

HUBBLE SPACE TELESCOPE EDUCATION PROGRAM
Space Telescope Science Institute's Office of Public Outreach

COMPREHENSIVE EVALUATION—2000-2010

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EXECUTIVE SUMMARY

The Space Telescope Science Institute (STScI) is the operations center for the Hubble Space Telescope (HST) Mission—an international cooperation between NASA and the European Space Agency (ESA). STScI is responsible for providing products and services required to execute HST's science program. Through its Office of Public Outreach (OPO), STScI delivers an array of products and services designed to communicate the science and discoveries of HST to astronomers, educators and the general public. The efforts of OPO's three branches—News, Online Outreach and Education—focus on meeting the needs of the news media, users of the Internet and educators in both formal and informal education communities. The Education branch provides products and services for K-14 formal education venues as well as informal education arenas such as museums, science centers, etc.

Cornerstone Evaluation Associates LLC has been engaged to conduct an external evaluation of OPO's Education branch. Cornerstone is a Pittsburgh-based, client-centered research firm specializing in program evaluation. In particular, the firm has extensive experience in educational evaluations including STEM programs, E/PO efforts and professional training and development. Moreover, Cornerstone is versed in monitoring and assessing Web and social networking sites as well as evaluating free choice educational opportunities in venues like museums and science centers. As such, the firm is uniquely positioned to carry out a comprehensive evaluation of HST's formal and informal education efforts.

The purpose of this evaluation is threefold—1) to document over the past decade the growth and dissemination of the Education branch's formal and informal programs as well as to demonstrate the impact and value of the branch's work, 2) to provide evidence of the soundness of the strategies used to accomplish the branch's work and its effectiveness as a team and 3) to broadly review findings and 'lessons learned' in order to provide direction for future undertakings. Methodologically, we have relied on a review of more than 2,500 pages of documents related to the OPO-Education branch's work efforts over the past decade and interviews with select STScI and OPO-Education staff members who participate in creating the HST program's products and services.

FINDINGS

STScI's Office of Public Outreach answers to NASA SMD, GSFC and STScI in accordance with the contractual arrangements among these organizations. Representing about 15% of the OPO, the Education branch is comprised of six team members with expertise in formal and informal education, evaluation and exhibit production. The Education branch also relies on the expertise and contributions of STScI's scientists, technical and multimedia specialists within OPO, made possible by STScI's matrix organization. The OPO-Education branch of today represents an evolution that has taken place over a fifteen year period. Although formal and informal education efforts began 'under one roof', by 2000 these efforts were re-assigned to two separate branches and in 2008 they were recombined within the Education branch.

Program Impact

The story of the impact of HST's formal and informal education programs is told by chronicling the milestones of its expansion and ever increasing reach over the past 10 years and describing how the HST program is meeting its goals and objectives.

Growth and Dissemination—Formal Education—The HST program includes two main components for formal education—1) curriculum support tool development, including Amazing Space and 2) formal education community support. The *curriculum support tool development* component has its origins in the 1996 launch of the Amazing Space Web site. This site features an online education program with topics based on national standards, needs of teachers and availability of Hubble data. The focus is on K-14 teachers and students as well as pre-service/in-service teacher education. Since the Web site's 1996 launch highlights of its growth and dissemination have included...

- 1999-2007—Web sessions increased from 40,000 to 220,000 per month
- By 2002—25 states used Web site as educational tool; by 2007 all 50 states were involved
- 2005—Ohio integrated Amazing Space Web site into teacher training, citing it as exemplary of 'best practices' for middle and high school teachers
- 2010—Education branch added Tactile Astronomy designed to reach the visually impaired

The *formal education community support* activities provided by the Education branch have blossomed since the branch's earliest efforts. Initially, the branch conducted a handful of training workshops and gave presentations at conferences of professional organizations such as NSTA, AAS, AAPT and SACNAS. Today, it conducts training workshops in partnership with 27 organizations. Results of the branch's efforts signifying growth and dissemination include...

- Partnerships forged with Appalachian Regional Commission and the Outreach to Space Museum Project to reach underserved, underrepresented audiences in non-traditional venues
- The number of professional organizations and educational institutions to whom the Education branch has provided materials and implementation strategies has grown from 38 in 2005 to 410 in 2010
- On average, 10 presentations of white papers and posters are made at conferences each year; reaching 50-100 participants at each meeting
- In 2010, the Education branch embraced the latest cost-effective technology by beginning to present NSTA workshops via Webinars

Growth and Dissemination—Informal Education—The HST program also includes two major components for informal education—1) exhibits and shows, including ViewSpace and 2) informal science education community support. Originally anchored by ViewSpace, a self-updating permanent exhibit, the branch's informal education efforts have increased in breadth and depth. This growth is attributable to a proliferation of products and services as well as achieving widespread dissemination. *ViewSpace* has continued to be the centerpiece of the informal education product line. ViewSpace was developed in 2000 as a series of PC-based multimedia presentations addressing specific requirements of planetariums and science centers. Today its record of accomplishments includes...

- 2000—ViewSpace was developed as PC-based, multimedia presentations running in over 50 institutions from its inception and is now playing in 44 states across the country

- 2005—ViewSpace venues potentially extend to library systems through its introduction at the American Library Association annual convention where potentially 20,000 librarians were introduced to it

While ViewSpace is the focal exhibit of HST's informal science education efforts, the branch has also produced a proliferation of *other exhibits and shows*. These products represent a dramatic expansion of offerings from the early days when planetariums were simply provided with slides, visualizations and other source materials. Today, traveling exhibits and exhibit components have been made available to informal education venues throughout the United States. Highlights of the milestones for these traveling exhibits/shows are...

- 2004—Over 700 low-cost, high quality 35mm slides were made available to nearly 3,000 planetariums through an arrangement with the IPS; today digital files are distributed
- Since 2004—The exhibit 'Heavens Above: Photographs of the Universe from the Hubble Space Telescope' has enjoyed bookings in venues serving underserved and underrepresented communities
- Since 2008—Video Immersive Planetarium Visualizations used in high definition versions by the National Geographic and Discovery television networks
- 2010—Education branch provided visualizations for the collaborative development of the IMAX production 'Hubble 3D' released by Warner Brothers

In addition to developing ViewSpace and other exhibits and shows, the Education branch offers *informal science education community support* including workshops, Webinars, teleconferences, and community events. Accomplishments include...

- Since 2009—55 US libraries have received the traveling exhibit 'Visions of the Universe: Four Centuries of Discovery' along with a professional development workshop for informal educators
- 2010—Hubble science briefings, designed to update informal educators on the science and engineering that drive the Hubble mission; held 7 teleconferences for 304 educators
- 2010—OPO-Education team scientist featured in online learning community Web chat attended by students from 16 states
- 2010—Education branch now averaging 12 community events per year with approximately 50-200 attendees each

Other Indicators of Success—Three additional indicators of the program's success are discussed in the evaluation—1) the expanding evolution of professional development opportunities for formal and informal education communities, 2) attention to employing evaluation tools and techniques for creating sound educational products and services and 3) the acclamation of the program's quality through awards and recognition. The story of the evolution of the HST program's *professional development* efforts provides yet another example of the program's growth and widespread dissemination. It also demonstrates how the shapers of the program respond to the changing needs of the education communities they serve and take advantage of opportunities to partner with organizations that help them ensure cost-effective means for 'getting the word out'. Of note, findings indicate...

- Responding to educator needs, the Education branch conducted over the past 15 years 148 professional development workshops with 5,621 attendees

The HST program's dramatic success also lies in its attention to employing a variety of *evaluation* strategies in developing sound education products/services. In other words, conducting evaluations throughout the development and dissemination process largely ensures that the resultant products/services will be top quality and highly effective...

- 1996-2000—Education branch conducted 44 evaluations—68% of which were for the branch itself, 32% for other OPO branches
- Education branch's evaluations for its own products/services are 74% formative used in the development process and 26% summative/impact studies

Another indicator of the HST program's success is the esteem with which it is held by the communities it serves—the *awards and recognition* it receives. The program has a strong history not only of having its products and services in high demand, but also of being recognized with a variety of awards including the prestigious Scientific American Award received for the Amazing Space Web site and the MUSE Award recognizing ViewSpace's outstanding achievements. Acclaim includes...

- Since 1998 the branch received 21 awards, some of which have been awarded multiple times
- 85% of the awards received by the Education branch have been for its Amazing Space Web site
- 47% of the awards received are from online resource directories that are recognizing Amazing Space for its quality science content and pedagogy
- HST program also receives large number of invitations to be incorporated into teacher training and national media productions
- Education branch was asked to develop and implement an educational workshop for the 2007 historic GSFC visit of the Queen of England

Managing for Success—While the story of the HST program's success is evident in its growth and widespread dissemination over the past decade, understanding how the program has achieved such an impact lies in its management—how it is monitored, how it meets its objectives and how its objectives align with the goals of its governing bodies.

The work of the Education branch is closely monitored through a variety of reporting mechanisms occurring both quarterly and annually and addressing the requirements of each oversight institution—GSFC, NASA and STScI...

- Education branch completes on average 93% of its deliverables annually
- Planned deliverables are in alignment with STScI's guiding philosophies and values
- Planned deliverables align with NASA's major education goals and E/PO evaluation criteria

Program Strategies and Teamwork

The evaluation turns away from chronicling the HST program's growth and dissemination in order to discuss the way in which the Education team goes about doing its work in order to ensure its success. It provides evidence of the soundness of the strategies the team uses to select the products/services it works on, the 'best practices' it relies on in developing these selected products/services and the effectiveness of their teamwork approach...

- The Education branch is guided by established criteria for selecting products/services on which it chooses to work
- 'Best practices' and current educational research are used in developing these products/services

- *The OPO-Education branch works effectively as a team by...*
 - 1) *Sharing a common culture and establishing productive partnerships which contribute to a highly functioning, effective team*
 - 2) *Planning, coordinating, employing feedback mechanisms and adapting to change that keep the team focused and productive*
 - 3) *Using 'lessons learned' to effect change*

A LOOK TO THE FUTURE

Cornerstone Evaluation Associates has undertaken this evaluation in order to uncover evidence of the HST program's effectiveness and to understand how the Education branch works in order to accomplish its success. Through comprehensive document review and interviews, the evaluation has revealed the following broad-brush findings...

- *Over the past decade, the OPO-Education branch has made stellar progress in developing and disseminating formal and informal educational products and services*
- *The Education branch's products/services have proven to be high quality, audience-friendly and effective—having wide-ranging impact on the educational community*
- *The Education branch itself has exhibited great skill in faithfully meeting its goals and objectives*
- *The Education team presents itself as being a group of 'like-minded' colleagues who collaborate, partner and manage their limited time and resources well in order to achieve results*
- *OPO staff who are matrixed to the Education team have indicated that working with the team has been a true partnership from which they have benefited greatly*

The team's vision for what comes next involves...

- *Strengthening the matrix infrastructure through improving communication and reinforcing the matrix culture*
- *Soliciting ideas for new dissemination strategies for products/services*

This evaluation has provided compelling evidence for the effective way in which the Education branch functions as a team in order to turn out high quality products and services that have a resounding impact on the educational community. The branch has even set forth 'best practices' for addressing problems that may be encountered in delivering education and public outreach. By working OPO-wide to understand the 'big picture' and integrate 'best practices' in teamwork, the entire OPO staff will prosper, resulting in a highly functioning organization with increased productivity. It is also hoped that such a fertile environment will spawn myriad creative ideas for product and service dissemination. The teamwork traits, 'best practices' and creative dissemination plans that have served the Education branch so well can be adapted organization-wide through a process of open dialogue. By integrating these effective strategies/techniques, the Office of Public Outreach will be in the best possible position to embark on the growing demands of future projects including Hubble's successor, JWST.

PART 1—INTRODUCTION AND EVALUATION PLAN

The Space Telescope Science Institute (STScI) is the operations center for the Hubble Space Telescope (HST) Mission—an international cooperation between NASA and the European Space Agency (ESA). STScI is responsible for providing products and services required to execute HST's science program. The Institute is operated for NASA by the Association of Universities for Research in Astronomy, Inc. (AURA), with NASA's Goddard Space Flight Center (GSFC) overseeing the work of STScI in connection with the HST program. STScI has also been selected to fulfill the same role for Hubble's successor, the James Webb Space Telescope (JWST), scheduled to launch later this decade.

Through its Office of Public Outreach (OPO), STScI delivers an array of products and services designed to communicate the science and discoveries of HST to astronomers, educators and the general public. The OPO's efforts focus on meeting the needs of the news media, users of the Internet and educators in both formal and informal education communities. In order to serve these disparate audiences, the OPO is organized into three branches—News, Online Outreach and Education. The Education branch provides products and services in K-14 formal education venues as well as in informal education arenas such as museums, science centers, etc.

The efforts of the 41 member OPO complement one another although each of the three branches targets a different audience. They share resources and staff with the purpose of maximizing efficiency and impact. Under the aegis of the Education branch, the OPO also administers two NASA grant programs and hosts the Science Education and Public Outreach Forum (SEPOF) which coordinates education and outreach activities under NASA's Astrophysics theme. Additionally, the Education branch provides product and program evaluation services to the entire OPO in addition to conducting evaluations for its own team.

STScI's Office of Public Outreach answers to NASA SMD, GSFC and STScI in accordance with the contractual arrangements among these organizations. In summary, the organizations and their respective roles are...

- **NASA's Science Mission Directorate (SMD)**—responsible for deploying the Hubble Space Telescope and awarding the contract for its associated science program to STScI
- **NASA's Goddard Space Flight Center**—responsible for managing the HST project on NASA's behalf
- **Space Telescope Science Institute**—responsible for conducting the HST project's science program

Cornerstone Evaluation Associates LLC has been engaged to conduct an external evaluation of OPO's Education branch. Cornerstone is a Pittsburgh-based, client-centered research firm specializing in program evaluation. In particular, the firm has extensive experience in educational evaluations including STEM programs, E/PO efforts and professional training and development. Moreover, Cornerstone is versed in monitoring and assessing Web and social networking sites as well as evaluating free choice educational opportunities in venues like museums and science centers. As such, the firm is uniquely positioned to carry out a comprehensive evaluation of HST's formal and informal education efforts.

The purpose of this evaluation is threefold—1) to document over the past decade the growth and dissemination of the Education branch’s formal and informal programs as well as to demonstrate the impact and value of the branch’s work, 2) to provide evidence of the soundness of the strategies used to accomplish the branch’s work and its effectiveness as a team and 3) to broadly review findings and ‘lessons learned’ in order to provide direction for future undertakings. The overarching questions guiding this evaluation are as follows...

- **Program impact. Section 2.2**—*Is the OPO-Education branch meeting its goals and having an impact? What evidence is there that the HST program has grown, reaching broader and more diverse audiences over the past decade?*
- **Program strategies and teamwork. Section 2.3**—*Is the OPO-Education branch employing sound strategies for selecting what products/services it works on and using ‘best practices’ in developing these selected products/services? Is the OPO-Education branch working effectively as a team?*
- **A look to the future. Part 3**—*What ‘lessons learned’ and recommendations have emerged from the data and how can these be beneficial in guiding the future work efforts of the OPO-Education branch?*

To explore these questions, we have relied primarily on two distinct methods—1) a review of more than 2,500 pages of documents related to the OPO-Education branch’s work efforts over the past decade and 2) interviews with select STScI and OPO-Education staff members who participate in creating the HST program’s products and services.

PART 2—FINDINGS

2.1—Background

The OPO-Education branch represents about 15% of the Office of Public Outreach’s 41 member staff. The Education branch’s six members include its team leader who has extensive experience in evaluation as well as stints as an educator. Along with the team leader, four of the remaining members are responsible for developing products and services. They include three education specialists—one each in elementary, middle and high school education as well as one specialist in informal education. The sixth team member is responsible for exhibit distribution and coordination. The Education branch also relies on the expertise and contributions of STScI’s scientists and technical and multimedia specialists within OPO.

Drawing upon the talents of others within the OPO branch is facilitated by STScI’s matrix organization. Rather than a traditional linear management structure, STScI maintains a structure in which functional and product departments are combined in a dual authority system. Those with specialized expertise in graphic arts, for example, report to OPO, but are assigned as needed to each of its three branches. In this way, the branches are not forced to duplicate resources by hiring their own staffs with specialized skills.

The OPO-Education branch of today represents an evolution that has taken place over a fifteen year period. Some of the milestones in the Education branch's history are summarized below...

EVOLUTION OF STScI's OPO-EDUCATION BRANCH		
Year	Milestones	Focus
1995	Establish national education and outreach program for all of Astrophysics	Focus on development of hard copy curriculum support tools for formal education community and identification of needs of educators working in informal venues
1996	Creation of Amazing Space Web site—showcase for education products	Collaboration of the Education group's education specialists, evaluation specialist, graphic artists, Web designers and programmers
2000	Education branch's staff separates into two branches—formal and informal	Formal—focus on K-14 education community Informal—target informal science venues and institutions with development of ViewSpace, a self-updating multimedia exhibit
2004	Amazing Space Web site's online curriculum tools transition to the Hubble Amazing Space Formal Education program	Formal education program represents a more holistic philosophy for bringing the most recent scientific discoveries and research to the classroom through educator, student and scientist entry-points. Features of the core program for educators and developers were the Web site, hard copy products and teacher training workshops
2008	Formal and Informal branch recombined	Recombined team collaborates with educators and scientists to develop standards-based online and hard copy curriculum support tools, exhibits and professional development workshops for both the formal and informal education communities
2009	Servicing Mission 4 (SM4) and the International Year of Astronomy (IYA)	Devote resources to OPO's special projects for SM4 and IYA
2010	Hubble's 20 th Year Anniversary	Devote resources to OPO's special E/PO effort to focus on products for Hubble's 20 th Anniversary including the making of Hubble 3D: The IMAX Film

TABLE 1. Evolution of STScI's OPO-Education branch.

Using the discoveries and scientific data from the Hubble Space Telescope, formal education efforts include the development of resources that are linked to national education standards and reflect NASA's Education Strategic Coordination Framework by providing a progression of educational opportunities for K-14 students, teachers and faculty. Informal education efforts involve forging links with science centers, planetariums, natural history museums, observatory visitor centers, libraries and similar forums patronized by public audiences seeking to broaden their understanding of science and nature.

The OPO-Education branch delivers an array of products and services. The major categories for these products and services are illustrated in Table 2. This evaluation of the OPO-Education branch's work concentrates on the products and services it delivers to the formal/informal education communities. It does not include product and program evaluations conducted for the other two branches of OPO—News and Online Outreach—nor for other E/PO grants administered for NASA.

STScI's OPO-EDUCATION PRODUCTS & SERVICES CATEGORIES	
Formal Education	Informal Education
Curriculum support tool development—Amazing Space Web site and hard copy education materials	Exhibits and shows—ViewSpace, a self-updating permanent exhibit and traveling exhibits
Formal education community support—professional development workshops and conference support	Informal science education community support—Hubble science source materials and briefings, partnerships, conferences and events
Product and program evaluation	
E/PO grants administered for NASA	

TABLE 2. STScI's OPO-Education products & services categories.

2.2—Program Impact

This section focuses on the results of Cornerstone's systematic review of more than 80 documents related to the HST Education Program and OPO's Education branch. Summing to approximately 2,500 pages, these documents include annual products and services delivery plans from FY00 to FY11, quarterly reports to NASA over a three-year period, the Institute's annual reports from 1999 to 2009 and prior evaluations including an impact study. The Amazing Space Web site <http://amazing.space.stsci.edu> as well as its sister site, Hubblesite <http://hubblesite.org>, were also among the materials available for review. This document review has offered copious evidence of the program's impact and success. The 'big ideas' that have emerged can be loosely summarized as follows...

- HST education program has grown over the past decade in the number and complexity of products and services offered
- HST education program is widely disseminated
- OPO-Education branch has formed a growing number of productive partnerships and collaborations
- HST education program is award-winning and widely recognized for its quality
- OPO-Education branch employs sound evaluation tools in developing and delivering its programs
- Management has an effective system for monitoring its progress towards achieving goals and objectives—deliverables from annual products and services plans are met at a rate of over 90%

The story of the impact of the HST program is told in the next two sections: 2.2.1—**growth and dissemination** that is a summary of the program's expansion and ever increasing reach over the past 10 years and 2.2.2—**managing for success** that is a description of how the HST program is meeting its goals and objectives, despite having three masters.

2.2.1—Growth and Dissemination

The document review offers evidence of the growth of a comprehensive program in both formal and informal science education. From 2000 to 2008, the Education branch was split into two separate groups—one devoted to formal and the other to informal education. While separate, there were opportunities for the two groups to collaborate on projects. However, in the summer of 2008, the groups and their resources were reunited, thus bringing more synergy to efforts for developing products and services for both formal and informal education audiences.

Evaluation methods—What follows is the story of the growth of the HST program’s formal and informal education products and services. This story is laid out as a loosely chronological series of critical milestones that emphasizes the origins of products and services, provides evidence of program growth and draws upon dissemination data—particularly efforts to reach underserved, underrepresented audiences. Our method for the systematic review of the HST education program involved the following steps...

- Create Excel spreadsheet to organize the outputs of the HST program by year and by product/service line as obtained from documents reviewed
- Trace the thread of the evolution of products/services from their inception to present
- Identify milestones in the development, growth and dissemination of these products/services
- Select products/services that best exemplify the HST program’s reach in terms of diversity, new audiences, appropriateness for audiences and growth
- Weave these milestones and exemplary products/services into a story about the impact of HST’s formal and informal education components
- Incorporate from interviews additional findings that had not become evident in the document review

The review is augmented by brief discussions of three additional indicators of the program’s success—1) the expanding evolution of professional development opportunities for formal and informal education communities, 2) attention to employing evaluation tools and techniques for creating sound educational products and services and 3) acclamation of the program’s quality through awards and recognition. For the story of the evolution of professional development efforts, we culled documents from the Education branch as well as interviews with team members. In discussing evaluations and awards, we used a similar strategy to the one bulleted above to extract vital information from available documents. However, rather than discuss these topics in milestone chronologies as we did with formal and informal education, we chose to present them thematically with descriptive statistics and examples to illuminate emerging themes.

Growth of formal education—The HST program includes two main components for formal education—1) curriculum support tool development, including Amazing Space and 2) formal education community support. A chronology of milestones for each of these components is presented in this section. A related piece, a comprehensive account of the evolution of HST’s professional development opportunities in both the formal and informal arenas, starts on page 14.

The *curriculum support tool development* component has its origins in the 1996 launch of the Amazing Space Web site. This site features an online education program with topics based on national standards, needs of teachers and availability of Hubble data. The focus is on K-14 teachers and students as well as pre-service/in-service teacher education.

Even in its earliest days, the Education branch sought the involvement of teachers in summer workshops to develop ideas for activities subsequently offered on the Web site. In fact, by 2007 the National School Board Association (NSBA) identified Amazing Space as a model Web site to use when reviewing and refining curriculum and assessment practices. An important feature for this recommendation was that teachers as well as scientists/engineers at STScI had helped in developing the Web site’s activities. The quality of the site’s activities has also been enhanced by the Education branch’s attention to externally beta-testing materials and to continuing evaluation efforts as materials are released for public use. These evaluations are conducted in a variety of venues such as teacher workshops and classroom settings.

By 2002, educators and other individuals in more than 25 states were using the Web site as an educational tool. In 2007, an impact study conducted by the Education branch found that it was used in all 50 states. The study also revealed that between 1999 and 2007 the number of sessions for the Web site had increased from 40,000 to 220,000 per month.

Formal Education—Amazing Space

- 1996—Launch of Amazing Space Web site
- 1999-2007—Web sessions increased from 40,000 to 220,000 per month
- By 2002—25 states used Web site as educational tool; by 2007 all 50 states were involved
- 2004—Web site transformed into Hubble Amazing Space formal education program that included the Web site, hard copy products and teacher training workshops
- 2005—Ohio integrated Web site into teacher training, citing it as exemplary of ‘best practices’ for middle and high school teachers
- 2007—NSBA identified Amazing Space as a model Web site for curriculum and assessment practices
- 2010—Added Tactile Astronomy designed to reach the visually impaired

Growing use of the Web site was aided, no doubt, by its becoming the focal piece of a comprehensive program. In 2004, the offering of curriculum tools online through the Amazing Space Web site was transformed into the Hubble Amazing Space formal education program. A new brochure geared to educators and curriculum developers highlighted the program’s core features—the Web site, hard copy products and teacher training workshops. The integration of professional development workshops and conference support within one comprehensive program afforded an opportunity to offer well-coordinated products and services in the realm of Hubble science.

A feather in the cap for the HST program was the State of Ohio's 2005 announcement that it was integrating the Amazing Space Web site into its teacher training venues. They cited the Web site as exemplifying 'best practices' in training middle and high school educators.

The Education branch did not then and does not now rest on its laurels. Offerings on the Web site continue to increase in breadth and depth. From 2005 up to the present, the Education branch counts making annual updates to the Web site among its deliverables. Those features that are continually updated include *Hubble Classroom Updates*, *Star Witness News*, Education lithographs and posters. Materials are designed to leverage the visuals and science featured in the OPO's News releases. Hubble's 15th and 20th anniversaries have been marked by special products designed to tie in with the events. Special accommodations have also been made for the International Year of Astronomy (IYA), Service Mission 4 (SM4) and Early Release Observations (ERO). New features continue to be added regularly.

The Amazing Space Web site has also provided a venue for delivering Hubble science to seldom-reached audiences. The visually impaired community can now experience the Web site because of the 2010 addition of Tactile Astronomy. It includes 'Images of the Month' that can be downloaded and printed on thermal paper expansion machines which ultimately allow the visually impaired to feel what they otherwise cannot see.

The *formal education community support* activities provided by the OPO-Education branch have blossomed since the branch's earliest efforts. Initially, the branch conducted a handful of training workshops and gave presentations at conferences of professional organizations such as NSTA, AAS, AAPT and SACNAS. Today, it conducts training workshops in partnership with 27 organizations.

By 2004, as the offering of teacher workshops became integrated into the Amazing Space program, the Education branch began to reach beyond providing workshops at conferences. It initiated partnerships with a variety of organizations such as the Maryland Science Center, NASA's Pre-service Teachers Conference and universities such as Louisiana State University and Stevenson University.

Formal Education—Community Support

- *The Education branch currently conducts workshops with 27 partnering agencies including professional organizations, science centers and universities as well as with other branches of NASA*
- *Partnerships forged with Appalachian Regional Commission and the Outreach to Space Museum Project to reach underserved, underrepresented audiences in non-traditional venues*
- *Partnerships with a variety of professional organizations have dramatically increased the reach of the HST program. For example, 6,000 educators visiting the branch's exhibit at the 11th Annual eTech Ohio Conference*
- *The number of professional organizations and educational institutions to whom the Education branch has provided materials and implementation strategies has grown from 38 in 2005 to 410 in 2010*
- *On average, 10 presentations of white papers and posters are made at conferences each year; reaching 50-100 participants at each meeting*
- *Requests to conduct field-tested, professional development workshops are granted at a rate of approximately 8 new venues annually. Sites are selected based on established criteria such as percentage of underserved, underrepresented educators and students, academic achievement and access to NASA science*
- *Professional development workshops incorporate the latest trends garnered from current educational research*
- *In 2010, the Education branch embraced the latest cost-effective technology by beginning to present NSTA workshops via Webinars*

Although the Education branch receives numerous requests to conduct workshops, selection of the partnering venues is based upon established criteria such as the percentage of underrepresented educators and students, academic achievement and access to NASA science. Typically, as many as eight locations are chosen annually. The Education branch is now reaching beyond the scope of its original plan and conducting several additional workshops each year.

These partnerships are formed on local, regional and national bases to disseminate curriculum support tools, demonstrate how to effectively integrate the most recent scientific discoveries from Hubble into the classroom and support professional development activities. Partners are often selected because of their access to underserved audiences. For example, in 2007 a regional partnership was formed with the Appalachian Regional Commission and a national partnership was established with the Outreach to Space Museum Project OTS. The latter is a National Science Foundation grant to ten museums in six states serving rural and underrepresented audiences in the Midwest in non-traditional venues such as county fairs and festivals.

Offering an even greater reach for the HST program are the partnerships added in 2009 with the American Library Association, ComPADRE Digital Library and netTrekker Program. These partnerships involve the collaboration of both formal and informal science education specialists. Taking full advantage of these partnerships has greatly increased the reach of the program. For example, the Education branch hosted an exhibit booth at the 11th Annual eTech Ohio Conference in Columbus which attracted some 6,000 educators.

Today the Education branch continues to provide education and public outreach support to professional organizations and educational institutions. The number of venues touched by the Education branch in this way has grown from 38 in 2005 to 410 by 2010. The support offered involves providing materials to enhance educators' science content knowledge and pedagogical skills for integrating Hubble science discoveries into the classroom. The Education branch also provides support by participating in program planning committees, writing white papers and conducting poster sessions to share 'lessons learned' with the E/PO community at large. The Education branch estimates that they present an average of 10 white papers and posters per year at local, regional, state-wide and national conferences. They estimate that they reach 50-100 participants at each of these conference meetings.

Most recently, the Education branch has focused its efforts on introducing educators at conferences to the benefits reaped from the 2008 recombining of HST's formal and informal education teams and programs. Specifically, the education community is being made aware of the cross-over products and formal/informal collaborative projects that can simultaneously support educational programming, classroom instruction, exhibits and public events. Conferences, in fact, are perfect venues for drawing educators from both the formal and informal education communities. Embracing such audiences bodes well for opening opportunities to extend the HST program's reach into the informal education community.

The Education branch remains on the forefront of bringing Hubble science to educators and incorporating cutting-edge trends from educational research. To this end, in 2007 the branch conducted workshops for Baltimore City Schools' science teachers that included the latest strategies for aligning with standards and dispelling scientific misconceptions. Other professional development workshops for K-14 educators are designed to demonstrate effective techniques for incorporating inquiry learning into the classroom. They have been field-tested along with the materials for pre- and in-service educators.

More recent efforts to 'keep up with the times' have focused on strategically using the Internet and distance learning technologies to provide science content presentations to both educators and groups of students. For example, an additional accomplishment in 2010 was presenting an NSTA Webinar. This format offers two immediately apparent advantages—1) savings in travel costs for potential users and presenters alike and 2) availability of the presentation, which is archived on the NSTA site, for educators unable to attend the initial conference.

Growth of informal education—The HST program also includes two major components for informal education—1) exhibits and shows, including ViewSpace and 2) informal science education community support. Originally anchored by *ViewSpace*, a self-updating permanent exhibit, the branch's informal education efforts have increased in breadth and depth. This growth is attributable to a proliferation of products and services as well as achieving widespread dissemination.

The evolution of the HST program's informal education component is told here in a continuous flow. However, the reader should be reminded that although formal and informal education efforts began 'under one roof', by 2000 these efforts were re-assigned to two separate branches and in 2008 they were recombined within the Education branch. Regardless, ViewSpace has continued to be the centerpiece of the informal education product line.

ViewSpace was developed in 2000 as a series of PC-based multimedia presentations addressing specific requirements of planetariums and science centers. Playing in a continuous loop in an alcove or lobby of these venues, ViewSpace combined images, text, music and digital movies/animations. Content was derived from Hubble news releases and other archived material. At its inception it was running in over 50 institutions throughout the United States with the institutions providing their own playback system.

Informal Education—ViewSpace

- 2000—ViewSpace was developed as PC-based, multimedia presentations running in over 50 institutions from its inception and is now playing in 44 states
- 2003—ViewSpace first disseminated over the Internet, allowing same-day delivery of Hubble news releases
- 2003—ViewSpace content expanded in partnership with Sun-Earth Connection Forum to include a Spitzer Space Telescope feature; additional content developed with Chandra team
- 2004—Tonight's Sky segment released, providing information on the night sky
- 2005—ViewSpace venues expand to malls when it becomes part of a Jet Propulsion Laboratory exhibit in the Santa Monica Place Mall
- 2005—ViewSpace venues potentially extend to library systems through its introduction at the American Library Association annual convention where potentially 20,000 librarians were introduced to it
- 2006—Partnerships forged to add Earth Science features to ViewSpace as well as special coverage of Hubble anniversaries, SM4 and IYA
- 2010—OPO-Education branch's effort to identify 'active' ViewSpace users from its list of subscribers is in progress

The OPO-Education branch provides annual updates to ViewSpace in the form of modules running 8-12 minutes in length. In 2004, a Tonight's Sky segment was developed providing information about the night sky. It continues to be updated monthly for the latest view. Tonight's Sky is among the ViewSpace content that is available on the Amazing Space Web site, incorporating national standards and related products.

The dissemination of ViewSpace content over the Internet first began in 2003. Internet delivery required the one-time purchase of playback proprietary software developed by Scala. This purchase enabled same-day delivery of short segments based on Hubble news releases. Recognizing the increased costs associated with the start-up of this Internet product, the Education branch sought sponsors for a program to disseminate plasma screens, computers and software to community and school-based planetariums and science centers operating on slim budgets. In this way, underserved and underrepresented venues could take advantage of ViewSpace online.

This same year also marked the expansion of ViewSpace content beyond Hubble science to include a Spitzer Space Telescope feature on the Sun in partnership with the Sun-Earth Connection Forum and to develop content with the Chandra team. Partnerships for presenting expanded content continued as Earth Science features were added in 2006 along with special coverage of events such as the Hubble anniversaries, SM4 and IYA.

By 2005, the variety of venues in which ViewSpace was available expanded to include a shopping mall by becoming part of a Jet Propulsion Laboratory exhibit in the Santa Monica Place Mall. This foray into a non-traditional venue illustrates the broad appeal of ViewSpace and the Education branch's commitment to seeking new opportunities for showcasing Hubble science in the context of astronomy. That same year, libraries were also added to the mix when 20,000 librarians from public, private and university libraries and library systems were introduced to ViewSpace at the American Library Association annual convention in Chicago. ViewSpace was also promoted at the American Association of Museums conference.

Recognizing the potential that ViewSpace showed for moving beyond the traditional venues of museums and science centers, the Education branch conducted a survey in 2008 to identify the remaining markets appropriate for hosting ViewSpace. The results of this survey spawned the plan to turn attention to colleges and universities once the museum/planetarium/science center market is saturated. The most recent evaluation activity, currently in progress, is the coordination of a ViewSpace audience evaluation and subsequent field-test in both formal and informal education settings.

With an eye to better serving venues in which ViewSpace is displayed, the development of a user's guide was initiated this past year, technical support has been made available and a platform upgrade is in the works. The museums, science centers, planetariums and other venues tapping into ViewSpace content, known as subscribers, have grown over the past decade and it is now playing in 44 states throughout the U.S.

Consequently, the Education branch has recently embarked upon an effort to identify 'active' users of the product. In order to be counted among the venues in which ViewSpace is 'active', subscribers will be required to maintain and report viewer statistics and demonstrate that they are fully engaged in using the exhibit.

With ViewSpace again in the purview of the Education branch, making the effort to tighten up the management of contractual arrangements with partner venues is not the only area of concern. NASA is giving greater scrutiny to informal education and wants to ensure that informal education meets strict criteria and is not simply outreach that is already being done. The criteria dictate that informal education must...

- Be standards-based
- Have a docent available to interact with visitors
- Be accompanied by follow-up materials, i.e., educational information

The recombining of formal and informal education efforts has facilitated the necessary steps to ensure that these criteria are being met. So now if someone has purchased ViewSpace, they can augment it with standards-based materials that go with it and have a docent available. In this way, the benefits of combining formal and informal education are evident in the branch's ability to deliver an integrated, multi-dimensional product.

While ViewSpace is the focal exhibit of HST's informal science education efforts, the informal branch has also produced a proliferation of *other exhibits and shows*. These informal education products represent a dramatic expansion of offerings from the early days when planetariums were simply provided with slides and other source materials.

Meeting today's demands of nearly 3,000 planetariums, low cost, high quality 35 mm slides have been distributed through an arrangement with the International Planetarium Society (IPS). By 2004, over 700 different slides had been made available to planetariums through this service. Currently the OPO-Education branch supports the planetarium community by providing digital files for conversion to slides, continuing to distribute this material through the IPS Slide Service. Planetarium educators are now receiving not only Hubble images, but also images from other NASA services such as JPL.

During the past decade, visualizations have been a staple among the source materials produced for informal science education venues. These products have grown in complexity and sophistication to meet the demands of end users. Since 2008, Video Immersive Planetarium Visualizations are in high demand. They have been sent in high definition versions to television networks such as National Geographic and Discovery, in addition to being made available to the digital planetarium community.

By providing visualizations, the OPO-Education branch significantly contributed to the latest STScI IMAX production, 'Hubble 3D', released by Warner Brothers in 2010. More than a quarter of the 41 minute film includes visualizations and involves the creation of 3D models using Hubble data. This was a collaborative effort with IMAX, the National Center for Supercomputing Applications and the Spitzer Science Center. This group also developed and released to the public two additional 3D visualizations of Hubble images.

In 2005, the informal education team went beyond producing slide shows and visualizations. First, they embarked on major exhibit upgrades at the National Air and Space Museum as part of Hubble's 15th anniversary celebration. Upgrades included a photo gallery, new Hubble exhibit graphics, a mural and IMAX film showings. Additionally, they created the Hubble IMAX short film—*Hubble: Galaxies Across Space and Time*—that was distributed across the US and Canada.

In subsequent years, traveling exhibits and exhibit components have been made available throughout the United States to informal education venues such as museums, planetariums and park visitor centers. Exhibit components allow for the customization of exhibits in wide-ranging settings. Educators, developers, interpreters and producers in free choice learning venues can easily find resources suitable for them. These resources include exhibits and shows, source materials and other events and services offered on the HubbleSOURCE Web site at <http://hubblesource.stsci.edu/>. The Web site was created to offer end users quick access to these products and services.

**Informal Education—
Other Exhibits and Shows**

- 2004—Over 700 low-cost, high quality 35mm slides were made available to nearly 3,000 planetariums through an arrangement with the International Planetarium Society. Today IPS slide service continues to distribute digital files to the planetarium community
- Since 2004—The exhibit 'Heavens Above: Photographs of the Universe from the Hubble Space Telescope' has enjoyed bookings in venues serving underserved and underrepresented communities
- By 2005—Major exhibit upgrades completed at the National Air and Space Museum as part of Hubble's 15th anniversary celebration
- 2005—IMAX short film 'Hubble: Galaxies Across Space and Time' distributed in US and Canada
- Since 2008—Video Immersive Planetarium Visualizations used in high definition versions by the National Geographic and Discovery television networks
- Today, traveling exhibits and exhibit components that allow for customization are available in wide-ranging settings throughout the country
- Today, HubbleSOURCE Web site offers end users quick access to exhibits, exhibit components, source materials and other events and services
- 2010—Provided visualizations for the collaborative development of the IMAX production 'Hubble 3D' released by Warner Brothers

Over the past decade, the tale of events and services provided for informal science education settings has been one of ever increasing numbers of exhibits to an even greater variety of users. In 2004, a traveling exhibit—'Heavens Above: Photographs of the Universe from the Hubble Space Telescope'—was organized by the OPO-Informal Education branch and the Midland Center for the Arts in Midland, MI. The low-cost traveling exhibit included a plasma display panel featuring ViewSpace and presented Hubble's breathtaking images of the universe. In that year, the exhibit enjoyed five bookings in MI, NC and TX, venues selected specifically to reach underserved and underrepresented communities.

In addition to developing ViewSpace and other exhibits and shows, the OPO-Education branch offers *informal science education community support* including workshops, Webinars, teleconferences, and community events. In 2009, an integrated approach used for the American Library Association offered professional development workshops in conjunction with a traveling exhibit 'Visions of the Universe: Four Centuries of Discovery'. This approach has expanded to include 55 libraries throughout the country that were selected because they serve rural or urban communities with limited access to NASA resources.

The informal science community is also supported by monthly Hubble science briefings. Offered in collaboration with NASA's Museum Alliance, Hubble science briefings provide informal educators an opportunity to learn about the science and engineering concepts that drive the Hubble mission. Specifically, they are designed to assist informal educators with communicating the latest scientific discoveries to the general public. Seven teleconferences were held in FY10, reaching a total of 304 informal educators and museum professionals.

The Education branch is now averaging attendance at 12 community events per year with 50-200 attending each event, further extending its reach in the informal education community. The branch is frequently invited to support or participate in special community events hosted by museums, science centers, libraries, or other informal venues such as...

- Space Day celebrations
- Museum or planetarium openings
- STEM festivals
- Commemorations of significant milestones

The concept of a 'community event' now embraces the 'online community' as well. Accordingly, the OPO-Education team scientist was featured in a NASA INSPIRE online learning community Web chat. This Web chat reached students from 16 states offering them a demonstration of the wide-ranging talents and skills involved in producing 'Hubble 3D'. Students were excited to learn that STEM careers could involve skills in technology, graphic arts and writing in addition to science.

Informal Education—Community Outreach

- *Since 2008—Frequent invitations received for OPO-branch to provide community support by giving science talks and participating at MD Science Center's Space Day events and science fairs*
- *Since 2009—55 US libraries have received the traveling exhibit 'Visions of the Universe: Four Centuries of Discovery' along with a professional development workshop for informal educators*
- *2010—Hubble science briefings, designed to update informal educators on the science and engineering that drive the Hubble mission, held 7 teleconferences for 304 educators*
- *2010—OPO-Education team scientist featured in online learning community Web chat attended by students from 16 states*
- *2010—Public event called 'Girl Power: Changing the Face of STEM' touched 150 girls of all ages*
- *2010—Now averaging 12 community events per year with an average of 50-200 attendees each*

In 2010, the OPO-Education branch seized the opportunity to host a booth at a public event called 'Girl Power: Changing the Face of STEM' held at the JHU Applied Physics Lab in connection with NASA's Solar System Ambassadors program. This event was open to girls of all ages to explore STEM career pathways in fields like aerospace, computer science, electrical engineering, geology, information technology, and space mission engineering.

In addition, the Education branch hosted question and answer teleconferences with 150 elementary school children attending a space camp hosted by the NASA Solar Systems Ambassador program. Events such as these exemplify the ever-growing reach of the informal science education efforts. In addition, increased participation in, and support of, community events is addressing STScI's mission to better reach and serve local communities.

Like ViewSpace, traveling exhibits/shows as well as informal support services are undergoing a transformation. Again the recombination of formal and informal education efforts is conducive to more integrated products and services. The Education branch is seeking non-traditional venues for disseminating materials as is evident by its foray into libraries. With science centers and museums under increasing financial pressure, libraries that are free to the public provide ever increasing accessibility to underserved, underrepresented communities, one of NASA's central goals.

Evolution of professional development—The story of the evolution of the HST program's professional development efforts provides yet another example of the program's growth and widespread dissemination. It also demonstrates how the shapers of the program respond to the changing needs of the education communities they serve and take advantage of opportunities to partner with organizations that help them ensure cost-effective means for 'getting the word out'. In fact over the last 15 years, the HST program has conducted 148 workshops reaching nearly 6,000 educators.

Table 3 offers a summary of the phases in which HST's professional development program took shape. From its earliest days of creating curriculum support materials, the Education branch quickly realized that educators required assistance in applying Hubble science and using technology and data in the classroom. The HST program's foray into professional development sprang from understanding this need. Professional development efforts continued to evolve and grow in response to the changing needs of the formal education community. Seeking a solution to the ever growing demand for their services, the Education branch responded by initiating and maintaining productive relationships. They have since taken the 'lessons learned' with formal education professional development and applied them to training for informal educators.

Additional Indicators of Program Success

- *Responding to educator needs, the Education branch conducted over the past 15 years 148 professional development workshops with 5,621 attendees*
- *To serve the formal/informal education communities, the Education branch has partnered with organizations to ensure cost effective means of 'getting the word out'*
- *Education branch employs a variety of evaluation strategies for developing sound education products/services*
- *1996--2010—Education branch conducted 44 evaluations*
- *Education branch conducts 68% of its evaluations for the branch itself and 32% for other OPO branches*
- *Education branch's evaluations for its own products/services are 74% formative and 26% summative studies*
- *Since 1998 the Education branch received 21 awards, some of which have been awarded multiple times*
- *85% of the awards received by the Education branch have been for its Amazing Space Web site*
- *47% of the awards received are from online resource directories that are recognizing Amazing Space for its quality science content and pedagogy*
- *HST program also receives large number of invitations to be incorporated into teacher training and national media productions*
- *Educational branch asked to develop and implement an educational workshop for the 2007 historic GSFC visit of the Queen of England*

PROFESSIONAL DEVELOPMENT OVERVIEW: PHASES OF IMPLEMENTATION 1996-2011

Phases/ years	Number of workshops	Number of participants	Highlights
Phase 1— Getting started 1996-1999	22	717	<ul style="list-style-type: none"> • Focus—Professional development for in-service educators with emphasis on beta-testing products and using technology in the classroom • Partners—Maryland State Department of Education and educators attending NSTA, University of Maryland Baltimore County and Johns Hopkins University • Accomplishments—Developed hard-copy support tools for formal education community with help from summer program teachers; created Amazing Space CD for educators with limited Internet access
Phase 2— Changing needs 2000-2002	15	651	<ul style="list-style-type: none"> • Focus—Shifted focus to selecting and using resources; integrating up-to-date science content and Hubble discoveries in the classroom • Partners—Expanded reach to not only local, but also regional and national levels adding Maryland Science Center, GSFC and NASA's Aerospace Educators Program • Accomplishments—Responded to demand for standards-based products addressing core curricular science topics and initiated action plans to meet upcoming legislated needs for interdisciplinary resources to teach science content in reinforcing reading/math skills
Phase 3— A focused approach 2003-2008	73	2,728	<ul style="list-style-type: none"> • Focus—Increased focus and comprehensive approach to establish and sustain long-term partnerships and provide PD for long-term partners to offer pre- and in-service teachers NASA science and expertise to populations with limited access • Partners—Added partners with pre-existing infrastructure to track participant data for measuring impact as well as reaching underserved populations at colleges and universities. Long-term relationships established with additional national and regional programs • Accomplishments—Despite limited staff and resources, responded to teachers' need for science content, training on pedagogical strategies and 'best practices' as well as NASA and STScl diversity initiatives. Crafted strategic partnerships to make this possible
Phase 4— Connecting with informal education community 2009-2011	38	1,525	<ul style="list-style-type: none"> • Focus—Applying 'lessons learned' and strategies from formal education PD program to address needs of informal education community in the wake of the recombining of formal and informal education branches • Partners—Maintain existing formal education partnerships while adding informal education partners such as NASA' Museum Alliance, American Library Association • Accomplishments—Determining the needs of informal education communities' sub-groups—museum professionals, after-school program providers, planetarium educators, etc.—while discovering how to address each sub-groups' unique needs, programs and venues. Began to introduce PD opportunities for informal educators and to experiment with most effective means of dissemination
TOTAL	148	5,621	

TABLE 3. Professional development overview: Phases of implementation 1996-2011.

Product/service evaluation—Part of the story of the HST program's dramatic success lies in its attention to employing a variety of evaluation strategies in developing sound education products/services. In other words, conducting evaluations throughout the development and dissemination process largely ensures that the resultant products/services will be top quality and highly effective.

The OPO-Education branch is responsible for product/program evaluation for the entire Office of Public Outreach. Table 4 indicates that of the 44 evaluation projects conducted by the formal education team from 1996 to 2010, 68% were for the Education branch itself, while 32% were carried out for other branches within the OPO.

OPO-Education Branch Evaluation Projects—1996-2010			
	# of evaluations	% of evaluations for Education branch	% of ALL evaluations
OPO-Education branch evaluations			
• Needs assessments	14	47%	32%
• Formative field-tests/reviews	8	27	18
• Implementation studies	2	6	4
• Impact/outcomes studies	6	20	14
SUBTOTAL	30	100%	68%
Evaluations for other OPO branches			
	# of evaluations	% of evaluations for Other branches	% of ALL evaluations
• Needs assessments	5	36%	11%
• Formative Web site evaluations	2	14	5
• Usability studies	6	43	14
• Impact studies	1	7	2
SUBTOTAL	14	100%	32%
TOTAL	44		100%

TABLE 4. OPO-Education branch evaluation projects—1996-2010.

More pertinent to this investigation, of course, is the Education branch's long history in conducting both formative and summative evaluations for its own formal/informal science education products and services. Sound evaluation tools and techniques have been employed from the earliest days of the branch's work in developing, reviewing, revising, releasing and continually monitoring its products and services. The branch's evaluation efforts fall into four categories—needs assessments, field tests/reviews, implementation studies and impact/outcomes studies. Each of these types of evaluations is described below with illustrations of specific studies the branch has conducted...

Needs assessments—From 1997 to 2009, the Education branch has conducted 14 needs assessments, all but three focusing generally on K-12/14 educators and their instructional needs. 'Big picture' studies sought—

- to identify resources/support materials that educators need for space science instruction and that high school physics teachers need to supplement their teaching
- to understand the role of standards in instruction and what HST could provide to promote standards use
- to explore teachers' understanding of and comfort level with inquiry-based instruction
- to determine the role of interdisciplinary materials in space science
- to target students' misconceptions in science (K-14)
- to identify teachers' professional development needs
- to understand teachers' familiarity with using data in the classroom

Several needs assessments focused exclusively on what teachers need to support their use of Amazing Space. Finally, three studies on specific topics and involving select audiences sought to understand what information scientist/educator collaborators need in developing educational materials, what resources local educators need to meet the requirements of the MD school assessment science achievement test and what services are required to support the informal science community. Surveys and interviews were the predominant methods in attempting to answer these questions.

Formative field tests/reviews—The Education branch conducted all eight of these formative studies during a cluster of years from 2002 to 2006. Four of the studies focused on solar system classification activities and were designed to see how educators and students receive and react to these classification systems. Additionally, the studies probed to understand if this type of system could be used with informal education communities. Two other investigations field-tested 'Telescopes from the Ground Up' with pre-service educators and 5th graders to determine the appropriateness of the materials with each audience. Finally, two of these studies involved formative reviews of HubbleSite by gathering information to determine the feasibility of using image processing materials for educational purposes and the practicality of using the HST model in relation to technology education standards.

Implementation studies—Two implementation studies in 2006 and 2009 sought to better understand effective implementation of both formal and informal education products. One addressed the implementation of a career education program for youth and the effectiveness of collaborations in this endeavor. The second involved how ViewSpace is being implemented at various venues and its impact on the informal education community.

Impact/outcomes studies—From 1996 to 2010, the Education branch also conducted six impact/outcomes studies. One focusing on the effectiveness of Amazing Space has been ongoing throughout this entire time period. Another was an outcome study conducted by the external consultant company McREL that focused on how online, interactive lessons and materials enhance student learning of key science concepts. Through the five remaining impact studies, the Education branch has sought to understand—

- how HST materials were being used/disseminated through the ERCs
- how formal and informal communities alike used HST materials for the 2003 Astronomy Day event
- how effective was ViewSpace in its many informal science venues
- the impact of Hubble's 15th anniversary promotional materials for the online exploration, 'Telescopes from the Ground Up'
- how effective were the products/services developed for 2009's International Year of Astronomy

These five evaluations relied predominately on telephone interviews and surveys, mailed surveys and Internet searches.

Awards and recognition—Another indicator of the HST program's success is the esteem with which it is held by the communities it serves. The program has a strong history not only of having its products and services in high demand, but also of being recognized with a variety of awards including the prestigious Scientific American Award received for the Amazing Space Web site and the MUSE Award recognizing ViewSpace's outstanding achievements.

In order to understand how the program has been recognized, the Education branch supplied Cornerstone with a list of awards they received for Amazing Space which we supplemented with information found in annual delivery plans and on the Internet. The branch has received a total of 21 awards since 1998, some of which have been awarded multiple times. For the purpose of our analysis, we counted these awards only once. The Amazing Space Web site has garnered 85% of the awards, with 10% for ViewSpace/Skywatch and 5% recognizing an Education branch team member's contribution to the IMAX Hubble 3D film team.

Tables 5 and 6 summarize the types of organizations bestowing the awards and the qualities of the products and services that the awards lauded. A full 47% of the organizations bestowing the awards were online resource directories seeking Web content that provides quality resources for educators as well as engaging science activities for children and homeschoolers. We also found that most of the organizations making awards lauded the Education branch's products for excellence in science content and pedagogy.

OPO-EDUCATION AWARDS: ORGANIZATIONS MAKING AWARD—1998-2010		
Category of organization	# of awards N=21	% of type of organization. N=21
• Online resource directories for educators— <i>content suitable for children, homeschoolers</i>	10	47%
• Professional/trade organizations	4	19
• Media— <i>online publications, radio programs</i>	3	14
• Museums/planetariums	2	10
• Specialists in space markets for job hunters	1	5
• Network facilitating educators' use of Internet and emerging technologies	1	5
TOTAL	21	100%

TABLE 5. OPO-Education awards: Organizations making award—1996-2010.

OPO-EDUCATION AWARDS: QUALITIES CITED BY AWARD—1998-2010		
Qualities	# of awards N=21	% of quality cited N=21
• Science content— <i>completeness, accessibility, contributions</i>	8	38%
• Pedagogy	7	33
• Usability of Web site— <i>navigation, functionality, design, technology</i>	5	24
• Overall excellence— <i>top quality, caliber of work</i>	3	14
• Suitable content— <i>K-12 students, families, public</i>	3	14
• Engagement— <i>interactive activities</i>	3	14
• Resource— <i>outstanding Web resource, valuable to teachers</i>	3	14
• Homework help feature	1	5

TABLE 6. OPO-Education awards: Qualities cited by award—1996-2010.

Awards are not the only means by which the efforts of the Education branch are recognized. Through the years, additional accolades have taken the form of...

- Amazing Space Web site integrated into teacher training venues for the State of Ohio, citing it for 'best practices' in teaching for middle and high school educators
- Staff members invited to contribute to industry-wide efforts to bring Hubble science to the public
- Education branch asked to develop and implement an educational workshop for the 2007 historic GSFC visit of the Queen of England
- Education branch invited to present workshops on topics for which their expertise is respected such as 'best practices' and 'lessons learned'
- Amazing Space support materials incorporated into national releases such as the 2005 release of "Zathura: A Space Adventure" motion picture and Bill Nye's 'Greatest Discoveries' DVD
- Education branch invited to present at the Digital Signage Expo to share best practices in reaching users of signage software in innovative ways

2.2.2—Managing for Success

While the story of the HST program's success is evident in its growth and widespread dissemination over the past decade, understanding how the program has achieved such an impact lies in its management—how it is monitored, how it meets its objectives and how its objectives align with the goals of its governing bodies.

Evaluation methods—This section focuses on the success of the HST program in achieving its goals and objectives. Finding evidence for this success was a result of our comprehensive document review offering information about the goals and objectives for the Education branch's three oversight organizations—STScI, GSFC and NASA SMD.

This review included annual fiscal year delivery plans prepared for GSFC for FY00 through FY11 and STScI's 2002 five-year strategic plan. Additionally, to demonstrate the success of the HST program in meeting NASA's expectations, we referenced SMD's E/PO program factors that serve as a standard for the qualities that NASA SMD expects from the programs it funds. Moreover, we relied on select quarterly reports that the Education branch compiled for NASA from 2004 to 2010. Our method for the systematic review of the HST program's success in meeting its goals and objectives for all three 'masters' involved the following steps...

- Create Excel spreadsheet to organize the HST program's planned and completed deliverables by year and by product/service line
- Tabulate the number of deliverables actually completed by year in both formal and informal education
- Evaluate and summarize actual performance vs. plan submitted to GSFC
- Select ways in which the HST program demonstrates the guiding principles of STScI and NASA SMD E/PO evaluation factors
- Present data and select demonstrations of alignment with goals and objectives
- Incorporate from interviews additional findings that had not become evident in the document review

Overall monitoring process—The work of the Office of Public Outreach is overseen by NASA SMD, GSFC and STScI, all of which are either a part of or contractually bound to NASA. It is no surprise, therefore, that as OPO develops its strategic plans and annually prepares its more detailed plans that NASA's goals play a significant role in guiding these efforts.

The work of the OPO-Education branch is closely monitored through a variety of reporting mechanisms occurring both quarterly and annually and addressing the requirements of each oversight institution. The Education branch's achievements are catalogued in an annual report required by GSFC and quarterly reports submitted to NASA SMD. All reporting initially passes through the Directorate of STScI to ensure that its goals and objectives are being met as well.

Meeting objectives: Annual reports to GSFC—Reporting to GSFC provides comprehensive planning and control documentation. In particular, the annual fiscal year delivery plan documents the activities planned for each upcoming fiscal year. The fiscal year review, a companion piece, documents the accomplishments of the prior fiscal year using that year’s plan as the yardstick by which those milestones are measured. By setting forth its deliverables in the plan and reporting on the extent to which those deliverables have been achieved, the OPO-Education branch is documenting its accountability to GSFC and demonstrating its achievement of the branch’s objectives.

A sample summary table compiled for the Education branch and included in the ‘fiscal year review’ is provided in Table 7. This sample, pertaining to the accomplishments of the OPO-Education branch, was created by excerpting entries from the review for FY09. It illustrates each type of status for OPO-Education branch deliverables—see the legend.

SAMPLE—STATUS OF PROJECT/SERVICES FOR A FISCAL YEAR REVIEW		
Project/Service	Status	Additional Information
CURRICULUM SUPPORT TOOL DEVELOPMENT		
Hubble Classroom Updates		
Hubble Classroom Update posted to the Amazing Space Web site (2)	●	11 additional Updates were produced and posted
Star Witness News hardcopy edition	○	Delayed due to timing of EROs
Early Release Observations (ERO) Education Projects		
Star Witness News hardcopy edition	●	
Tonight’s Sky	●	
ERO Release Programming	⊕	
FORMAL EDUCATION COMMUNITY SUPPORT		
Education Partnerships	●	
Educational Support	●	
Professional Development for Educators		
NASA’s Pre-service Educator Workshop	✘	NASA cancelled the workshop
NEAT Workshop	⊕	

TABLE 7. Sample—Status of projects/services for a fiscal year review.

LEGEND: ● - Completed ○ - In Progress ⊕ - Additional Projects ✘ - Not Completed

Summary tables created annually offer management the opportunity to quickly review actual performance vs. planned deliverables, i.e., whether the deliverables have been met, exceeded, not met or in progress. It also provides information about accomplishments added to the original, annual plan. Additional projects could potentially replace planned deliverables or parts of deliverables that may not be completed and therefore become ‘substitute’ deliverables. They may also represent the branch’s achievement in reaching beyond their original plan to take advantage of serendipitous opportunities. These summaries also log delays and cancellations.

A longitudinal examination of the status of deliverables over the past five years clearly reveals the success of the OPO-Education branch in doing its job. The annual plan and accompanying plan reviews prepared for GSFC from 2006 through 2010 provide the most comprehensive listings available of deliverables for the upcoming year and their status once the year concludes. The chart below presents an annual accounting of the number of deliverables, both planned and unplanned, that the OPO-Education branch sought to accomplish and the percentage of deliverables actually met.

OPO-EDUCATION BRANCH COMPLETED DELIVERABLES—FY06-FY10					
	FY06	FY07	FY08	FY09	FY10
# of planned and unplanned goals and deliverables	22	35	37	60	56
% completed	91%	94%	95%	93%	93%

TABLE 8. OPO-Education branch completed deliverables—FY06 –FY10.

Over this five-year period, the Education branch accomplished an average of 93% of its deliverables. A deliverable was counted as being ‘accomplished’ if it was designated as ‘completed’ on the summary table. A ‘completed’ deliverable with multiple parts, such as preparing monthly (N=12) updates, was counted as only one ‘completed’ deliverable. It should be noted that deliverables frequently involve multiple iterations of an effort, such as preparing four educational posters or the science education material for monthly updates to a Web site feature such as Tonight’s Sky. Consequently, tasks completed may exceed the actual number of deliverables.

The document review revealed that factors external to the Education branch typically caused the delays or cancellations leading to deliverables being abandoned (not complete) or remaining ‘in progress’ at the end of the fiscal year. Plan reviews completed by the Education branch indicate that these external factors often included delays in missions, event cancellations by sponsors/partners or the substitution of special event materials for planned updates.

The data on Table 8 not only demonstrate the Education branch’s success in completing a high percentage of the tasks they set out to accomplish, but also provide further evidence of the growth in the program’s offerings. In the first two years after the formal and informal education branches were recombined (FY09 and FY10), the number of deliverables increased by more than 50% over 2008.

Figure 1 provides a graphic representation of the number of planned and unplanned (additional projects) deliverables for formal and informal education over the last five fiscal years. It further illustrates the growth in the HST program as follows...

- The total number of deliverables undertaken over the past five years has nearly doubled for formal education and more than quadrupled for informal education
- Formal education has realized more growth among planned deliverables, while still modestly increasing its ‘additional projects’
- Informal education has undertaken more ‘additional projects’ in the last two years than in the prior three years before being recombined with formal education

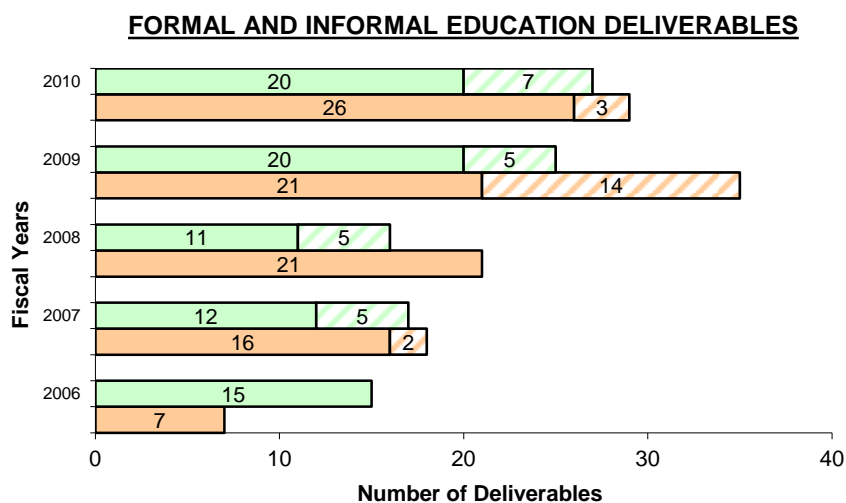


Figure 1. Formal and informal education deliverables.

Legend

Green Solid—Formal planned deliverables

Green Stripes—Formal unplanned deliverables

Tan Solid—Informal planned deliverables

Tan Stripes—Informal unplanned deliverables

In the midst of our evaluation, the plan for FY11 was completed and became available for review. We found that the total number planned deliverables for FY11 was 31—19 for formal and 12 for informal education. The number of planned formal deliverables is in line with the number of formal deliverables for FY09 and FY10. The number of planned informal deliverables for FY11 represents a significant reduction over the prior years in which 21 and 26 planned deliverables were counted for FY09 and FY10, respectively. The change reflects the following...

- Informal education deliverables are being grouped in a more compact way
- More integrated approach of formal and informal education as result of recombining
- Increased demands of five other 'big' projects now being undertaken by the Education branch

Alignment of goals: STScI's strategic plan and SMD's goals—It is not sufficient, however, to be satisfied that the Education branch is meeting its objectives and ensuring its accountability to GSFC. It is equally necessary to provide assurance that these objectives are in alignment with the goals of STScI and NASA, on whose behalf the Institute undertakes the Hubble mission.

As stated in STScI's five-year strategic plan developed in 2002, the overarching goals for the Education branch are twofold—1) facilitating the development of formal education resources linked to national standards and 2) increasing the effectiveness with which astronomy is communicated to public audiences in informal settings. The Institute is in the process of updating its strategic plan as it moves through the waning of the Hubble mission and embarks upon the James Webb Telescope mission.

In its strategic plan, the Institute has set forth its guiding philosophies and values. While specific short- and long-range objectives may change as strategic plans are updated, the philosophies and values provide the foundation for all the Institute's undertakings. Each year as objectives are developed for the delivery plan, the Institute's guiding principles are at the forefront of all the Education branch sets out to accomplish. Before the Education branch's plan and accompanying review are delivered to GSFC management, they are passed through the Institute Directorate to ensure that the planned goals are in accordance with the Institute's guiding philosophies and values. Table 9 below illustrates the Education branch's success in adhering to the Institute's philosophies and values. While not meant to be an exhaustive list, these examples illustrate ways that the HST Education Program is guided by what the Institute values.

HST PROGRAM ALIGNMENT WITH STScI's MISSION	
Guiding Philosophies And Values	Demonstrated In HST Program
Focusing on the needs of those we serve	<ul style="list-style-type: none"> • Conducts needs assessments • Surveys ViewSpace audiences
Sharing our knowledge and skills with the widest possible community	<ul style="list-style-type: none"> • Professional development workshops • Educational tools developed to meet national science teaching standards disseminated into all 50 states and on the Amazing Space Web site • ViewSpace and other informal science education products placed throughout the nation's museums, planetariums and science centers
Developing partnerships to reach a larger audience	<ul style="list-style-type: none"> • Numerous partnerships and collaborations initiated and nurtured for both formal and informal education products and services
Applying innovative methods and technologies to enhance communication	<ul style="list-style-type: none"> • Internet, social media and Webinars
Placing Hubble and its successors' science results within their larger astronomical contexts	<ul style="list-style-type: none"> • Exhibits, shows and curriculum support tools incorporating Hubble science are regularly updated to present new science in context with products such as Tonight's Sky • Created show to introduce the upcoming JWST project for ViewSpace

Table 9. HST program alignment with STScI's philosophies.

The Education branch has also been skillful in creating goals and objectives that align with NASA's major goals. In 2006, NASA's Education Coordinating Committee published 'NASA Education, Strategic Coordination Framework: A Portfolio Approach' in which it called for the continuation of NASA's three major goals—1) strengthening NASA and the nation's future workforce, 2) attracting and retaining students in STEM disciplines and 3) engaging Americans in NASA's mission.

Exemplifying these overarching goals, NASA SMD evaluates the programs it funds in accordance with four critical elements—their intrinsic merit, relevance to NASA objectives, cost and program balance factors such as diversity and STEM pipeline. The SMD provides guidance about the meaning of these four elements in the form of 'subfactors' that serve to clarify 'what NASA is looking for. In the remainder of this section, we offer examples of how the Education branch adheres to these critical elements, thus illustrating how these factors provide a framework for the branch to build successful programs.

Intrinsic merit

Quality, scope, realism and appropriateness—The HST program exemplifies **realism** in a variety of ways, specifically by its adherence to realistic goals set forth by NASA and its proximity to Hubble scientists. HST's annual delivery plans clearly state the objectives for both its formal and informal education components. These objectives flow from the goals of NASA SMD and STScI. There are clear lines of responsibility to GSFC, who manages the Institute's work on behalf of NASA, to NASA SMD and within the Institute as demonstrated by management reporting. Inasmuch as STScI handles all of the science operations for the Hubble Space Telescope, the Education branch is in a unique position to benefit from the expertise of the scientists who are on-site. The Education branch has the potential to work closely with Hubble scientists in developing educational tools and materials based on Hubble science.

Products and services developed by HST are **appropriate** to the needs and interests of their target audiences—formal and informal science educators, astronomers and the public. Members of these audiences are involved in product/services testing and evaluation through needs assessments, beta-testing and consumer surveys. Furthermore, these audiences indicate their appreciation of the **quality** of HST's products/services by their continual patronage.

The Education branch has demonstrated that the **scope** of their efforts is realistic inasmuch as they are accomplishing an annual average of 93% of their deliverables; typically thwarted in their endeavors only by external factors outside their control. They have consistently shown that they are able to plan their annual work scope and to work that plan.

Continuity—With HST products/services such as ViewSpace, there is great potential that the spark of curiosity initiated by Hubble images can draw widespread audiences from many NASA missions. Formal and informal science educators have an innate **interest** in Hubble-related science and in sharing it with students and the public. The excitement created by Hubble's beautiful images offers the HST program a powerful 'hook' for **engaging** large and diverse audiences.

Partnerships/sustainability—The Education branch has been successful in building and maintaining **partnerships** locally, regionally and nationally. Formal and informal professional development workshops serve as vehicles for **sustaining** the teaching of Hubble science currently and into the future.

Evaluation—The Education branch has a long history of using sound **evaluation techniques** in the development, field-testing and impact evaluation of its products and services. Moreover, metrics collected are now ready for inclusion in the new NASA system, OEPM.

Relevance to NASA objectives

Customer needs focus—Needs assessments are regularly conducted to inform the Education branch about products and services needed in both the formal and informal science education communities that the branch serves. **Customer needs** are also addressed by beta-testing formal education products with teachers in their classrooms.

Content—Hubble's science **content** is the centerpiece of all the Education branch's efforts to involve students, teachers and the public in NASA STEM. The Education branch involves mission scientists not only in the development of its products/services, but also in their delivery, such as Hubble science briefings designed to assist informal educators with communicating the latest scientific discoveries to the general public. Audiences of all ages and levels of understanding are touched by Hubble science—be it with tools for educators on the Amazing Space Web site, products directed to students or exhibits and multimedia shows presented to the general public.

Cost

Resource utilization—STScI's matrix organization, along with a strong team approach, contributes to the Education branch's effective **resource utilization**. The talents of STScI's staff members are tapped as needed to complete tasks without regard to reporting lines. This ensures that the 'best person for the job' contributes to a common goal. Another resource saver approach used by the Education team involves capitalizing on products created by other OPO branches. In this way, the Education team does not need to 'reinvent the wheel' to develop its formal and informal educational materials. Moreover, establishing and nourishing partnerships and relationships with outside organizations such as museums, schools, universities and libraries ensures that the Education branch's products and services can be disseminated in a wide variety of venues in a cost-effective manner.

Program balance factors

Pipeline and diversity—The Education branch has continually strived to reach **diverse populations** with Hubble-based science products and services designed to excite and engage students and therefore increase their potential for moving toward STEM-based courses and careers. The **pipeline** begins with engaging students of all ages through a variety of products that feature Hubble imagery. These products are often disseminated to rural communities' planetariums, science centers and museums as well as in other underserved/underrepresented venues. For example, ViewSpace exposes the general public not only to Hubble science but also to the science of other NASA missions. Care is also taken to engage students in elementary and middle school through the Amazing Space Web site with features such as Star Witness News. Additionally, the HST program offers educational tools and products to students through high school and into post-secondary education. Undergraduate students have participated in summer research programs to further encourage their participation in STEM careers.

In its efforts to ensure that it reaches **diverse audiences**, the Education branch has targeted not only underserved/underrepresented groups but also has developed products, such as Tactile Astronomy, that serve those who may not otherwise be able to access Hubble science. Participation in events such as 'Girl Power: Changing the Face of STEM', open to girls of all ages for the exploration of STEM career pathways, also demonstrates the Education branch's commitment to promote STEM careers to populations underrepresented in science.

2.3—Program Strategies and Teamwork

So far we have concentrated our attention on documenting the growth and dissemination over the past decade of the OPO-Education branch's formal and informal education programs. And in so doing, we have been able to demonstrate the impact and value of the branch's work. In this section, we turn our attention toward the ways in which the OPO-Education team goes about doing this work that ensures the success of the branch's programs. We attempt here to provide evidence of the soundness of the strategies the team uses to select the products/services it works on, the 'best practices' it relies on in developing these selected products/services and the effectiveness of their teamwork approach.

Relying on extensive, unstructured telephone interviews, we sought information about program strategies and teamwork from select members of the Education branch and their collaborative colleagues in other OPO branches. The ‘big’ ideas emerging from these conversations are...

- The Education branch is guided by established criteria for selecting products/services on which it chooses to work
- ‘Best practices’ and current educational research are used in developing these products/services
- The OPO-Education branch works effectively as a team by...
 - Sharing a common culture and establishing productive partnerships which contribute to a highly functioning, effective team
 - Planning, coordinating, employing feedback mechanisms and adapting to change that keep the team focused and productive
 - Using ‘lessons learned’ to effect change

The story of how the Education team works is told in two sections: 2.3.1—**setting the stage** that describes the team’s composition and the environment in which it works and 2.3.2—**seven traits of a highly effective team** that lays out strategies the team uses to create and deliver products and services.

Evaluation methods—To understand how the Education branch excels and has such a profound impact in the E/PO community, we turned to team members in the best positions to reveal how they do their work and how the team functions. More than six hours of interviews were conducted with the team’s leader and select team members—both from the Education branch itself and from other OPO branches. The duration of each interview was approximately 45 minutes, except for the team leader with whom we conducted a series of three interviews lasting anywhere from 60 to 90 minutes each.

Once all interviews were completed, the data were content analyzed in order to identify emerging themes. Then the emergent themes were organized to relay the story of the composition of the team, the way the members interact within their environment and the strategies they use to select and develop the branch’s products and services.

2.3.1—Setting the Stage

Putting our findings in context, we first ‘set the stage’ by describing the Education branch team’s composition and the environment in which it selects, develops, evaluates and delivers its products and services. The team is led by an Education manager, who is also one of OPO’s two deputy directors. In addition to overseeing the team’s work, she has responsibilities for program evaluation, grant administration and project management. The remaining five members of the team also ‘wear many hats’. Table 10 summarizes their roles and responsibilities. Their primary roles as content specialists of either formal or informal education projects are indicated in red. Their ancillary roles, appearing in the right-hand column, represent areas of core competencies which they contribute to projects being carried out across the Education branch.

“Each one on the team has become responsible for being the ‘go-to’ person about something...it may be more than one thing, but there is something we are responsible for being on top of.”—Education branch team member

EDUCATION BRANCH TEAM’S ROLES AND RESPONSIBILITIES		
Team member	Primary role	Ancillary roles
#1	Elementary education content specialist	<ul style="list-style-type: none"> ▪ State standards expert ▪ Professional development content creator
#2	Middle school education content specialist	<ul style="list-style-type: none"> ▪ Impact data manager ▪ Workshop specialist
#3	High school education content specialist	<ul style="list-style-type: none"> ▪ Education product developer ▪ Chronicler of project milestones/target dates
#4	Informal education specialist	<ul style="list-style-type: none"> ▪ Implements hands-on demonstrations ▪ STEM career workshop presenter
#5	Exhibits and distribution coordinator	<ul style="list-style-type: none"> ▪ Matrixed to STScl exhibits 35% of her time ▪ Coordinates booths and exhibits
Matrixed to education team		
Scientist		Shared with other branches
Graphic Artist		Dedicated to Education branch
Science Content Writer		Called upon for education writing projects
Computer Expert		Called upon for Web projects
Animator		Called upon for animations

Table 10. Education branch team’s roles and responsibilities.

Also shown in Table 10 are staff members from other OPO branches who are called on an ‘as needed basis’ to work with the Education branch. Resources outside the branch are tapped in order to provide special expertise. Those who are ‘matrixed’ to the Education branch bring their unique talents and perspectives to the branch’s projects. In this way, all members of one of the Education branch’s project teams have an opportunity to learn from one another as they come from ‘different worlds.’

Moreover, the product development process is facilitated when these ‘outside’ experts are familiar with ‘best practices’ for presenting K-14 science content both in text and graphics. Consequently, having a graphic artist and Web programmer dedicated to the Education branch helps to streamline this process. However, it is also critically important that these ‘matrixed’ workers also maintain involvement with members of their own creative teams, for example other graphic artists and programmers, in order to nurture their talents in their own specialty areas.

The environment in which the Education branch operates is characterized not only by being part of a matrix organization, but also by being accountable to multiple funding sources and oversight organizations. The Education branch delivers the HST program in addition to five other major projects. These projects include—1) **JWST** James Webb Space Telescope, the mission for Hubble’s successor, the ‘next generation’ telescope, scheduled to launch later this decade, 2) **VAO** Virtual Astronomical Observatory, an NSF-funded project which will require the addition of a half-time person, 3) **SEPOF** Science Education and Public Outreach Forums, participation in support of NASA SMD Astrophysics Division, 4) **ComPadre’s Astronomy Center**, a NSF-funded project in partnership with AAS and AAPT and 5) **EOS** NASA Earth Space Observation Network grant to integrate Earth science content into the ViewSpace network, impacting informal education in particular with an increase of two to six Earth science shows.

A common thread running throughout our interviews was that the greatest challenges faced by the team are those arising outside the team itself. Their concerns were the following...

- Having multiple ‘masters’ periodically creates conflicts that must be managed and overcome
- Drawing personnel from other branches outside the Education team may result in those staff members being pulled from the team to work on other projects
- Organizational culture differences among various OPO teams can present challenges when communication and common planning tools are not shared across teams
- Issues arise from circumstances outside the control of the Education team—e.g., NASA canceling an event during which an HST program workshop was scheduled to be given
- STScl partners may not live up to their responsibilities—e.g., the non-active users of ViewSpace

The remainder of this section focuses on methods and strategies the Education team has developed to meet and overcome the challenges presented by its environment both within and outside the Education branch. We have organized these findings as the ‘seven traits of a highly effective team’.

2.3.2—Seven Traits of A Highly Effective Team

Our document review revealed that the Education branch consistently produces high quality and effective products and services as demonstrated by the HST program’s impact, the awards and recognition it receives and its ability to achieve its goals. How the Education team is able to perform at such a high level is evidenced by the traits its members exhibit.

Trait 1: Nurture shared culture—Interviews revealed that the Education branch’s staff members share a culture that propels them forward toward functioning as an effective team. In Tables 11 and 12 we describe this culture with regard to—1) characteristics of the team members that they view as contributing to their success and 2) actions that are taken to ensure that team members have a nurturing environment in which to work. Supporting these characteristics and actions nurtures the Education team and thus contributes to the continued success of HST products/services.

The *characteristics* emerging from interviews drive home the point that the Education branch members are not only ‘on the same page’ with respect to understanding goals and objectives that they are charged with attaining, but also share the same philosophical underpinnings that support their efforts. Also of note is that four of the six branch members share backgrounds as educators. One team member stated that being former teachers, the education specialists “have had real world experience in the classroom.” She attributes the team members’ positive attitudes and flexibility to their classroom experiences, adding that “when you are in the classroom you have to be ready for anything, go with the flow and what the students hand you.”

SHARED CULTURE—CHARACTERISTICS OF SUCCESSFUL TEAM MEMBERS	
Characteristics	How exemplified
Shared educational philosophy	All three education specialists are former teachers
Competence	Solid educational/professional background in primary and ancillary responsibilities, bringing unique skill sets to each project
Flexibility	Able to adapt to loss/reassignment of resources and changing priorities
Positive attitude	Positive, ready for anything, go with the flow attitude
Awareness of environment	Know goals and expectations; all on same page
Introspection	Reflect on performance—think about what they do, how they do it and how to improve it
Shared interest in science	All team members are interested in science and in ensuring that they are ‘getting the science right’

Table 11. Shared culture—Characteristics of successful team members.

The interviews also revealed a variety of *actions* that were taken to ensure that team members enjoyed a nurturing environment/culture in which to succeed. Table 12 presents the actions taken by the team’s leader and its members that contribute to maintaining their shared culture. The actions cited paint a picture of team members who not only share characteristics contributing to their success in being ‘on the same page’, but also take measures to ensure that they stay ‘in sync’. Team members are collaborative, communicate well and use tools to ensure that they monitor projects to ‘stay on track.’

The team leader creates an environment, a nurturing culture, which allows team members to take actions that contribute to their success. Interviews clearly indicated that team members take responsibility for their own performance as they participate in multiple project teams. According to the team leader, the following are the most critical actions for ensuring that a team is positioned for success...

- **Knowing your staff**—maximizing the use of team members' strengths and skill sets
- **Creating an effective environment**—basing scheduling on individual needs, while at the same time ensuring 'all day' coverage
- **Providing appropriate tools to do the job**—ensuring access to up-to-date technology and training
- **Partnering to ensure excellence**—having team members check one another's work, relying on input from OPO branch scientists for 'fact checking', i.e., ensuring access to 'experts' to make certain that the science is 'right'

SHARED CULTURE—ACTIONS TAKEN TO ENSURE NURTURING ENVIRONMENT	
Actions	How exemplified
Allocate resources for maximization of coverage	Team leader is aware of team members' needs and schedules accordingly to maintain coverage and adjusts to vagaries inherent in matrix organizational structure
Partner within team to ensure science is 'right'	Team members offer their particular area of expertise to ensure science as well as pedagogy are right
Pursue professional education opportunities annually	Team members keep up-to-date by taking advantage of professional development opportunities in evaluation, AAAS standards alignment and other training to maintain skill sets
Collaborate to fill in competency gaps	Rely on 'experts' within team to fill in competency gaps
Communicate	Maintain both formal and informal channels of communication through meetings, telecommunications and written plans/checklists; promptly convey changes that may impact others
Hold meetings with purpose	Meetings held include project, production, daily—tag-ups, ad hoc, crisis and annual planning
Monitor performance, paying close attention to detail	Employ checklists, check each other's work with a 'fresh eye' and different perspective
Look out for interest of end users as well as 'multiple masters'	Always cognizant of the needs of the end user, particularly empathic to educators, conduct needs assessments to ensure the 'right' products and services are developed and delivered

Table 12. Shared culture—Actions taken to ensure nurturing environment.

Trait 2: Employ established criteria to make product/service selection—Interviews revealed a second trait that the Education branch employs to assure its success, that is, using established guidelines to select the products and services on which it works. Underpinning these selection guidelines/criteria are the goals/objectives of the branch's 'three masters'—NASA SMD, GSFC and STScI. An equally important consideration in selecting what products/services to work on is the type of science the Hubble telescope offers, for example, not all Hubble science is appropriate at an elementary level. Consequently, products and services to be developed must be geared to the most appropriate grade levels.

Selecting potential products and services for development is guided by a process requiring the team to ask and answer the following questions...

- What work is being funded?
- Does a potential project raise the profile of STScI?
- What are the benefits to all entities in selecting a particular partner, the partner's potential impact on the community and the partner's ability to collect data?
- What are the results of a needs assessment designed to test perceived benefits?
- What is currently available in a particular product/service area? What is not being offered for which the Education branch can fill a need/gap?

“Currently we are looking at two options for developing new products/services...a new partner for professional development who would bring data to the table, measure impact and assist us in doing evaluations...or work on a strong science content piece without the evaluation benefits and we'd need to work really hard to do the dissemination. As a group and using our guidelines, we'd probably go with the former.”—Education branch team leader

Since recombining the formal and informal education efforts, a modified version of the selection process is underway specifically for informal education. In this case, the guidelines are not for developing new products/services, but rather for taking a second look at existing products/services such as ViewSpace. The charge is to improve the product/service and its dissemination. This process involves...

- Looking at the product 'as is' to determine how it might be improved and to discover less costly means of delivery for both the end user and STScI
- Ask what planetariums, small science centers and museums may need that the HST program is not producing and conduct research to uncover unmet needs in informal education
- Ask what else is needed in informal education in addition to ViewSpace

The Education branch is frequently approached to consider potential projects outside their annual plans. The branch has developed an approach or guidelines for dealing with these requests. The team puts together a 'decision package' that documents all information and data supporting their final decision. This strategy is particularly helpful when the team must deny a request. It serves as an effective means for informing those who are denied about the true value of their proposals, while at the same time increases their awareness of the Education branch's limited resources and mandates from other funding sources. The downside in creating decision packages for each requester is that this process is time-consuming and can divert the team from its primary goals.

Trait 3: Research and use 'best practices' in developing products/services—For more than 15 years, the Education branch has been researching and implementing 'best practices' in both pedagogy and professional development. The team leader reports that the first two years were spent strictly in researching 'best practices' in order to build a foundation on which to begin developing the branch's products and services. It is this initial, careful work that contributes to the ongoing quality and success of all that the Education branch undertakes.

This body of 'best practices' has served as the guiding light for creating products and services that are on the cutting-edge of what is happening in professional development, educational standards, curriculum support, etc. This body of 'best practices' is continually updated. Moreover, the products and services that are developed from these practices are themselves tested through a series of evaluations, revisions and implementations. Table 13 summarizes how the branch has selected 'best practices' for guiding its work and how products and services incorporating these practices are then rigorously examined.

STRATEGY FOR SELECTING AND USING 'BEST PRACTICES'	
Selecting 'best practices'	Questions asked/Actions taken
Conduct research	1—Literature review 2—Expert experience—tap resources of others... <ul style="list-style-type: none"> • <i>What do scientists know about 'best practices'?</i> • <i>What is going on in other sciences—e.g., environmental science, a pioneer?</i> • <i>How are the astronomy community/professional organizations training educators?</i> • <i>What do professional development trainers know about 'best practices'?</i>
Incorporating 'best practices' into products/services	Actions taken
Conduct evaluations	1—Needs assessments 2—Formative evaluations <ul style="list-style-type: none"> • <i>Alpha- and beta-testing of products</i> • <i>Test what is learned at professional organizations</i> • <i>Conduct pilot/demonstration projects—e.g., Amazing Space Web site (1996)</i>
Revise product/service	Make revisions based on what is learned through pilot projects
Implement product/service	Partner with those who can assist with delivery of professional development programs

Table 13. Strategy for selecting and using 'best practices.'

As part of this evaluation, our staff asked the Education branch to share any documentation exhibiting the types of research and resources in 'best practices' that they use to develop products and services. They gave us a list of 274 sources/references on a variety of 'best practices' including dispelling misconceptions, inquiry-based learning, project-based learning, needs assessments and professional development. These sources included research articles, reviews of research, seminar presentations, Web sites and articles and lists of resources and books. The complete lists are available from the Education branch. In Table 14, we have summarized the areas of 'best practices' that the Education branch researched as well as number of sources they examined for each.

The team leader and members alike report that the competence and expertise of the team ensures that 'best practices' are implemented and kept 'up-to-date'. They also indicated that they are continuously reviewing educational research literature to learn about the latest thinking so they are certain to remain on the 'cutting edge'.

NUMBER OF REFERENCES CITED IN 'BEST PRACTICES' EXAMINATION	
Best practices	Number of references
Dispelling misconceptions	25
Inquiry-based learning	88
Project-based learning	49
Needs assessment	25
Professional development	
<ul style="list-style-type: none"> • <i>Designing professional development for science and mathematics teachers (Louck-Horlsley PD model featured)</i> 	75
<ul style="list-style-type: none"> • <i>Needs of K-12 teachers (needs assessments for PD)</i> 	12

Table 14. Number of references cited in 'best practices' examination.

Trait 4: Establish partnership between scientist and educator—A fourth trait of the Education branch that shapes the success of its work is the partnership forged between scientist and educator. This partnership is the key to the branch's success in developing educational products and services that reflect accurate scientific and pedagogical content.

The skill sets of the scientist and those of the educator complement each another. While the educator is 'tuned in' to the understanding of science that is appropriate by grade level, the scientist ensures that the 'science is right'. Early in the history of the HST program, there were no educators on board. This resulted in teachers failing to make effective use of the Amazing Space Web site offerings, because they didn't understand the science or how they could make it understandable to their students. Introduction of the education specialists into the product development process resulted in products and services that teachers were able and eager to use.

"The thing we stand on is always having the educator/scientist partnership—always. This is the thing we pride ourselves on...how we can effectively use a scientist and an educator together. So we've developed a strategy for developing programs and products to ensure accuracy, both for the pedagogy and the science."—Education branch team leader

The OPO maintains a staff of astronomers who are available to work with all of its branches. One of the astronomers, however, is the only scientist who is matrixed to the Education branch in addition to serving other branches within OPO. According to him, the Education branch is "the one place where the scientist matters". He went on to explain that not every scientist can work with the Education branch because they must fit the following criteria...

- Be 'tuned in' to the background of the students to whom they are directing the science
- Understand the context in which science is presented to students
- Know what teachers need—that teachers are constrained by state standards and curriculum
- Know how science is used in the classroom

The scientist has gained this perspective by having partnered with the Education branch for more than a decade. He noted that one of the nicest things about working with the Education team is having the scientist work with the educator—“it really feels like a partnership.” In most other cases, he explained that he is only called in on an ‘as needed’ basis and a true partnership is never established.

The choice of a scientist who works with the Education branch is so critical to the process that sharing the scientist with other branches can present challenges for the team. If the science for a project must be checked and the scientist is unavailable, the team members have a ‘work-around’ until he is. Work on that particular project, consequently, must come to a temporary standstill, potentially delaying its completion.

As we conclude this evaluation, we have learned that a new team member has been hired—a scientist who is positioned as a science content specialist reporting directly to the Education branch. This action undoubtedly will lead to changes in the ways the team works together. In particular, it will reduce the number of times that the team must wait for a scientist to check content, thus minimizing delays in finishing projects. The OPO scientist who is currently matrixed to the team will continue to support the branch’s efforts.

Trait 5: Form effective partnerships outside the team—In addition to the critical partnership established between scientist and educator, we have previously noted that team members partner with one another within the Education branch by contributing their unique expertise to projects and verifying the work of their peers.

Over and above the partnerships forged among the Education branch’s team members, however, partnering outside the branch is a key ingredient in successfully delivering the branch’s educational products and services. The team partners with OPO employees in other branches in order to bring skilled resources in graphics, technology and science writing to the team’s work. Moreover, the team partners with organizations outside STScl, primarily in the delivery of products and services.

Partnering among the OPO branches brings both advantages and disadvantages. Most notable are those presented in Table 15. Pulling resources from all OPO branches is a cost-effective learning opportunity, but can lead to interrupted work and problems with combining disparate work cultures. Nevertheless, over the years the advantages of partnering across all OPO branches has far outweighed the disadvantages. The Education team itself has developed successful strategies for working around the disadvantages in order to meet its goals and objectives.

PARNTERNING AMONG OPO BRANCHES		
Topics	Advantages	Disadvantages
Shared resources	Cost effective —each branch avoids maintaining its own specialized staff	Interrupted work —can be pulled from project to meet competing obligations
Multi-disciplinary teams	Learning opportunity —learn about respective disciplines from each other; bring different perspectives together	Disparate organizational cultures —due to varying work cultures, team members from different branches may not all have the same level of communication and project monitoring skills; this may lead to difficulties in carrying out projects

Table 15. Partnering among OPO branches.

Partnering with external institutions and organizations also plays a critical role in the dissemination of products. As previously mentioned, the Education branch prefers its potential partners to have specific qualities. The Education branch seeks to engage partners who have existing distribution channels and the ability to collect data. Moreover, the branch selects partners that enhance the profile of projects and those that promise to have an impact on the community. With regard to partners involved in professional development activities/projects, the branch consistently seeks collaborators who can orchestrate a ‘train-the-trainer’ model in order to maximize program impact and dissemination. Employing such a model enables a small staff to eventually reach a greater number of teachers.

“We look for partnerships so the Education branch does not have to recruit participants...we look for ready-made audiences, i.e., where educators are already gathered. Plus, we really like when partners keep data over time.”—Education branch team leader

Trait 6: Plan and coordinate the work of the team—Another important aspect of the Education branch that promotes its success is the way in which the team’s work is orchestrated. Expert planning and coordination of the workload lead to the team’s overall success in reaching goals/objectives and turning out high quality, award-winning products/services. This is no easy task in an environment where team members are responsible not only for myriad deliverables for the HST program, but also for playing an integral part in the outcomes of five additional, major projects—JWST, VAO, SEPOF, Astronomy Center and EOS, all of which are described at more length on page 27.

Interviews revealed that the team leader and staff draw upon their strong team culture to provide appropriate strategies/techniques for managing the workload. As members of multiple teams responsible for completing projects, the staff of the Education branch is highly skilled at communicating and monitoring work flow. Additionally, the staff is kept informed and ‘on top of’ changes in projects through various types of meetings that are held for specific purposes and through the maintenance of checklists.

The team leader also pointed out that having team members who are knowledgeable and ‘up-to-speed’ on projects also ensures the uninterrupted continuation of these projects even when strategic human resources are occasionally diverted. According to the team leader, if gaps are created by losing someone to another piece of work, sound practices such as the following ensure that the project ‘stays on track’...

- Checklists to ensure that nothing is missed
- Frequent meetings held to discuss project objectives and approach
- Flexibility in moving people around as circumstances change

The team leader also cautioned that all of the OPO branches need to function under similar planning and coordination guidelines. In this way the staff shared among these branches can experience optimal structure, consistency and clarity in their working environment. In the course of our investigation, interviewees mentioned that a lack of systemization across OPO branches and faulty communication paths lead to potential work-related difficulties. The team leader added that, as an organization, the OPO branches acknowledge the need for better communication and have made a long-term commitment to resolving the problems.

“If another branch’s team does not make checklists and doesn’t have a strong process...this becomes a weak link. All other branches need to be tight, because we share the same staff.”—Education branch team leader

Trait 7: Use ‘lessons learned’ to effect change—The final trait of a highly effective team that emerged from our interviews is the team’s ability to use ‘lessons learned’ to make positive changes in the way it does business. The long history of the HST program affords the Education branch an opportunity to reflect upon its evolution, in particular, the mistakes that have been made along the way and the productive ways in which these problems have been rectified. In fact, the Education branch has compiled a document highlighting the most crucial ‘lessons learned’ and the ways these lessons have been used to effect change. In our interviews with the team leader we requested that she revisit this topic, asking her to point out those ‘lessons learned’ that she deemed most important in shaping the HST program as it is today. These are summarized in Table 16...

DETAILED SUMMARY OF ‘LESSONS LEARNED’	
Lessons Learned	Details
Give educators what they need	Take steps to discover what is missing in educators’ arsenal of teaching tools... <ul style="list-style-type: none"> • <i>Do needs assessment to confirm that proposed product/service ‘fills in the gaps’</i> • <i>Give teachers professional development that goes with classroom materials produced</i>
Employ educators to work with education community	Educators bring the following qualities... <ul style="list-style-type: none"> • <i>Know classroom environment first-hand</i> • <i>Understand grade level capabilities</i> • <i>Know state standards and curriculum needs</i>
Work with scientists effectively	Take steps to ensure a successful collaboration with scientists for creating education products of value to education community... <ul style="list-style-type: none"> • <i>Learn scientists’ language</i> • <i>Understand scientists’ perspective</i> • <i>Share the education perspective</i> • <i>Educate scientists about the expectations of the education community</i>
Fix mistakes immediately	Take steps to unearth what goes wrong and fix it immediately... <ul style="list-style-type: none"> • <i>Hold meetings to figure out what went well and what did not</i> • <i>Investigate problems found—team member assigned to task</i> • <i>Figure out how to fix problems</i> • <i>Determine what is needed to fix problem and marshal needed resources</i> • <i>Test, test and retest the solution</i> • <i>Take preventive measures to keep the problem from occurring again</i>
Keep the program focused in the face of distractions	Plan, organize and adapt to overcome distractions that may include... <ul style="list-style-type: none"> • <i>Mandates from multiple funding sources</i> • <i>Involvement with other competing projects</i> • <i>Project resources diverted to other OPO branches</i>

Table 16. Detailed summary of ‘lessons learned’.

Reflecting on the early days of the HST program, the team leader noted that at that time there were no educators involved in developing products and services. The program was solely in the hands of scientists. She went on to explain that for this reason, no science background materials were included on the Amazing Space Web site because it was assumed that users did not require such information. As a result, the Web site content was not being used in these early days by teachers.

Subsequently, educators were hired to work with scientists in creating HST's educational products and services. The educator/scientist partnership thus formed yielded program improvements and produced a more teacher-friendly Web site. Currently on the Amazing Space Web site there is a Science Q & A for every product that is based on research conducted with teachers to uncover common questions they have. For each product, a complete package is put together focusing on the needs of the education community. These products are used easily and widely by classroom teachers.

Keeping an ear to the ground, the Education branch learned that teachers wanted to know even more information than what was available online; giving rise to professional development offerings. These workshops filled the needs of teachers seeking more guidance in both pedagogy and science. Subsequently, the branch conducted needs assessments that confirmed areas in which teachers' needs were not being met and revealed potential products/services that they would value. The program has continued to evolve by uncovering and addressing teachers' needs.

The interviews also revealed that early 'hands-on' activities designed solely by scientists were not always student-friendly. Sometimes they proved to be unsafe for young children or the science was 'over their heads'. Again, infusing educators into the work team helped bridge the gap between scientist and education community. Having first-hand and practical classroom knowledge/experience, these newly-hired education specialists were well-positioned to ensure that products/services being developed would be aligned with the needs of students and the education community at large.

The Education branch works hard to keep focused on its priorities—to meet its commitments to GSFC by accomplishing milestones set in its annual plans. Among 'lessons learned', the Education branch has developed flexible strategies for overcoming barriers, while at the same time never losing sight of its priorities. The branch's planning and organizational skills have enabled it to keep focused on the HST program despite periodic derailments.

The Education branch continues to learn from its mistakes, making crucial changes to improve the quality and effectiveness of its products/services. The branch uses these 'lessons learned' in a formative feedback loop—identifying potential challenges, adopting strategies that get to the source of these challenges, correcting them and instituting measures to prevent repeating them in the future. The team doesn't stop there, however. It passes along to others these 'lesson learned'. In fact, the Education branch has assisted NASA SMD in examining critical issues and has been asked by NASA to present workshops on 'best practices' for addressing these issues in delivering education and public outreach.

PART 3—A LOOK TO THE FUTURE

Cornerstone Evaluation Associates has undertaken this evaluation in order to uncover evidence of the HST program's effectiveness and to understand how the OPO-Education branch works in order to accomplish its success. Through comprehensive document review and interviews, the evaluation has revealed the following broad-brush findings...

- Over the past decade, the OPO-Education branch has made stellar progress in developing and disseminating formal and informal educational products and services
- The Education branch's products/services have proven to be high quality, audience-friendly and effective—having wide-ranging impact on the educational community
- The Education branch itself has exhibited great skill in faithfully meeting its goals and objectives
- The Education team presents itself as being a group of 'like-minded' colleagues who collaborate, partner and manage their limited time and resources well in order to achieve results
- OPO staff who are matrixed to the Education team have indicated that working with the team has been a true partnership from which they have benefited greatly

"Our productivity level points to success. When you look at the amount of work taken on by very few people, I think it's because of the way we function together that we're able to manage to meet every deadline despite the challenges encountered...because we all know enough about one another's work to pitch in where needed."—Education branch team leader

In its inimitable fashion, the Education branch is not resting on its laurels. The team is once again looking toward the future and asking itself 'how might we achieve even more and do a better job?' Interviews suggest that the team's vision for what comes next includes two areas they seek to improve—strengthen the matrix infrastructure and solicit ideas for new dissemination strategies for products/services.

Strengthening Matrix Infrastructure—Improve communications by giving all OPO team members a better sense of the 'big picture'...

- Hold quarterly OPO 'all hands' meetings—*each branch shares where it is and where it is going ensuring, for example, that OPO is made aware of guiding principles for both formal and informal education*
- Complete the latest strategic plan and make it widely available—*share benchmarks to ensure all OPO staff are 'on the same page'*
- Ensure that there is a mechanism in place to promptly share with all branches any changes in plans and personnel
- Share with all branches of OPO the 'best practices' for managing projects—*widespread use of checklists and other management tools to assist teams in functioning seamlessly*
- Encourage team members to be introspective—*ask 'how can I change to initiate communications if I feel I'm not being kept 'in the loop', informed?'*

Strengthening Matrix Infrastructure—Reinforce matrix culture across OPO

- After initial orientation, provide ‘refresher’ training to reinforce ideas of matrix culture and responsibilities

Disseminating Products/Services—Solicit ideas for new dissemination strategies for products/services.

- Consider the possibility of building in time for product and program maintenance. Products and programs need to be updated to reflect new science and discoveries. Otherwise, it becomes challenging to maintain a production schedule unless time for updates is included and accounted for in program planning.
- Explore new and effective ways to disseminate products by changing technology—*e.g., use a versatile video format to replace Scala software*
- Solicit OPO branch members for their ideas and ‘pet projects’ that may lead to the development of more integrated products—*e.g., using visualizations with products built around them*
- To reduce internal interruptions, establish and ‘advertise’ a specific time/process to consider ‘unplanned’ proposals—*much like a proposal submission process, perhaps requiring those submitting to do research*

This evaluation has provided compelling evidence for the effective way in which the Education branch functions as a team in order to turn out high quality products and services that have a resounding impact on the educational community. The branch has even set forth ‘best practices’ for addressing problems that may be encountered in delivering education and public outreach.

By working OPO-wide to understand the ‘big picture’ and integrate ‘best practices’ in teamwork, the entire OPO staff will prosper, resulting in a highly functioning organization with increased productivity. It is also hoped that such a fertile environment will spawn myriad creative ideas for product and service dissemination.

The teamwork traits, ‘best practices’ and creative dissemination plans that have served the Education branch so well can be re-shaped and adapted organization-wide through a process of open dialogue. By integrating these effective strategies/techniques, the Office of Public Outreach will be in the best possible position to embark on the growing demands of future projects including Hubble’s successor, JWST.