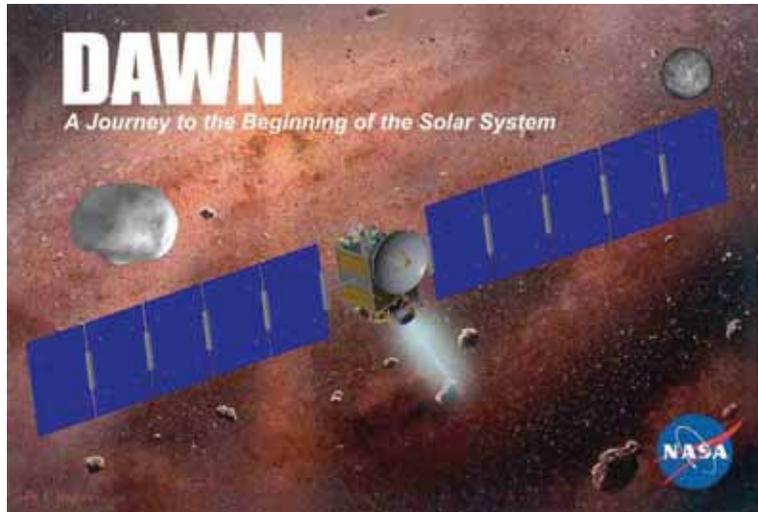


**DAWN MISSION EDUCATION AND PUBLIC OUTREACH:
A SUMMATIVE EVALUATION OF PROGRAM DESIGN AND DELIVERY**



Submitted to

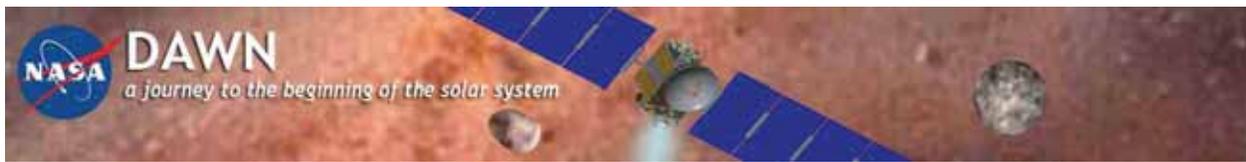
Dawn E/PO Team

by

Magnolia Consulting, LLC



February 15, 2011



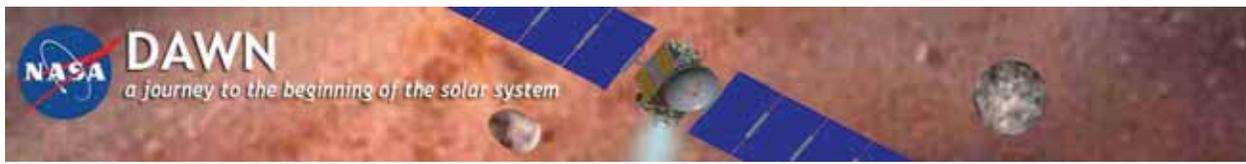
ACKNOWLEDGMENTS

This evaluation study represents a collaborative effort involving Dawn Education and Public Outreach (E/PO) team members from the New Roads School in Santa Monica, California, and from Mid-continent Research for Education and Learning (McREL). Magnolia Consulting would like to thank E/PO team members John Ristvey, Joe Wise, Judy Counley, and Whitney Cobb for their contributions to the summative evaluation process. Their efforts to understand lessons learned and their dedication to integrating evaluation findings into E/PO efforts reflects their commitment to producing high quality outreach materials and resources on behalf of NASA's Dawn mission. We would also like to thank the individuals who participated in stakeholder focus group interviews including personal from NASA, education outreach providers, and formal and informal educators. We would like to thank Becky Siceloff of Magnolia Consulting for her contributions to the literature review process. Finally, a special thanks to Judy Counley for her transcription of the focus group interviews.

The authors,

Carol Haden, EdD.

Stephanie Wilkerson, PhD.



CONTENTS

INTRODUCTION TO DAWN EDUCATION AND PUBLIC OUTREACH INITIATIVE 1
 Target Audiences 1
 E/PO Approaches and Intended Outcomes 1

SUMMATIVE EVALUATION DESIGN 2
 Research Questions 3
 Data Collection and Analysis 3

FINDINGS 4
 Contextual Factors Influencing Dawn E/PO 4
 Strategies for Promoting Effective E/PO 6
 Components for Promoting Effective E/PO 8

SUMMARY AND RECOMMENDATIONS 20

REFERENCES 23

APPENDIX A: Dawn Logic Models 25
 Delivery and Communication Components 26
 Education Development Component 27
 Evaluation Component 28

APPENDIX B: Evaluation Matrix 29

APPENDIX C: Dawn E/PO Team Response to Recommendations 30

REFERENCES 30

LIST OF TABLES

Table 1: Dawn and Best Practice in Professional Development 14
 Table 2: Dawn and Best Practices in Materials Development 17

INTRODUCTION TO DAWN EDUCATION AND PUBLIC OUTREACH INITIATIVE

As part of its Discovery Program, the National Aeronautic and Space Administration (NASA) awarded funding for the Dawn mission in December 2001. Dawn, the first mission to the Main Asteroid Belt, investigates Ceres and Vesta, two of the largest protoplanets remaining intact since their formation. The mission addresses the role of size and water in determining the evolution of the planets by measuring their mass, shape, volume, and spin rate with imagery and gravitational analysis of the spacecraft motion. Through this investigation, scientists aim to characterize the conditions and processes of the solar system's earliest epoch. As noted on its website, the Dawn mission offers a variety of information and data for the informal and formal educators as well as the public:

It [Dawn] brings images of varied landscapes on previously unseen worlds to the public including mountains, canyons, craters, lava flows, polar caps, and, possibly, ancient lakebeds, streambeds, and gullies. Students can follow the mission over an entire K–12 experience as the mission is built, cruises to Vesta and Ceres, and returns data (“Dawn: A Journey,” 2003)

Dawn began its trek with a successful launch on September 27, 2007. The craft will have traveled four years before it reaches Vesta and another four years before reaching Ceres and completing its mission in 2015.

The Dawn E/PO team consists of specialists from the New Roads School (Santa Monica, CA), and Mid-continent Research for Education and Learning (McREL) who work to develop and disseminate high quality educational resources and materials in support of NASA's Dawn mission. Through emerging technologies, the team delivers scientific knowledge to classroom teachers and students, informal educators and learners, and the general public. The Dawn E/PO website (<http://dawn.jpl.nasa.gov>) offers age-appropriate, mission-related activities that enable users to, for example, analyze images for cratering, perform photometry on images to produce light curves, and discuss with mission scientists the significance of Vesta and Ceres to understanding solar system origins. Dawn E/PO educational tools are designed to encourage student collaboration, visualization, and peer review in ways that conform to and further define the national standards in math and science education.¹

Target Audiences

Dawn's target audiences include (a) kindergarten through postsecondary teachers and students; (b) the general public (business people, parents, policymakers adult learners, and retirees); (c) members of the media² (national and local broadcast, print, trade, and Internet journalists; and producers of instructional TV, radio, and public service announcement); (d) informal educators associated with science centers and museums, arts organizations, speakers bureaus, youth programs, and service clubs; and (e) disadvantaged and underserved populations.

E/PO Approach and Intended Outcomes

The E/PO effort aims to enhance educator, student, and public engagement in space science through the following overarching efforts.

- Developing products and activities that reflect "best practices" in education (i.e., they are standards-driven, pedagogically appropriate, and designed to meet the needs of all students, including the disadvantaged and underserved).

¹ Excerpt from the Dawn mission E/PO final proposal, July 21, 2000.

² Media requests are deferred to Jet Propulsion Laboratory (JPL) media relations; however, Dawn E/PO provides press packets and resources for media professionals via the Dawn mission website.

- Developing and enhancing practical and technologically efficient systems for reaching, communicating with, and disseminating products and services to educators and the public.
- Leveraging resources and maximizing reach by establishing a broad range of working partnerships between related projects and groups.

The Dawn E/PO outreach strategy supports NASA's vision and seeks to achieve eight long-term outcomes in four component areas: delivery, communication, education, and evaluation.

Delivery and Communication Outcomes

1. E/PO efforts reach broad target audiences through high quality products and dissemination mechanisms. Primary contacts share what they learn about the Dawn mission and associated science with their colleagues.

Education Outcomes

2. As a result of the knowledge and skills obtained from Dawn E/PO products and activities, participants have a better understanding of the formation of the solar system.
3. As a result of using Dawn E/PO products and activities, participants are interested in solar system science.
4. Students will conduct science within a real-life context leading to increased academic achievement.
5. Educators have a better understanding of how to implement inquiry processes, leading to improved practices.

Evaluation Outcomes

6. Dawn E/PO products and services are of high quality and utility because they reflect audience needs.
7. Dawn E/PO can demonstrate the effectiveness of its outreach as evidenced by the impacts of its high quality products and activities.
8. Future mission E/PO efforts will have a blueprint from which to make informed decisions based on extensive documentation of lessons learned from Dawn E/PO.

These long-term outcomes are supported by 17 intermediate outcomes. Logic models were created to illustrate the activities, intermediate outcomes, data collection methods, and ultimate outcomes for each component (see Appendix A).

SUMMATIVE EVALUATION DESIGN

To date, five annual evaluation reports have presented formative and summative information on the Dawn E/PO delivery, communication, and education components described in Outcomes 1 - 5. Evaluation Outcomes 6 and 7 were also represented in these reports to the extent that information was obtained on the quality, utility, and impacts of E/PO products. Specifically, the evaluation reports have included results from pilot- and field-testing of education materials, professional development workshops and conference presentations, and visibility and dissemination efforts. Evaluators provided E/PO team members with specific recommendations based on the findings of each report, and E/PO team members made some program modifications based on those recommendations.

RESEARCH QUESTIONS

During the sixth year of project evaluation, Magnolia Consulting, LLC added a more comprehensive summative evaluation component focused on Outcome 8. Outcome 8 purports to document lessons learned so that future E/PO providers will have a model for developing and implementing mission outreach. Thus, evaluation efforts focused on the effectiveness of the E/PO process in developing and delivering outreach to target audiences. The following overarching questions guided the summative evaluation efforts.

1. What are the contextual factors specific to the Dawn mission that influenced the design, implementation, and impacts of the Dawn E/PO project?
2. What are the strategies that promote effective development and implementation of Dawn E/PO activities?
3. What are the components that promote the effectiveness of Dawn E/PO?

Evaluators identified subquestions for each overarching question. Appendix B presents the evaluation matrix including questions, subquestions, and the data sources and methods that guided the evaluation design and implementation.

DATA COLLECTION AND ANALYSIS

Evaluators used a qualitative approach designed to capture lessons learned and identify key strategies and components of the Dawn E/PO process and model. Evaluators collected data from E/PO team members, key stakeholders and partners, project documentation, and current science, technology, engineering, and mathematics (STEM) education literature. Data collection methods included (a) an in-depth focus group interview with E/PO project team members, (b) focus group interviews with representative stakeholders, partners, collaborators, and other outreach providers; (c) a review of project documents; and (d) a comparative analysis of best practices as evidenced in the STEM education literature. Data collection activities included the following.

E/PO team in-depth interview. Evaluators conducted a group interview by telephone with four members of the Dawn E/PO team on August 3, 2010. Interviewees included team members from McREL and New Roads School. Questions focused on (a) contextual factors influencing Dawn E/PO efforts; (b) perceptions of the effectiveness of E/PO efforts in maximizing mission events and science; (c) leveraging of resources to enhance E/PO efforts; (d) the nature and extent of partnerships and collaborations, (e) the innovativeness of Dawn E/PO efforts; and (f) the role of evaluation in guiding E/PO efforts. The telephone interview lasted approximately 90 minutes.

Stakeholder focus group interviews. Evaluators conducted four focus group interviews with NASA Dawn mission personnel, key stakeholders, partners, and other outreach providers to gain an understanding the effectiveness of E/PO efforts in maximizing mission events and science, and to understand how Dawn E/PO might best move forward to prepare for future mission events. Three of the interviews took place during the Dawn E/PO Planning Team meeting August 19 - 20, 2010. Interviewees were separated into groups: formal educators, informal educators and mission representatives. NASA outreach providers joined formal and informal educators during those focus groups. Evaluators conducted a fourth interview by telephone with NASA headquarters personnel on November 1, 2010.

Stakeholder interview questions focused on (a) perceptions of the effectiveness of Dawn E/PO efforts in maximizing mission events and science; (b) understanding effective platforms for dissemination of outreach information and materials; (c) educator and outreach personnel needs related to future Dawn E/PO efforts; (d) best practices in STEM education and public outreach; and (e) feedback on the Dawn Mission E/PO Guide (Dawn E/PO Team, 2010). Focus groups included four or five individuals per group and lasted approximately one hour each.

Document review. Evaluators examined Dawn E/PO documents including past evaluation reports, monthly team project reports, and the Dawn E/PO Guide. Document review complemented interview findings in illuminating Dawn E/PO efforts and effectiveness.

Review of STEM education literature. To conduct a comparative analysis of Dawn E/PO against best practices identified in the literature, evaluators drew upon a previous literature review on best practices in STEM professional development. Evaluators reviewed additional literature on STEM curriculum development, effective outreach, and literature on dissemination platforms to supplement the existing literature review.

A process of analytic induction was used to analyze qualitative data from interviews, project document reviews, and comparative analyses. Analytic induction is a process whereby evaluators read and re-read the data corpus in order to generate analytic assertions (Erickson, 1986). Data are coded and assertions are refined and supported with excerpts from the data and other data sources. The excerpts are linked to the assertions, themes, and findings in a manner to support analytic generalization (Glaser, 1978). Evaluators imported interview data into HyperResearch, a qualitative data analysis software program, to assist in retrieval, coding, and management of the data corpus.

FINDINGS

The findings section of this report begins by examining contextual factors affecting Dawn Education and Public Outreach (E/PO). This section is followed by a section on strategies for promoting outreach and concludes with a section on Dawn E/PO components that promote effective outreach and education.

CONTEXTUAL FACTORS INFLUENCING DAWN E/PO

The Dawn E/PO team planned, developed, and implemented their project in a context that required them to identify key stakeholders and to respond to factors beyond their control. These contextual factors have influenced the way in which E/PO has been actualized, and lessons learned have served to move Dawn E/PO forward over the course of the mission.

Identifying Key Stakeholders

At the outset, Dawn E/PO members were cognizant of the importance of conveying the science of the mission and the excitement of discovery to all key stakeholders. Identifying those stakeholders was the first step in designing effective outreach for a mission. First and foremost, the team identified educators and members of the general public as key stakeholders. Reaching educators meant reaching their students, whether in a formal or an informal educational setting. With respect to educators, one team member stated,

I think about how to hook those folks, how to give the teachers taking the story back to the classroom enough to use – and giving them a place they can return to over and over again to enable them to transfer the message on to the kids. That’s who I’m always thinking about. I’m investing in these teachers now. They’re working with these younger kids and they move through fast, we need to get it [space science education] in there early.

Another team member pointed out that because of the length of the mission, some students who were in middle school at the start of the mission will be in college when the mission reaches Ceres. This provides the possibility for sustaining engagement across many years, something unique to a mission of long duration.

Team members agreed on the need for E/PO efforts to reach the general public as key stakeholders. They noted that parents need to be educated so as to better understand their world and to support their students in learning. Team members felt that missions have a responsibility to show the public how government funds are being spent, and E/PO becomes an important vehicle for conveying this information. Mission E/PO can also bolster public support for future scientific endeavors.

The Dawn E/PO team also identified other E/PO providers as key stakeholders separate from the public and the education community. A distinctive characteristic of the Dawn E/PO team and their efforts is the goal of leaving behind a legacy for other mission E/PO teams. Their intention is to do this by creating a model for effective E/PO based on the Dawn mission. One team member stated,

We have kept in mind those who will follow us. It's our legacy that the work we do should live on—not necessarily the Dawn materials—but what we've done will move through the other missions in terms of E/PO. What we do with Dawn needs to live on in living missions.

The Dawn E/PO team noted that identifying stakeholder needs is foremost in their minds when designing and developing E/PO resources. The key, as one team member stated it, is “finding a marriage of what they need and what we can provide.” The E/PO team cited the Core Planning Team as vital to the process of getting input from stakeholders to aid in the development process. Collaborating with colleagues in formal and informal education who review educational materials before pilot-testing is part of the process of ensuring stakeholder representation. The process of piloting and field-testing materials to receive early formative feedback during development is another unique way to engage stakeholders in creating quality materials that will be of use to a varied group of educators.

Influences on Dawn E/PO Development and Implementation

The in-depth interview with the Dawn E/PO team illuminated key factors that influenced the design, development, and implementation of Dawn E/PO efforts. These factors included changes in mission status, delays in funding, and the way in which E/PO is funded for the mission.

Early on, the mission was cancelled and then subsequently re-instated. Prior to cancellation, there were times when the E/PO team had a number of “stop work” situations due to delays in funding of one to two months. E/PO team members reflected that at the time the changes were happening, they had a significant effect on E/PO planning. Had the mission cancellation been permanent, it would have had repercussions for staffing within the McREL organization as well as for staffing in partner organizations. Stop work situations and changes in mission status meant stop-and-go work on the Dawn website, the overarching method of delivery and dissemination of E/PO efforts.

In reflecting on the change in mission status and delays in funding, E/PO team members noted that these events had an impact on the E/PO project timeline and priorities, but that due to the overall length of the mission, the impacts were not as devastating as they would have been had the mission been of shorter duration. Team members noted that the “silver lining” to the cancellation was that once the mission (and hence E/PO) were reinstated, it made the E/PO team “think more strategically” about how to make Dawn E/PO efforts “live beyond the mission.” The E/PO team considered how best to achieve the goal of developing Dawn E/PO as a model for E/PO efforts for future NASA missions.

More significant to the development and design of Dawn E/PO was the somewhat unusual way in which E/PO was funded for the project. Typically, funding for E/PO is high for launch and for encounter, but there is little money available between major mission events. Following the initial funding delays, the Dawn mission obtained long-term funding that would remain fairly level across the years, allowing them to design and develop E/PO in a more “rational way,” as a team member put it, rather than being limited by events that happened in the mission. One team member noted,

Previously E/PO funding was given at launch and encounter, but there was no money to develop efforts in anticipation of encounter. Dawn has provided an opportunity for other

missions to look at what we've done in anticipation of encounter. We could create materials that were used and are now available for arrival—the materials are already in place. Because of the level funding, we've been able to create a storyline that is bigger than the Dawn mission [extending to] research in the solar system.

Because of the mission length and level funding, the E/PO team is able to develop materials that will engage educators and the public throughout the mission, including the arrival at Vesta. One team member noted that this differs from other missions “where arrival happens and the money is already spent and you have data that you can't do anything with” beyond arrival. Funding for E/PO continues after Vesta arrival and will allow the team to use real data in continued development of its educational materials. This is a significant element in achieving the longterm goal of ensuring that Dawn E/PO leaves a legacy both in relation to the mission itself and to future mission E/PO efforts. Because funding remains consistent, the E/PO team can remain intact over the years of the mission. This allows for a continuous effort, coherence in the design, and the ability to plan E/PO resource development into the future.

STRATEGIES FOR PROMOTING EFFECTIVE E/PO

The Dawn E/PO team has developed multiple strategies to promote effective development and implementation of Dawn E/PO efforts. Included among these are the leveraging of resources, partnerships, and collaborations to extend reach, leveraging E/PO across missions, and maximizing mission events for effective communication of mission science to the public and to educators.

Leveraging Resources, Partnerships, and Collaborations

To maximize the reach of Dawn E/PO, the team has leveraged resources through partnerships with formal and informal education venues and networks, institutions, professional organizations, and other NASA missions. One team member noted, “We've done a good job from the beginning at looking at any possible opportunity to leverage.”

Dawn E/PO team members have seized on opportunities to link Dawn to other NASA mission outreach programs in addition to creating outreach events and resources specifically for the Dawn mission. Educational materials are designed to work thematically across other missions and contribute to the work of other E/PO teams. As an example, the E/PO team cited its series of interactives around the instrumentation used in the Dawn mission. The interactive demonstrating the use of a spectrometer, for instance, could be easily adapted for any mission that uses a spectrometer.

The Dawn E/PO team has sought to maximize its reach by taking advantage of existing networks among informal and formal educators. Team members have introduced Dawn mission information and E/PO resources to programs such as NASA's Aerospace Education Services Project, the Museum Alliance, NASA's Solar System Ambassadors program and other networks that exist through NASA's Jet Propulsion Laboratory (JPL).

The Dawn E/PO team also noted that McREL has received a NASA-funded ROSES grant focused on “small bodies, big concepts” that will allow them to spend extended time working with a group of educators on Dawn mission science and data. The team offered this example as another way they have worked to leverage resources to support Dawn E/PO efforts.

To further leverage Dawn E/PO, the team is currently examining ways in which it can support NASA's upcoming Year of the Solar System (YSS) through Dawn materials and resources. YSS involves 23 months (a Martian year) of unmanned exploration of the solar system (<http://solarsystem.nasa.gov/yss/about.cfm>). NASA personnel suggested ways to tie in Dawn mission and science to YSS themes through E/PO activities, videos and resources that could “plug in” to the YSS website. One interviewee noted that some of these efforts are underway with the Dawn E/PO team and that the team has a “blank canvas” for pulling Dawn materials into the YSS. Specifically, NASA personnel mentioned the relevance of Dawn to the upcoming July theme of “Rocks from Space.” Team members

note that while supporting YSS, this collaboration will also serve to raise awareness of Dawn E/PO activities.

Leveraging Across Missions

A mission focus group participant noted that E/PO projects have a unique opportunity to leverage across missions. This individual noted that missions such as EPOXI and Stardust, and Dawn fit together thematically, stating, “We should be advertising and paying it forward to the next mission.” Others suggested that mission E/PO providers should work together to share outreach materials across missions so that when the an E/PO team is unable to attend outreach events, their its materials will still be distributed. Related to this, the Dawn E/PO team noted that they it looks at what other projects NASA is funding, to determine whether those projects tie to E/PO for Dawn, and in turn, how Dawn can leverage those opportunities to work across projects to raise visibility of the Dawn materials.

Leveraging E/PO across missions is consistent with the philosophy of the Dawn E/PO team to use E/PO materials and resources to go beyond promoting the Dawn story to promoting the larger story of discovery associated with all NASA missions. One E/PO team member stated, “What Dawn E/PO has done is stayed true to presenting the mission but also remained true to a bigger NASA picture of how Dawn fits into the larger NASA mission of trying to understand the solar system.” E/PO team members identified this approach as a strength of Dawn E/PO.

Maximizing Mission Events

Prior to the time of this evaluation, Dawn E/PO team members had conducted education and outreach activities around two major mission events: the mission launch and the Mars flyby. A pre-launch Dawn Mission Educators Conference drew educators from more than 20 states to Florida for a 3-day conference to raise excitement for the Dawn mission and to provide educators with information and activities to bring back to their classrooms. Participants interacted with scientists and mission personnel, toured Kennedy Space Center and attended breakout sessions tailored to their grade levels. Educators had the opportunity to provide feedback on materials and on the conference itself as well as to share ideas for new materials and resources. An E/PO team member commented, “Educators could see the scientists and vice versa. Participants were able to feel like they were part of the education plan.” This was possible because the educator conference was held in conjunction with the science symposium at the same facilities.

The Dawn Mars Flyby Educator Workshop was a unique offering where workshops were held simultaneously in four locations around the country on March 7, 2009. Workshop locations included NASA Jet Propulsion Laboratory (Pasadena, California), the Oregon Museum of Science and Industry (Portland, Oregon), Denver Public Schools Career Education Center (Denver, Colorado), and the NASA Independent Verification and Validation Facility Educator Resource Center (Fairmont, West Virginia). Facilitators included members of the Dawn E/PO team from McREL, New Roads School and University of Maryland, as well as NASA personnel. Mission scientists and engineers shared key updates with the participants through NASA’s Distance Learning Network in a live webcast. Educators at each site participated in hands-on activities developed by the E/PO team for use in their classrooms. Team members observed that these events were well received by participants and provided a means for increasing visibility and dissemination of Dawn materials, resources and mission science. One mission representative noted that effective outreach “seizes the opportunity to keep the mission in the news and on people’s minds.” NASA and mission stakeholders felt that the pre-launch conference and the Mars flyby workshops were effective in this respect, and that excitement and education should be sustained through capitalizing on future mission events. This approach to professional development is a model for other NASA professional development efforts including a thematic professional development opportunity for the Discovery program called “Thrill of Discovery” in March of 2011.

At the time of this evaluation, the Dawn E/PO team was looking toward the next major mission event, the spacecraft’s arrival at the protoplanet Vesta in July of 2011. Because the craft will remain in Vesta orbit

for a year, there is an opportunity to leverage an unusually long mission event. The mission principal investigator stated,

Arrival is the period of time when we will have discoveries. Now, the discovery can be as mundane as “We’ve never seen this before—it looks just like the moon but these are new terrains that we’ve never seen before,” or, they may end up being really exciting things that are clearly paradigm-changing. I think we should be keying off the newness—that we’ve never gotten to an asteroid before; we’ve never looked asteroids of these sizes before. We’ve certainly seen lots of asteroids, so that’s an issue. But, to see more planetary processes like we expect to see here; these will be new and not seen before.

Thus, E/PO can emphasize the newness of discoveries to engage the public in the excitement of Vesta encounter and as an opportunity to educate the public on mission science. The mission principal investigator talked about how media events and E/PO can mirror the stages of exploration at Vesta, beginning with viewing Vesta from a distance then moving closer and closer to the surface, emphasizing what is learned at each stage.

In anticipation of Vesta arrival, the Dawn E/PO team continues to develop materials and resources for educators, students and the public. Other ongoing E/PO efforts include revamping the continuously updated Dawn website to provide mission updates and images, new interviews and podcasts with scientists and engineers, links to E/PO presentations at conferences, links to activities and resources for the public and educators, and social networking tools to disseminate mission outreach.

Key stakeholders including mission personnel, NASA headquarters personnel, and other NASA E/PO providers offered ideas for maximizing the encounter with Vesta. Stakeholders suggested the use of educator webinars in the vein of what was done for the Mars flyby, where educators could interact with scientists and engineers and have an opportunity to explore educational materials and resources related to Vesta arrival. A NASA outreach coordinator commented that the use of webinars would provide a means to maximize reach beyond those attending an event to “engage them in anticipation of the year-long orbiting.” Other suggestions included linking to outreach events such as a “Friends and Family Event,” and JPL open house prior to arrival at Vesta to build excitement and anticipation for encounter. One interviewee likened this to “sneak previews” for movie events to get educators and the public interested and provide a “hook” to engage them in what is coming up with the mission. Stakeholders also suggested working with NASA mission media personnel to provide an “image of the day” through social networking venues.

NASA personnel suggested that the Dawn E/PO team capitalize on the duration of the Vesta encounter by providing not only images of the day or week, but “data sets of the day” as well. They emphasized that providing authentic data is a way of engaging educators and their students as well as the general public by allowing “audiences to get involved with the data and to understand the data” related to the event. Suggestions also included ways to involve the general public in activities such as target selection for camera views of Vesta similar to what has been done in the Mars Reconnaissance Orbiter mission.

NASA personnel emphasized the need to maintain communication between the E/PO team, mission media personnel, the science team, and public service staff to ensure clearly defined goals and objectives for Vesta arrival. Goals and objectives for arrival can then be examined for feasibility given funding levels and constraints. Interviewees suggested leveraging science team meetings in the coming year as a place for the E/PO team to interview scientists and engage them in new ideas for outreach. One interview participant noted that often mission scientists and engineers are not aware of the outreach that has been done on missions, and that greater communication between teams could broaden awareness and visibility of outreach efforts.

COMPONENTS FOR PROMOTING EFFECTIVE E/PO

Several facets of Dawn E/PO are designed to promote effectiveness in addressing outreach goals. They include (a) platforms for disseminating mission science and materials; (b) professional development,

including workshops using Dawn materials and resources; (c) the development of high quality educational materials; (d) the development of the Dawn E/PO Guide to document lessons learned for future missions; and (e) the role of continuous program evaluation. This section of the report examines program components to identify the ways in which they support the effectiveness of Dawn E/PO in meeting program goals, and the ways in which they align to best practices in curriculum development and professional development.

Visibility and Dissemination

The Dawn website is the main dissemination platform for Dawn education and public outreach. Visitors to the site can view the mission timeline, check mission updates, hear scientists' podcasts and read their journals and profiles, watch videos, and access other resources for educators and the public.

Professional conferences and workshop are also vehicles for disseminating Dawn E/PO resources and materials. E/PO team members routinely distribute bookmarks, fact sheets, and information about upcoming educator events, and present workshops to demonstrate use of Dawn materials.

Dawn E/PO has had a continued presence at conferences and workshops of the National Science Teachers Association, state level science teacher's associations, the National Afterschool Association, the National Middle School Association, the Lunar and Planetary Institute, and NASA Earth and Space Science Education. In addition to conference presentations and workshops, the EP/O team recruits classroom teachers to pilot- and field-test Dawn curricular materials, raising awareness not only among the teachers, but promoting dissemination to others within their professional relationships and networks.

Informal and formal educators noted that professional conferences are a source for accessing information about resources, materials and professional development related to space science education. All participants indicated participation in professional organizations closely aligned with their work and with their goals and objectives for student education. This indicates that Dawn E/PO outreach through these venues is an effective strategy for dissemination.

One interviewee noted that although conference presentations and workshops are effective, they are not sufficient to reach the wide audience targeted by E/PO goals. In addition to conferences, workshops, and the website, the Dawn team produces an e-newsletter that is updated regularly with mission events and links to resources.

Despite the multiple and varied efforts to raise the visibility of Dawn E/PO efforts, the need to expand educator and public awareness of Dawn E/PO website, materials, and resources emerged as a theme of several focus group interviews. The Dawn E/PO team noted that the key to dissemination is to match the target audience with what it needs. They felt that there is room for improvement in marketing Dawn resources so they are more visible to their audiences. A team member said, "We have great stuff, but we need to do a better job of getting it into the right hands."

In a separate interview, a mission representative echoed this sentiment, stating, "I think we have a lot more to do. I think it would be nice to leverage much more than we are. We've got the materials, but they're not getting out into the hands of everybody we think we could use them." Another interviewee commented, "Maybe it's not just Dawn, but the place where a lot of NASA products get stopped in their shoes is teachers not being aware that they're there."

Interviews with educators corroborated these assertions. Evaluators asked formal and informal educators where they go to find resources for their students. Informal educators said that they were most likely to go to the Google Internet search engine when looking for science education materials and activities related to a particular topic, rather than going directly to NASA websites. They noted that search engines have become so refined that they can narrow down a search quickly. One said,

I know I want to do an activity about stars, my thought process is, 'yeah, you could go to NASA and it would probably pull up something,' or I could type it into Google, and within

the first three results, I'll get an activity about stars. I'll read through it and it will accomplish the goal of being educational in some way, and entertaining.

Informal educators also mentioned going to YouTube for videos related to science. However, they raised the issue that when using search engines and sites such as YouTube, the next step is wading through a lot of useless or low quality sites and materials to find things that are worth implementing with their students. Formal educators also said they use the Internet to find resources, citing not only similar searches but the use of Wikipedia to find background information on science topics.

A NASA E/PO representative who was part of the informal science focus group interview queried educators on their awareness of the searchable page on the NASA website where educators can look for materials based on topic, grade level, and type of materials. Educators were unaware that this page existed but felt it would be useful to them in the future. Others noted that for a searchable page to be useful, it should incorporate science standards as a searchable criterion. This again, raised the issue of a lack of connection between the development of high quality materials and accessibility and awareness of their existence by the target audiences. These findings suggest that, if not already done, the Dawn E/PO website should be tagged so as to appear high on the list of search results under relevant topics.

A NASA staff member who conducts professional development workshops at professional conferences noted that she begins many workshops with training in how to use the NASA website. She suggested that Dawn E/PO providers do the same with the Dawn website when presenting activities and materials at professional conferences. This would couple the already effective use of professional conferences as a dissemination venue with a way to raise the visibility and awareness of the Dawn E/PO online resources.

With respect to raising visibility and dissemination, one NASA interviewee stated,

I feel that Dawn and any other missions need to utilize networks that are available to them, like NEON, like Solar System Ambassadors, like the Museum Alliance. Because what I'm finding working the way I do, is that people gather information in many different ways. You have to be everywhere, even though you can't.

This participant referred to the listserv NEON developed through the Aerospace Educator's Specialists Program as a place where participating educators can share information about their programs and strategies with other educators on the listserv. She recommended Dawn E/PO find a way to link to this or similar resources to provide a platform for sharing Dawn E/PO resources with educators.

The Dawn E/PO team is exploring ways to incorporate social networks like Facebook and Twitter into education and public outreach efforts. The potential of social networks to engage and excite the public in science is increasing rapidly. This can facilitate increased visibility not only of mission science, but of E/PO materials and resources as well. Lohwater (2010) noted that social media "opens up a whole new world for educators and scientists to communicate directly to individuals and groups." She writes that in this context, the use of social media can increase public engagement with science to achieve goals that might include "mutual learning for the public and scientists, empowerment and development of skills to participate in civic activities, increased awareness of the cultural relevance of science, and/or the recognition of the importance of multiple perspectives and domains of knowledge to understanding and decision making related to science-based societal issues" (p.320). Other authors note that social networking can effectively allow educators a means to connect with one another to share resources, participate in ongoing educational discussions, and to connect to "real science and scientists" (Brunsell & Horejsi, 2010).

One interviewee noted that social networking provides "an interesting intersection of media and public outreach." Formal educators felt that Facebook and Twitter are "good tools" that more and more educators are subscribing to as a means of increasing their awareness of science resources and materials. As the Dawn E/PO team moves forward in developing these strategies, a NASA representative noted that use of social networking tools can be effective, but must be targeted to specific goals and outcomes. This individual stated,

I think that the important thing now is that they need to decide what it is that they want to accomplish with social networking and develop a plan based on what tools to use and what approach is best based on their goals. That's an important piece of it. It shouldn't be random. You should consider your target audiences. You should consider your goals and objectives. You should consider 'Is it all aspects of my E/PO plan that I want to target or are there special audiences I want to target?' Look at it that way.

Targeting social networking to specific goals and objectives may mean developing separate Twitter or Facebook sites for educators and for the general public. As an example, this is currently being done through Goddard Space Flight Center's Solar Dynamics Observatory. E/PO efforts there involve one Twitter site specifically to raise awareness of mission resources and materials for educators and a separate Twitter site for sharing mission updates and mission-related science with the general public. Social networking sites also could enable educators who have used the Dawn materials to share their experiences, successes, and challenges.

Across several focus groups, interviewees felt that the E/PO team should study uses of social networks by other missions and science programs to identify effective strategies. Participants mentioned the Asteroid Watch Twitter site through NASA Jet Propulsion Laboratory. This site has attracted a large number of followers by capitalizing on public fascination with near-Earth objects. The Dawn E/PO team is currently working through NASA channels to explore the idea of creating a unique Twitter site or linking Dawn-related imagery to existing sites such as Asteroid Watch. NASA representatives noted that the timing for Twitter feeds and Facebook updates is critical to maximize on public interest and engagement. Keeping broadcasts close to the time of key mission events will generate excitement for being "in the moment."

Interview participants noted that NASA headquarters prioritizes getting mission information to the public quickly and regularly. Participants discussed continuing the use of blogs and scientist podcasts as media tools for disseminating mission science in addition to using social networks particularly in anticipation of Vesta arrival.

Educator Professional Development

Dawn E/PO team members view professional development workshops as an important vehicle for raising awareness and interest in effective science materials and increasing the likelihood that educators will use those materials in the classroom. Through venues such as the previously mentioned Dawn Mission Educator Conference and Mars flyby workshops, the team offers educators the opportunity to learn about and explore Dawn materials specific to their grade levels, teaching specialties, and content standards. Workshops involve the presentation of the materials as well as the opportunity for "hands-on" exploration of the activities.

In recent years, the science education community has built consensus on what constitutes effective professional development (PD) for educators. The National Science Education Standards include standards for professional development for teachers of science. Several books have been written devoted solely to designing and providing quality professional development to teachers of science and mathematics (Loucks-Horsley, Love, Stiles, Mundry & Hewson, 2003; National Science Teachers Association, 2001, 2005). Although many articles and reports on professional development programs tend to be descriptive in nature or to employ less than rigorous research designs to evaluate program effectiveness, a number of studies do add to the knowledge of what constitutes effective professional development in STEM education (Banilower, Boyd, Pasley & Weiss, 2006; Garet, Porter, Desimone, Birman, & Yoon, 2001; Kennedy, 1998).

Many of the characteristics of effective professional development in science are associated with long-term efforts to reform science education, but others can be applied to shorter duration efforts such as the educator workshops facilitated by Dawn E/PO. Effective professional development provides opportunities

for teachers to gain not only content-specific knowledge but also the knowledge of the best methods for structuring learning to engage students optimally in learning (Loucks-Horsley et al., 2003). There has been a considerable focus in recent years on providing professional development that is based on both how adults (the teacher-learners) and children (the student-learners) come to construct meaning (Bransford, 2000; Donovan & Bransford, 2005; National Research Council, 2007). Quality professional development is grounded in a research-based understanding of how people learn (National Staff Development Council, 2001b). Effective professional development embodies an understanding of how students learn and how their thinking surrounding a discipline develops, as well as how adult learners who are recipients of the professional development construct meaning around their experiences. Professional development opportunities should be framed from the perspective of teachers' needs (learner-centered) and include a focus not only on content knowledge, but the pedagogical content knowledge necessary for a deeper understanding of how to successfully apply learning in the classroom (Bransford, 2000; Guskey, 2003).

Garet et al. (2001) found that active learning is one of the three core features of professional development that can lead to change in practice in the classroom. For teachers and their students, active learning involves the use of learner-centered rather than teacher-centered strategies. It involves interaction with content, materials, questions, and unstructured problems, and it forms the heart of the inquiry-based approach to science education advocated by the National Science Education Standards (National Research Council, 1995). For teachers to understand and apply inquiry-based, student-centered approaches to learning, including those represented in the Dawn materials, they must have the opportunity to experience this type of learning themselves in professional development experiences. A formal educator familiar with the Dawn E/PO workshops noted that Dawn workshops were highly effective from this perspective by allowing teachers the opportunity to experience the activities as their students would. He noted,

I think the Dawn group has done a great job with teacher trainings. The teacher workshops where you take an activity, you run people through the activity [are most effective]. To take an activity out of a book and actually use it effectively—it's a huge effort to get that to a usable state.

This individual discussed how the Dawn E/PO team approach to workshops allows teachers to ask questions and clarify their understanding of the activities. He stated,

I think that the support of professional development workshops for teachers is one of the most highly effective tools for disseminating science knowledge—it's extremely important to give them the background, give them the activities, answer their questions and catch the misunderstandings. When you talk to them and work with them, many problems get answered!

For professional development to be effective, it must link to other parts of the educational system (Loucks-Horsley et al., 2003). For teachers, this means the professional development experience must be applicable to classroom goals for student learning. These goals, in turn, are influenced by state and national standards as well as district and state student assessments. Penuel, Fishman, Yamaguchi, and Gallagher (2007) found that teacher perception of the alignment of curricular materials with district and teacher goals for student learning was a strong predictor of whether or not they implemented the program in their classrooms. In their research involving a national random sample of more than 1,000 mathematics and science teachers who participated in Eisenhower Mathematics and Science professional development efforts, Garet et al. (2001) found coherence with other learning activities, and with district and school goals, to be a core feature of effective professional development. Dawn educational materials clearly delineate the standards addressed through the activities, and connections to standards are made apparent during workshops.

Loucks-Horsley et al. (2003) identified features of effective workshops and other forms of professional development for teachers, including (a) making participants aware of the goals and purposes of the session; (b) appealing to different learning styles; (c) providing time for interaction; and (d) providing

access to further resources. If not already present in Dawn educator workshops, these elements should be included in the future. Workshop facilitators can encourage educators to discuss how they might incorporate Dawn materials into their curricula to address standards and learner needs. Orienting participants to the Dawn website and outlining other places they might go to find additional resources could further the goal of extending learning beyond the workshop itself.

Educators need professional development opportunities that are flexible, convenient, cost effective, and that take advantage of schools' technological infrastructures (National Staff Development Council, 2001a). Many focus group participants stated that time and access to funds to attend professional development sessions were the greatest barriers to accessing workshops and other offerings. They noted that in-person professional development is always preferred, but it is not always feasible. All of the educators who participated in focus group interviews reported that they attend conferences in their field (a main venue for Dawn workshops), but they noted that there is a time and monetary commitment involved in attending even local offerings. In a time of increasing economic pressures on school districts and informal education programs, funds are often not available for professional development. Educators noted that if professional development could be brought to them, it would increase the reach and accessibility for themselves and their colleagues. Formal educators noted the need to access professional development around the Dawn materials that is targeted and practical for implementation. They noted that web-based approaches could be particularly effective in increasing usability of the materials. One individual stated,

I think with the K-12 teachers, you hit the nail on the head, that PD is number one. But that's not going to happen with everybody. So, I think using our multimedia resources just along with a teacher guide, and it has to be short, it can't be long—a little five-minute video: 'Here's how you set it up, here's the main objectives, this is what it looks like'—quick little things like that. 'Here's the finished product. Here's what we're trying to do'—just so that a teacher can click on that, review it.

The Dawn E/PO team may consider using more online strategies such as webinars, podcasts, and videos to provide professional development around the Dawn materials and to increase access and usability. These strategies could also serve to increase the visibility and dissemination of Dawn materials. Web-based professional development could provide educators with a means of accessing Dawn workshop offerings in a way that offers flexibility in the time and place for learning. Educators in focus groups suggested the Dawn website provide "PD on demand" by including links to videos of teachers demonstrating the use and implementation of Dawn activities. The E/PO team could consider filming some of the in-person workshop offerings for inclusion with the materials on the Dawn website.

In addition to providing professional development specifically on the Dawn materials, webinars and other online strategies could become a useful way of integrating mission outreach with professional development while raising the visibility of Dawn materials for educators. Online professional development efforts capitalize on the "just-in-time" assistance that educators require, provide access to experts and resources that would otherwise be inaccessible, and can reach a larger audience than face-to-face offerings (Henke, 2007). Dawn E/PO team members could consider the development of a series of webinars that use inquiry-based activities to teach space science concepts and effective pedagogy. Webinars could be archived and linked to the Dawn website. To increase the visibility of these offerings (and in turn of the Dawn materials) the E/PO team may consider ways to locate and allocate funds for access to databases of individuals such as district science curriculum coordinators or informal science educators. They could then develop listservs for email blasts that highlight professional development efforts around the Dawn materials.

Workshops and extended professional development offerings differ in their intended objectives. Workshops such as those previously conducted for Dawn E/PO are useful for raising awareness of Dawn materials and for increasing the likelihood that they will be implemented effectively. In the words of one E/PO member, short duration professional development around the Dawn materials can serve to "highlight Dawn, are motivating and highlight some tenets of best practice but have a different end in mind [than longer duration professional development]." To affect deeper change, the Dawn E/PO team is

looking toward future efforts involving professional development that is longer in duration. These efforts would serve a different purpose: using the Dawn mission science and materials as a means to “engage educators with real data” involving “tools and methodology” over a longer period of time to encourage changes in practice. Such longer duration efforts will be aligned with best practice for professional development intended to affect deeper change than that associated with single activities or resources (Garet et al., 2001).

In summary, Dawn E/PO professional development for educators features several characteristics of best practices, including providing opportunities for active learning with the Dawn materials and with other participants, focusing on key content and pedagogy, and alignment to instructional goals and objectives. Table 1 summarizes areas of Dawn E/PO alignment with key features of best practices in professional development.

Table 1
Dawn and Best Practices in Professional Development

Best Practices in PD	Dawn E/PO
Provides opportunities for developing content and pedagogical knowledge (Bransford, 2000; Guskey, 2003; Loucks-Horsley et al., 2003).	Centers on key content present in the materials; focuses on effective pedagogy for implementing materials.
Provides opportunities for participant interaction (Loucks-Horsley et al., 2003)	Allows for interactions with providers and other educators around adapting materials to the classroom.
Utilizes active learning for participants (Garet et al., 2001)	Allows educators to experience the Dawn materials through hands-on learning opportunities
Aligned to instructional goals for student learning Loucks-Horsley et al., 2003, National Research Council, 1995).	Standards are addressed through PD and use of materials.
Appeals to different learning styles (Bransford, 2000; Donovan & Bransford, 2005; National Research Council, 2007)	Combines hands-on learning, content delivery and interactions with scientists.

Dawn Educational Materials

Dawn educational materials include learning activities and content modules for educators, their students, and the general public that teach key science content while promoting the excitement of the Dawn mission. The development of high quality science education materials is essential to communicating science clearly, accurately, and in a way that motivates students and the public to engage in learning. Stocklymayer, Rennie, and Gilbert (2010) contended that curriculum reform to promote scientific literacy involves increasing student engagement, finding ways to clearly demonstrate the relevance of the content, promoting inquiry-based learning, and providing for transdisciplinary contexts and for cultural and social differences. It is also important to reflect the nature of science in a modern context as well as promote understanding of its historical context and development. The Dawn E/PO team members identified several ways in which Dawn materials were designed to reflect these and other best practices in curriculum development, including (a) alignment of materials to science education standards, (b) attention to different learning styles, (c) inclusion of inquiry-based approaches, and (d) incorporation of effective strategies for diverse learners.

The National Science Education Standards (National Research Council, 1995) include among the goals for school science that of educating students who can (a) “experience the richness and excitement” of learning about the natural world, (b) understand the scientific process for personal decision-making, (c) engage in discourse about scientific matters, and (d) benefit personally from the skills of scientific literacy. High quality educational materials exemplify best instructional practices in support of these goals.

With the science testing requirements for upper elementary, middle, and high schools put into place with the No Child Left Behind Act of 2001, districts have been revising science instruction to better meet the needs of their students. Access to and availability of high quality materials support teachers and their students in improving teaching and learning in science classrooms. High quality materials are based on the constructs that define good science instruction. The National Science Teachers Association's position statement on elementary science education states that elementary students learn science best when (a) exploration and inquiry skills are nurtured, (b) instruction builds on the student's conceptual framework, (c) content is organized around conceptual themes, and (d) mathematics and communications skills are an integral part of instruction (National Science Teachers Association, 2002). Allen (2007) noted that research on effective science curriculum indicates that effective materials and instruction provide opportunities for student discourse around their learning; provide adequate time and opportunities to conduct investigations and raise questions; allow for writing opportunities before, during, and after the investigation; and focus on the underlying key science concepts targeted by the learning. Dawn materials are developed with these key characteristics in mind, providing opportunities for student writing in module activities, taking an investigative approach to learning in modules and activities, and encouraging student discussion of questions and findings.

Effective science instruction takes into account research on how students learn and how students learn science (Bransford, 2000; Donovan & Bransford, 2005), including the need for attention to student preconceptions and misconceptions, understanding how instruction supports the development of scientific thinking, and creating opportunities for the development of classroom communities of practice where students share responsibility for their learning. Dawn educational materials for the classroom are developed around these constructs by organizing learning around themes related to the Dawn mission, incorporating inquiry-based approaches to student instruction, emphasizing key mathematics skills, and providing opportunities for students to communicate the results of their investigations.

NASA has embraced the use of inquiry-based methods in the classroom as a means of improving students' attitudes toward science and increasing scientific literacy (Loston, Steffen & McGee, 2005). The National Science Education Standards (National Research Council, 1995) define student objectives to support the use of scientific inquiry in the classroom. For students to effectively learn science, they need to design and conduct investigations to answer scientific questions, use tools and techniques to facilitate data collection and analysis, make predictions, explain and justify results using evidence, and communicate the results of their investigations. Jorgenson, Cleveland, and Vanosdall (2004) noted that not only does inquiry-based instruction facilitate the goals for student learning set forth in the National Science Education Standards, it also "keeps young students engaged in science by cultivating the excitement of discovery." Dawn educational materials are designed to increase engagement in science through inquiry-based activities that incorporate the standards and objectives for inquiry set forth in the National Science Education Standards.

Nelson (2004) noted that for NASA-related educational materials to be effective and useful for teachers, they must be aligned to science education standards and target the key concepts and skills teachers are responsible for teaching in the science classroom. Formal educators corroborated this assertion in focus group interviews. They noted that their approach to selecting materials for the classroom involves identifying the standards they need to address and finding materials aligned to those standards that will engage students and promote learning. Formal educators noted that standards-based materials tied to current science events (such as the Dawn mission) help to supplement the often-outdated science textbooks that are available to teachers in many schools.

One educator noted the limited amount of time available to teachers at the elementary level for science instruction. She emphasized that science instructional materials were particularly useful for elementary teachers when they tied to standards across disciplines such as those related to mathematics and writing. She commented,

The amount of time given over to a science lesson is relatively small—one or two hours maybe a week, if you're lucky. But, if you can make sure that you offer a writing exercise, then we can spill over into English and I can justify it to my principal and say, 'Here is the

writing portion that we did that covered my writing standards.' We've talked about a hands-on activity...but can you take that and look at in terms of math or English, or even a little bit of history—try to stretch it out so you can take the time to do some of these lessons correctly.

Another interviewee commented,

It's only useful, these materials, increasingly, as the pressure comes to fit to a particular set of standards or curriculum. If you're going to use something, you can only really use it if you really check off the boxes of what you're going to do—better than some other topic.

The Dawn E/PO team develops educational materials in alignment with key standards for science including standards for physical and space science, history of science, and scientific inquiry. One interviewee commented on the importance of not only developing materials aligned to standards, but also making sure those standards are clearly presented to potential users of the curriculum. She said, “[The E/PO team] needs to make sure that [materials] are not only aligned to a standard that’s necessary, but also that it’s advertised that way. It’s not just a mission to an asteroid...it’s building a tool.” Standards are clearly identified in the teacher’s guides that accompany the Dawn modules and activities so that teachers may assess the degree to which the materials align with their instructional goals.

High quality science lessons allow students of varying backgrounds and learning styles to effectively engage with content that supports important and developmentally appropriate science learning goals (Weiss, Pasley, Smith, Banilower & Heck, 2003). Instruction and instructional materials need to be designed to address differences in learning styles and strategies so that curricular materials and instruction will be suitably matched to students’ needs to maximize learning (Committee on Programs for Advanced Study of Mathematics and Science, 2002). Utilizing learner-centered approaches and attending to students’ backgrounds in what they think and know, while focusing on what is to be taught and why increases the likelihood that learning objectives will be accomplished (Donovan & Bransford, 2005). To attend to differences in learning styles, Dawn E/PO members work to develop materials that all learners can access through multiple modalities including tactile, visual, and auditory modes. One team member noted that these strategies reach diverse learners including English Language Learners and younger students. She noted, “When you are trying to differentiate instruction, you want to offer a variety of ways for students to glean understanding.”

Dawn E/PO team members are cognizant of incorporating best instructional practices into materials to ensure that they maximize student learning. They incorporate research-based features of effective classroom instruction including use of graphic organizers, modeling activities, kinesthetic learning and opportunities to generate and test hypotheses (Marzano, Pickering & Pollock, 2004). In reflecting on how their materials evidence best practices in curriculum development, Dawn E/PO team members commented on the incorporation of strategies such as direct vocabulary instruction to connect students to vocabulary using multiple experiences. They discussed the use of graphic organizers to help students construct meaning that connects Dawn-related concepts (for example, instrumentation) to key scientific concepts (the electromagnetic spectrum). Team members have developed interactives that promote learning for kinesthetic learners to maximize engagement and understanding. They have incorporated the use of modeling as an opportunity to understand abstract ideas, and provide questions for understanding throughout the materials. Table 2 presents key features of Dawn curriculum aligned to best practices.

Table 2
Dawn and Best Practices in Materials Development

Best Practices	Dawn E/PO
Aligned to the National Science Education Standards (National Research Council, 1995; Nelson, 2004)	Key standards are identified and addressed in materials development and made explicit in teacher materials.
Attend to differing learning styles and the needs of diverse learners (Weiss et. al, 2003; CPASMS, 2002).	Educational materials include text-based information, hands-on opportunities for learning, interactives, and modeling exercises.
Promote student engagement in science (National Research Council, 1995; Stocklmayer, 2010).	Materials capitalize on the excitement of discovery of the Dawn mission as a vehicle for delivering standards-based science instruction.
Utilize inquiry approach to learning (Loston et al., 2005; National Research Council, 1995; Stocklmayer, 2010).	Materials provide opportunities for student investigations and sense-making around the scientific inquiry process.

Across interviews, NASA personnel and educators perceived the Dawn materials to be “robust,” of considerable depth and of high quality and utility to educators. They noted that materials target varying grade levels and reach a wide audience including students in formal and informal learning environments as well as members of the public. One educator noted that providing materials that span grade levels takes advantage of the duration of the mission to expose students multiple times over their educational careers to Dawn mission science and content.

NASA personnel and educators offered suggestions for future Dawn E/PO materials. One NASA representative noted that from her experience, “educators want data-rich exercises, laboratory activities, and authentic data that the students can do something with.” Opportunities for working with real data can be incorporated into key mission events such as Vesta arrival. A formal educator echoed this sentiment in a separate interview, noting that materials need to “reflect the type of science that is actually planned to be done” by incorporating not only real data, but the process of discovery into educational aspects of the mission. He stated,

This is a big science mission—what exactly are they going to be looking for? How are you going to know if the mantle is exposed on Vesta? How are you going to tell if it's been differentiated or not—at what level? Which instrument do you use? What are the limitations of the instruments and why, for addressing these issues? This comes down to the nitty-gritty of the mission. They make a discovery and they say, ‘We discovered this.’ But, how did they do that? What data was used? What analysis, how did it come together?

Others offered suggestions such as increasing the visibility and understanding of the engineering aspects of the mission, and emphasizing the contributions of women and other underrepresented scientists and engineers to the Dawn mission. Formal educators noted that for Dawn materials to be used they must be easy to access and implement, and they must offer educators ways to see how they are used in the classroom. Informal educators noted that information on the Dawn website needs to be at an “accessible level” when communicating the purpose of the Dawn mission and communicating the science of the mission to younger students and members of the public. Including fun facts about the mission and describing the mission in a way that young children and the general public can understand it were among suggestions these stakeholders had for increasing the effectiveness of E/PO efforts.

Evaluation as an E/PO Program Component

Dawn E/PO team members engaged with evaluators from program inception to ensure that the design and development of outreach materials were targeted to clearly defined program goals and objectives. This process supports a utilization-focused approach to evaluation that presumes evaluation results will

be used in program improvement and decision-making as well as for understanding the impact of the program on all who receive its services (Patton, 1997). Evaluation of NASA education programs and services is increasingly seen as necessary not only for purposes of accountability but also for continuous program improvement.

Evaluators collect and analyze data on Dawn E/PO products and services and produce yearly reports to present findings and offer recommendations for improvement. Team members noted that for many E/PO programs evaluation is an afterthought, whereas for Dawn it is considered a key program component. One team member commented,

The Dawn E/PO evaluation reports challenge us as a team through [evaluators'] recommendations and our response to those recommendations. It helps us to make improvements to our efforts. Evaluation is a dynamic piece rather than just reporting. Other missions use it more as summative piece and don't spend the time or resources to act on the recommendations. We feel that the Dawn mission is an exemplar to using evaluation formatively to improve practice.

A NASA education representative noted that the Dawn E/PO team's approach to incorporating evaluation is unique and valuable to making E/PO efforts meaningful and is something not always demonstrated in mission E/PO. This individual said,

One of the things that struck me when thinking about what other missions are doing is that the Dawn E/PO team seems to take very seriously updating their E/PO by using the early evaluation results to make course changes and to bring in a large, strong evaluation team. There are a number of our missions who probably haven't updated their E/PO since their implementation plan. I know that part of this is because Dawn has a sort of long pathway but so do some of our other missions. That approach is one I think is valuable to our program.

Another NASA representative commented that Dawn E/PO has "exemplified leadership" with respect to evaluation structure. This individual identified feedback from stakeholders as key to ensuring quality of E/PO materials. Dawn E/PO team members recognize this and believe that evaluation provides them a way to stay in touch with the needs of stakeholders. This is especially important for a mission of long duration. A Dawn E/PO team member stated,

It's how we stay in touch with our stakeholders. If we don't get feedback we don't know how things are changing—and things are changing fast when you have a mission that lasts over a decade. We can get carried away without feedback.

The Dawn E/PO team recognizes the importance of piloting and field-testing educational materials to ensure quality and utility. They commented that not only does the process improve materials but also serves as a means to engage educators and students in the material development process. This is very different from the approach of developing materials without stakeholder input and releasing them to intended audiences with the hope that they will be used.

Dawn E/PO team members view continuous program evaluation as a means not only to improve their efforts and understand impacts on stakeholders, but also to document "what has worked well and not well" for other mission E/PO providers. Corroborating this view in a separate interview, a NASA representative discussed how the Dawn E/PO team's approach to evaluation provides the opportunity for learning within the E/PO community. She emphasized that as new strategies for outreach (such as social networking) are explored, teams like Dawn can provide leadership in developing ways to measure and document the effectiveness of such approaches. This individual commented, "That is something that we as an E/PO community and the mission director can begin to learn from. It's opportunities like this with well-organized teams that, if they take advantage of it, we can all learn from it."

Although annual evaluation reports are read and considered by the E/PO team and mission principal investigator, it is unclear whether other stakeholders read them. The E/PO team noted that it would be helpful to have evaluation findings presented in other formats so as to increase the likelihood of stakeholders accessing and considering the findings. Team members suggested the possibility of developing journal articles around findings to reach other E/PO providers, or making available an executive summary with key findings and recommendations highlighted for easy review.

The Dawn E/PO Guide

Evaluation efforts are coupled with E/PO efforts to achieve Outcome 8: guiding future mission efforts by developing a blueprint for making informed decisions based on extensive documentation of lessons learned. The Dawn E/PO team sees the documentation of lessons learned not only as a way to improve future Dawn E/PO efforts, but also to provide guidance for E/PO teams on other NASA missions. Thus, the team developed the Dawn E/PO Guide: Vesta Arrival for the purpose of documenting progress toward outcomes. Team members noted that the process of developing the guide was a useful tool to examine past efforts while planning for subsequent development and modifications to E/PO products and services. Team members explained that as they were conceptualizing Dawn E/PO design and development, it became apparent that other missions had not been effective at “leaving a trail” for other E/PO teams to follow. Documenting Dawn E/PO efforts for the purpose of providing information to other teams became a guiding principle woven throughout the actual work of design, development, and implementation of E/PO activities.

Evaluators sought feedback on the Dawn E/PO Guide from NASA personnel in one focus group interview. These individuals appreciated the forethought on the part of the E/PO team to put together the guide. One individual noted that the section on E/PO deliverables was particularly useful for updating the reader as to which products and services had been developed, which were ongoing, and which had not been successful. NASA representatives expressed some confusion as to the purpose of the Dawn E/PO Guide. They noted that it seemed in some ways “disorganized” and unclear in its purpose. As to clarifying the purpose of the guide, one individual stated,

If it's a report on things that have been done and/or are ongoing, then that's okay. Let's pull that out and make it a report. If it's meant to talk about who the team is and how we got to where we are, that's less of a report—that's more of a guide.

NASA personnel commented that the guide in its present form appears to be more of a report on what had been done and what is ongoing. They noted that if the purpose is to serve as a report, the guide is adequate for that purpose. They noted that it would be useful to see more detail on the timeline and E/PO plans related to Vesta arrival as indicated in the subtitle of the document.

Alternately, group members indicated that if the purpose is to provide guidance to other E/PO providers, and to leave a trail for others to follow, the Dawn E/PO Guide could incorporate additional elements to make it more useful. The guide could “tell the story of Dawn E/PO” in more detail. The guide could document and describe the way in which E/PO was envisioned, and “how things went as the Dawn E/PO came together and started working with the science team.” It could address such questions as “What expertise did they draw on both on the science side and the E/PO side? What compromises were made? What was the process of initiation and development of the E/PO plan? What role did the evaluator play in the process?”

The guide could become more of a reflective document to help others understand the choices made by the team as to which audiences to focus on and which strategies would best meet the needs of those audiences. In other words, it could illuminate the “whys” and “hows” of the Dawn E/PO process and provide “tips” for other E/PO providers. Group members also suggested the guide include an appendix summarizing key evaluation findings. This would help “to answer the question for others about whether the team is achieving its goals.” Group members understood that the guide is a “living document” that has been through previous iterations and will be revised to incorporate future efforts.

SUMMARY AND RECOMMENDATIONS

The summative evaluation of Dawn E/PO sought to examine the journey of Dawn E/PO thus far and to illuminate lessons learned so that future E/PO efforts might be improved. Summative evaluation findings revealed key features of Dawn E/PO that support the E/PO team's efforts to produce quality materials, and it revealed issues for consideration in further development.

The Dawn E/PO team has taken a systematic and well-conceptualized approach to the design and implementation of outreach efforts associated with the Dawn mission. The team clearly identified key stakeholders including the public, educators, and their students and designed materials with targeted outcomes for each group in mind. Additionally, Dawn E/PO is unique and innovative in identifying other E/PO providers as key stakeholders, seeking to leave a "legacy" behind not only through the creation of an exemplary website and materials, but also by documenting the process and products of E/PO efforts for others to learn from.

The Dawn E/PO team faced early challenges with respect to mission cancellation and changes in funding, but saw those as lessons learned to help them plan more strategically for future efforts. Dawn E/PO providers have a somewhat unique opportunity due to level funding across years and the long duration of the mission to make lasting contributions to the field of E/PO through the development of exemplary materials and resources for space science education. The Dawn E/PO team actively seeks opportunities to leverage the excitement of discovery of the Dawn mission through successful partnerships and collaborations with informal and formal educators, presentations at conferences, stakeholder involvement in E/PO planning and materials development, opportunities to leverage E/PO across missions, and by maximizing key Dawn mission events.

Although current strategies for visibility and dissemination have proven effective, stakeholders and the Dawn E/PO team agreed that more could be done to maximize the reach of Dawn mission E/PO. The Dawn website is exemplary in its multiple modes of communicating mission science and events to the public. Raising the visibility of the website to educators should be a key strategy for future E/PO efforts. Educators noted that Dawn materials are of high quality, but many of their colleagues are unaware of them. E/PO team members are currently exploring new venues to disseminate Dawn E/PO efforts and are actively seeking ways to be innovative in this respect.

The Dawn E/PO team has produced materials that are viewed as exemplary and are grounded in best practices in science education. The process of developing Dawn materials is unique in that it involves key stakeholder input from the start, and materials are revised and improved based on evaluation through pilot- and field-testing. Professional development efforts associated with the materials are effective in helping to ensure that participating educators have the opportunity to understand the materials on a deeper level before implementing them in the classroom. Ensuring that educators who cannot access in-person professional development associated with the Dawn materials have alternate means to learn about and experience the materials could serve not only to extend the reach of the materials, but also to ensure that the materials are used more effectively.

In sum, Dawn E/PO demonstrates the following characteristics of best practices in education and public outreach.

- Identification of key stakeholders for targeted outreach efforts.
- Leveraging resources and partnerships within and across missions to maximize outreach efforts.
- Maximizing mission events to capitalize on the excitement of Dawn.

- Implementing effective strategies for dissemination of Dawn materials including the Dawn website, and networking with formal educators, informal educators, and other NASA E/PO providers.
- Implementing effective strategies for professional development around the Dawn materials.
- Creating curricular materials that incorporate best practices in science education.
- Engaging in collaborative evaluation of Dawn materials and resources to ensure quality and utility to key stakeholders.
- Documenting lessons learned in the development and implementation of E/PO.

RECOMMENDATIONS

Based on the evaluation findings from the summative evaluation, the following recommendations are provided for consideration by the Dawn E/PO team. These suggestions are intended to facilitate continued project success in project implementation and assure accountability with regard to project outcomes.

With respect to visibility and dissemination the following recommendations are made.

- Continue to incorporate the use of scientists' podcasts, journals, and such "in time" strategies as images of the day and data sets of the day to keep the mission alive in the eyes of the public and educators. Consider adding additional features with women and racial or ethnic minority scientists and engineers to inspire underrepresented students and members of the public.
- Continue to engage educators, students, and the public in the excitement of the Dawn mission by emphasizing the "newness" of the Dawn discoveries. Vesta arrival will offer a unique yearlong opportunity for continuous communication of mission information to the public.
- Consider the development of conferences and webinars that maximize Vesta arrival along the lines of the Dawn Mission Educator Conference Workshop and Mars Flyby Educator Workshop.
- To broaden the visibility of the Dawn mission and expand dissemination and use of E/PO resources, consider building a database of individuals who could get materials into the hands of informal and formal educators, including perhaps district science curriculum coordinators and parallel individuals in informal science networks.
- Because educators use Internet search engines to find space science materials for their students, ensure that the Dawn website is tagged to appear at the top of search results on relevant space science topics.
- Explore new ways to link Dawn E/PO to existing listservs within NASA and in the broader education and public outreach communities.

With respect to new platforms for outreach, the following recommendations are made.

- When considering the development of social networking platforms for Dawn E/PO, carefully consider goals and intended outcomes during development.
- Look across NASA missions that are using social networking to see how it is being used and to identify seemingly effective strategies for such dissemination efforts.

- Incorporate evaluation into the use of social networking not only to ensure that targeted outcomes are met, but also to help inform the broader field of E/PO about this new strategy for outreach.

With respect to professional development, the following recommendations are made.

- Continue to provide opportunities for professional development around the Dawn educational materials. Consider creating professional development webinars that can go deeper into the science behind the materials and can be archived on the Dawn website. Also consider short video clips, including video of classroom teachers using Dawn materials, to maximize the effective implementation of the materials.
- If not already doing so, spend time at in-person workshops showing participants how to use the Dawn website to access mission updates, science, and materials.
- Continue to offer professional development that focuses on active learning and an understanding of how people learn.
- Continue with plans for longer duration professional development efforts that will allow educators to go deeper into Dawn science and focus on effective science instruction. Consider ways in which evaluation will be incorporated into these efforts to ensure that targeted outcomes will be achieved.

With respect to future educational materials development, the following recommendations are made.

- Continue current strategies in materials development that will ensure that Dawn educational materials continue to be of high quality and utility to educators, including aligning materials to science education standards, incorporating scientific inquiry into activities, and creating materials that are effective with diverse learners that attend to differences in learning styles.
- Educators want data-rich exercises for their students. Consider developing activities and materials that maximize Vesta arrival and the duration of the encounter by taking advantage of the continuous data collection efforts of the mission.
- Continue to involve evaluation as a key program component through continued pilot- and field-testing of newly created materials.

Dawn has a unique and valuable philosophy toward education and public outreach. The Dawn team seeks to “leave a legacy” for other E/PO providers so that Dawn E/PO efforts will live beyond the mission. With respect to leaving a legacy for other E/PO providers, the following is recommended.

- Consider “telling the story” of Dawn E/PO from inception through implementation in a way that will be accessible to other outreach providers. This could be done through the Dawn E/PO Guide or through other vehicles such as a book or a series of journal articles. Focus such an effort on the decision-making process, the development process, successes and challenges, lessons learned, and key findings from evaluation.

After reviewing this report, the Dawn E/PO team reflected on the recommendations and strategized ways to address the recommendations as Dawn E/PO work moves forward. Dawn E/PO team responses to recommendations, submitted to the evaluation team in February of 2012, are presented in Appendix C of this report.

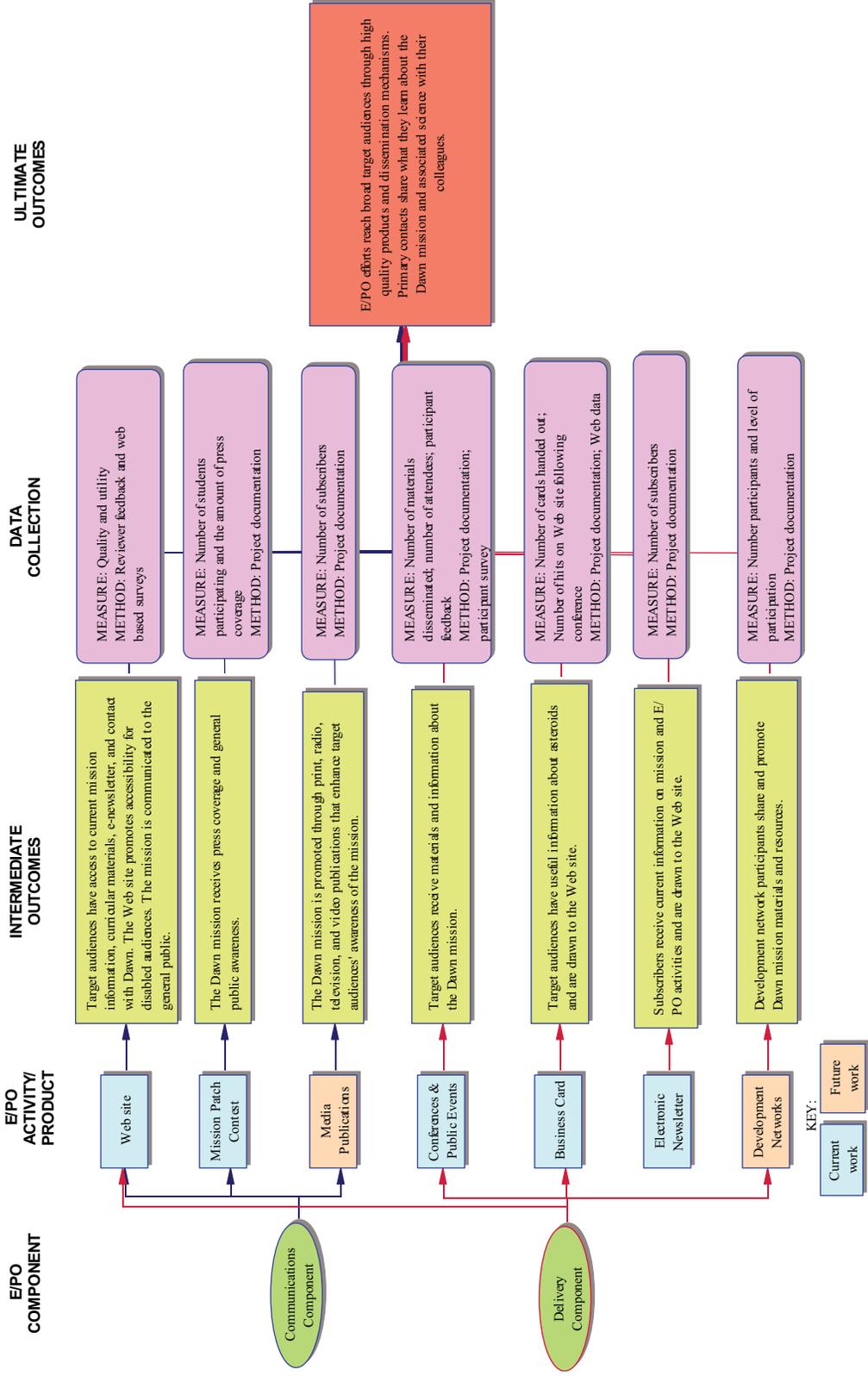
REFERENCES

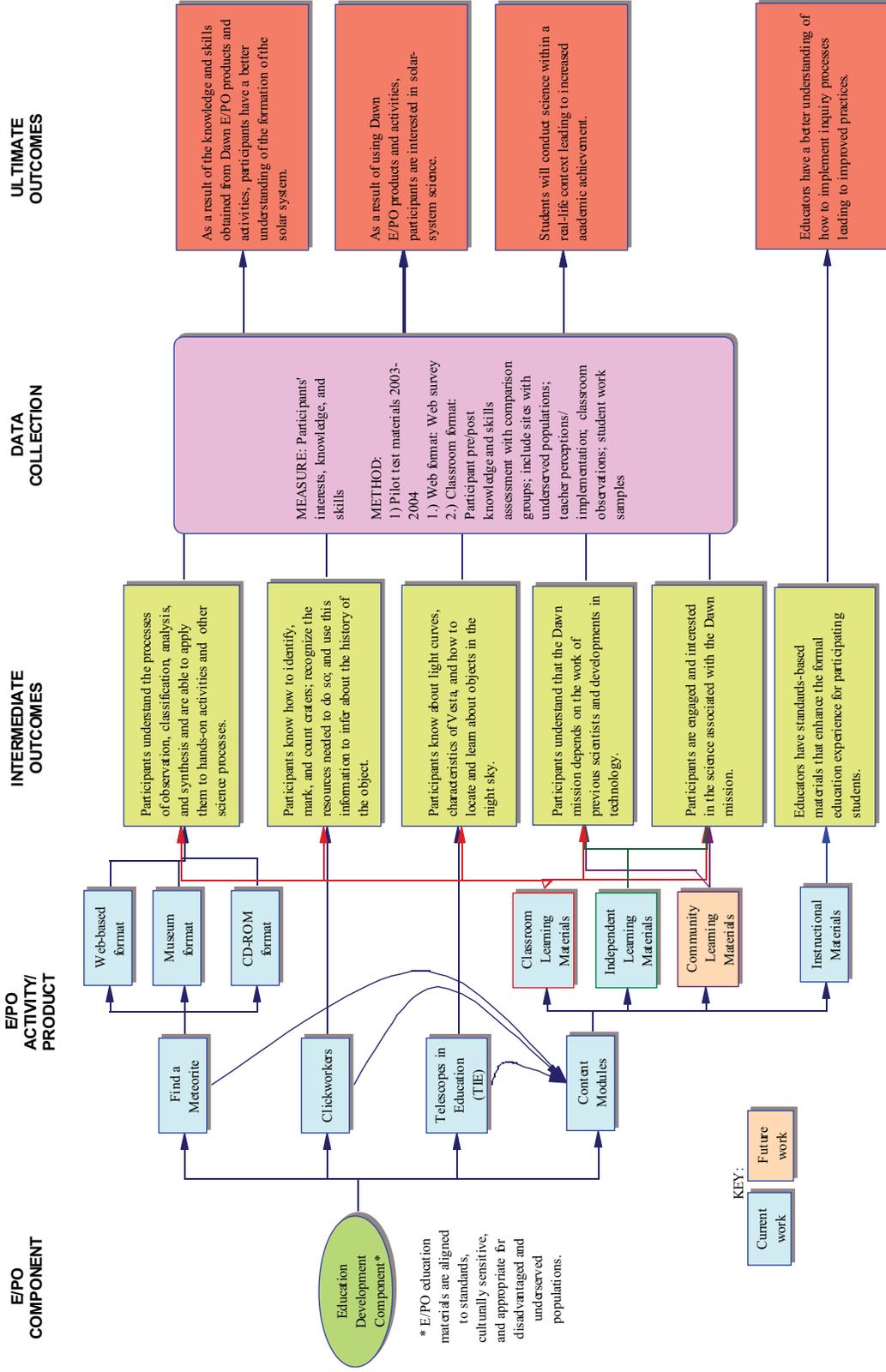
- Allen, R. (2007). *Essentials of science, grades 2 -12: Effective curriculum, instruction and assessment*. Alexandria, VA: Association for Supervision and Curriculum Development.
- Banilower, E., Boyd, S., Pasley, J., & Weiss, I. (2006). Lessons from a decade of mathematics and science reform: A capstone report for the Local Systemic Change through Teacher Enhancement Initiative. Chapel Hill, NC: Horizon Research, Inc.
- Bransford, J. (2000). *How people learn: Brain, mind, experience, and school*. Washington, DC: National Academy Press.
- Brunsell, E., & Horejsi, M. (2010). Science 2.0: Using web tools to support learning. *Science Teacher*, 77(1), 12 - 13.
- Committee on Programs for Advanced Study of Mathematics and Science in American High Schools,. (2002). *Learning and understanding: Improving advanced study of mathematics and science in U.S. high schools*. Washington, DC: National Academies Press.
- "Dawn: A Journey to the Beginning of the Solar System" [Web page]. (2002). Retrieved from <http://dawn.jpl.nasa.gov>
- Dawn E/PO Team. (2010). Dawn E/PO Guide: Vesta Arrival, FY 10–FY 11, from http://dawn.jpl.nasa.gov/education/reports/FY_10-11.
- Donovan, M., & Bransford, J. (Eds.). (2005). *How students learn: History, mathematics and science in the classroom*. Washington, DC: National Academies Press.
- Erickson, F. (1986). Qualitative methods in research on teaching. In M. Wittrock (Ed.), *Handbook of research on teaching* (3rd ed.). New York, New York: MacMillan.
- Garet, M., Porter, A., Desimone, L., Birman, B., & Yoon, K. (2001). What makes professional development effective?: Results from a national sample of teachers. *American Educational Research Journal*, 38(4), 915-945.
- Glaser, B. G. (1978). *Theoretical sensitivity*. Mill Valley, CA: The Sociological Press.
- Guskey, T. (2003). Analyzing lists of the characteristics of effective professional development to promote visionary leadership. *NASSP Bulletin*, 87, 4 - 20.
- Henke, K. (2007). Learning in the 21st century: A national report on online learning. Retrieved November 18, 2010, from <http://www.blackboard.com/Solutions-by-Market/K-12/Learn-for-K12/Leadership-Views/Education-in-the-21st-Century.aspx>
- Jorgenson, O., Cleveland, J., & Vanosdall, R. (2004). *Doing good science in middle school: a practical guide to inquiry-based instruction*. Arlington, VA: NSTA Press.
- Kennedy, M. (1998). Form and substance in in-service teacher education: National Science Foundation. Retrieved November 3, 2010 from http://www.eric.ed.gov/ERICWebPortal/search/detailmini.jsp?_nfpb=true&_ERICExtSearch_SearchValue_0=ED472719&ERICExtSearch_SearchType_0=no&accno=ED472719

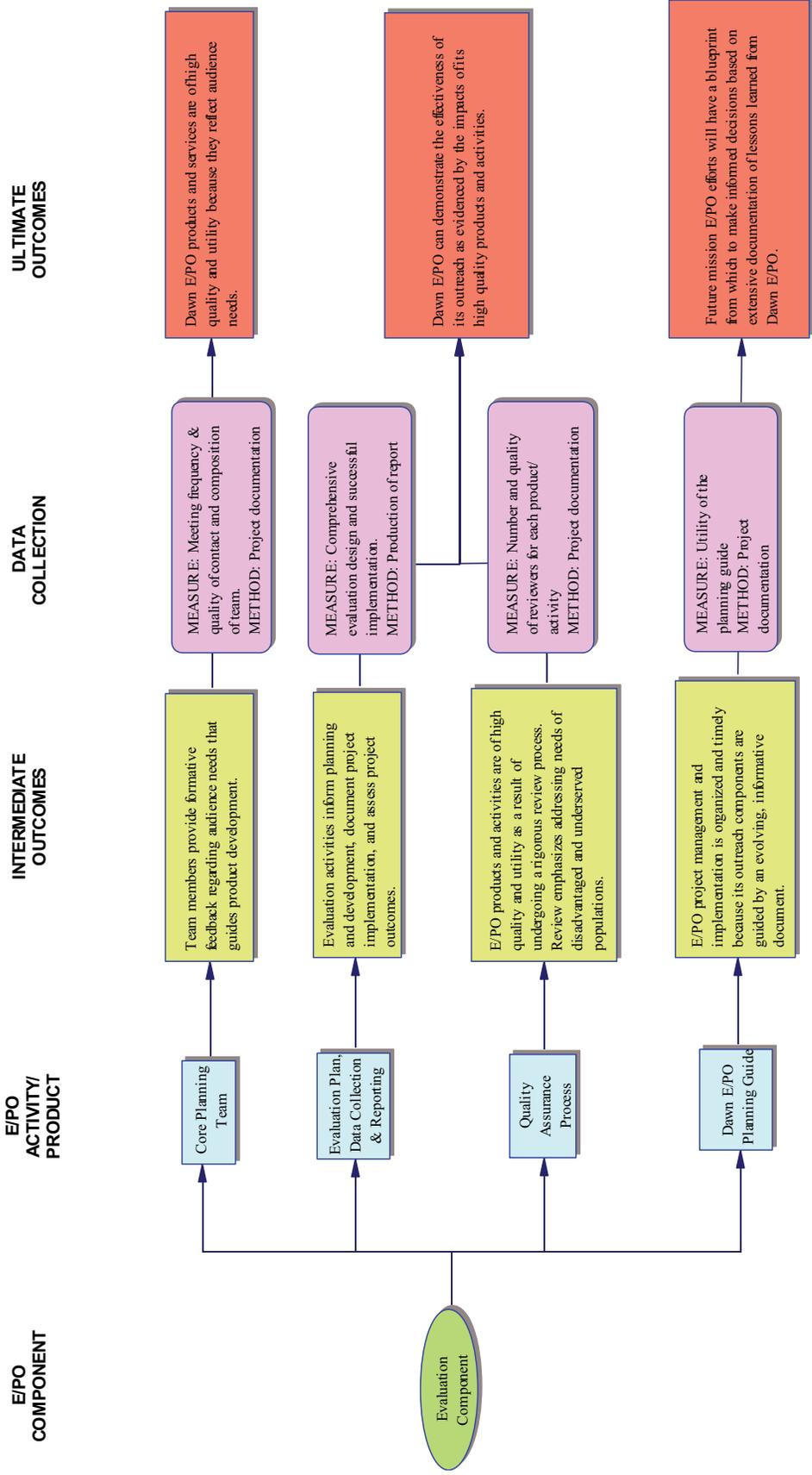
- Lohwater, T. (2010). Science communication and public engagement with science. In J. Rhoton (Ed.), *Science education leadership: best practices for the new century*. Arlington, VA: NSTA Press.
- Loston, A., Steffen, P., & McGee, S. (2005). NASA education: using inquiry in the classroom so that students see learning in a whole new light. *Journal of Science Education and Technology*, 14(2), 147-156.
- Loucks-Horsley, S., Love, N., Stiles, K. E., Mundry, S., & Hewson, P. W. (2003). *Designing professional development for teachers of science and mathematics* (2nd ed.). Thousand Oaks, CA: Corwin Press, Inc.
- Marzano, J., Pickering, D., & Pollock, J. (2004). *Classroom instruction that works: Research-based strategies for increasing student achievement*. Alexandria, VA: Association for Supervision and Curriculum Development.
- National Research Council. (1995). *National science education standards*. Washington, DC: National Academy Press.
- National Research Council. (2007). *Taking science to school*. Washington, DC: National Academies Press.
- National Science Teachers Association. (2001). *Professional development planning and design*. Washington, D.C.: NSTA Press.
- National Science Teachers Association. (2002). *NSTA position statement on elementary science*. Retrieved December 3, 2010, from <http://www.nsta.org/about/positions/elementary.aspx>
- National Science Teachers Association. (2005). *Exemplary science: Best practices in professional development*. Arlington, VA: NSTA Press.
- National Staff Development Council. (2001a). E-learning for educators: Implementing the standards for staff development. Retrieved December 3, 2010 from <http://www.nsd.org/library/authors/e-learning.pdf>
- National Staff Development Council. (2001b). Standards for staff development. Retrieved November 12, 2010 from <http://www.nsd.org/standards/index.cfm>
- Nelson, G. (2004). Issues in formal education: Keynote address. In Narasimhan, C, Beck-Winchatz, B., Hawkins, I & Runyon, C. (Eds.) *NASA Office of Space Science Education and Public Outreach Conference: Astronomical Society of the Pacific Conference Series Vol. 319*.
- Patton, M. (1997). *Utilization focused evaluation*. Thousand Oaks, CA: Sage.
- Penuel, W., Fishman, B., Yamaguchi, R., & Gallagher, L. (2007). What makes professional development effective? Strategies that foster curriculum implementation. *American Educational Research Journal*, 44(4), 921-958.
- Stocklymayer, S., Rennie, L., & Gilbert, J. (2010). The roles of the formal and informal sectors in the provision of effective science education. *Studies in Science Education*, 46(1), 1 - 44.
- Weiss, I., Pasley, J., Smith, P., Banilower, E., & Heck, D. (2003). *Looking inside the classroom: A study of K-12 mathematics and science education in the United States*. Chapel Hill, NC: Horizon Research, Inc.

APPENDIX A

Logic Models for Dawn Education and Public Outreach







APPENDIX B

Evaluation Matrix

EVALUATION QUESTIONS	DATA SOURCES	DATA METHODS
Key Question #1: What are the <u>contextual factors</u> specific to the Dawn mission that influenced the design, implementation, and impacts of the Dawn E/PO project?		
a. How did changes in the mission status affect the E/PO timeline?	E/PO team members	Focus group interview
b. How did the level funding affect E/PO tasks, direction, and potential to reach target audiences and project outcomes?	E/PO team members	Focus group interview
c. How has the project team maximized mission events and science to promote outreach?	E/PO team members Mission PI	Focus group interview In-depth interviews
Key Question #2: What are the <u>strategies</u> that promote effective development and implementation of Dawn E/PO activities?		
a. Who are the key E/PO stakeholders? What are the role and contributions of stakeholder representatives in the planning, development, and implementation process?	E/PO team members Stakeholder representatives	Focus group interview Focus group interviews
b. How has Dawn E/PO leveraged resources to enhance reach, visibility, and offerings?	E/PO team members Project documentation	Focus group interview Document review
c. What partnerships and collaborations have E/PO team members formed during the project period? What is the nature of these partnerships and collaborations? What are the characteristics of effective and ineffective partnerships and collaborations?	E/PO team members Project partners/collaborators	Focus group interview Focus group interviews
d. How has Dawn E/PO contributed to moving the field of E/PO forward through innovative practices?	E/PO team members NASA project partners	Focus group interview Focus group interviews
Key Question #3: What are the <u>components</u> that promote the effectiveness of Dawn E/PO?		
a. What role has the Dawn E/PO Guide had in the project over time? Is this appropriate? How could it be more useful?	E/PO team members	Focus group interview
b. What role did evaluation have in the project? How could it be more useful? How do other missions use evaluation?	E/PO team members Other E/PO providers	Focus group interview In-depth interviews
c. What makes the visibility and dissemination platforms for outreach effective? How can these platforms be improved?	E/PO team members Other E/PO providers Project partners Best practice literature	Focus group interview In-depth interviews Comparative analysis
d. In what ways does Dawn outreach to educators reflect best practices in STEM professional development?	E/PO team members Other E/PO providers Best practice literature Project documentation	Focus group interview In-depth interviews Comparative analysis Document review
e. How do the Dawn education materials reflect best practices in curriculum development?	E/PO team members Best practice literature Project documentation	Focus group interview Comparative analysis Document review

APPENDIX C

Dawn E/PO Team Response to Recommendations

Following are the Dawn E/PO team's response to the recommendations generated in this report.

With respect to visibility and dissemination,

- ∅ Continue to incorporate the use of scientists' podcasts, journals and such "in time" strategies as images of the day, and data sets of the day to keep the mission alive in the eyes of the public and educators. Consider adding additional features with female and minority scientists and engineers to inspire underrepresented students and members of the public.

The Dawn EPO team recognizes the need to actively engage the public, students, and educators in the process of science. To accomplish this goal, the team will continue to deploy:

-Image of the Day-

Each day an exciting image is featured on the Dawn Website, accompanied by a caption including information about the image. As the mission progresses, the detail in the captions is increased. The image of the day is also tweeted and posted to the Dawn Facebook page, where the team monitors, guides and encourages lively discussion of the image and the possible science to be gleaned from it.

-Dawn Journals and Status Updates-

Bi-weekly mission status updates and monthly Dawn Journal entries by lead engineer Marc Rayman are posted to the website, and then are tweeted and posted on Facebook.

-Facebook-

The Facebook page keeps people up to date with new results since it is overseen by a real scientist, allowing the discourse on the page to be supervised and educational. This page includes both Dawn website posts as well as news and links from around the internet to give the public a well-rounded picture of the science and achievements of Dawn.

-Diversity-

- The team has made an effort to show the diversity of the Dawn team by making the Science Team and Staff pages user friendly and including pictures of each of the scientists and engineers. These include women and minorities. Young science team members receive equal billing with senior scientists on the webpage.
 - For public events, the EPO team has a goal of representing the team's diversity by including speakers from the international team and women.
 - The EPO Team also makes available Dawn materials translated to Spanish to help encourage Spanish-speaking members of the public to engage in Dawn.
 - For Dawn's arrival, we held a "Vesta Fiesta" that connected with and engaged members of the public across the globe. By providing a mix of materials and suggestions for how the public could host their own Vesta Fiesta celebrations, the Dawn EPO team encouraged people to bring the science of Dawn into their own communities and cultures, which was a resounding success.
- ∅ Continue to engage educators, students and the public in the excitement of the Dawn Mission by emphasizing the "newness" of the Dawn discoveries. Vesta arrival will offer a unique opportunity as a yearlong encounter to allow for continuous communication of the mission to the public.

The Dawn EPO team is committed to bringing the excitement of the Dawn Mission by emphasizing the "newness" of the Dawn discoveries.

-Image of the Day-

Each day the Dawn Website features what is “new” with the mission: a new image is featured on the Dawn Website, accompanied by a caption including information about the image.

-Dawn Journals and Status Updates-

Bi-weekly mission status updates and monthly Dawn Journal entries by lead engineer Marc Rayman are posted to the website, and then are tweeted and posted on Facebook. These update the public on mission activities, like transiting to new orbits, reaching data goals, or making new decisions and discoveries.

-Dawn E-news-

Dawn E-news highlights the main new science results from Dawn in each issue.

-Facebook and Twitter-

The Dawn Facebook page and Twitter feed is constantly updated with news and tidbits from the mission, including images, discussions at science team meetings, and at professional meetings.

-Vesta Fiesta-

Vesta Fiesta was a major undertaking by the EPO team. The goal of the Fiesta was to highlight Dawn’s achievements, make connections to build a network of Dawn supporters world-wide, and to provide educational materials for the public and schools. Using a strategy of online and media publicity, the Dawn EPO team built a website to host and promote the Fiesta. The EPO team held a large Flagship Fiesta in Pasadena, CA with booths, games and activities, and presentations from the science team. Online live and pre-recorded materials were made available, as well as games and activity plans. An online sign-up for Fiestas was used to post private and public Fiesta locations on an interactive map so that interested parties could connect with hosts in their area. Live broadcasts from the flagship event in Pasadena were available for those who could not make a Fiesta. Over 1000 people attended the Flagship Fiesta, and over 100 remote Fiestas took place in 9 countries.

- Ø Consider the development of conferences and webinars that maximize Vesta arrival along the lines of the Educator Launch Workshop and Mars Flyby Educator Workshop.

Educator conferences tied to mission events have yielded good participation in the past as evidenced by the success of the launch (2007) and fly-by (2009) workshops. Dawn E/PO plans to build on lessons learned from these events and continue to hold workshops across the country for educators to learn about the storyline of Dawn and how the mission contributes to our overall understanding of the origins of the solar system. Dawn E/PO will continue to leverage other small body mission events and NASA funded projects to bring the science and educational materials to educators in grades K-12. What follows is an outline of executed and planned professional development featuring Dawn.

Educator Workshop, Date	Event and Location	Summary
Exploring Small Worlds October, 2010	EPOXI Encounter with Hartley 2 Denver Museum of Nature and Science, Colorado	McREL teamed up with NASA’s Discovery Program missions, University of Maryland, and the Space Science Institute’s National Center of Interactive Learning (NCIL) to herald the EPOXI, Stardust-NExT, and Dawn missions’ arrival at their respective comets and asteroids in the next twelve months.
NASA Week October, 2010	EPOXI Encounter with Hartley 2 Fayetteville, Tennessee	Coordinated by D/NF E/PO manager Shari Asplund on behalf of the Program Office at Marshall Space Flight Center, the educators in Fayetteville reviewed current mission highlights, led hands-on activities, in a three-hour educator workshop for 30 pre-service and in-service.

SD NExT Educator Workshop February, 2011	Stardust-NExT Encounter with Tempel 1, Pasadena California and Ithaca New York	Coordinated by Stardust NExT E/PO, McREL presented Dawn activities at Stardust-NExT educator workshops at JPL and Cornell University. The conference featured presentation by project manager Bob Mase.
Thrill of Discovery March, 2011	Thematic workshops in Pasadena California, Houston Texas, Champlin Minnesota, and Laurel Maryland	The workshop focused on the many significant events taking place in 2011 with Discovery and New Frontiers missions: EPOXI comet Hartley 2 flyby, Stardust-NExT comet Tempel 1 flyby, MESSENGER orbit insertion around Mercury, Dawn orbit around Vesta, and Juno and GRAIL launches. 160 participants attended the multi- city workshop. The conference featured a presentation by Dr. Marc Rayman.
NSTA National Conference	Year of the Solar System Short Course in San Francisco California	The day-long workshop featured Dawn mission activities including In Search Of...Modeling in 3- D, Veggie Light Curves. 30 participants attended this event sponsored by the Planetary Science Education and Public Outreach Forum.
Small Bodies Big Concepts July, 2011, June, 2012	2-week professional development in Denver Colorado, Tucson, Arizona	Sponsored by a NASA EPOSES grant, this summer McREL pilot tested the professional development that combines an instructional design framework, <i>Designing Effective Science Instruction</i> , with current and important space science discoveries (imagery and related data), including NASA mission science results and related E/PO instructional materials from Dawn, NEAR, Deep Impact, and Stardust.
School Science and Mathematics National Conference November 12, 2012	Colorado Springs, Colorado,	Presentation of STEM lessons that connect real-world science to your middle and high school curriculum. Mathematics was used to help figure out: Where are you? (to compare planet sizes and distances) How Bright Are You? (to look for trends in asteroid magnitudes through graphing) and discover some fun Patterns in the Sky (to predict new planets). This workshop was applicable to all mathematics and space science educators.
Colorado Science Conference November	Denver, Colorado	Ongoing state science education meeting each fall.
NASA Week, November 28- December 1	Rainsville Alabama	Professional development for educators featuring Discovery Mission E/PO materials for teachers in association with student classroom visits.
Vision of Discovery March 10, 2012	Multiple locations	A follow-up to the 2011 Thrill of Discovery workshop, this professional development will feature findings from Dawn and MESSENGER.

∅ To broaden the visibility of the Dawn Mission and further dissemination of Dawn E/PO materials and resources to educators, consider ways to create a database of individuals who could get materials into the hands of the informal and formal educators, including perhaps district science curriculum coordinators and parallel individuals in informal science networks.

Based on feedback from our advisory meeting, Dawn's EPO team will work to establish a key point of contact within NASA EPO circles that can disseminate to the following targeted groups. These groups can then distribute to their mailing lists and contacts.

- Jason Project
- MESA – Math Engineering and Science Association
- NSTA – National Science Teacher Association
- ERC – NASA Educational Resource Centers

- AESP – NASA's Aerospace Education Services Project
- Night Sky Network
- Amateur Astronomer
- AAPT – America Association of Physics Teachers
- ASTC – Association of Science and Technology Centers
- NAA – National After School Association
- National Association of Earth and Space Science Teachers
- National Center for Earth and Space Science Education (NCESSE)
- NASA Nation Wide
- CS3 - Council of State Science Supervisors
- Twitter and Facebook associations
- Don Boonstra from the Planetary Science Education and Public Outreach Forum

(SEPOF) is working with NSTA in the area of e-learning. We have scheduled a call with Don to determine first steps for working with NSTA e-learning to determine best approach for integration of Dawn EPO with NSTA.

- Ø Because educators use Internet search engines to find space science materials for their students, ensure that the Dawn Web site is tagged to appear at the top of results for searches on relevant space science topics in Google Searches Dawn does not come up for “asteroid”, or “solar system” what are some ways we can change that?

The updated code Raytheon used for the new Dawn website redesign will help increase Search Engine Optimization (SEO). Just a few specific examples of updated coding practices include the use of HTML tags **<h1>** and **<h2>** (header 1 and header 2), which helps Google web page crawlers identify page headers. In addition, using the new Dawn website uses text for page headers instead of images, which that also helps improve page ranking because Google crawlers prefer the use of text instead of images to display important names, content, or links.

Below are some basic SEO guidelines we will follow going forward. We will do a review of the new Dawn website after it launches to see what improvements can be made. This will be good timing with adding Google Analytics to the website. Being mindful of these guidelines will help us improve ranking in Google searches for certain keywords and phrases, such as “asteroid” or “solar system.” For example, there are ways we can use these terms more often in page titles, page headers, or in page content itself- such as within articles and activities.

We will determine the specific words or phrases we would like search engines to associate with the Dawn website, in addition to “asteroid” and “solar system,” and we will focus on incorporating these terms into the Dawn site during the SEO review process.

In reviewing Dawn web stats keyword searches, it looks like we use the following words well, since this is what keywords people most often used in finding the Dawn website: *Dawn mission, NASA Dawn, Dawn spacecraft, Dawn, Dawn Vesta, Mission Dawn, Dawn, Mission, NASA, Spacecraft, Vesta, Ceres.*

Search Engine Optimization Guidelines

<p>1. Make sure every page has a unique title tag (i.e. the page title that shows up in the top, left-hand corner of a browser window)</p>	<p>* This is one of most important places to include good keywords.</p>
<p>2. Use keywords in page body text.</p>	<p>For example, when referencing Ceres and Vesta, perhaps use “asteroid Vesta and dwarf planet Ceres” to increase page ranking for keywords “asteroid” or “dwarf planet.”</p>
<p>3. Have well-named page headers by using keywords in content between H1 and H2 tags.</p>	<p>* This is also one of the most important places to include good keywords.</p>
<p>4. Use targeted keywords when naming links within a website.</p>	<p>For example, instead of naming a link “+ Get directions,” the link should include specific keywords, such as “Directions on Creating Dawn Mission Patch.”</p> <p>A best practice in naming links is to make sure the name of the page matches up to the words you clicked to get there. For example, if you click on a link or button that says, “Hot mashed potatoes,” the site should take the visitor to a page named, “Hot mashed potatoes.”</p>
<p>5. Image Alt Tags should use good keywords whenever possible.</p>	<p>Whenever logical, name the JPG image with good keywords. (i.e. Save the JPG as <i>asteroid-vesta.jpg</i>, rather than <i>vesta-thumb.jpg</i>)</p>
<p>6. Review keywords and phrases in Google Analytics to see what types of searches people are doing to find your website, and increase the frequency of use of those particular keywords in current and future page content.</p>	<p>Keywords can be added to page titles, image ALT-tags, in page headers, and within page content itself.</p>
<p>7. Make URLs search-engine-friendly by naming them with clear keywords.</p>	<p>For example, a URL named www.puppyfun.co.uk/puppyhealth/vitamins’ is more search-engine friendly than www.puppyfun.co.uk/11789/s201.htm’</p>
<p>8. Keep content fresh. Updating regularly and often is crucial for increasing traffic.</p>	<p>One way this is often done is through regularly updating a blog.</p>
<p>9. Use social media platforms to distribute links to fresh content on your website.</p>	<p>Whether recommended, re-tweeted, or re-distributed by someone else, this strategy multiplies the number of opportunities to drive traffic back to your website.</p>

∅ Explore new ways to link Dawn E/PO to existing listservs within NASA and in the broader education and public outreach communities.

Dawn E/PO contacted the Planetary Science E/PO Forum (SEPOF). A spreadsheet of list services, partner networks, and social media was compiled for use with Year of the Solar System (YSS) efforts. We received this list in January, 2011. It has been used extensively to connect with potential audiences specifically in promoting the Vesta Fiesta events that occurred throughout the world in August 2011. As

the spreadsheet is updated, it will be a useful tool for recruiting participation in other planned Dawn E/PO events through the end of the mission.

With respect to new platforms for outreach,

- Ø When considering the development of social networking platforms for Dawn E/PO, carefully consider goals and intended outcomes for participants during development.

Traditional distribution platforms (e.g. hard copy documents, CDs and DVDs, Listserves, web pages, e-news), are being augmented by the use of social networking. In brief, people are creating their own networks, points of contact, and making connections to areas of personal and professional interest. The trend is to search by “Googling,” going to Wikipedia, checking out Youtube, and Facebook.

Dawn’s guiding principle 2 – using practical and technologically efficient systems for reaching, communicating with and disseminating products and services to educators and the public, demands that we develop a presence in these new distribution platforms.

We currently have the Dawn Video available through Youtube and Google Video, we have a Dawn Facebook page, and we are monitoring the Wikipedia page for opportunities to update information there and to make sure that the information posted is accurate and current. Finally, we are working to increase our presence on any Google search done on Dawn “key words,” such as asteroid, solar system, Vesta, and Ceres.

All of these efforts are attempts to draw our audiences (e.g., teachers, group leaders, and independent learners) to current accurate information and materials developed by Dawn’s E/PO to build anticipation and expectation for the Dawn spacecraft’s arrival at Vesta and then Ceres.

The following are the expected outcomes of using Social Networking:

1. Social networking provides speedy, up-to-date mission details that draw people to targeted and relevant pages on the Dawn website
2. Social networking provides opportunities to develop a virtual community of Dawn Mission followers
3. Social networking provides opportunities for posting local activities and events for wider participation
4. Social networking provides a wider net for people to find and interact with Dawn information and materials
5. The Dawn webpage provides the anchor to all of these social networking activities. Links are used to draw teachers, group leaders, curators, and independent learners to Dawn materials designed to inform and create anticipation for the arrival of Dawn at Vesta and Ceres

The Dawn EPO team will set time for revising our logic model for evaluation to measure progress toward goals and outcomes for social media. Building on the success of gaming models, Dawn’s EPO will seek

- to make visitors feel as though they are participating in the Dawn mission.
- to communicate the epic nature of the Dawn mission.
- to make people feel that they are “better” by having participated in the Dawn mission.
- to engage people in a frequent asynchronous “conversation” with Dawn.
- to be inclusive by creating a bigger than the individual activity.

In addition to these general public activities, we will seek to provide forum based support for best formal and informal learning practices.

- Ø Look across NASA missions that are using social networking to see how it is being used and to identify seemingly effective strategies for such dissemination efforts.

Dawn E/PO has made inquiries of the Planetary Science E/PO Forum about learning from other missions and how they are using social media. Several online webinars have been offered this year including:

- “The ‘Social’ Social Media.” A chance to find out about the innovative social media work going on in NASA E/PO and get to know some of the “experts” among us was held on August 29, 2011.
- PD Webinar: Making the Most of Twitter: Tips, Tricks, and Analytics. In this session ways to effectively build your twitter community, strategically follow and get followed, and track your impact on the Internet were discussed. Methods to use your twitter feed to update other social media were also addressed. Examples showcased were Tweetie (Mac and OSX) and TweetDeck (multi-platform). This session was held on June 15, 2011.

We will incorporate ‘best practices’ in social media from both these webinar events and from mission E/PO members (e.g., Pamela Gay).

- Ø Incorporate evaluation into the use of social networking to not only ensure that targeted outcomes are met, but also to help to inform the broader field of E/PO related to this new strategy for outreach.

Dawn’s EPO team will work closely with our evaluation team to leverage opportunities for evaluation of our EPO product and services through our emerging social network efforts with Facebook and Twitter. Examples could be, “like” votes for vignettes or activities.

With respect to professional development,

- Ø Continue to provide opportunities for professional development around the Dawn educational materials. Consider creating professional development webinars that can go deeper into the science behind the materials and can be archived on the Dawn Web site. Also consider short video clips, and demonstrations of teachers in classrooms using Dawn materials to maximize the likelihood of implementation and to ensure the materials are used effectively.

As video and webinar endeavors tend to be costly, we will work to leverage existing opportunities. For example, we can consider videotaping short clips of planned activities at Dawn’s Colorado Science Conference professional development workshop in November 2011, and the *Small Bodies Big Concepts* (SBBC) two day follow up workshop in February 2012. The clips would help teachers visualize elements of both content and pedagogy and in this way deepen the reach of our Educator Guides. In the same vein, videotaping elements of the SBBC field test, in June 2012, in Tucson, AZ can also be considered if funding allows. Many Dawn materials will be highlighted in this 80 hour professional development teacher workshop.

- Ø If not already doing so at in-person workshops, spend time orienting participants to the Dawn Web site to familiarize them with the myriad ways in which it serves to provide mission updates, science and materials to those who access it.

Here are some ways that we will acquaint conference participants and visitors to our new website:

- Face-to-face orientation/walk through of the different features and sections of the website.
- Featuring podcasts more prominently—Dawn kids
 - Facebook
 - E-News
 - Homepage
- Use Google Analytics to assess most frequently visited pages to inform whether we are targeting audiences appropriately
- Using a wall/slideshow to feature upcoming events/activities/modules
 - Education section
 - Homepage
- We will explore creating an online video highlighting features and navigation

- Ø Continue to offer professional development that focuses on active learning and an understanding of how people learn.

See response to next recommendation.

- Ø Continue with plans for longer duration professional development efforts that will allow educators to go deeper into Dawn science and focus on effective science instruction. Consider ways in which evaluation will be incorporated into these efforts to ensure that targeted outcomes will be achieved.

Many NASA EPO workshops are for a single day. There is really no plan for follow-up with participants who have attempted activities and who have questions and/or feedback. Dawn's EPO will work to establish longer duration professional development by exploring the use of Go-to-Meeting, Webinars, and social networking to establish best practices and networks of support for effective change in formal and informal educational practices.

An opportunity to deepen our capacity rose through Dawn E/PO's collaboration in a NASA EPOSES grant, *Small Bodies Big Concepts (SBBC)*. The *Small Bodies, Big Concepts* course being offered during the summers of 2011 and 2012 includes 80 hours of face-to-face professional development with additional online elements as teachers implement lessons. Designed for middle school teachers, the workshops are facilitated by McREL staff and NASA mission scientists and engineers.

SBBC will develop and test PD that uses an instructional design framework, *Designing Effective Science Instruction*, to investigate current and important space science discoveries incorporating visual imagery and associated data. NASA mission science results and related E/PO instructional materials from Discovery missions to small bodies—NEAR, Deep Impact, and Stardust, EPOXI and Stardust-NExT as well as Dawn—will be leveraged using best practice in how both adults and students learn. Teachers deepen their own planetary science background, skills and understanding of visual data and pedagogy to enable them to implement lessons in their home classrooms effectively.

This collaboration has already allowed Dawn E/PO to develop additional storylines augmented by activities that unpack the underlying science and engineering. *SBBC's* approach has provided a pathway for the future Dawn visual imagery, as well as EPOXI, and Stardust/NExT and other missions of Discovery, to be integrated into existing middle school science, technology, engineering, and mathematics (STEM) curricula. The development of a *Small Bodies, Big Concepts* Facilitator's Guide will include background information, procedures, and sample rubrics so that NASA professional developers will be able to use the course.

Evaluation of *SBBC* is part of the grant's work. Preliminary work has assessed the approach as viable and valuable. Results from the first workshop will inform revisions to *Small Bodies, Big Concepts* prior to final development, evaluation and dissemination. These instruments as well as results will be leveraged as potential tools in future Dawn E/PO evaluation.

With respect to future educational materials development,

- Ø Continue current strategies in materials development that will ensure that Dawn educational materials continue to be of high quality and utility to educators including aligning materials to science education standards, incorporating scientific inquiry into activities, and creating materials that are effective with diverse learners that attend to differences in learning styles.

The Dawn EPO team remains committed to these goals and will continue its efforts to be inclusive and effective in its products.

- Ø Educators want data-rich exercises for their students. Consider developing activities and materials that maximize Vesta arrival and the duration of the encounter by taking advantage of the continuous data collection efforts of the mission.

The Dawn EPO team is work with the science team and NASA Media to provide avenues for delivering data in near real time. We are working with “Moon Zoo” to create “Vesta Zoo” in which the public will be able to participate in data analysis. We are providing real time data through the development of a Vesta component to Eyes on the Solar System. We are also investigating providing real time information as to the status of the spacecraft, e.g. which instrument is on, altitude of orbit, etc.

We are in the process of releasing our CM#5 on the origins of the solar system and Dawn's role. We will also leverage the existing Data Analysis and Generalization module: (http://genesission.jpl.nasa.gov/educate/scimodule/data/index_data.html). We will also work with the Heliophysics Forum and Don Boonstra.

- Ø Continue to involve evaluation as a key program component, through continued pilot- and field-testing of newly created materials.

The Dawn EPO team is committed to continued pilot- and field-testing of materials. We are actively seeking avenues for expanding the reach of our pilot- and field testing pool of educators, widening our demographics, and geographical regions. We continually recruit via workshop signups, web signups, and signups at presentations.

Dawn has a unique and valuable philosophy toward education and public outreach. The Dawn team seeks to “leave a legacy” for other E/PO providers so that Dawn E/PO efforts will live beyond the mission. With respect to leaving a legacy for other E/PO providers,

- Ø Consider a way to “tell the story” of Dawn E/PO from inception through implementation. This could be part of the Dawn E/PO Guide or through other venues such as a book or a series of journal articles that will be accessible to other outreach providers. Focus such an effort on the decision-making process, the development process, successes and challenges, lessons learned and key findings from evaluation.

This was done in some degree in the Dawn Book (not yet published) through the EPO chapter. We are looking for avenues to keep our materials active and in development beyond the length of the Dawn mission. Further publications are a possibility since we have, publishing articles, as a priority in our task list. We have collaborated and continue to collaborate with the OSIRIS-REx E/PO to port our Dawn E/PO materials to them for continued development and dissemination.