (11)	8% (3)	0% (0)	0% (0)
4. The instructor modeled teaching strategies I hope to emulate in my own teaching.	31% (11)	**39% (14)**	25% (9)	6% (2)	0% (0)

Course Content

Please indicate your agreement level to the following statements.	Strongly Agree	Agree	Not Sure	Disagree	Strongly Disagree
1. I have learned new ways of teaching science from taking this course.	31% (11)	**53% (19)**	11% (4)	3% (1)	3% (1)
2. I have learned how to use the City, museums, and other informal resources in teaching science from taking this course.	**60% (21)**	40% (14)	0% (0)	0% (0)	0% (0)
3. I feel more confident and prepared to teach geological systems after completing this course.	**46% (16)**	43% (15)	6% (2)	6% (2)	0% (0)
4. I have increased my content knowledge a great deal in this course.	**47% (17)**	42% (15)	11% (4)	0% (0)	0% (0)

Course Organization

Please indicate your agreement level to the following statements.	Strongly Agree	Agree	Not Sure	Disagree	Strongly Disagree
1. The course objectives were clearly described by the instructor.	**61% (22)**	36% (13)	3% (1)	0% (0)	0% (0)
2. The assignments in this course were helpful for me to demonstrate what I have learned.	42% (15)	**47% (17)**	8% (3)	3% (1)	0% (0)
3. The tests and assessments in this course were helpful for me to demonstrate what I have learned.	31% (11)	**50% (18)**	14% (5)	3% (1)	3% (1)

Appendix B: Summary of Course Evaluation Responses

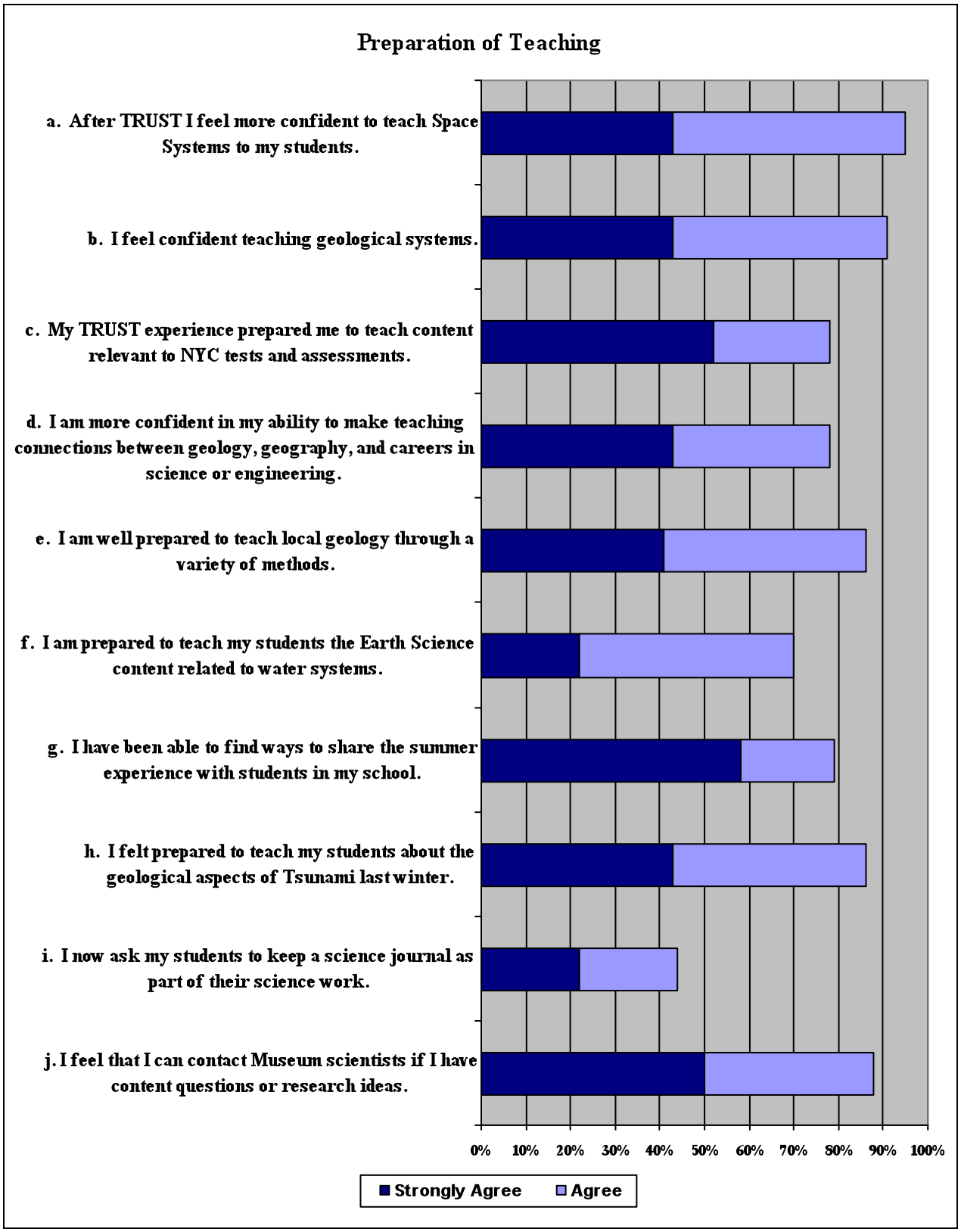
Student-Oriented Approach

Please indicate your agreement level to the following statements.	Strongly Agree	Agree	Not Sure	Disagree	Strongly Disagree
1. I was encouraged to think for myself in this course.	**47% (17)**	39% (14)	3% (1)	11% (4)	0% (0)
2. The instructor was open to other viewpoints.	**44% (16)**	**44% (16)**	8% (3)	3% (1)	0% (0)
3. The instructor showed respect for the questions and opinions of students.	**54% (19)**	34% (12)	11% (4)	0% (0)	0% (0)
4. I felt the instructor was genuinely concerned with my progress in the course.	31% (11)	**39% (14)**	28% (10)	3% (1)	0% (0)

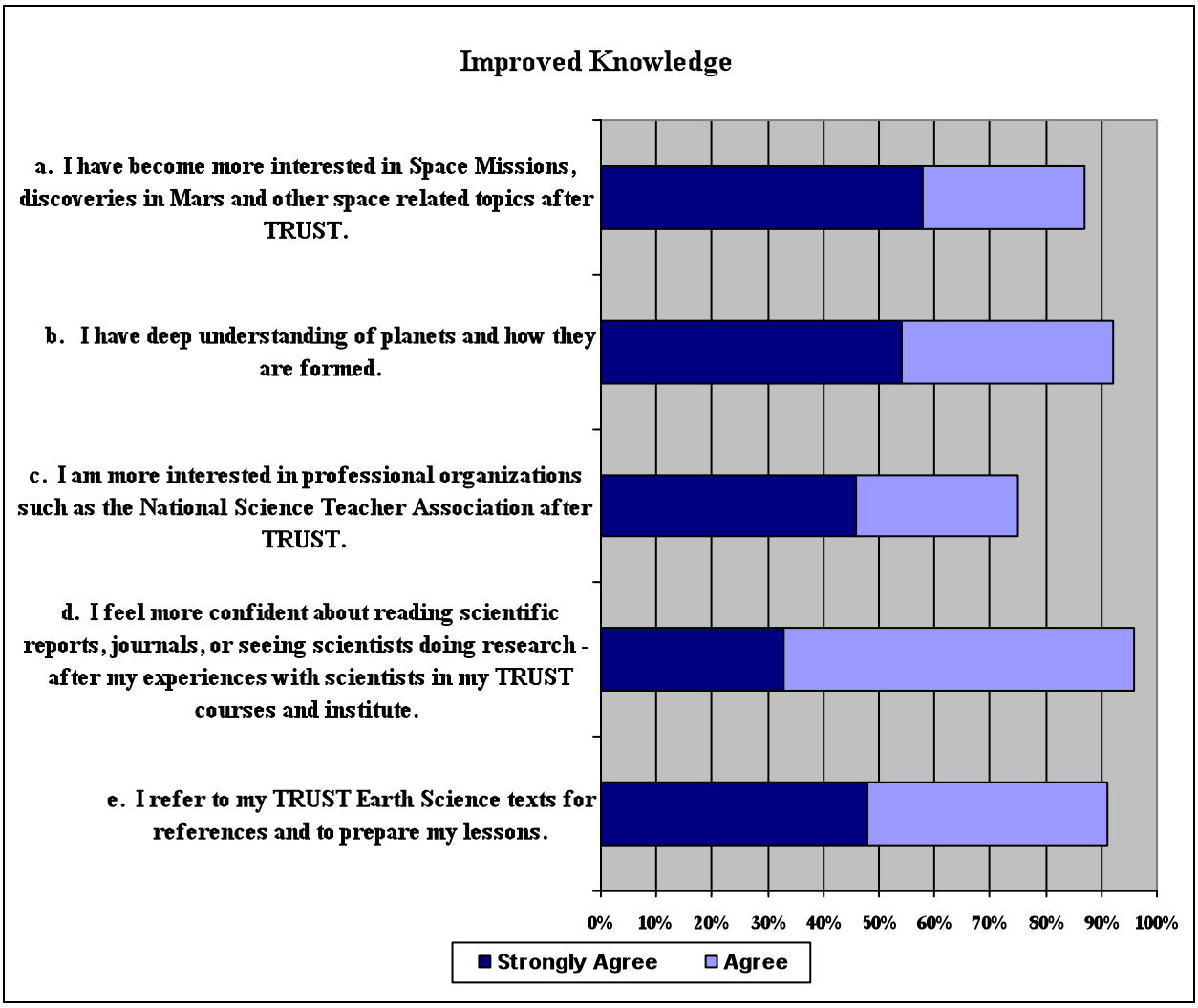
Overall Course Assessment

Please indicate your agreement level to the following statements.	Strongly Agree	Agree	Not Sure	Disagree	Strongly Disagree
1. Class meetings were profitable and worth attending.	**44% (16)**	39% (14)	11% (4)	6% (2)	0% (0)
2. Overall I would give this course high ratings.	39% (14)	**47% (17)**	11% (4)	3% (1)	0% (0)
3. I would recommend other students take this course.	42% (15)	**44% (16)**	11% (4)	3% (1)	0% (0)

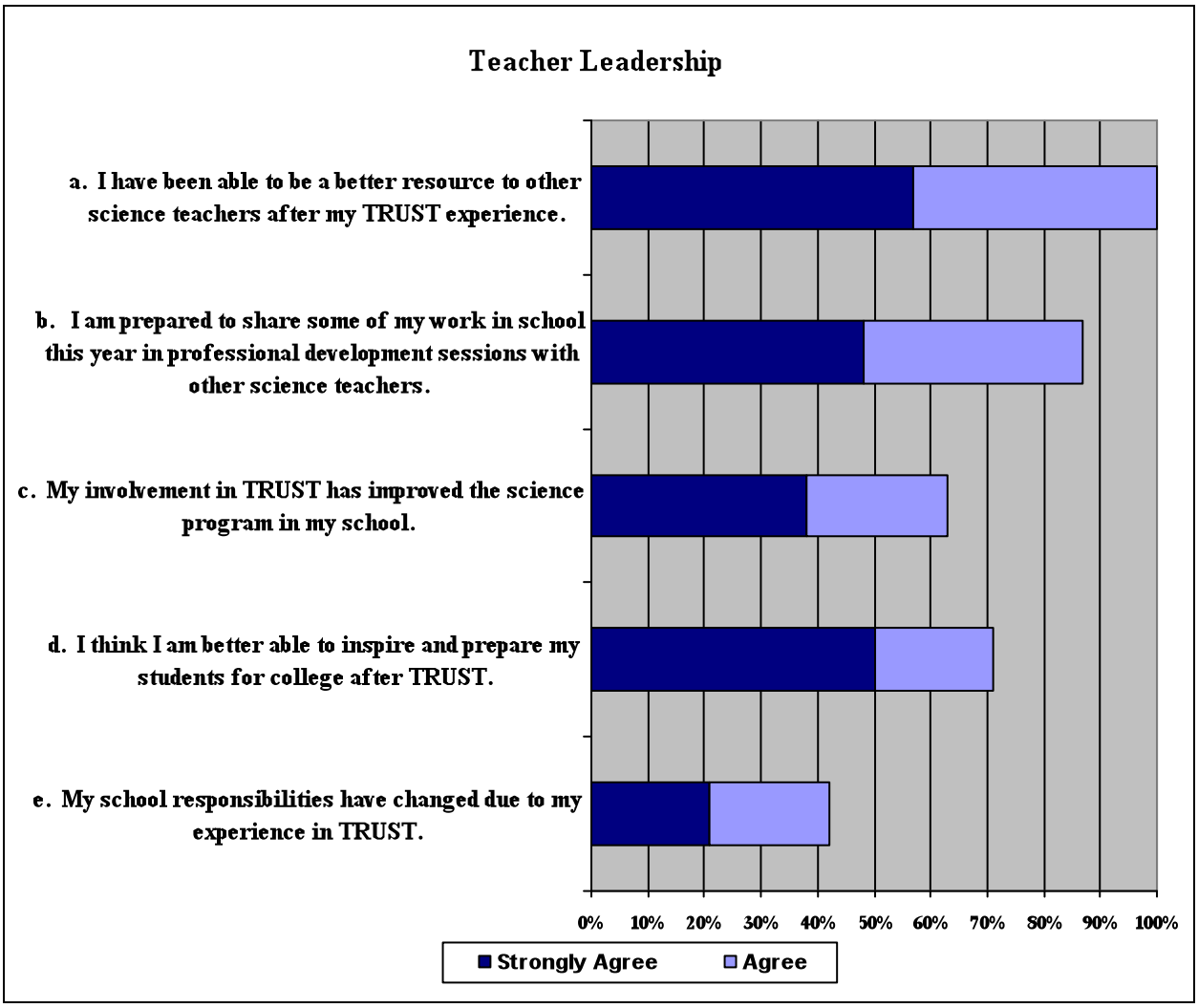
Appendix C: Survey Item Responses



Appendix C: Survey Item Responses



Appendix C: Survey Item Responses



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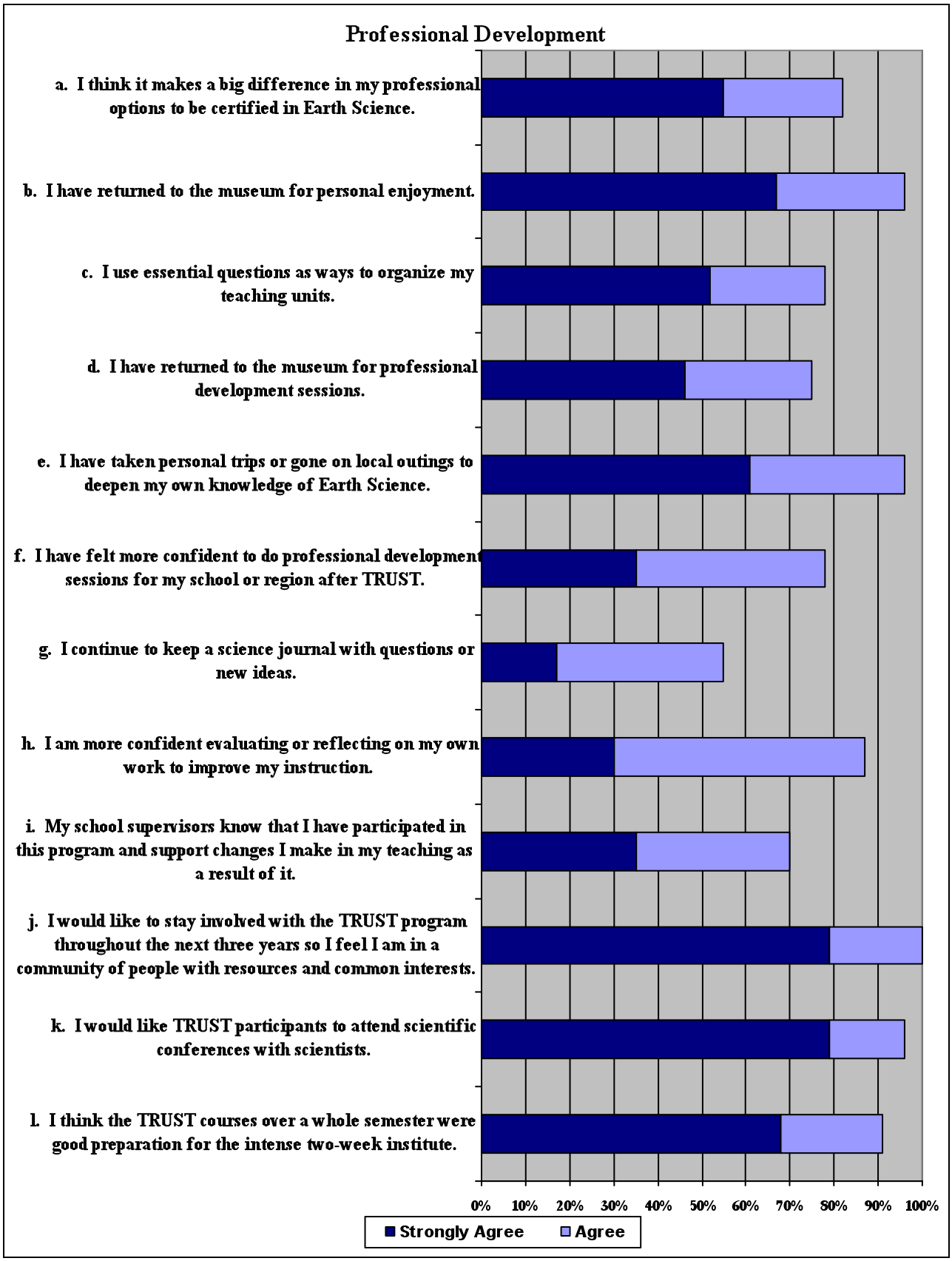

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