On-Line Resources for Classroom Use: data and science results from NASA's Hubble Space Telescope and other missions

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The data, scientific results, and expertise from NASA's Hubble Space Telescope (HST) and other NASA Missions are being integrated into programs that support innovative and experimental methods to improve content in science and math education. Partnerships with science museums, teachers, other educators, community colleges, universities and other key organizations integrate unique and cutting edge science data and the associated satellite technology into resources which have the potential to enhance science, math and technical learning. The inspiring nature of astronomical data and the technology associated with the HST and other missions can be used by teachers to engage students in many inventive activities. The resources created through collaborative teaming will be discussed, as well as the process for creating partnerships to benefit the education community. Many NASA supported programs encourage electronic access and distribution of multi-media interactive activities and curriculum support materials distributed across the Internet. Space Telescope Science Institute (STScI), in particular, is endeavoring to make the science results announced through the news media and through public information channels particularly relevant to a broad audience, including through resources for pre-college classrooms and informal science centers.

1. Introduction

1.1. *Background: NASA Involvement*

The science divisions within NASA have a specific charter to provide unique and often new technology instrumentation in orbit for the purpose of conducting top rank science research in the Earth, Space, Planetary and Astrophysical Sciences. The expense of commissioning useful orbiting observatories necessitates that excellent research be efficiently accomplished with the facilities. Therefore, by and large, NASA mission support concentrates on optimal planning and scheduling of telescope use, efficient data acquisition, rapid delivery of data to science researchers, appropriate analysis software, and robust archival services. At the same time, it is realized that public awareness of the purpose and results of NASA missions is frightfully incomplete, and in addition, the collective perception of the return on the investment in NASA is vague. The Office of Space Science (OSS) along with several other divisions in NASA are struggling to initiate and support programs and strategies to improve return on the dollar to the public, and the strategies proposed have notable, but hopefully not debilitating, impact on science research.

It is keenly realized that NASA should not and could not redirect the *majority* of its effort towards education, outreach, and public understanding of science. Therefore, the educational resources being created through several NASA funded programs are dominated by strategic partnerships and cooperatives making leveraged use of NASA funded expertise and resources, without taking on systemic reform of the entire educational system - the latter task is best left to other agencies. The NASA programs for education often emphasize innovation, new approaches, experimentation, and electronic access to digital materials.

1.2. *Strategic Partnerships*

The strategic partnerships being established by NASA missions should be guided by the principle that mission scientists, engineers and staff must bring to the table unique expertise and experiences along with knowledge and capability to access NASA data, tools, information and related resources. Mission personnel must develop a healthy respect for and understanding of the expertise of educators, informal science (museum) personnel, and other individuals in order for collaborations to be successful . In addition, it is an important goal that NASA missions, which will be shorter lived and less well funded than those in the past, feed products and resources into self- sustaining infrastructure and existing systems which have a charter to disseminate information to the public. Strategic partnerships are built on the insight that access to NASA mission resources is dynamic and that interaction with specific researchers and technical staff, financial support and enthusiasm can dwindle. The HST STScI, for example, has partnerships with informal science education centers (science museums), planetaria, various teacher organizations and community efforts in addition to its fairly good relationship with the press and media, but these connections must be continually infused with new energy, expertise, and enthusiasm to reinforce firm trust between collaborators.

1.3. *Electronic Access and Innovation*

It is no secret that the scientific and technical community has totally integrated electronic access into its functional structure, with the business community shortly to follow. In contrast, in spite of the pressure to obtain electronic connectivity, the public hunger for access to commodities such as posters, slides, lithographs, prints, and mission paraphernalia reaches almost unbelievable proportions, especially with regard to some of the exquisite HST data. However, as users become more technically literate and capable, electronic access to images, graphics, animation and software services is recognized as more affordable and acceptable. In recognition of this, many NASA education/outreach programs must emphasize innovation and experimentation using electronic means to catch the eye and retain the interest of the future target audience. These programs also accentuate prototyping and testing without the obligation (or funding) to scale, replicate or expand specific projects into systemic initiatives, as for example, the IDEA program†. A feasible strategy is to offer highly modular resources that are reasonably de-coupled from the distribution interface – this encourages reuse and longevity.

2. Resources Available

2.1. *Example 1: Hubble Space Telescope Integrated Releases*

http://www.stsci.edu/

The Office of Public Outreach (OPO) at STScI is charged with disseminating information regarding the Hubble Space Telescope to the public. Our response to this directive is to showcase scientific results and technological advancements (brought forward by principal investigators) through high visibility public information releases. The process requires an understanding and delicate treatment of the various, often fickle, clientele (media, journalists, funding agencies, scientists, engineers). Releases demand a resource intensive, "immediate"investment which results in a variety of modular products, such as images, text, animation, graphics, video and audio clips, that have the potential to be used in venues beyond the short lived news, journal articles and electronic communiqus. OPOs new scheme is to integrate the transient process into a longer term integrated production cycle that should result in resources suitable for education, informal science, and "life-long learning"applications. Integrated packages are aligned along themes and topics and serve a fairly broad audience.

The integration initially involves intensive work with the principal investigators (scientist or engineer) and their colleagues to map out the type of information, data, other products and key points contained in a specific scientific or technical release. Image processing, animation, graphics, video, interviews and textual material are co-authored by a team that has a mix of expertise in graphics, animation, writing, video, instructional design, informal science and education. Rarely is the science result initially delivered in a form that can be used verbatim for

† Initiative to Develop Education in Astronomy: http://www.stsci.edu/idea.html

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public release‡ , and therefore usually must be reconfigured before it is considered comprehensible. ***This situation is symptomatic in projects that do not include representatives of the target audience in the creation process.***

The "educational resources"are created over a longer investment period than required for the initial release. Some materials are fairly simple, but more complex resources, including those available on the Web are created by teams of teachers, scientists, technical staff, informal science experts and production staff. These richer resources are created in the specific context of a classroom activity, a series of lesson modules or a self-guided application. Once the activity is threaded together, the modular pieces are regenerated in a fairly generic form (if possible), and offered independently for use in other contexts. Generally, OPO has not placed emphasis on the creation of stand- alone custom software, but rather, of modules accessible over the Internet through Web browsers†.

An example of a release package which is the headliner topic for several resources and modules is the Hubble Deep Field, observed with HST during 10 contiguous days in December 1995. The data was released from the STScI Archive immediately after calibration, with no proprietary data rights reserved. Teachers and their teams have been designing activities to use HDF for math and science classes, including exercises to classify, measure and count galaxies, test various counting methods, record journals of projects, collect data from other students around the Web, form theories regarding galaxy types, write and present reports, and conduct further inquiry into both historical records on the understanding of the nature of galaxies as well as current research on the HDF.

Other packages in progress or planned are based on themes such as Technology of HST, Technology of Satellites, Servicing HST, Origin of Planetary Systems, Lifetimes of Stars, to name a few. The kinds of resources should include interactive models of satellites, interactive evolutionary sequences of stars, Web based "games", planning and scheduling various satellite related activities, etc. Some of these resources will be directly related to the Smithsonian Traveling Exhibit showcasing HST, so that teachers will have a suite of activities available for classroom use before and after a visit to the exhibit at their regional museum. One additional program, which also supported the "Passport to Knowledge"*Live from Hubble*, program, provides students with an opportunity to collaborate collectively and under the guidance of an advocate scientist, to specify and analyze observations collected during a few HST orbits dedicated to educational use. Numerous other programs are supported by OPO also, but *Integrated Releases* form the core of the OPO/STScI resource creation.

2.2. *Example 2: Remote Sensing Public Access Center (RSPAC)*

http://rspac.ivv.nasa.gov/

Numerous other educational initiatives fill out the ensemble of programs sustained by NASA. One of them, created to enable *Public Use of Remote Sensing Data* (RSD) was initiated to explore methods for Earth Science and Space Science to become useful specifically over the Internet, to the general public, commercial ventures and the education community. This program, initiated under NASAs Information Infrastructure Technology and Applications (IITA) component of the US Federal High Performance Computing and Communications (HPCC) program, was expanded through separate funding to bring Aeronautic content to the classroom.

‡ There are impressive exceptions to this rule however, where scientists or engineers have made a real effort to make modular encapsulations of their science results and tools.

† However, some resources may require special capabilities in the browser such as Java, RealAudio and other products for full impact of the material. Resources also must be only loosely coupled to the interface to prepare for migration to newer information technology interfaces.

Hubble Deep Field (HDF) Products and Resources

Initial Release	Images —Wide view, high res, colors Text – Image Captions Discovery, major result – counts, cosmology, implications for galaxy formation, morphologies General Background – Context of the HDF program, research being conducted, methods of analysis Video/Audio – Science Team Interviews, Zoom in sequences
Resources-modular	Digital products as above, Slides, Lithographs, Prints
Educational Activities/ Resources	Math – Galaxy Counting: collect results from around the Web; Proportions, area, volumes; Geometric calculations Math, Research Methods – Galaxy morphology, galaxy color Astronomy – Nature of Galaxies, Galaxy Trading Cards with facts, Links to other information Poster – Working poster with educational manual

The RSPAC was commissioned to create access methods for all varieties of NASA data, and also to coordinate the projects specifically funded under the RSD program. The center creates a forum for exchange of information on problems and best practices from the projects, and offers other services such as software testing and porting resource evaluation and coordination of efforts to defend funding. RSPAC provides one of the entries to the projects including:

• *Windows to the Universe – University of Michigan (PI: Roberta Johnson)*: Rich array of Earth and Space science resources for museums, libraries, and student research, Emphasis on historical and cultural ties between science, exploration, and human experience, Multi-level threads for beginner, intermediate and advanced users, Encapsulated self-guided modules.

• *Weathernet 4,- - WRC-TV, Washington D.C.(PI: Dave Jones)*:RSD and state-of-the-art visualization in daily weather reports: Tornadoes, Lightning strikes, weather trends, What is the weather predicted for the Olympiad? etc., Collection of data from school weather stations, Dissemination to 214 other TV stations.

• *The Public Connection – Rice University (PI: P. Reiff)*: Digital museum publicly accessible through four interactive displays of real-time earth and space science data at the Houston Museum of Natural Science (HMNS), Touch screen kiosks, auto-download to schools and other institutions.

• *Science Information Infrastructure - University of California Berkeley (PI: C. Christian - UCB & STScI)*: Described below.

• *Virtually Hawaii – University of Hawaii (PI: Peter Mouginis-Mark)*: Real-time imagery of Hawaii for daily TV weather tourists, residents and students (K-12 and community colleges), Space Shuttle photography, Imaging radar data from SIR-C/X-SAR experiments, NASA aircraft data (visible, thermal and microwave), Aircraft data from private-sector partner.

• *Classroom of the Future – Exploring the Environment - Wheeling Jesuit College, West Virginia (PI: Robert Myers)*: Problem-based course modules for high shool teaching of environmental earth science, Summer in-service teacher instruction.

2.3. *Example 3: The Science Information Infrastructure (SII)*

http://www.cea.berkeley.edu/~edsci/SII/

The SII was created to serve as a demonstration project in response to a specific need for a stable, coordinated framework and infrastructure for dissemination of educational and informal science resources, especially those from NASA, across the US. In the SII model, informal science education centers (i.e., science museums and planetaria) form the pylons for the infrastructure. Science museums in the US are institutions which serve as nodes for informal science exploration, exhibition of technology but also contribute significantly to the professional development of teachers. One of the key success criteria for brokering science information to the education community is the element of trust and credibility. With explicit regard to education, science and math teachers know that the curriculum support, scientific expertise and resources and knowledge concerning educational standards can often be found at science museums. Remarkably, this effective venue for interacting with educators has not been given much general attention by the NASA community, although there are particular examples to the contrary. More detail on the SII is presented elsewhere at this conference.

2.4. *Summary*

NASA researchers are participating in numerous projects aimed at delivering research results, information, materials and technology to a wide audience. Several coordinated programs supported by the Office of Space Science and the Aeronautics Division of NASA are producing innovative resources for education accessible from the Internet. These efforts are characterized by strategic partnerships that involve educators and science museum personnel to be effective. In addition, the Education Division at NASA and individual missions are producing additional products and materials for educational use.