Abstract. The NASA Science Mission Directorate (SMD) Astrophysics Education and Public Outreach (EPO) community and Forum work together to capitalize on the cutting-edge discoveries of NASA Astrophysics missions to enhance Science, Technology, Engineering, and Math (STEM) instruction. In 2010, the Astrophysics EPO community identified online professional development for classroom educators and multi-wavelength resources as a common interest and priority for collaborative efforts. The result is NASA’s Multiwavelength Universe, a 2–3 week online professional development experience for classroom educators. The course uses a mix of synchronous sessions (live WebEx teleconferences) and asynchronous activities (readings and activities that educators complete on their own on the Moodle, and moderated by course facilitators). The NASA SMD Astrophysics EPO community has proven expertise in providing both professional development and resources to K–12 Educators. These mission- and grant-based EPO programs are uniquely poised to foster collaboration between scientists with content expertise and educators with pedagogy expertise. We present examples of how the NASA Astrophysics EPO community and Forum engage the K–12 education community in these ways, including associated metrics and evaluation findings.

1. Introduction

In 2009, NASA’s Science Mission Directorate (SMD) awarded cooperative agreements for the creation of four Science Education and Public Outreach Forums (SE/POFs), one for each of its science divisions. The charge of the SE/POFs was to work with and across their respective Division EPO communities to increase the collaboration, coordination, and coherence of the SMD Education and Public Outreach (EPO) effort, which uses NASA scientists, educators, facilities, and science results to uniquely contribute to the improvement of STEM education and ultimately the STEM workforce in the U.S.

In keeping with these objectives, the SMD Astrophysics SE/POF, among its many initiatives, has worked closely with its community of mission and program EPO professionals to coordinate and collaborate on the development of NASA-based resources for use in STEM Instruction. This poster is part of a series that documents the current and
multifaceted collaborative work of the SMD astrophysics community by describing an online professional development course for middle and high school educators.\textsuperscript{1}

2. Reinforcing the Methodology

The SMD Astrophysics Forum and community employ education best practices in a feedback loop to achieve meaningful outcomes. Evidence-based approaches are used to leverage resources and expertise to create impactful efforts. We then share what works—which feeds back into the evidence-based approaches that inform the next generation of effective programs and projects.

Community engagement through shared resources uses this reinforcement approach, in turn furthering our shared goal of enhancing STEM instruction, as outlined in the narrative that follows.

3. Evidence-Based Approaches

3.1. Understanding Audience Needs

Identifying the needs of the audience we strive to serve is foremost in using NASA assets to create targeted educational resources that are implicitly useful and useable. The Forums identify the needs of education audiences and how to support them by:

- Organizing working groups to engage these audiences, develop and confirm a knowledge base, and develop strategies for creating initiatives.
- Conducting audience surveys to determine needs.
- Reviewing literature to corroborate, confirm, and enlighten the effort.

The course addressed audience needs determined by the forum-led K–12 working group by providing course materials rich in NASA science and data. The NASA’s Multiwavelength Universe Course responds to audience needs and provides resources K–12 educators have indicated they find most useful including:

- NASA lessons and activities.
- NASA videos and visualization.
- NASA website based information/activities.
- Authentic NASA data.
- Professional development experiences that teach science content and model hands-on activities.
- Having a NASA scientist present his/her data and research (74%).

\textsuperscript{1}The course format and resources along with the archived video of archived sessions can be viewed here: http://universe.sonoma.edu/cosmo/.
• Sharing PD experiences with peers who teach in a similar grade (71%).

The course was piloted by a collaborative group of SMD EPO professionals and the results of the pilot were used to refine the course for subsequent sessions.

All course materials passed NASA Product Review, conducted by an independent team of scientists and educators.

3.2. Using Best Practices

3.2.1. Misconceptions Research

Throughout the course, the participants are engaged in discussions concerning student misconceptions. Research in instructional strategies shows that students of teachers who accurately predict the most common misconception held by their students are more likely to reject that conception and embrace the scientifically correct response (Sadler 2013). During the course the teachers are introduced to researched tools to measure conceptual shifts as a result of a program. These tools are also used with the teacher participants themselves as evaluation tools for the course. These tools are linked to:

• K–12 physical science and earth science content.
• K–8 life science content in the NRC National Science Education Standards.
• Research literature documenting misconceptions concerning science concepts.

3.2.2. Understanding By Design

The community members who designed the course used the course design techniques described in Understanding by Design. The course objectives were refined through the pilot course.

Course participants will be able to:

• Use astronomical examples (phenomena, images, spectra) to describe the nature of light and color in terms of regions of the electromagnetic spectrum.
• Explain why NASA uses a variety of telescopes and space-based instruments to make observations of the universe.
• Identify several specific NASA science and educational resources and how they are relevant to their own goals for student learning.
• Identify common student misconceptions about the nature of light and color; and ways that NASA resources/astronomical examples can help in addressing these misconceptions.

4. Leveraging Resources and Expertise

Creating NASA’s Multiwavelength Universe online professional development course engages both NASA SMD EPO community members and Educators in leveraging resources and expertise. The community members learn from each other and the participants through exploring distance-learning technologies, gaining experience with long-distance multi-institutional collaborations, learning more about each other’s EPO materials and expertise, and extending the reach of existing resources. Educators participating in the course learn from each other and the EPO community members through
experiencing a unified selection of NASA content and materials that support classroom goals, exploring misconceptions and gaining access to science and education experts.

5. Sharing What Works

The Forums facilitate connections both within the SMD EPO community and beyond to the K–12 educator community. These collaborations strengthen partnerships, build best practices, and enhance coherence for NASA SMD-funded EPO missions and programs.

Among the specific ways in which the Forums accomplish this are to post references and information for the SMD EPO community workspace online for ready access and encourage online thread discussions. Forums also sponsor Meetings of Opportunity and workshops at professional conferences of societies such as the AAS and AGU to bring together scientists, educators, and EPO professionals to discuss needs, share and review their work, identify best practices, and forge connections. The NASA’s Multiwavelength Universe Course was developed through these sessions and other online collaborative meetings facilitated by the forums. In addition, results from this project are shared back to these stakeholders through conference presentations and publications, such as this one, at internal meetings and through online postings.²

5.1. Metrics and Outcomes

Teachers participating in the course took pre- and post-content surveys that they later learned how to administer and use with their own students as diagnostic tools and to evaluate their own teaching. In both iterations of the course, participants demonstrated an increase in scores from pre to post.

Table 1. Participant Pre-/Post- Survey Scores by Year

<table>
<thead>
<tr>
<th>Year</th>
<th>Pre-Score Average</th>
<th>Post Score Average</th>
</tr>
</thead>
<tbody>
<tr>
<td>2012</td>
<td>79%</td>
<td>95%</td>
</tr>
<tr>
<td>2011</td>
<td>83%</td>
<td>94%</td>
</tr>
</tbody>
</table>

In addition, teachers self report that they learned and intend to use the course materials in their professional practice.

5.2. Participant Comments

Participants provided a wealth of feedback for the course both in evaluations and during a synchronous session towards the end of the course. A few selected comments appear below:

I plan to introduce the Electromagnetic Spectrum, allow them time to explore the NASA website³ and amazing-space, and I will use the activities in

²http://universe.sonoma.edu/cosmo/.
³http://www.nasa.gov
the GEMS book to teach the Electromagnetic Spectrum so that students get a better understanding on how light travels with high interest activities. I also plan to continue to use MOSART for misconceptions.

I feel more comfortable and confident talking about EMS to my students now. I can bring great examples and do more hands-on with my students. I know that some of the students will be excited, for example, to get images from the telescopes in space and edit them to get images. I think that on the long run, some of my students might think of getting a job at NASA.

6. Mission-Based, Science-Driven

The Forums facilitate easy access to the resources developed by the SMD EPO community. SMD EPO is embedded within each mission, allowing scientists and educators to efficiently develop products that deliver mission science to the higher education community—and in doing so, enhance the STEM experience of students taught by the instructors who use these products.

Through the means described—by using evidence-based approaches, leveraging resources and expertise, and sharing what works—we can encourage ongoing refinements to continually improve science education using NASA mission-based, science-driven content and experience.

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Figure 1. Teacher Self-Report Data on Understanding of Course and Intent to Use
the University of Chicago EPO group, the Wilkinson Microwave Anisotropy Probe (WMAP), the Kepler Mission, the University of Texas-Austin, and the Spitzer Space Telescope/IPAC.

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References