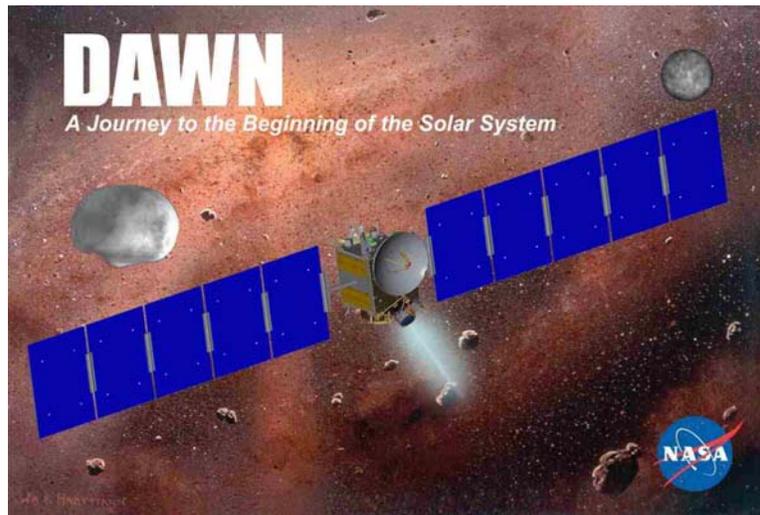


DAWN MISSION EDUCATION AND PUBLIC OUTREACH: SECOND ANNUAL EVALUATION REPORT



Submitted to:

Dawn E/PO Team

Submitted by:

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May 30, 2006

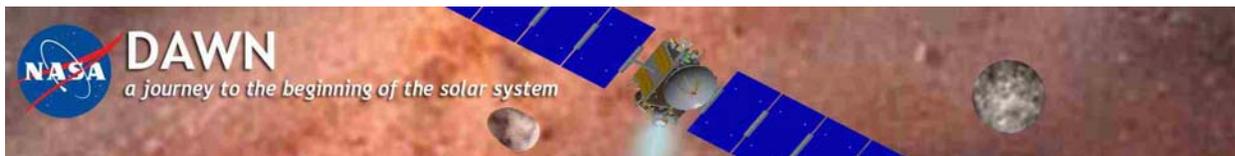
Cover credit: Background painting, "A cocoon nebula, perhaps the primordial solar nebula" by William K. Hartmann. Courtesy of UCLA.

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INTRODUCTION

As part of its Discovery Program, NASA awarded funding for the Dawn mission in December 2001. Dawn, the first mission to the Main Asteroid Belt, will investigate Ceres and Vesta, two of the largest protoplanets remaining intact since their formation. The mission will address 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.¹ 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.²

Dawn begins its trek with a launch in 2007. The craft will travel four years before it reaches Vesta and almost another three years to reach Ceres with an end of mission date of 2015.

THE DAWN EDUCATION AND PUBLIC OUTREACH INITIATIVE

Dawn E/PO consists of a national team of Education and Public Outreach (E/PO) specialists from the University of Maryland, New Roads School (CA), and Mid-continent Research for Education and Learning that develop and disseminate high quality educational resources and materials in support of NASA's Dawn Mission. Dawn E/PO delivers emerging technology and scientific knowledge to the public, to classroom teachers and students, and to informal educators and participants. Through the Dawn E/PO Web site, students, educators, and the public engage in age-appropriate mission activities that include, for example, analyzing images for cratering, doing photometry on images to produce light curves, and discussing with mission scientists the importance of Vesta and Ceres to our understanding of solar system origins. Dawn E/PO concurrently uses innovative, educational tools to encourage student collaboration, visualization, and peer-review in ways that conform to and further define the national standards in math and science education.³

Target Audiences

Dawn's target audiences include a.) educators (teachers and students, K–Post Secondary); b.) general public members (businesses, parents, politicians, adult learners, and retired); c.) media journalists⁴ (national and local, broadcast, print, trade publications, Internet, instructional TV, radio and public service announcements); d.) informal educators (science museums/centers, arts community, speakers bureaus, youth programs, and service clubs); and e.) disadvantaged and underserved populations.

E/PO Approach and Outcomes

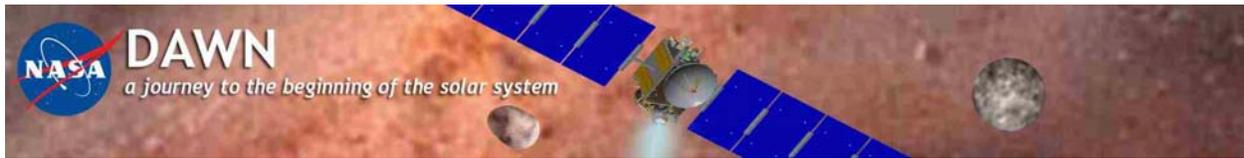
The Dawn E/PO team employs a strategic outreach approach, which supports NASA's vision and the Dawn E/PO goals. This approach is based on four components: Delivery, Communication, Education Development, and Evaluation. In conceptualizing its work based on the four components of the outreach

¹ Dawn: A Journey to the Beginning of the Solar System (2002). The online site for the Dawn mission. Retrieved from the World Wide Web, June 5, 2003, <http://www-ssc.igpp.ucla.edu/dawn/>.

² Dawn Science Web site: <http://www-ssc.igpp.ucla.edu/dawn/>

³ Excerpt from the Dawn Mission E/PO final proposal, July 21, 2000.

⁴ Media requests are deferred to JPL media relations, however Dawn E/PO provides press packets and resources for media professionals via the Dawn mission Web site.



model, the E/PO team identified eight, long-term ultimate outcomes, which 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 (refer to Appendix A). The following lists the eight ultimate 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.
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.
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.

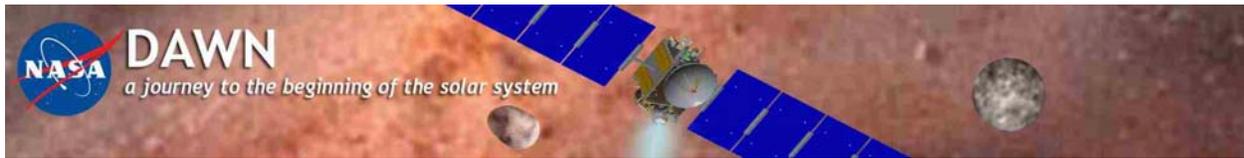
EVALUATION DESIGN

The evaluation emphasizes a collaborative approach to evaluation, which requires the active participation of E/PO program staff in the design and implementation of the evaluation work. The evaluation design includes both qualitative and quantitative methods in order to provide meaningful formative and summative information. Formative evaluation information provides feedback to project staff, which is intended to guide project planning and development, and allows for a continuous reflective process throughout project implementation. Summative evaluation information addresses the progress made toward intended outcomes of the outreach effort with a description of how the desired outcomes were realized. Furthermore, logic models were developed as a tool for defining and depicting how project activities connect to project intermediate and ultimate outcomes.

EVALUATION QUESTIONS

There are seven key evaluation questions, which link to E/PO intended project outcomes and are supported by additional evaluation questions, information sources, and data collection methods (see Appendix B for the Evaluation Matrix). The following key evaluation questions focus on impacts of the outreach initiative on the public, teachers, and students, as well as the quality and utility of materials and resources.

1. Do users of the Dawn E/PO products and services perceive them to be of high quality and utility?

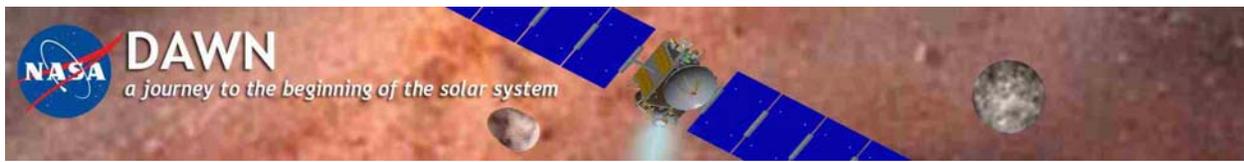


2. To what extent do formal and informal educators and students access and use the Dawn E/PO materials and resources?
3. To what extent do public members access and use the Dawn E/PO materials?
4. Are participating students engaged and interested in the Dawn mission science as a result of using E/PO materials?
5. Do participating students have an increased understanding of the formation of the solar system?
6. To what extent has the Dawn E/PO effort enhanced participating teachers' capacity to teach space science?
7. To what extent has the Dawn E/PO effort affected public interest in and understanding of the Dawn mission?

DATA COLLECTION

The evaluation design encompasses both qualitative and quantitative data collection methods and, in some cases, more than one method is used to address a given evaluation question in order to strengthen the credibility of the findings. The field-test component of the evaluation includes an experimental design with pretest and posttest assessments of randomly assigned treatment and control groups. This design is employed in order to assess the impact of the Dawn E/PO curriculum materials on student learning. Data collection methods include pilot and field-test instrumentation for teachers and students, Web statistics, workshop participant feedback forms, Web-based surveys, and dissemination data.

Evaluation activities during the reporting period included analysis of the field test data for the *History and Discovery of Asteroids* content module. Evaluators developed teacher and student data collection instruments for pilot and field testing of the *Find a Meteorite* (FAM) activity and the second E/PO content module, *Ion Propulsion*. Additionally, E/PO staff recruited teachers and schools for pilot testing FAM. The findings presented in this report are based on the results of the fall 2004 field test and a review of outreach activities through project documentation and monthly reporting.



FINDINGS

During the second year of Dawn E/PO, the project experienced several occasions in which outreach providers were asked to cease all project work. These lapses affected the development and delivery timelines for the outreach work as well as the implementation of evaluation activities. With respect to these delays and in keeping with the original annual timeframes designated for reporting, this evaluation report covers activities occurring from October 2004 through September 2005. This section presents findings related to the seven evaluation questions and is organized into the following sections: Developing and Disseminating High Quality Products and Services, Reaching and Impacting Students, and Reaching and Impacting Formal and Informal Educators.

DEVELOPING AND DISSEMINATING HIGH QUALITY PRODUCTS AND SERVICES

The Dawn E/PO team develops and disseminates a variety of mission-related products and services to target audiences. E/PO products undergo a rigorous review process that includes expert review, pilot and field testing, and multiple revision periods. E/PO products include educational materials for a variety of target audiences and are disseminated primarily via the Web site, professional conferences, formal and informal educational settings, and public E/PO engagements. E/PO services include professional development workshops, conference presentations, Web site development, and information dissemination. This section presents development and dissemination information about the different E/PO products and services and describes how team members ensure their quality and utility. In addition, there is special emphasis on the quality and utility of the curriculum modules and activities based on feedback from pilot- and field-test participants.

Ultimate Outcomes

1. E/PO efforts reach broad target audiences through high quality products and dissemination mechanisms.
6. E/PO products and services are of high quality and utility because they reflect audience needs.

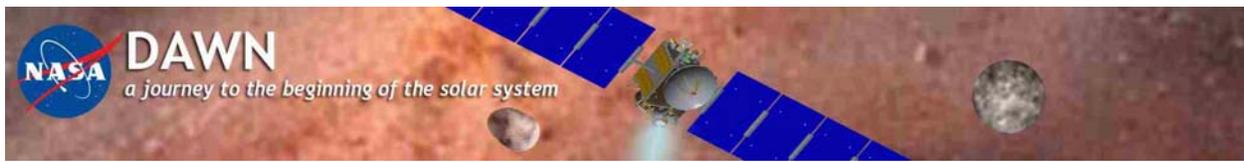
Key Evaluation Questions

1. Do users of the E/PO products and services perceive them to be of high quality and utility?
2. To what extent do informal and formal educators and students access and use the E/PO products and services?
3. To what extent do public members access and use the E/PO products and services?

Product Development

During the project period, the E/PO team continued with efforts to develop and revise outreach curriculum materials. Outreach providers focused on refining two content modules, *History and Discovery of Asteroids* and *Ion Propulsion*, and one stand-alone activity, *Find a Meteorite*.

The *History and Discovery of Asteroids* content module is intended to engage middle school learners in the wonder and curiosity that is inherent in discovery. Participants explore the historical sequence of events that led to the Dawn mission. The module provides a real-life example that allows students to experience science and science thinking over time, from the discovery of asteroids and the asteroid belt to the new science and discovery that is part of the Dawn mission. The module includes teacher guides and student activities as well as vignettes that provide historical snapshots of the discovery of asteroids, the technology used or developed, and the social and political issues at the time. The content module consists of inquiry-



based learning materials that guide students through a five-phase learning cycle. The module is aligned with the *National Science Education Standards* and the American Association for the Advancement of Science benchmarks for science education. During the project period, this product underwent field testing and final revisions. Team members also executed a plan for posting the module online so that users could search and access different components within the model according to their instructional needs. An Independent Learner Guide and an Informal Learner Guide also were developed in order to provide broader target audiences with an appropriate format for engaging in the module's activities.

The *Find a Meteorite* activity introduces the importance of meteorites to the understanding of the origin of the solar system. Since scientists believe that some meteorites are pieces of the asteroid Vesta, they may be very old remnants of the solar system in its earliest stages. The activity provides information and insight that allows participants to share scientists' expectations, based on meteoritic samples, of what we will find when the NASA's Dawn Mission visits Vesta and Ceres. Comparison between actual data and the meteorites here on earth may confirm that we are in possession of very valuable material indeed. The hands-on activity is an introduction to meteorite identification that aims to help learners differentiate between meteorites, and terrestrial rocks. During the project period, all components of the FAM activity were completed and a small number of teachers began testing a pilot version of the activity. During the fall of 2006, educators in formal and informal settings will field test the FAM activity. The next annual report will include a presentation of findings from both the FAM pilot and field tests.

The second E/PO content module entitled, *Ion Propulsion*, focuses on concepts of ion propulsion and challenges high school students to consider the guiding question: "How do we get to the asteroid belt?" The activities may provide students with the opportunity to learn about both conventional propulsion systems as well as the ion propulsion system utilized by the Dawn mission. By comparing the different systems, students recognize the limitations of conventional propulsion systems and realize why there has not been another mission to the asteroid belt prior to Dawn. As the module unfolds, students develop their background knowledge of Newton's Laws and Coulomb's Law through readings, hands-on activities, discussions, an interactive simulation, manipulation of data, or exploration of resources. Equipped with an understanding of these physical science concepts, students then experiment with a computer-based ion propulsion simulation developed at the Jet Propulsion Laboratory as part of the Next Generation Ion Engine program. In subsequent sections, students synthesize their knowledge and, ultimately, demonstrate their learning relative to the standards addressed in the module. During the project period, E/PO staff worked with science team members in developing and refining various module components including a PowerPoint presentation, an ion propulsion interactive simulation, student texts, a teacher guide, and student assessment activities. Team members submitted the draft of the module to JPL project content review and completed technical edits based on feedback. *Ion Propulsion* will be field tested in high school classrooms during the fall of 2006.

Rigorous Quality Assurance Review

The Dawn E/PO team has designed and implemented a product development and quality assurance process that includes initial peer and expert reviews, pilot and field testing in multiple sites, and iterative revising (see Figure 1). This development process ensures that the Dawn E/PO products are appropriate for the intended educational settings; meet the needs of students and educators; impact the knowledge, skills, and interests of participants; and are of high quality and utility to users. Each E/PO formal and informal education product will go through this process before it is broadly disseminated.

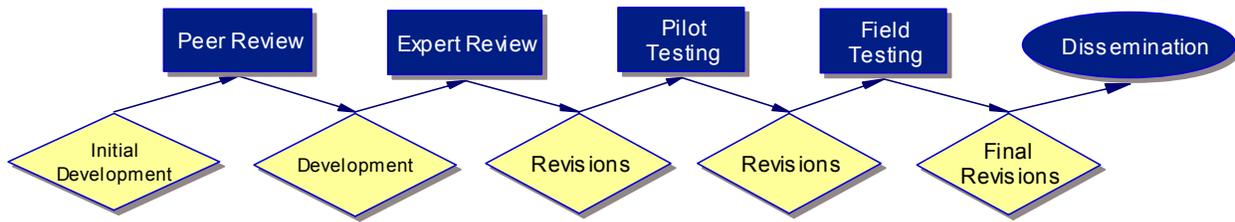
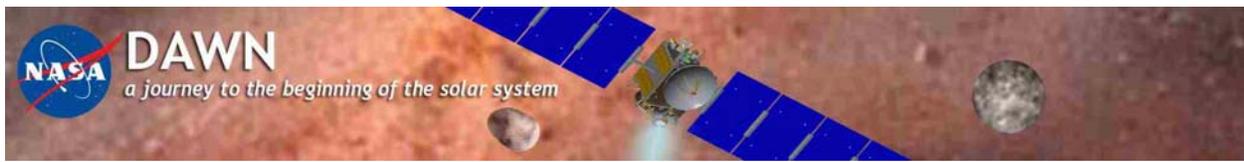


Figure 1. Dawn E/PO product development and quality assurance process.

The purpose of the peer review sessions is to present product components to educators in order to collect initial feedback regarding its quality and utility such as, grade-level appropriateness, potential to create student interest, necessary student experiences and background information, anticipated instructional time, and potential in developing student inquiry skills and understanding of the science concepts. The expert review process provides team members with specific feedback on the scientific and technical aspects of the content of the E/PO materials. The purpose of pilot testing products is to gain preliminary feedback from a small number of users regarding the appropriateness, fit, quality, and utility of the product. This allows for the identification of issues, challenges, and characteristics regarding the product's design, content, pedagogy, implementation, and efficacy with students. The purpose of the field test is to study the revised materials in a larger number of settings and to examine the effectiveness of the product in achieving teacher and student goals. The field test also generates important formative feedback, similar to the pilot test, to guide further revisions and modifications.

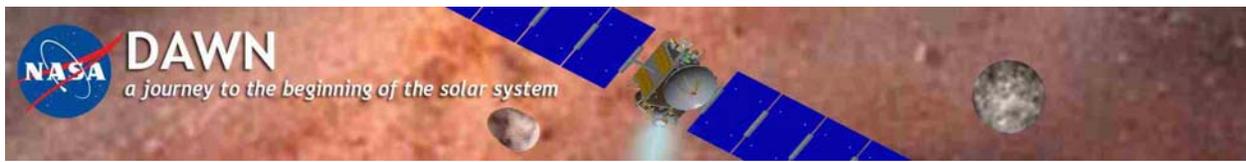
As part of this process, E/PO team members responded to the recommendations presented in the last annual report (see Appendix C). In summary, E/PO team members forged new partnerships with science museums and centers, professional associations, and a higher education institution. Team members also have developed a plan for educating scientists and engineering teams about Dawn outreach materials and resources. As recommended, all E/PO materials continue to undergo the quality assurance review process. Additionally, team members have identified various mechanisms for recruiting a diverse representation of educational settings.

During this project period, the E/PO team facilitated two peer reviews, also referred to as Core Planning Teams, with educators attending the Math and Science Institute at Mesa State College and the Kansas Association of Teachers of Science conference. The peer review sessions focused on specific activities within the Ion Propulsion content module. In total, E/PO team members received peer review feedback from 15 participants on these activities. Additionally, four teachers across two schools completed field testing of the *History and Discovery of Asteroids* in their classrooms. Those results are presented in the following sections.

User Perceptions of Product Quality and Utility

All field-test teachers provided in-depth feedback via the *Dawn Module Evaluation* survey regarding the quality and utility of the *History and Discovery of Asteroids* content module in one seventh-grade classroom and three eighth-grade classrooms. Overall, 75 percent of teachers indicated that the materials were very useful and of high quality. On a scale of 1 to 7, 1 being "not difficult" and 7 being "very difficult," teachers indicated that it was somewhat difficult to adapt the module to their teaching settings ($\chi=4.00$). Teachers were asked to indicate the extent to which they agreed or disagreed with several statements regarding the quality and utility of the content module (1=strongly disagree; 2=disagree; 3=neither agree nor disagree; 4=agree; and 5=strongly agree). Figure 2 presents the percentage of respondents who agreed or strongly agreed with statements related to the content and design of the module, its appropriateness for diverse students, and standards and assessment.

As shown in Figure 2, all teachers thought that the content was scientifically accurate. Half of the teachers thought that the module promoted inquiry-based, hands-on learning; was culturally appropriate and



developmentally appropriate, and allowed teachers to engage in ongoing assessment. Half of the teachers reported that the alignment with the standards enhanced the module's utility; however, one teacher commented that state standards, not the NSES standards, were the main drivers of their instructional decisions. Teachers rated other items lower such as the appropriateness of the materials in meeting the diverse needs of students. These teachers indicated that some of the reading material and math concepts were too difficult for their students.

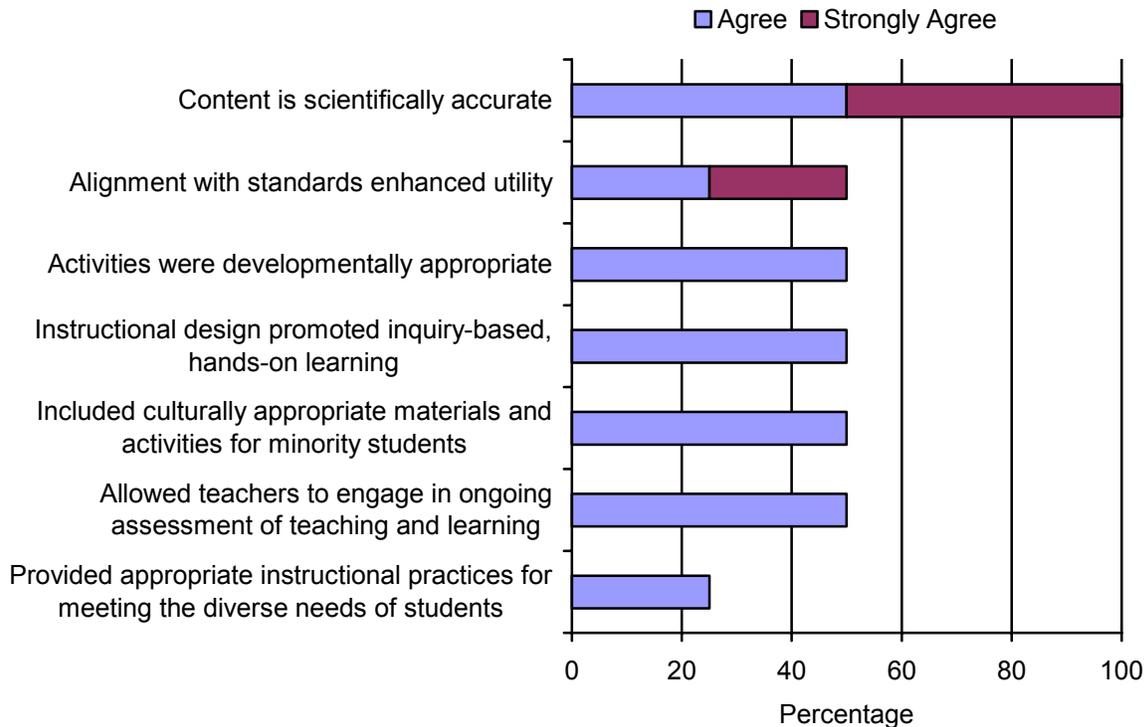


Figure 2. The percentage of field-test teachers (n=4) agreeing or strongly agreeing with quality and utility statements regarding the content module.

Outreach Dissemination and Visibility

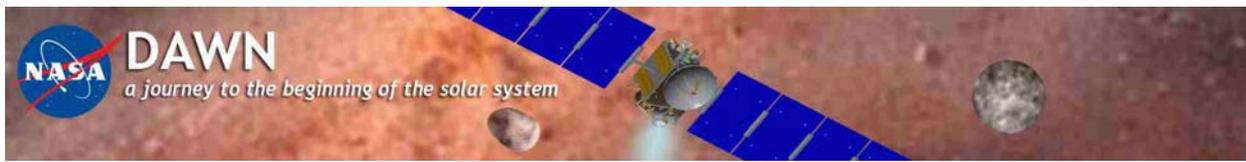
E/PO team members provide access to materials, resources, and information regarding the Dawn mission through various means. During this reporting period, outreach efforts focused on promoting visibility through the Dawn mission Web site, presentations or displays at educational and public events, and dissemination of print materials such as business cards, bookmarks, fact sheets, and posters.

Conferences, Presentations, and Workshops.

During the project period, E/PO team members represented the Dawn mission at several educator events. Staff presented on “Calibrated Peer Review in the Science Classroom” at the Colorado Science Teachers annual conference in November 2004, and gave presentations on teaching about ion jet engines at the Kansas Association of Teachers of Science annual conference (April 2005) and the Western Colorado Math/Science Institute (August 2005). At the February 2005 National After School Association Conference, staff presented



E/PO conference presentation



on “Science Through Storytelling” and engaging students in space science with NASA activities. In addition, team members gave two presentations on the Dawn mission at the McREL’s PEAK Afterschool Conference in June 2005, one on “Integrating Science and Language Arts Through Space Exploration,” and a brief informal presentation of NASA materials for after-school programs.

Outreach Materials.

Materials and resources range from Dawn Mission posters and bookmarks to the Dawn Mission e-newsletter, and from mission-related activities for young children to standards-based curriculum modules for teachers and students. Figure 3 presents quantities of project materials that were disseminated during the past year.

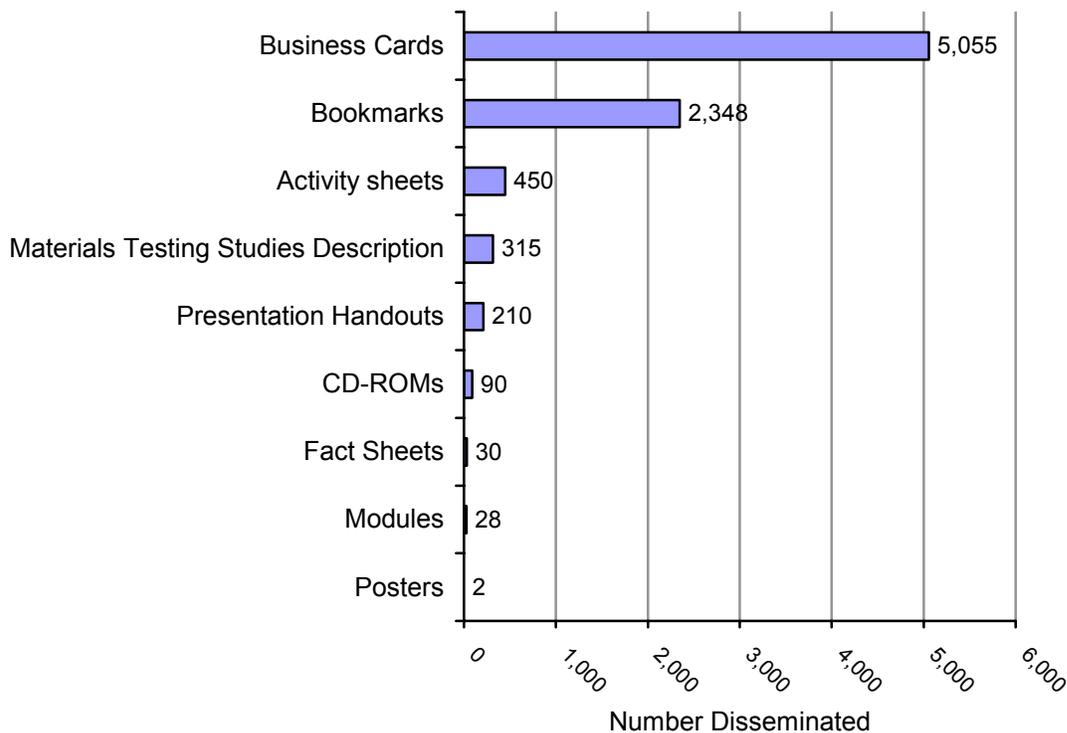


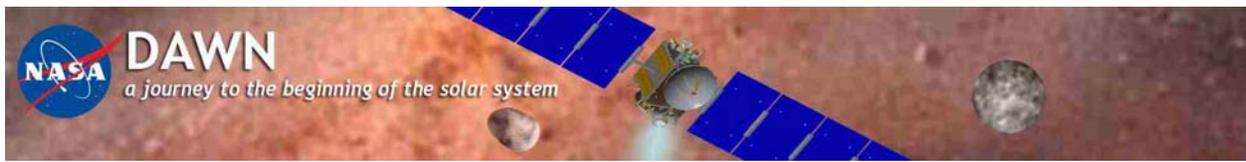
Figure 3. Materials disseminated to target audiences.

From October 2004 to September 2005 over 5,000 Dawn Mission business cards and more than 2,300 bookmarks were disseminated to educators across the country. Approximately 450 copies of Dawn’s Kids activities sheets were also distributed, along with a number of fact sheets, module packets, and CD-ROMs containing module activities. In addition, 315 copies of the description of the field and pilot tests of the Dawn modules were given to educators.

During the reporting period, team members developed and disseminated monthly Dawn Mission e-newsletters to 955 subscribers. Subscribers register for the e-newsletter via the Dawn Mission Web site or by completing a subscription form at professional conferences attended by the Dawn Mission E/PO team.

Dawn Mission Web Site.

The site is a comprehensive information source and dissemination mechanism for the Dawn mission. It includes seven main sections that pertain to various aspects of the mission. During the first year of the project, the development of the Dawn Mission Web site was a central focus of E/PO efforts. In the year



following, team members continued to enhance the site. Activities during this reporting period include restructuring multiple pages on the site, adding a countdown to launch clock, updating the image gallery, expanding sections with new content, and posting a new “People” page and science team member interview.

Due to technical difficulties, data on Web site activities are available for only eight of the twelve months during the reporting period of October 2004 through September 2005⁵. During the eight months for which data exists, the site received 426,789 hits, 89,368 page views, and 1,427 visitor sessions⁶, compared to 137,699 hits, 15,223 page views, and 923 visitor sessions for the five months of May through September 2004. Almost all visitors (99.7%) accessing the Web site were from the United States, although there was also a very small amount of activity from Canada, Great Britain, and 25 other countries. Forty-six percent of visitor sessions lasted over one hour, 11 percent lasted 30 minutes to one hour, 17 percent lasted 30 seconds to 30 minutes, and 25 percent lasted less than 30 seconds (see Figure 4).

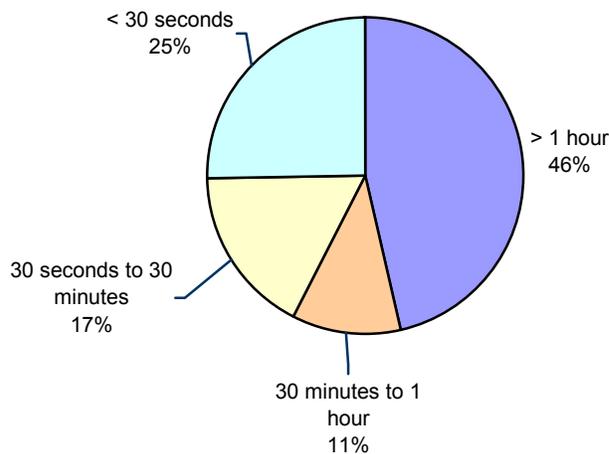


Figure 4. Duration of visitor sessions on the Dawn Web site from entry to exit.

Figure 5 shows the ten Web pages that received the most page views of the Dawn Web site, based on the data available from the reporting period. The Dawn Homepage had the greatest number of page views (43,317). Most of the other pages in the top ten were from the Mission section of the Web site, including the Mission section entry page (3,143 views), and the Trajectory, Spacecraft, Schedule, and Timeline pages of the Mission section.

⁵ Reported here is Web site activity for the months of October, November, and December 2004, and February, March, May, June, and September 2005.

⁶ A visitor session is a session of activity (all hits) for one visitor of a web site.

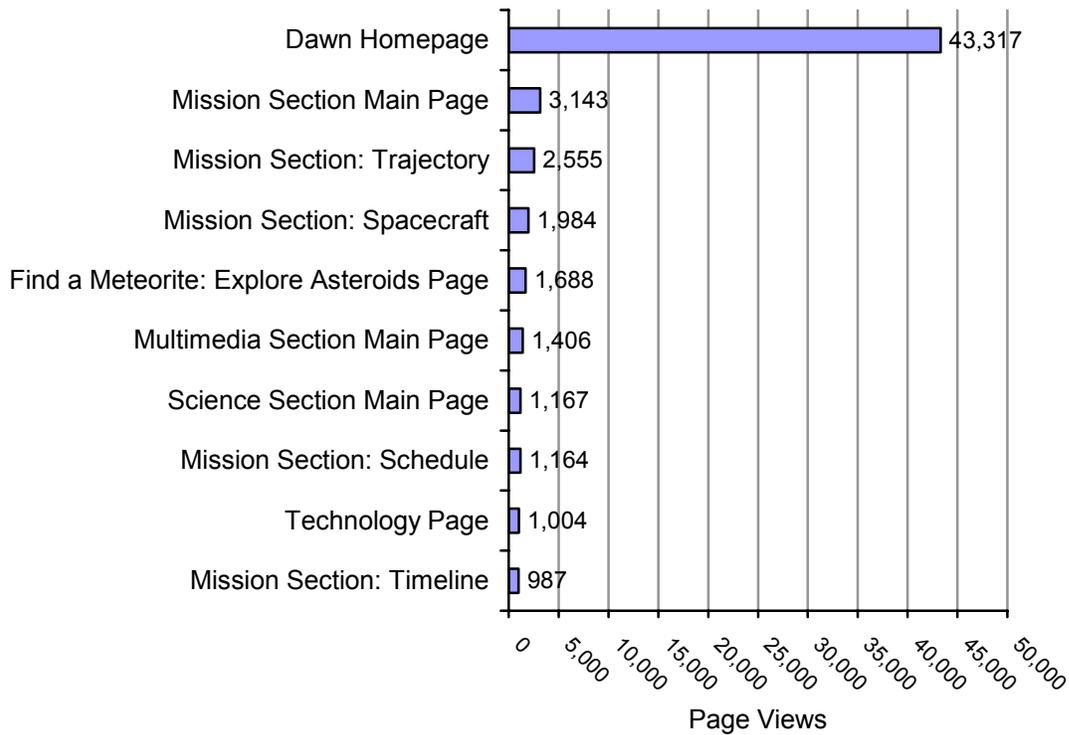
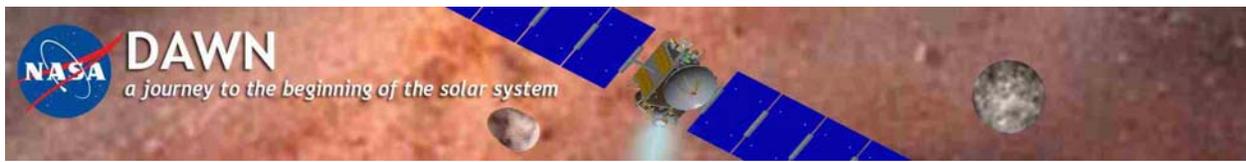


Figure 5. The ten most frequently viewed pages on the Dawn Web site.

Of the PDF documents available for download on the Dawn Web site, the media press package was most frequently viewed by visitors (179 page views), followed by the Find a Meteorite pilot study description (143 views) (see Figure 6). Most of the other popular PDF downloads were activities for students.

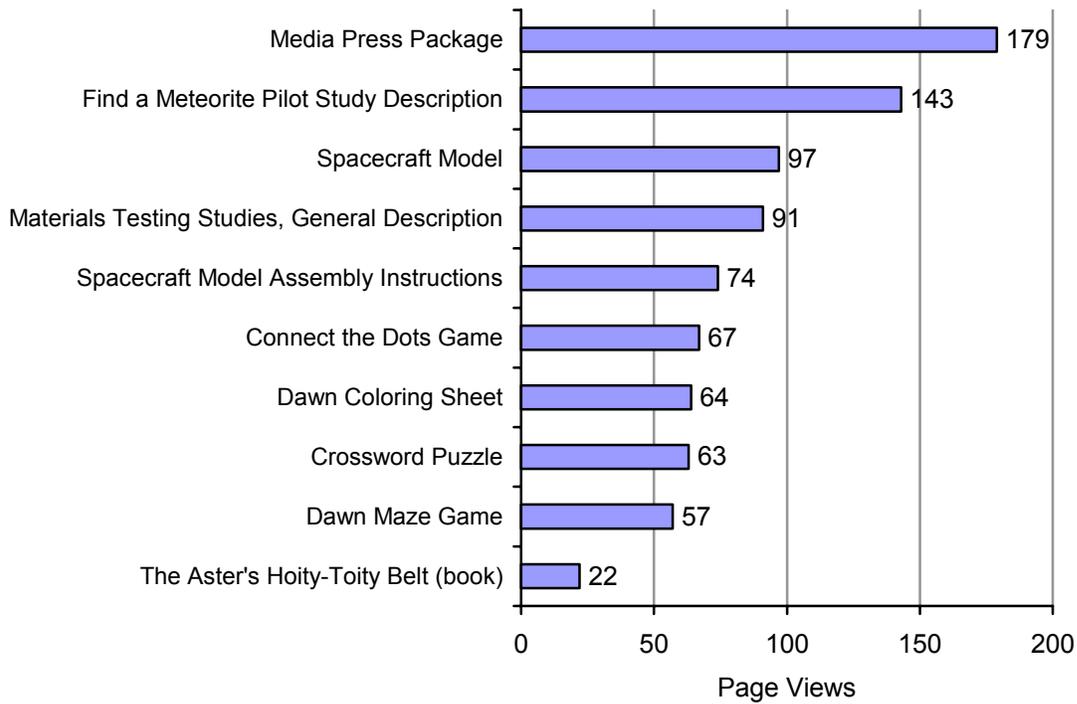
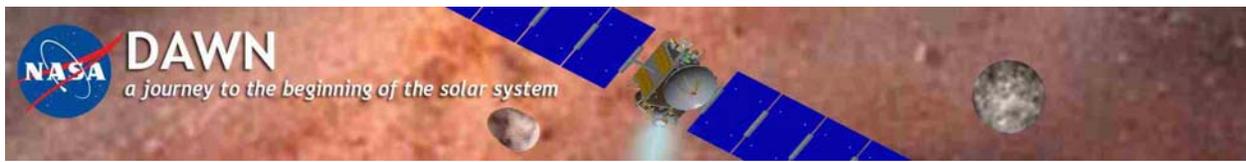


Figure 6. The ten most frequently viewed PDF pages on the Dawn Web site.

Target audiences can learn about the Dawn Web site through the Dawn newsletters; all project materials, which include the Web address; search engines; and links from other space science Web sites. Links from direct address or bookmarks accounted for 55% of page views of the Web site, 32% of page views originated from another Dawn Web site page, 9% were links from external Web sites, and 4% originated from an Internet search engine (see Figure 7).

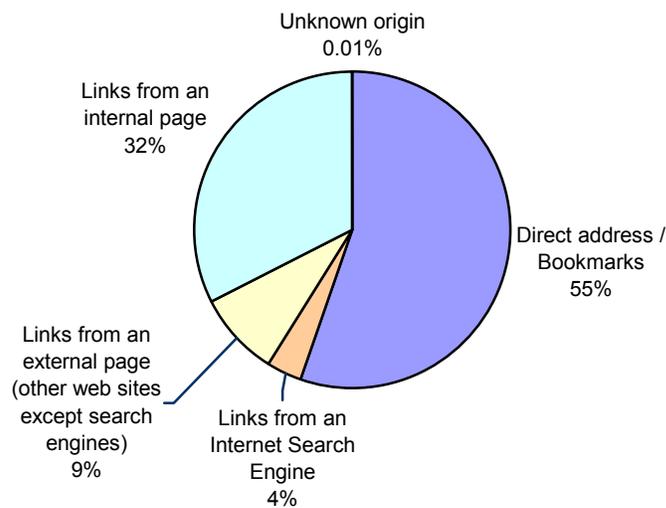
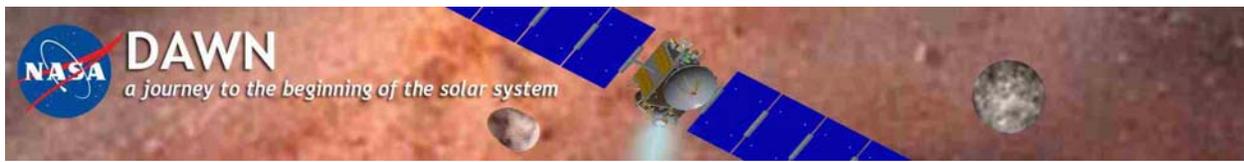


Figure 7. Web users' method of accessing the Dawn Web site.



REACHING AND IMPACTING STUDENTS

The E/PO team aims to improve student interest and learning in space science by engaging students in high quality, standards-based activities. E/PO team members reach their student audience through teachers, who use the Dawn science materials in their classrooms; informal educators, who facilitate student activities in museum, after-school, and summer school settings; and independent learners who access the activities on the Dawn mission Web site.

The Dawn science materials promote hands-on, inquiry-based learning with activities that allow students to connect classroom lessons to “real life” experiences. Enhancing student awareness of space-science careers is one component of making these “real life” connections. The learning cycle⁷ for each module supports student-initiated learning and facilitates process-oriented, critical thinking skills.

Ultimate 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.

Key Evaluation Questions

4. Are participating students engaged and interested in the Dawn mission science as a result of using E/PO materials?
5. Do participating students have an increased understanding of the formation of the solar system?

Characteristics of Participating Students

Four teachers participated in the field test of the *History and Discovery of Asteroids* content module. These teachers implemented all or components of the module with 229 students in the seventh and eighth grades. Fifty-three percent of the participating students were female and 47 percent were male. On average, students participated in the module’s learning activities over a period of 16 days, for almost 60 minutes a day. Before and after implementing the materials, seventh- and eighth-grade teachers administered the knowledge and skills assessment as well as the interest survey to the students.

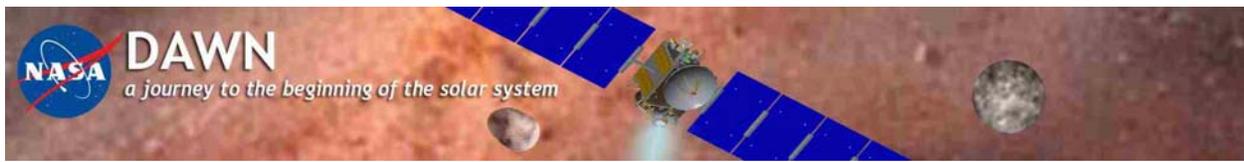


Students with a model of the Dawn spacecraft.

Increasing Student Interest in Solar-System Science

E/PO team members highly value students’ experiences and perceptions of participating in the module’s activities. As such, students were asked to provide anonymous feedback about the module activities pertaining to what interested them and what needed improvement as well as overall feelings toward science, inquiry, space science careers, and making connections between science and real life.

⁷ The learning cycle for each module is divided into the following five components: Briefing, exploration, development, interaction/synthesis, and assessment.



Students were asked to report the most interesting thing that they learned from the *History and Discovery of Asteroids* content module. Of the 208 students who responded to this item, students most frequently commented that learning about the discovery of asteroids and the “missing planet”, as well as how telescopes and how they were invented, was most interesting to them. Students cited a variety of additional things that were most interesting to them including learning about astronomers, star charts, and light as well as conducting hands-on activities. The following are examples of students’ written comments:

The most interesting thing that I learned from the Dawn activities was hearing about the first telescope made.

I liked learning about the discoveries of different asteroids. It was interesting how they could find an asteroid without much technology.

The most interesting thing I learned was information about the orbits and size of asteroids. I learned that Ceres and Vesta are like little planets that didn’t form right.

There has been many accomplishments by many people and there are lots of ways and things to study in astronomy.

I learned how to find the “missing planet” in the star chart.

Students also were asked what would make the module more fun and interesting. Similar with the pilot test feedback for the module, 67 percent of students wanted to do more hands-on activities and less reading and writing. In general, students wanted more ways to interact with the materials whether it was through model making, telescope observations, colorful visual aides, and computer simulations. One eighth-grade student captured what many students referred to in their comments in the following quote:

I think there should be more hands-on activities. If you want us to learn and remember things, we need to use our senses like seeing an experiment, touching, listening, smelling....All of these are vital to learning. If someone were to ask me in a year or so what I did for this unit, I might be able to tell them one or two things, but more, if I had done hands-on things.

As stated previously, the student interest survey was administered before and after field-test teachers implemented the materials. In addition to the open-ended items just mentioned, students responded to a series of Likert-scale items (4=Really agree, 3=Agree, 2=Disagree, 1=Really Disagree) related to students’ understanding of science’s connection to real life, their interest in science, their knowledge of conducting science investigation, and their interest in space-related careers. Figure 8 presents the mean ratings of students’ responses before and after participating in the module activities.

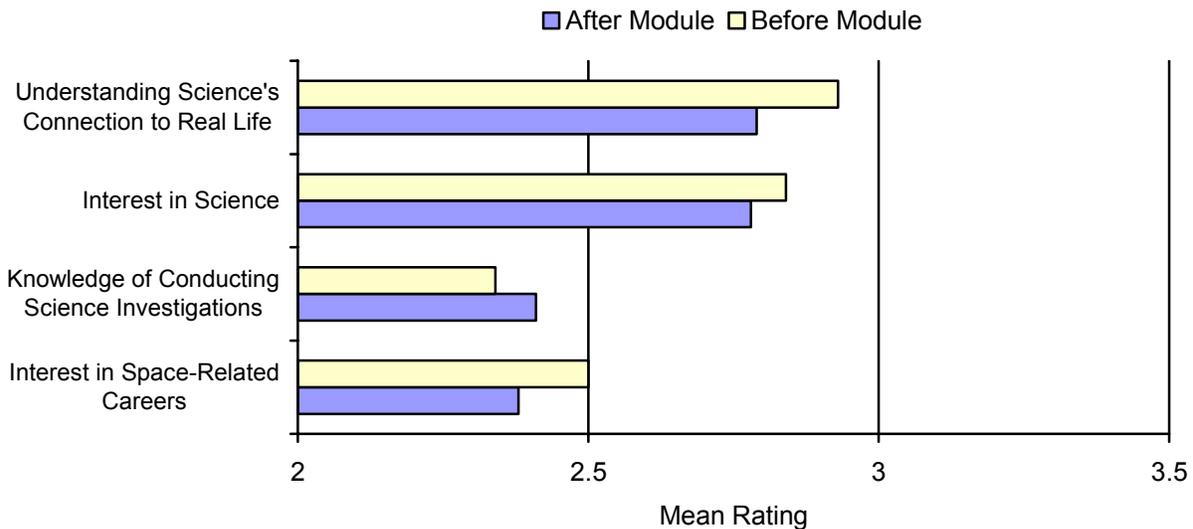
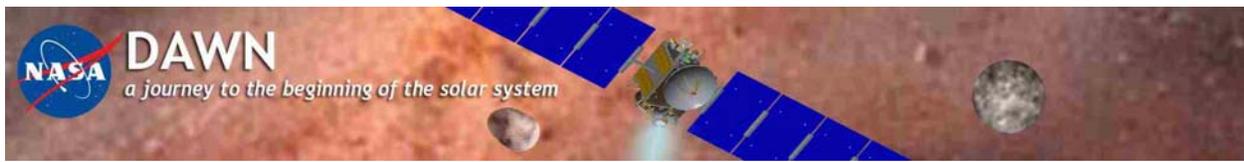


Figure 8. Mean ratings for students' level of agreement with statements regarding their perceptions of and experiences with science (n = 193 to 197 on items).

The results indicate that students, on average, had a moderate-level of agreement with the survey statements before they participated in the module's activities, with the exception of their knowledge of conducting science investigations, which increased slightly, but not significantly. Students' ratings decreased slightly after using the module, but not to a significant extent. Given that this was administered during the pilot study and that, it is difficult to make interpretations of the slight decrease in student interest and perceptions. When interpreting these results, readers must consider that student responses are not only influenced by their experiences with the Dawn activities, but also by their own background knowledge and experiences as well as the instructional practices and implementation of their teachers.

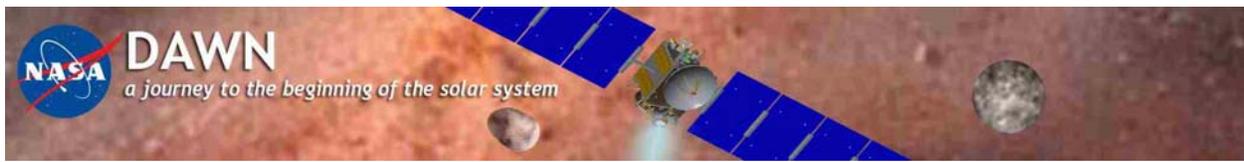
Teacher observations of student interest and engagement reveal that 75 percent of teachers thought that the Dawn activities enhanced students' interest in space-science careers, improved their learning of science concepts, and engaged them in the learning activities. Half of the teachers reported that students were more interested in science as a result of using the materials. Some teachers echoed the student disinterest in the required reading and the need for more hands-on activities. A couple of teachers shared the following written comments about their students:

Students generally had no idea about the content before beginning ~ now they are interested in following the Dawn mission.

As I have progressed into the specific study of the Solar System, my students already have a more in-depth background knowledge of the Asteroid Belt.

Increasing Student Knowledge and Skills

One eighth-grade teacher and 3 seventh-grade teachers administered a pre and post knowledge and skills assessment developed by the Dawn E/PO team. The standards-based assessment consisted of eight, multiple-choice items; three, "True or False" items; and seven, short answer items related to solar-system science. The highest possible score on the assessment was 20 points. One seventh-grade teacher was randomly assigned to use his existing curriculum pertaining to solar-system science, or the "control condition", while the other teachers used the Dawn activities, or "treatment condition." Of the students participating in the evaluation, 294 students (268 seventh graders and 26 eighth graders) completed both the pre and post knowledge and skills assessment. Of these, 101 students served in the control condition,



and 193 were treatment students.

Treatment Student Gains

The results indicate that students showed significant improvement over the study period. Table 1 presents the results of the paired-samples *t*-tests⁸ for all treatment students, seventh-grade treatment students only, and eighth-grade treatment students only. It includes the pretest and posttest scores, standard deviations, gain scores, *t*-test results, and effect sizes.⁹

Table 1.
Paired Samples *t*-Tests for Treatment Students

	Sample (n)	Pretest Score (of 20)	Posttest Score (of 20)	Pre-Post Mean Difference	<i>t</i> value	Degrees of freedom (<i>df</i>)	<i>p</i> value ^b	Effect Size (Cohen's <i>d</i>)
All Students	193	10.52 (3.84) ^a	14.24 (4.5)	3.72	11.73	192	.000	.89
Seventh Grade	167	10.86 (3.68)	14.16 (4.49)	3.30	10.54	166	.000	.81
Eighth Grade	26	8.31 (4.18)	14.73 (4.64)	6.42	5.83	25	.000	.1.46

^a Standard deviations are shown in parentheses.

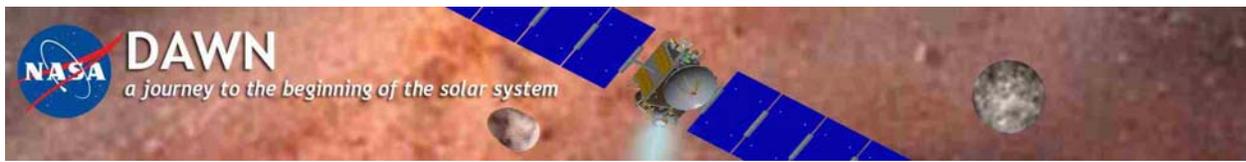
^b Alpha=.05; therefore *p* values less than or equal to .05 are significant.

The average student score on the assessment activity before using the Dawn E/PO materials was 10.52. After the module, the average student's score increased to 14.24. The difference between this average pre- and post-score was highly statistically significant ($p < .000$; see Figure 9). Grade-level analyses revealed that all treatment students showed highly significant gains during the study period, with the eighth grade students demonstrating an average gain of more than six points (see Figures 10 & 11). It is important to note that the average posttest score for all students equals a percentage-correct score of 71, which may indicate that the assessment was challenging for students.

Moreover, calculations indicate large effect sizes of +.89 and +.81 for the entire group and for seventh-grade students, respectively; and an incredibly large effect size of +1.46 for eighth-grade students. Effect sizes can be translated into percentile points for ease of interpretation. In this case, the effect sizes reflect what would be an average learning gain of 31 percentile points on a standardized test across all grades, a 29-point gain for seventh-grade students, and 43-point gain for eighth-grade students. Based on this information, it may be interpreted that students' use of the materials resulted in a substantial increase in

⁸ In this case, a paired-samples *t*-test is used as a test of statistical significance of the differences between a group's pretest scores and posttest scores.

⁹ An effect size is a unit of measurement that expresses "practical significance," or the magnitude of the increase or decrease in achievement of students. Effect sizes are expressed in standard deviation units. For example, an effect size of 1.0 indicates that student scores increased 1.0 standard deviation from their pretest score to their posttest score. Effect sizes were estimated using Cohen's *d* formula in which the mean pretest score is subtracted from the mean posttest score and then divided by the pooled standard deviation for the pretest and posttest.



their understanding of the science concepts and standards embedded in the materials.

All Students (n=193)

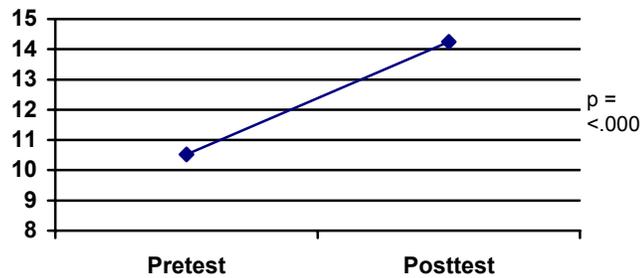


Figure 9. Overall scores, pretest to posttest for all participating treatment students.

Seventh-Grade Students (n=167)

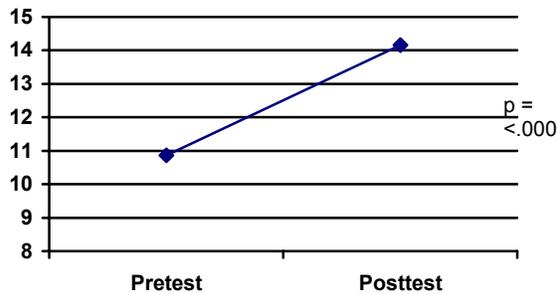


Figure 10. Seventh-grade scores, pretest to posttest.

Eighth-Grade Students (n=26)

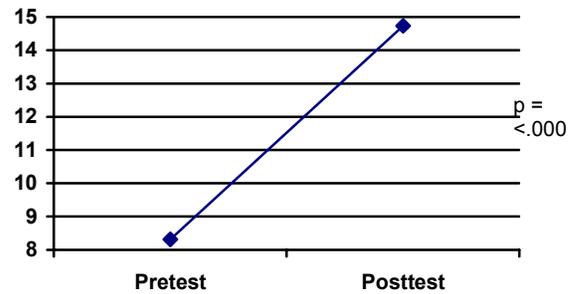


Figure 11. Eighth-grade scores, pretest to posttest.

Treatment and Control Student Comparisons

Evaluators examined if differences existed between seventh-grade treatment and control students on the posttest assessment when accounting for differences on the pretest. As such, analyses of covariance were conducted to determine if differences existed between the student groups. Table 2 reports posttest means and standard deviations for the assessment as well as results from the analyses of covariance and effect size calculations.

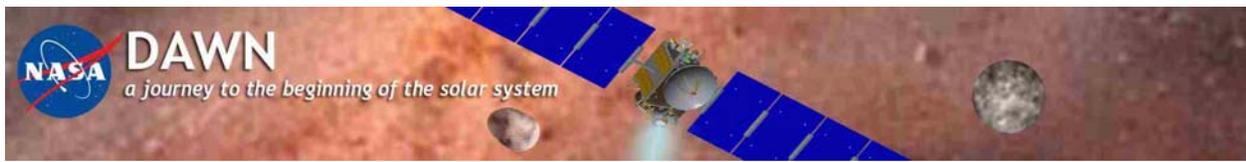


Table 2.
Seventh-Grade Posttest Results by Condition

Outcome Measure	Participant Students n=167	Control Students n=101	<i>F</i>	<i>p</i>	<u>ES</u> (Cohen's <i>d</i>)
	<u>Posttest</u>	<u>Posttest</u>			
M	14.06	7.25	130.60	.000	1.40
SD	4.50	2.17			

As shown in the table and Figure 12 below, posttest scores between participant and control groups were significantly significant, $F(1, 267) = 130.60, p < .000$, indicating that students using the Dawn activities outperformed students who used their regular curriculum on solar-system science. Accordingly, the effect size for between participant and control groups is very large ($d = 1.40$), indicating that the average student in the treatment group gained 42 percentile points more than the average student in the treatment group, overall.

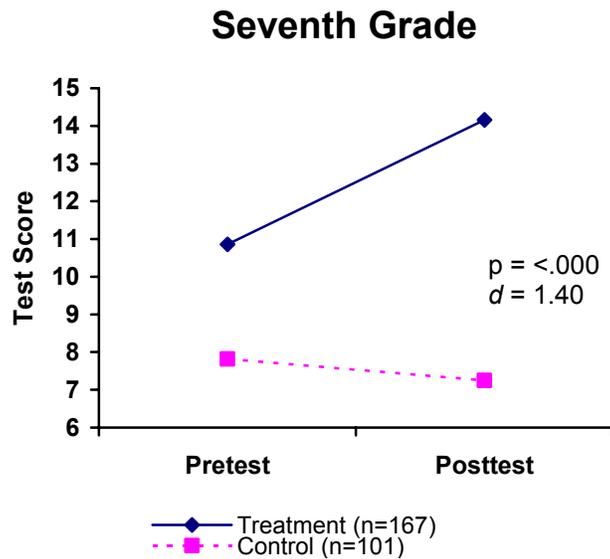
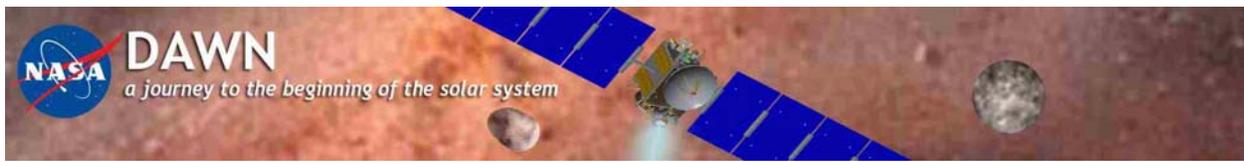


Figure 12. Comparison of pretest and posttest scores for treatment and control students.



REACHING AND IMPACTING FORMAL AND INFORMAL EDUCATORS

E/PO team members aim to improve formal and informal educators' access to standards-based materials as well as to deepen their understanding of how to facilitate inquiry-based practices. Through the Dawn outreach efforts, educators will be able to access standards-based curriculum modules, information on the science and the mission, and professional development. Team members reach their educator audience primarily through the Web site, professional conferences, workshops, and the education development networks. During this past year, evaluation focused on collecting feedback data from teachers in field-test sites. Unfortunately, because of the lapses in which the mission was mandated to cease all work, there were no professional workshops conducted in which a substantial number of participants provided feedback data.

Ultimate Outcome

5. Educators have a better understanding of how to implement inquiry process leading to improved practices.

Key Evaluation Question

6. To what extent has the E/PO effort enhanced participating educators' capacity to teach space science?

Accessing Dawn Materials and Resources

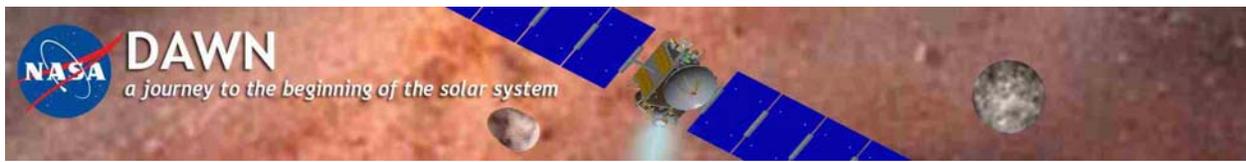
Educators seeking standards- and inquiry-based space science materials and resources can access and participate in the Dawn E/PO outreach efforts in several ways. Educators can become a NASA Field Associate by engaging in a long-term relationship with Dawn E/PO that involves pilot- and field-testing curriculum materials; completing the *Teacher Informational Questionnaire* and the *Dawn Module Evaluation*; and disseminating E/PO materials and resources. As E/PO products become available, educators also can access the materials without becoming a field associate. Non-network educators can download the educational materials from the Dawn Web site and provide feedback voluntarily by completing an on-line survey. Educators also access and participate in the E/PO initiative by attending Dawn workshops and trainings, where they can learn about the variety of Dawn resources and materials and provide feedback by completing the *Participant Evaluation* form. Additionally, educators can access educational materials and resources through the Dawn Web site and can provide feedback voluntarily on the content and utility of the Web site by completing the online *Dawn Web Site Evaluation* form.

Characteristics of Educator Participants

During this reporting period, evaluation efforts targeted formal education audiences for field-test feedback. The four teachers, who field-tested the *History and Discovery of Asteroids* across four schools, provided feedback via the *Teacher Informational Questionnaire* and the *Dawn Module Evaluation*. Three of these teachers taught seventh grade and one teacher taught eighth grade during the 2004–2005 school year. Schools represented urban, suburban, and rural settings. Fifty-two percent of the students were categorized by their teachers as economically or academically



After school educators learn about Ion Propulsion at the National, After School Association national conference



disadvantaged.

Capacity Building in Study Sites

Teachers were asked to respond to several items related to their capacity before and after implementing the *History and Discovery of Asteroids* content module. It is important to keep in mind that these findings represent the experiences and perceptions of 4 teachers.

Before and after using the content module, teachers described themselves as being comfortable in using inquiry-based, hands-on activities in the classroom, and as somewhat knowledgeable about space-related topics and issues. Aside from the Dawn mission, teachers indicated that they were somewhat familiar with other space-related or NASA education programs that are available to teachers. Teachers' use of the Dawn materials resulted in little to no changes in how they perceived themselves related to these characteristics.

Teachers were asked to respond to four statements regarding their perceptions toward science and their use of the module. Of the four teachers responding to these items, 75 percent agreed that using the module enhanced their capacity to teach science. Half of the teachers indicated that implementing the activities increased their interest in science; resulted in them liking to teach science more; and improved understanding of how to tie science learning to real-life contexts. Only one teacher reported that the materials resulted in a better understanding of how to facilitate inquiry-based, hands-on learning processes. This would be expected given that on a scale of 1-to-7 (1 = very uncomfortable; 7 = very uncomfortable) teachers' before using the module had an average rating of 6.75 regarding their comfort with using inquiry-based, hands-on materials (see Figure 13).

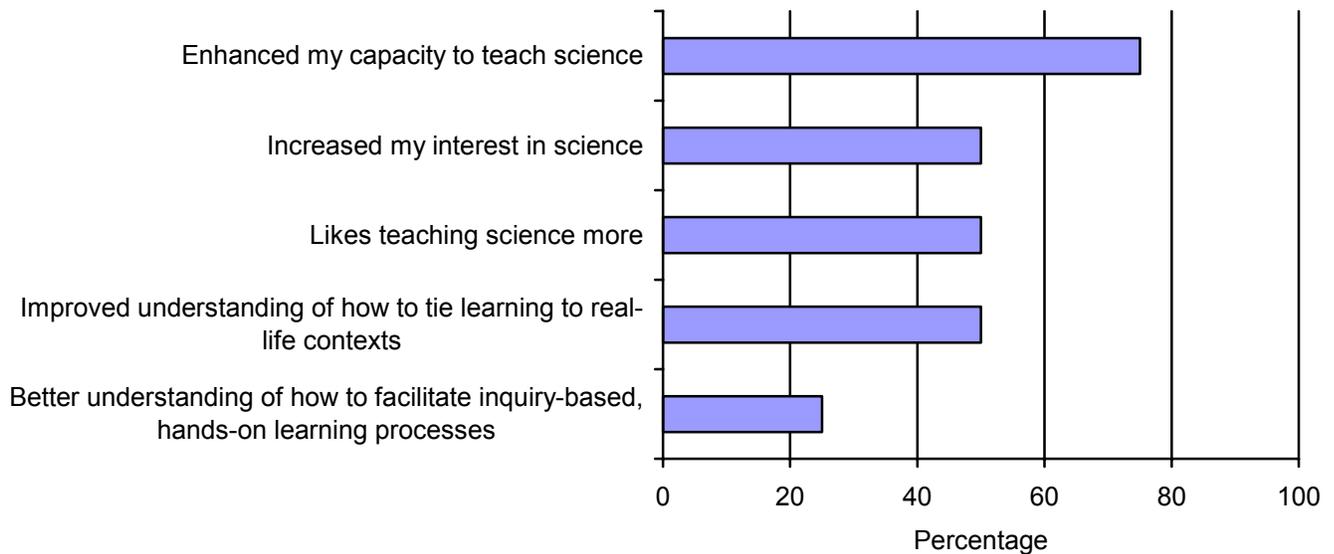
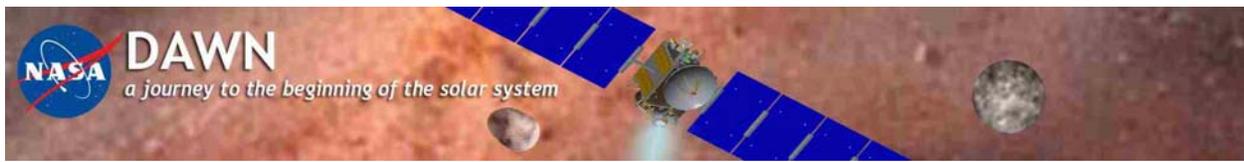


Figure 13. The percentage of teachers (n=4) who agreed or strongly agreed with statements regarding their use of the module.

When asked about what barriers prevented teachers from making better use of the materials, most frequently teachers cited poor alignment with curriculum and limited available class time.

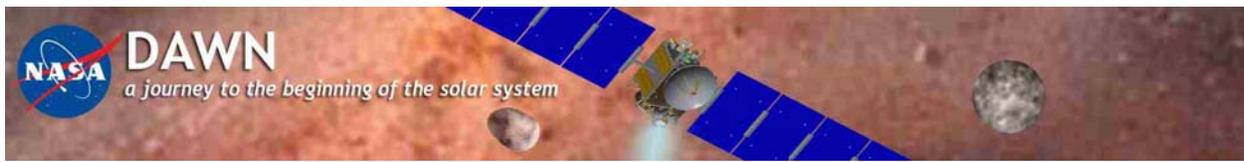


SUMMARY

During the project period for this report, October 2004 through September 2005, E/PO efforts focused on enhancing the Web site and its content, further refining existing educational materials and developing new ones, promoting educator awareness of and interest in the Dawn education materials, and reaching audiences through conferences and public events. Despite interrupted work periods and delays in production and outreach schedules, E/PO team members demonstrated progress in their outreach efforts to most of their target audiences.

During an eight-month period, the Dawn mission Web site experienced 1,427 visits (a 55% increase from the last reporting period) and 15,223 page views (six times the number of page views from the last reporting period) from people accessing the site. Most frequently, people accessing the Dawn Web site viewed the Homepage of the Mission pages. Fifty-five percent of the page views resulted from visitors entering the Web address directly or using a bookmark and 32 percent were from another Dawn Web site page. Almost all visitor sessions originated from the United States, although the site had a very small amount of international visitors.

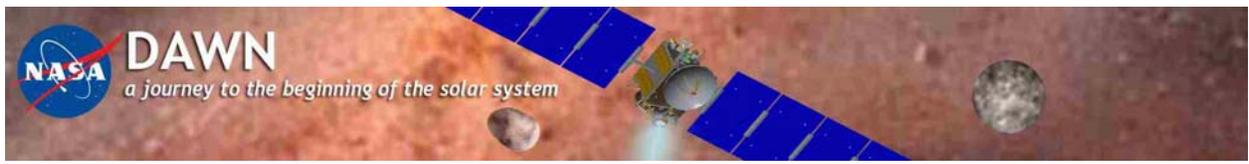
About 230 students had the opportunity to engage in the science materials through their participation in a field-test of the first content module, the *History and Discovery of Asteroids*. The results from the field-test of the *History and Discovery of Asteroids* content module reveal that treatment students experienced highly significant learning gains over control students in their knowledge about the historical periods involving the discovery of asteroids and the associated technological, political, and social contexts influencing the discovery process. Findings suggest that students, overall, were engaged and interested in the materials, although the majority of students requested more hands-on activities to promote their learning. The majority of teachers participating in the field test reported that using the Dawn materials enhanced their capacity to teach science. Half of the participating teachers indicated that their use of the module increased their interest in science and improved their understanding of how to tie learning to real-life contexts. Overall, most of the teachers found the materials to be of high quality and utility.



RECOMMENDATIONS

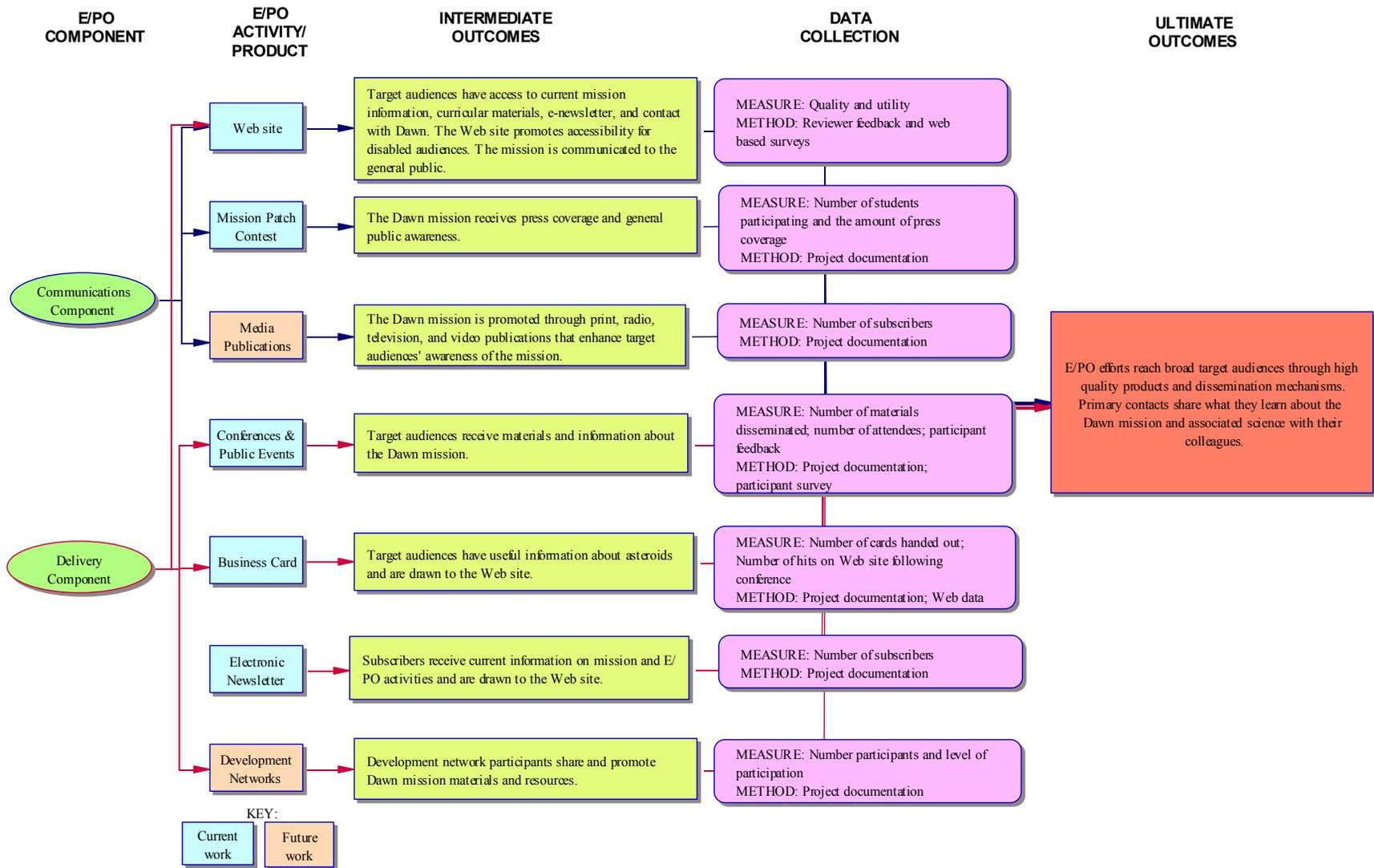
Based on the evaluation findings from the reporting period of October 2004 to September 2005, the following recommendations are provided for consideration by the Dawn E/PO team. Given the reinstatement of the mission, team members will be able to continue, expand, and enhance their outreach efforts. These suggestions are intended to facilitate continued project success in project implementation and assure accountability with regard to project outcomes.

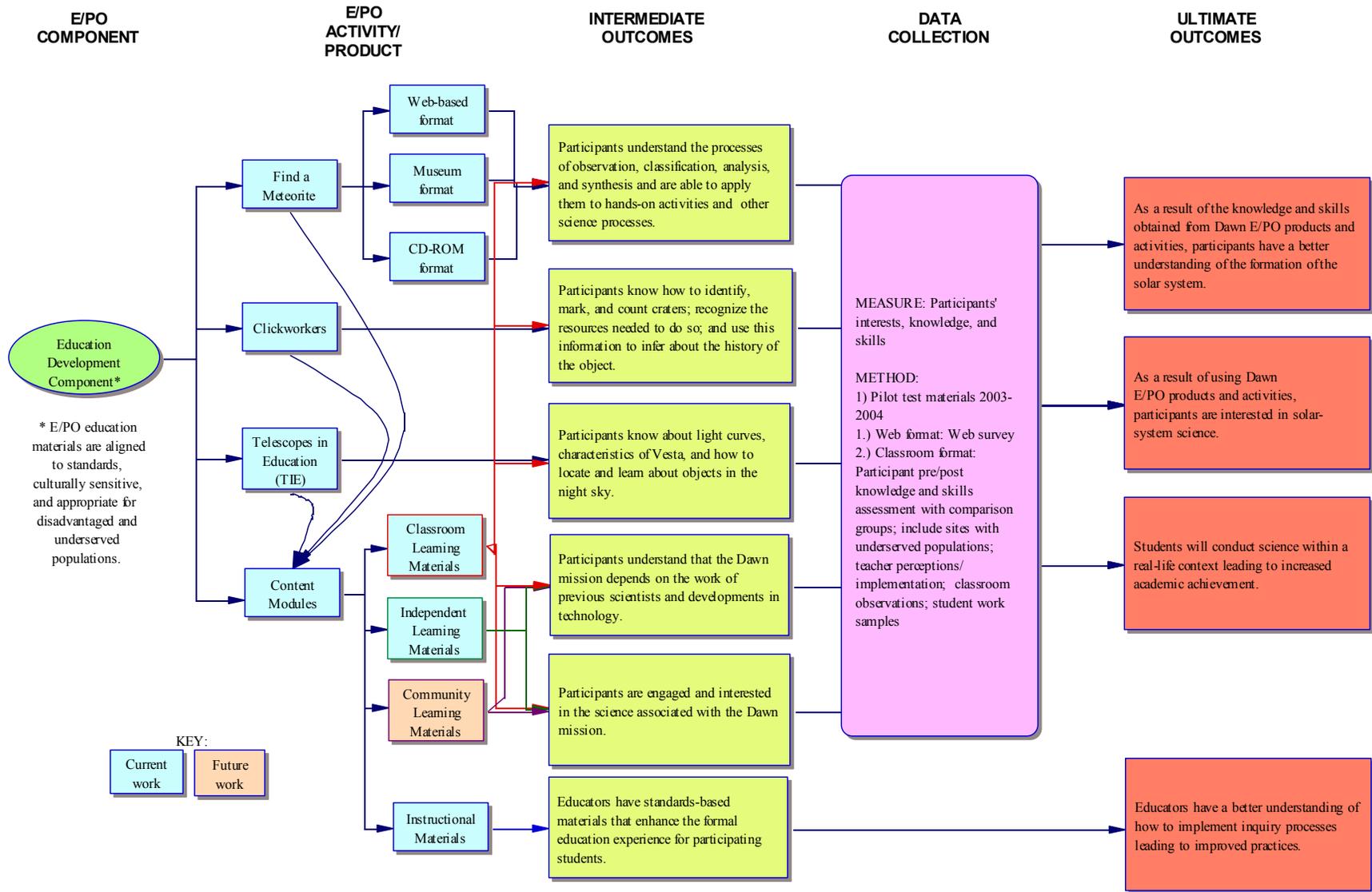
- Given that team members were unable to focus on educator capacity building during this reporting period, it is recommended that team members provide more professional development opportunities to informal and formal educators, including conference presentations and workshops.
- Given that students and teachers requested curriculum materials that promote learning through hands-on activities and that offer multiple learning modalities, it is recommended that team members continue to integrate differentiated learning materials for students and ensure their appropriateness and feasibility through pilot testing.
- Given that curriculum materials have been primarily Web disseminated pdf documents, it is recommended to “leave the paper behind” and attempt a new approach to designing an education module by use of a digital, online, dynamic platform that is highly interactive, easily accessible, and engages student learning.
- Given the impending launch, it is recommended that team members incorporate event-based learning opportunities into their outreach efforts preceding the launch.
- Given that the Dawn Web site is the primary mechanism of E/PO dissemination, it is recommended that team members continue with their visibility efforts that draw the general public and educators to the Web site. Team members also should explore how to increase Dawn visibility beyond the Web site.
- Given that partnerships are a critical factor in enhancing outreach efforts and visibility, it is recommended that team members continue to identify new partners, both nationally and internationally.

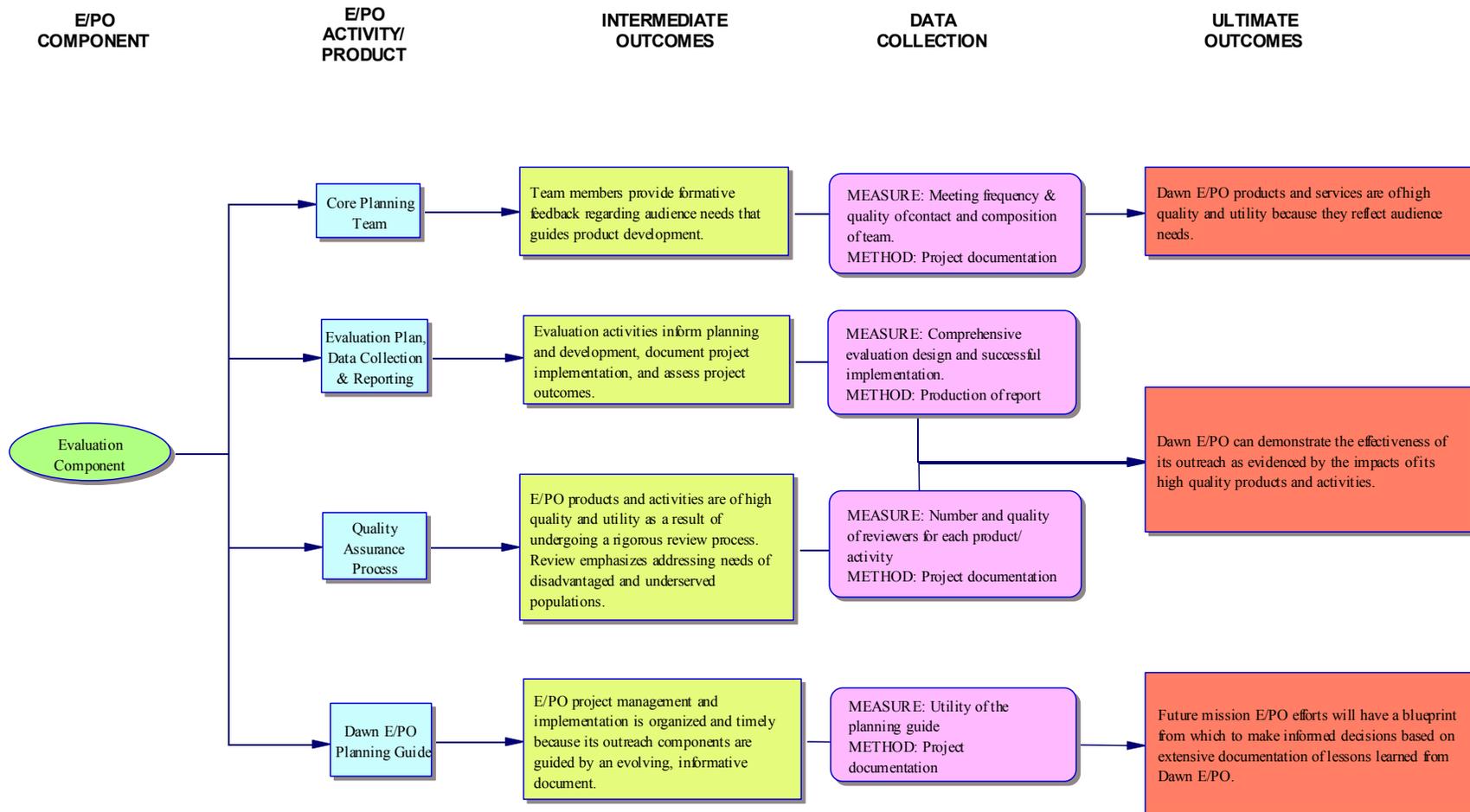


APPENDIX A:

Logic Models for Dawn Education and Public Outreach







**APPENDIX B:
Evaluation Matrix**

EVALUATION QUESTIONS	DATA SOURCES	DATA METHODS
<p>Ultimate Outcomes #1 & #6: E/PO efforts reach broad target audiences through high quality products and dissemination mechanisms. Dawn E/PO products and services are of high quality and utility because they reflect audience needs.</p>		
<p>Objective 1: To increase the availability of E/PO products and services related to the Dawn mission.</p>		
<p>1. Do users of the Dawn E/PO materials and resources perceive them to be of high quality and utility? 2. To what extent do teachers and students access and use the Dawn E/PO materials and resources? 3. To what extent do public members access and use the Dawn E/PO materials?</p>	<p>Internal and external reviewers Web site users Workshop participants Teachers Students Public members</p>	<p>Quality assurance process On-line surveys Participant feedback Web statistics Dissemination data</p>
<p>Student Ultimate Outcomes #2, #3 & #4: 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. As a result of using Dawn E/PO products and activities, participants are interested in solar-system science. Students will conduct science within a real-life context leading to increased academic achievement.</p>		
<p>Objective 2: To increase student awareness, interest, and understanding of space science.</p>		
<p>4. a. Are participating students engaged and interested in the Dawn mission science as a result of using E/PO materials? b. Do participating students have an awareness of and interest in space-related careers as a result of the Dawn E/PO materials? 5. a. Do participating students have an increased understanding of the formation of the solar system? b. Do participating students using Dawn E/PO materials perform better than non-participants?</p>	<p>Students in pilot- and field-test sites Students who access online resources</p>	<p>Pre/post student performance data with non-equivalent comparison groups Student survey (print/online) Teacher reports</p>
<p>Educator Ultimate Outcomes #1 & #5: Educators have a better understanding of how to implement inquiry processes leading to improved practices. Primary contacts share what they learn about the Dawn mission and associated science with their colleagues.</p>		
<p>Objective 3: To increase teachers' use of hands-on, inquiry-based educational materials related to the Dawn mission.</p>		
<p>6. To what extent has the Dawn E/PO effort enhanced participating teachers' capacity to teach space science?</p>	<p>Teachers in development networks Participants in workshops Teachers accessing Web site resources</p>	<p>Pre/post assessment of capacity Participant evaluations Web-based surveys</p>
<p>Public Ultimate Outcomes #2 & #3: 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. As a result of using Dawn E/PO products and activities, participants are interested in solar-system science.</p>		
<p>Objective 4: To increase public interest in and understanding of the Dawn mission.</p>		
<p>7. To what extent has the Dawn E/PO effort affected public interest in and understanding of the Dawn mission?</p>	<p>Public members accessing Web site or museum resources</p>	<p>Web-based surveys</p>

APPENDIX C:

E/PO Team Members' Response to Year Two Evaluation Recommendations

- Given that team members were unable to focus on educator capacity building during this reporting period, it is recommended that team members provide more professional development opportunities to informal and formal educators, including conference presentations and workshops.

Response (July 06): During the year prior to launch we plan to deliver two launch workshops (Florida and Colorado) and provide professional development sessions at state level conferences as well as one session at the NSTA National Conference in St. Louis MO. The team has been concerned with the apparent limited impact that occurs at large, national conventions and will review its practice of attending national conference to focus on smaller, local venues for professional development opportunities.

- Given that students and teachers requested curriculum materials that promote learning through hands-on activities and that offer multiple learning modalities, it is recommended that team members continue to integrate differentiated learning materials for students and ensure their appropriateness and feasibility through pilot testing. Additionally, learning materials should better address career awareness and opportunities in space science.

Response (July 06): We have recently launched the careers connections on the Dawn Web site. This effort, as with all of our products, is leveraged by integrating the information into all of our material via dynamic, differentiated dissemination. We will work to provide links to these career pages from other appropriate locations on the Web site including the education and classroom pages.

- Given that curriculum materials have been primarily Web disseminated pdf documents, it is recommended to “leave the paper behind” and attempt a new approach to designing an education module by use of a digital, online, dynamic platform that is highly interactive, easily accessible, and engages student learning.

Response (July 06): We have engaged in developing what we are calling dynamic, differentiated dissemination. This form of distribution takes full advantage of the dynamic nature of the content and flexibility of the internet. More details will be forthcoming.

- Given the impending launch, it is recommended that team members incorporate event-based learning opportunities into their outreach efforts preceding the launch.

Response (July 06): We have developed a Dawn Launch Agenda and will utilize pre-launch events whenever possible to enhance our outreach efforts. We will engage the Solar System Ambassadors through professional development and with a Speaker's Kit. These ambassadors have been extremely successful in identifying varying venues and opportunities for outreach. We will launch our Young Engineers program to engage young children and their parents as well as the young at heart. Teachers are engaged by our Launch Conference and Workshops in Florida and Colorado and the Western Alliance Planetarium conference. We currently have a “send your name to the asteroid belt” and a count-down to launch on our web page.

- Given that the Dawn Web site is the primary mechanism of E/PO dissemination, it is recommended that team members continue with their visibility efforts that draw the general public and educators to the Web site. Team members also should explore how to increase Dawn visibility beyond the Web site.

Response (July 06): We are submitting our website for consideration by various awards. This will help increase our visibility. We will make more effort with our wall calendar to present Dawn to a wider audience. We will soon have our mission video completed and plan to disseminate it through a major airline for in-flight viewing. In October we will engage the Solar System Ambassadors for more visibility.

- Given that partnerships are a critical factor in enhancing outreach efforts and visibility, it is recommended that team members continue to identify new partners, both nationally and internationally.

Response (July 06): Our partnerships continue to grow with contacts spread over formal, informal and public venues. One exciting example is The Museum Alliance (<http://informal.jpl.nasa.gov/museum/alliance/library/museumalliance-faq.pdf>). This is an effort by NASA to be sure that museums, science centers, and planetariums have easy, quick access to news, schedules, and other information about NASA missions to use in their public and educational programs and exhibits. Key to this partnership is clear, consistent, and timely communications. The primary tools for this are a list-serve, password-protected website, and telecoms. Three strong focus areas include 1) providing access to visual data including video productions, video B-roll, animations, and science visualization; 2) providing access to NASA experts; and 3) facilitating interactions among the Museum Alliance partners. The Museum Alliance has developed into a community of practice of informal science educators who bring NASA's work to their local audiences.

Another example of a new partnership is our recent contact and collaboration efforts with SACNAS (Society for Advancement of Chicanos and Native Americans in Science. Other new contacts include: the NASA CSULA SERENADES Laboratory and the Adler Planetarium & Astronomy Museum. We will continue to cultivate these partnerships and explore new ones as we develop and complete materials that these groups identify as needs.

Additionally, we have made efforts to feature the E/PO activities of our international partners and are actively engaged in making their efforts known through the Dawn web page.