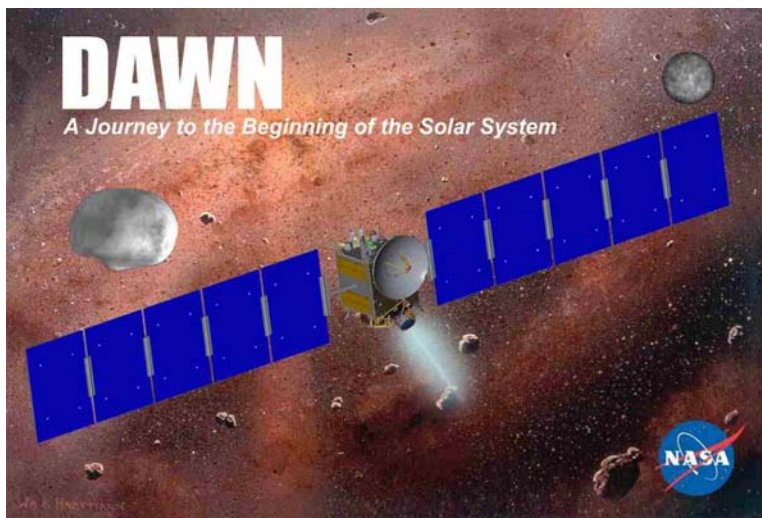


**DAWN MISSION EDUCATION AND PUBLIC OUTREACH PROGRAM AND EVALUATION  
REPORT:  
AUGUST 1, 2008–JULY 31, 2009**



Submitted to  
Dawn E/PO Team

Submitted by  
Magnolia Consulting, LLC



January 4, 2010

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

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## INTRODUCTION

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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, 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 planets' evolution 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.<sup>1</sup> The Dawn Mission offers a variety of information and data for 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.<sup>2</sup>

Dawn began its trek with a successful launch on September 27, 2007 (Figure 1). The craft will travel four years before it reaches Vesta and another four years to reach Ceres with an end-of-mission date of 2015.



Figure 1. Delta II rocket carrying the Dawn spacecraft at liftoff on September 27, 2007.

### 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 (McREL) who 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 including, 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.<sup>3</sup>

### Target Audiences

Dawn's target audiences include:

1. educators (teachers and students, K–post secondary);
2. general public members (businesses, parents, politicians, adult learners, and retirees) ;
3. media journalists<sup>4</sup> (national and local, broadcast, print, trade publications, Internet, instructional TV, radio, and public service announcements);
4. informal educators (science museums/centers, arts community, speakers bureaus, youth programs, and service clubs); and
5. disadvantaged and underserved populations.

<sup>1</sup> 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/>

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

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

<sup>4</sup> Media requests are deferred to JPL media relations; however, Dawn E/PO provides press packets and resources for media professionals through the Dawn Mission Web site.

## **E/PO Approach and Outcomes**

The Dawn E/PO team uses a strategic outreach approach that supports NASA's vision and the Dawn E/PO intended outcomes. This approach is based on four components: Delivery, Communication, Education Development, and Evaluation. In conceptualizing its work based on the outreach model's four components, the E/PO team identified eight, long-term ultimate outcomes, which are supported by seventeen intermediate outcomes. Evaluators and team members created logic models 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. Because of the knowledge and skills obtained from Dawn E/PO products and activities, participants better understand the solar system's formation.
3. Because 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 better understand 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**

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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 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 because 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' abilities 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 methodology and, in some cases, more than one data collection method is used to address a given evaluation question to strengthen the credibility of the findings. Evaluators conduct pilot- and field-testing of educational materials to provide E/PO team members with formative and summative evaluation information regarding implementation and impacts on target participants. Data collection methods include pilot- and field-test instrumentation for educators and students, Web statistics, workshop participant feedback forms, Web-based surveys, and dissemination data. Evaluation instruments implemented during this reporting period include the following:

- Dawn Web site survey. This 12-item online survey is intended for anyone who visits the Dawn Web site and wants to provide feedback regarding its quality and utility.
- Dawn Module Evaluation. This online survey is for formal and informal educators piloting or field-testing a Dawn education module or activity. This six-page survey collects in-depth information from educators regarding their implementation of the module, their perception of its quality and utility, and any changes in instructional practices and student learning.
- Formal education student survey. This paper-based survey is for students in pilot- and field-test classrooms. Students are asked to respond to items about the Dawn classroom materials and any impact they had on students' interest and learning.
- Focus group protocol. This instrument is for students who participated in the pilot test of the Calibrated Peer Review (CPR) tools. It includes eight open-ended questions related to students' perceptions and experiences using the CPR tools.
- Observation protocol. McREL E/PO team members used this instrument during the pilot test of the CPR tools in one pilot-test classroom. It guided observers to focus and document the lesson focus, implementation, and student engagement.
- Workshop participant feedback form. This paper-based form is for formal and informal educators participating in Dawn professional development opportunities, such as conference presentations and workshops. Participants are asked to provide feedback on the professional development's quality and utility as well as any effects that it had on their awareness and interest in the Dawn Mission.

Evaluation activities during the reporting period included instrument development, data collection, and analysis for the CPR pilot test as well as the field test of the *Ion Propulsion* module in formal education settings. Evaluators provided E/PO team members with data reports with formative feedback for both evaluation activities. The findings presented in this report are based on the results of the CPR pilot test, the *Ion Propulsion* field test, six E/PO workshops, the Web site survey, and Web statistics for the Dawn Web site.

## FINDINGS

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This reporting period from August 1, 2008 to July 31, 2009 continues to build on the excitement of the launch of the Dawn spacecraft on September 27, 2007. Since its launch, the Dawn spacecraft has completed various tests, engaged in a Mars gravity assist, and used the ion propulsion system to thrust along its trajectory in preparation for the Vesta flyby. E/PO team members were active in all aspects of outreach, including Web site enhancements and updates, Web site content development and design, material production, and outreach dissemination. This section presents findings related to key 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 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 including 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 through 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 materials 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

The Dawn E/PO team specializes in translating mission science into educational learning opportunities for students and public members. The E/PO educational materials include Web-based information and resources as well as supplemental curriculum materials and activities for formal and informal educators and students. To date, the E/PO team has developed three content modules, *History and Discovery of Asteroids*, *Ion Propulsion*, and *Interactions of Energy & Matter*, as well as various supplemental

activities/tools such as *Find a Meteorite (FAM)*, which is described below; *Career Connections*; *Potato Light Curves*; *Modeling in 3-D*, *Vesta Flip Book*, *Gamma Ray and Neutron Detector (GRaND) Interactive*; and the *Dwarf Planet Activity*.

The *History and Discovery of Asteroids* content module is intended to engage middle-school learners in the wonder and curiosity inherent in discovery. Participants explore the historical sequence of events leading 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 providing 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*<sup>5</sup> and the American Association for the Advancement of Science benchmarks for science education.<sup>6</sup> The module is available online and enables users to search and access different components within the model according to their instructional needs. An Independent Learner Guide and an Informal Leader Guide also were developed to provide broader target audiences with an appropriate format for engaging in the module's activities. This product has completed pilot- and field-testing as well as final revisions, and therefore, evaluation results for this module are not included in this report. During this reporting period, E/PO team members revised the module based on feedback from the NASA product review.

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 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, data manipulation, or resource exploration. 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, *Ion Propulsion* was field-tested in formal education classrooms during spring and fall of 2008.

The third content module, *Interactions of Energy & Matter*, introduces students to the ways that scientists, engineers, and technologists "in the real world" design instrumentation using the *interactions* between different frequencies/wavelengths of electromagnetic radiation (EMR) and matter to make scientific measurements and analyze data. Development of the module has involved

1. identifying relevant science education standards,
2. designing the learning cycle,
3. developing teacher guides and activities for the briefing and exploration sections, and
4. developing fact sheets, image sheets, and PowerPoint slides for each of the instruments.

During this reporting period, the Dawn team worked on the Development section of the module. In the first lesson about Gravity science, students study simulated data from locations within the orbits in which the spacecraft changes velocities. Students interpret these velocity changes (or Doppler shifts in radio signals) in terms of increasing or decreasing mass concentrations. In the second lesson, students will use simulated instrumental results (for each instrument) in order to better understand an aspect of an asteroid and eventually Vesta and Ceres. The team also began development of an interactive Data Cube featuring the VIR instrument in collaboration with the Italian Aerospace Center.

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<sup>5</sup> National Research Council. (1996). *National science education standards*. Washington DC: National Academy Press.

<sup>6</sup> American Association for the Advancement of Science. (1993). *Benchmarks for science literacy: A tool for curriculum reform. Project 2061*. Cary, NC : Oxford University Press.

The *Find a Meteorite* activity introduces the importance of meteorites in understanding the solar system's origin. Because scientists believe that some meteorites are pieces of the asteroid Vesta, they might be very old remnants of the solar system in its earliest stages. The activity provides information and insight, allowing participants to share scientists' expectations, based on meteoritic samples, of what we will find when NASA's Dawn Mission visits Vesta and Ceres. Comparison between actual data and the meteorites here on Earth might confirm that we possess very valuable material. The hands-on activity is an introduction to meteorite identification aiming to help learners differentiate between meteorites and terrestrial rocks. During the project period, E/PO team members made final revisions to the *FAM* activity based on field-test findings and feedback from NASA Product Review.

Calibrated Peer Review (CPR) is a suite of integrated Internet-based tools enabling students to learn through the process of writing and reviewing their peers' writing anonymously. Originally developed at the University of California, Los Angeles for use in university settings, CPR offers a promising option for secondary-school teachers wishing to integrate writing in the content areas. The three guiding principles of CPR are: 1) writing promotes understanding; 2) clear writing demonstrates clear thinking, and 3) evaluation requires higher-order, critical thinking skills. By incorporating CPR in the science classroom, teachers might find students are more motivated to write for an audience of their peers and that the reviewing process helps students to fine-tune and deepen their own understanding of the content. During the project period, one classroom of middle-school students pilot tested the CPR tools and process. E/PO team members observed students as they experienced the following four stages of the CPR:

1. **Read and Research:** In search of answers to a list of guiding questions, students started the assignment by reading a short text and then gathered information on the Internet about the history of the telescope.
2. **Write:** Students then communicated their understanding of the telescope's early history and its impact on science by writing a short essay.
3. **Review Essays:** Students experienced a trial run as a reviewer when they evaluated three sample essays. Then, with a better understanding of the expectations for the assignment, they got the chance to review their classmates' essays.
4. **Self-Assessment:** Finally, students became their own critic when they evaluated their own writing. They could then compare their self-assessment to the reviews their essay received from others.

### Rigorous Quality Assurance Review

The Dawn E/PO team has designed and implemented a product development and quality assurance process including initial peer and expert reviews, pilot- and field-testing in multiple sites, and iterative revising (see Figure 2). 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 goes through this process before finalization and broad dissemination.

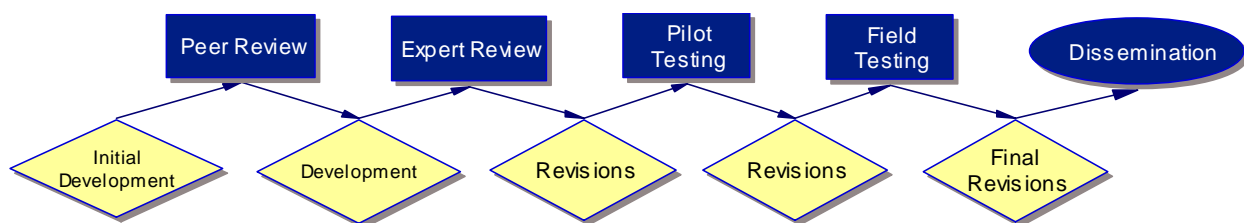


Figure 2. Dawn E/PO product development and quality assurance process.

The purpose of the peer review sessions is to present product components to educators 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 field test's purpose is to study the revised materials in a larger number of settings and to examine the product's effectiveness 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. Additionally, before the E/PO products are disseminated broadly to target audiences, they undergo NASA Product Review for approval.

Six teachers across four school districts completed field-testing of the *Ion Propulsion* module in their classrooms. The following sections present the results from the field test pertaining to user perceptions of the module's quality and utility.

### User Perceptions of Product Quality and Utility

Educators in six high-school classrooms across four districts field-tested the *Ion Propulsion* module in the spring and fall of 2008. Three teachers taught in a single school in Colorado, while the remaining three taught in schools in Florida, California, and Texas. Figure 3 shows the geographic distribution of *Ion Propulsion* field-test locations.

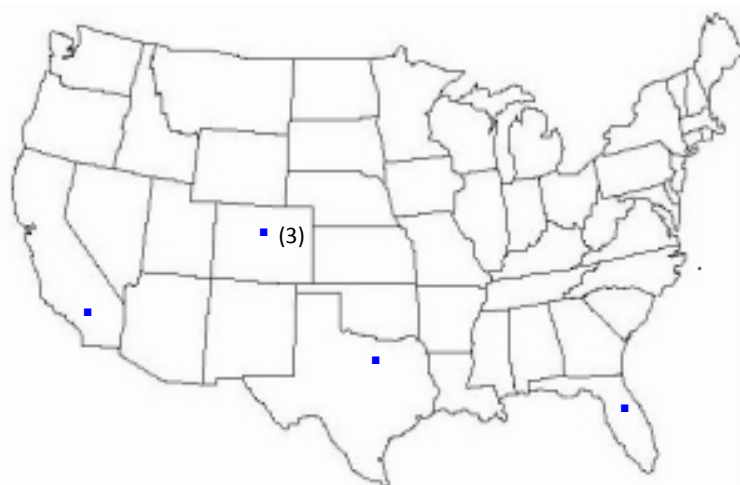


Figure 3. Locations of field tests of the *Ion Propulsion* module.

■ Field-Test Classrooms



Figure 4. Teachers participate in the Mars Gravity Assist Workshop at the Denver Public Schools.

Field-test teachers used the *Ion Propulsion* module with students in 9th—12th grades as part of units on physics, chemistry, and aerospace engineering (Figure 4). Teachers provided in-depth feedback regarding their perceptions of the quality and utility of the *Ion Propulsion* module through the *Dawn Evaluation Survey*. Survey results showed that all teachers found the materials very useful and of high quality. Additionally, all teachers perceived the materials developmentally and culturally appropriate for their students. On a scale of 1 to 7, 1 being “not difficult” and 7 being “very difficult,” educators overall indicated that it was not difficult to adapt the module to their teaching settings ( $\chi = 1.67$ ).

When asked about barriers to using the materials better in instruction, four teachers indicated “no barriers,” one teacher identified insufficient time as an issue, and one indicated that materials required some modification for 9th-grade students. Teacher survey responses and a follow-up interview with one implementer suggest that 9th-grade students had difficulty with the *Pushing with Plasma* reading activity and the RAFT writing. One noted, “The materials with slight modification were appropriate. The most difficulty was the reading and writing assignments which I modified to make them more grade level appropriate.” Teachers also mentioned students’ chemistry background knowledge as a factor in how difficult the materials were for students. Some suggested developing levels of questions (beginning, moderate, and advanced) based on student background knowledge for the *Pushing with Plasma* reading.

Teachers indicated the extent to which they agreed or disagreed with several statements regarding the quality and utility of the *Ion Propulsion* module (5 = strongly agree; 4 = agree; 3 = neither agree nor disagree; 2 = disagree; and 1 = strongly disagree). Figure 5 presents the percentage of respondents who agreed or disagreed with statements related to the activity content and design and alignment to standards.

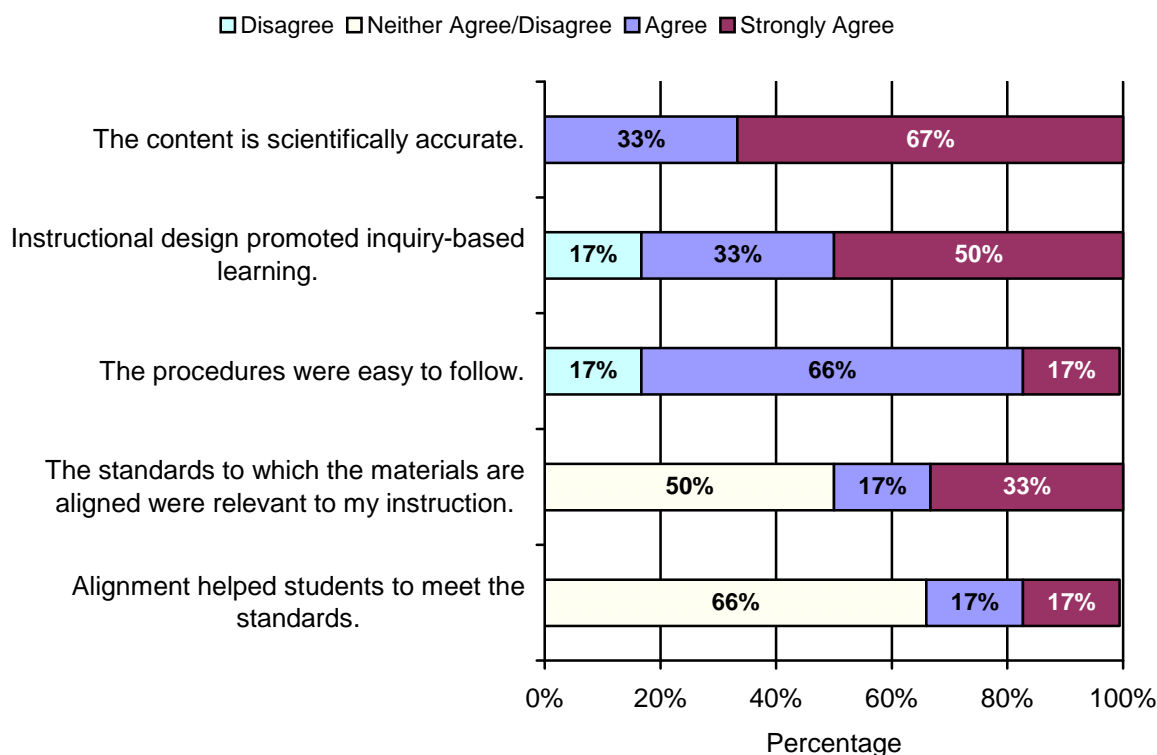


Figure 5. The percentage of educators (n = 6) agreeing or disagreeing with quality and utility statements regarding the *Ion Propulsion* module.

As shown in Figure 5, all educators agreed that the content is scientifically accurate. Five of six teachers (83%) found the procedures easy to follow and the design useful in promoting inquiry-based learning. Half of teachers found the alignment with standards relevant to their instruction, whereas the majority (67%) neither agreed nor disagreed that the alignment helped students to meet those standards.

### Outreach Dissemination and Visibility

E/PO team members disseminate materials and resources ranging from Dawn Mission bookmarks to the Dawn Mission e-newsletter and from mission-related activities for young children to standards-based curriculum modules for teachers and students. This section provides data about the various information dissemination and visibility activities E/PO members supported during the project period. Figure 6 presents quantities of hard-copy project materials disseminated during the reporting period.

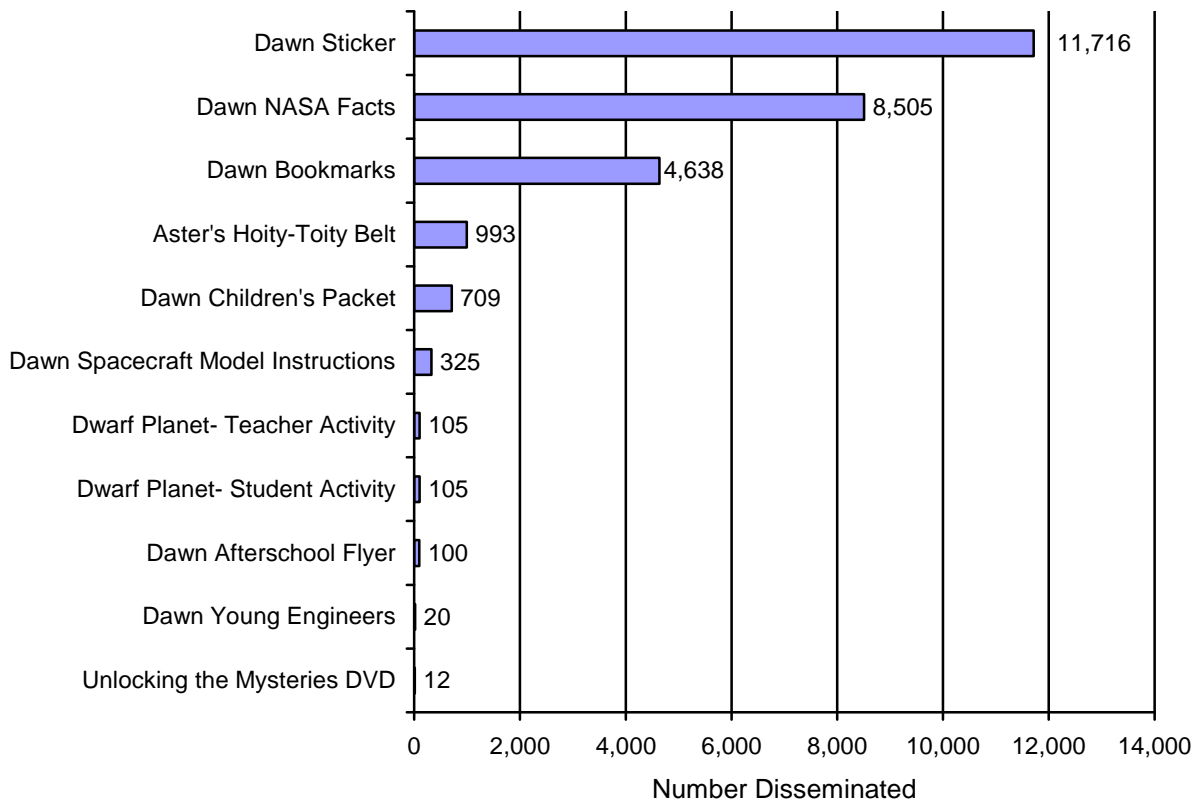


Figure 6. Quantities of hard-copied materials disseminated to target audiences.

From August 2008 to July 2009, approximately 11,700 stickers, 8,500 fact sheets, and 4,600 Dawn bookmarks were disseminated to educators across the country. Also distributed were a small number of Dawn Mission Events calendars, lithographs, activities, children’s packets, and DVDs featuring Dawn for NASA’s Discovery Program.

During the 2008–2009 reporting period, team members developed and disseminated quarterly Dawn Mission e-newsletters to 4,896, which is an increase of 49% from last year’s 3,519 subscribers. Subscribers register for the e-newsletter through the Dawn Mission Web site or by completing a subscription form at professional conferences attended by the Dawn Mission E/PO team.

In preparation for encounters with Vesta and Ceres, Dawn E/PO conducted four simultaneous workshops around the country in conjunction with the Mars Gravity Assist in March 2009. The Dawn mission team (Chris Russell, Carol Raymond, and Marc Rayman and EPO staff hosted a set of unique convergent workshops in Pasadena CA, Portland OR, Denver CO, and Fairmont WV. Dawn’s lead mission science and engineering scientists shared key updates, an overview of Dawn’s science and instrumentation, and how the mission will inform us of the origins of the solar system. The scientists and engineers were simulcast to each site via NASA’s Digital Learning Network. Each location had facilitators who engaged participants in Dawn EPO materials and hosted local tours/speakers. Dawn E/PO leveraged a facilitator from the NASA AESP (Oregon), and NASA ERC (West Virginia), the Denver Public Schools (Colorado), and the Jet Propulsion Laboratory (California) for this unique learning opportunity.

Additionally, two team members presented at the National Afterschool Association (NAA) Conference on the following topics:

- “Kids can learn science through fiction: Everyone loves a story.”
- “Small World in the Solar System: Hands-On Modeling Activities.”
- “Edible Rocks: Meteorites and Meteorwrongs.”

## Dawn Mission Web Site: Usage Statistics

The Dawn Web site is a comprehensive information source and dissemination mechanism for the Dawn Mission. During the 2008–2009 reporting period, team members made a wealth of updates, additions, and enhancements to the Dawn Web site, including timely mission status updates.

From August 2008 through July 2009, the site received 2,581,117 hits, 584,083 page views, and 13,248 visitor sessions.<sup>7</sup> Almost all visitors (99%) accessing the Web site were from the United States, although there was also a small amount of activity from China, Canada, Europe, and other countries. Most sessions (76%) lasted less than 30 seconds; 5% lasted 30 seconds to 2 minutes; 3% lasted 2 to 5 minutes, and 16% lasted longer than 5 minutes.

Figure 7 shows the ten Web pages that received the most page views of the Dawn Web site during the 2008–2009 reporting period. The Dawn homepage had the largest number of page views (158,817). The other most visited pages were in the Mission section, including the Where Is Dawn section (47,102 views), the Mission section entry page (25,466), the Mission Status page (15,380), and the Mission Journal (9,843 views). Education-related pages also received large numbers of views including the Education main page (10,161) and Dawn Kids (7,381). Additionally, this year, two items from the RSS Feed made it into the top 10 most frequently viewed pages: Dawn Journal (3,564 views) and Dawn E-News (3,221). The team took advantage of emerging social media platforms by posting “Share” button underneath Quick Links on homepage and each of the index pages and multimedia galleries. This allows users to easily share information about the Dawn mission with their friends.

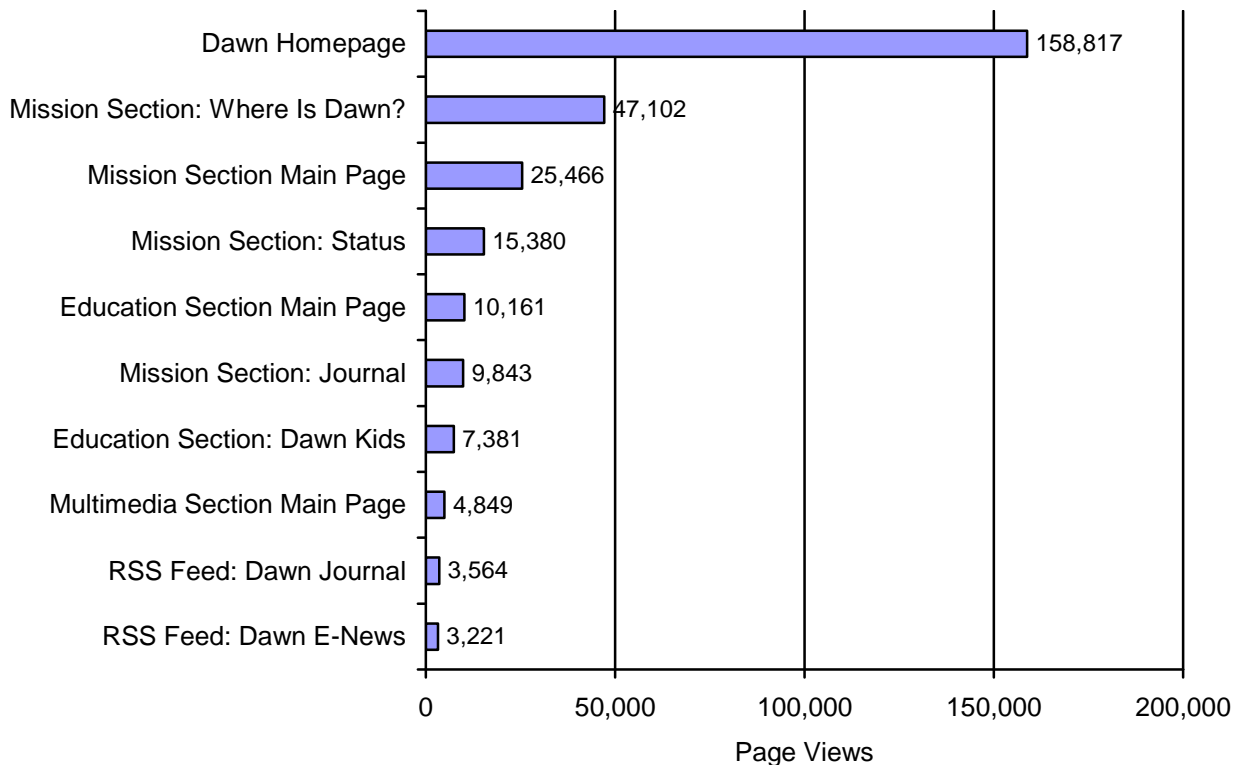


Figure 7. The 10 most frequently viewed pages on the Dawn Web site, August 2008–July 2009.

<sup>7</sup> A visitor session is a session of activity (all hits) for one visitor of a Web site.

The Dawn Web site offers many PDF documents that viewers can download. During the reporting period, the *Mission Fact Sheet* was the most frequently viewed PDF document, receiving 4,926 views (see Figure 8). Other popular downloads included a spacecraft model pattern, various teacher guides, and student activities and readings.

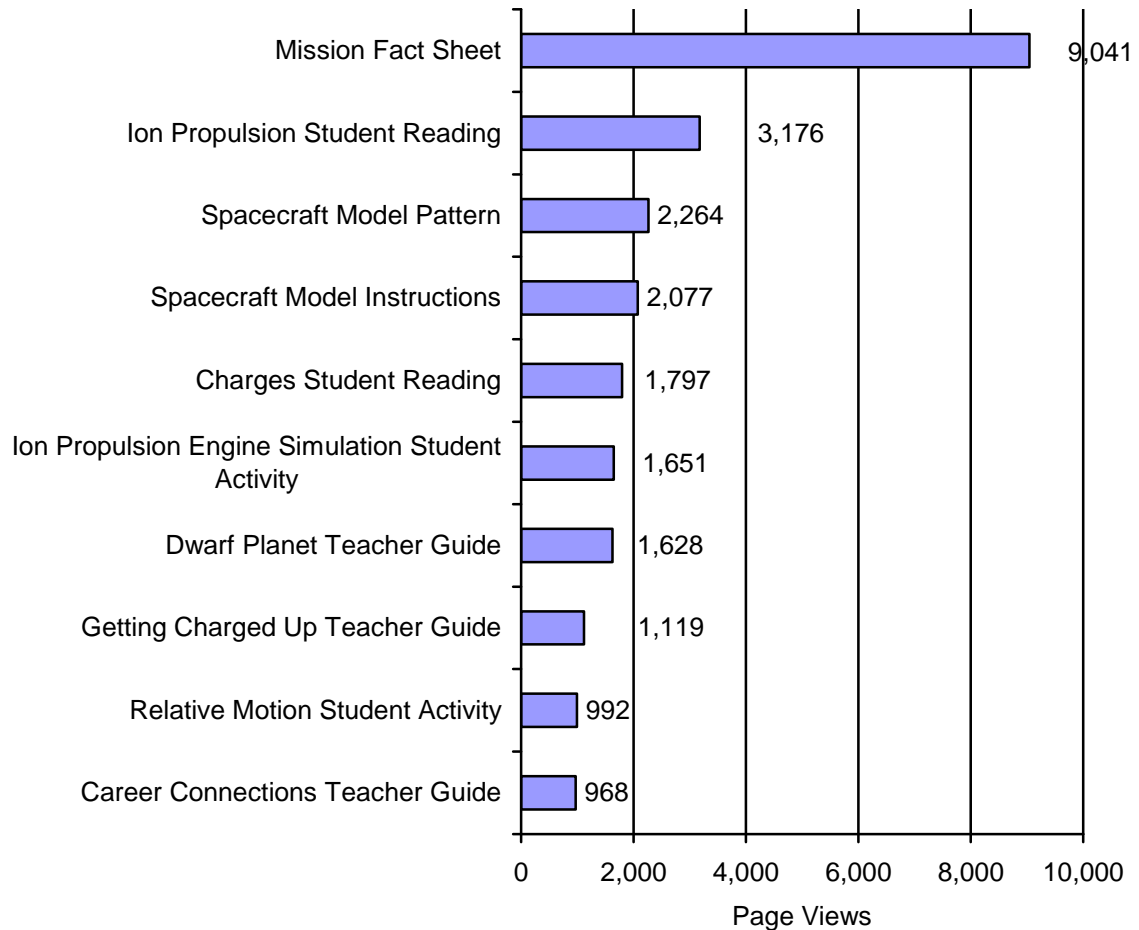
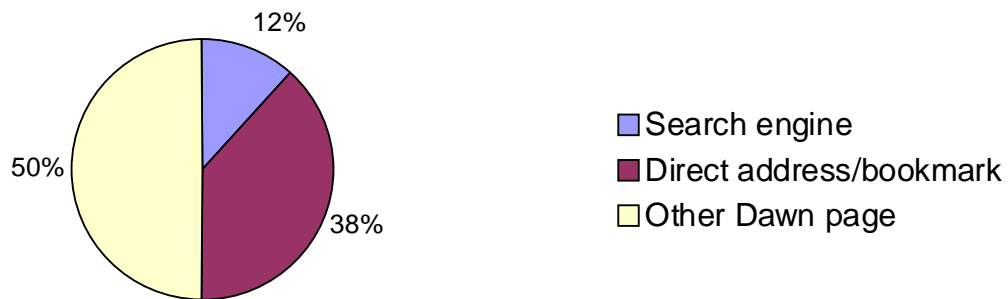


Figure 8. The 10 most frequently viewed PDF pages on the Dawn Web site, August 2008–July 2009.

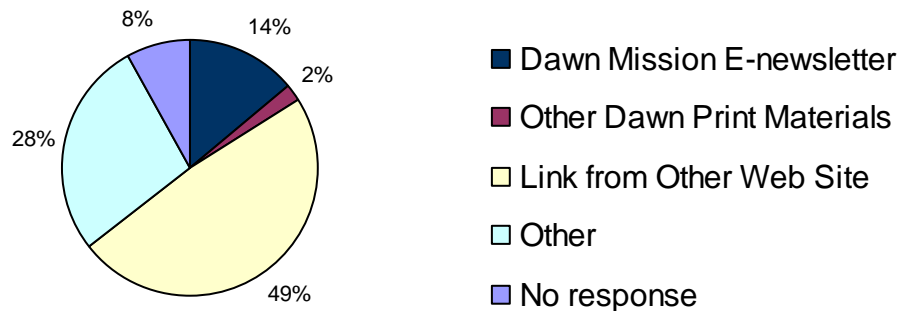
Target audiences can learn about the Dawn Web site through the Dawn e-newsletters; all project materials, which include the Web address; search engines; and links from other space science Web sites. During the study period, 50% of page views originated from another Dawn Web site page; 38% originated from direct address or bookmarks; and 12% from an Internet search engine (see Figure 9).



**Daw** *Figure 9. Web users' method of accessing the Dawn Web site.*

The Dawn Mission Web Site Evaluation survey assessed user perceptions of the site's quality and utility. Of the 43 users who completed the survey during the August 2008 to July 2009 reporting period, 51% identified themselves as members of the public, 23% as educators, 16% as students, and 9% as members of the science community. Of the 10 educators who responded to the survey, one reported teaching K–5; two reported teaching 6–8; two reported teaching 9–12; and five reported teaching at the university level. Of respondents, 67% classified themselves as female and 30% as male. One participant did not respond to this question.

Survey respondents indicated how they learned about the Dawn Web site. During the reporting period, 49% of respondents found the Dawn Web site through a link from another Web page. Of those reporting, 14% found the Web site through the Dawn Mission e-Newsletter. Additionally, 2% indicated that they learned about the Dawn Web site from other Dawn print materials. Those who indicated that they had found the Web site through other means (28%) cited Web searches (n = 5), interest in NASA (n = 3), referral by a friend or teacher (n = 2), and an open house (n = 1) (Figure 10).



*Figure 10. Survey respondents' method of accessing the Dawn Web site.*

The Web site survey contained several questions regarding the utility of the Dawn Web site. Respondents indicated their level of agreement on a five-point scale (5 = strongly agree; 4 = agree; 3 = neither agree nor disagree; 2 = disagree; 1 = strongly disagree) with statements about organization, ease of navigation, accuracy of content, and usefulness of resources. Figure 11 presents the results for these survey items.

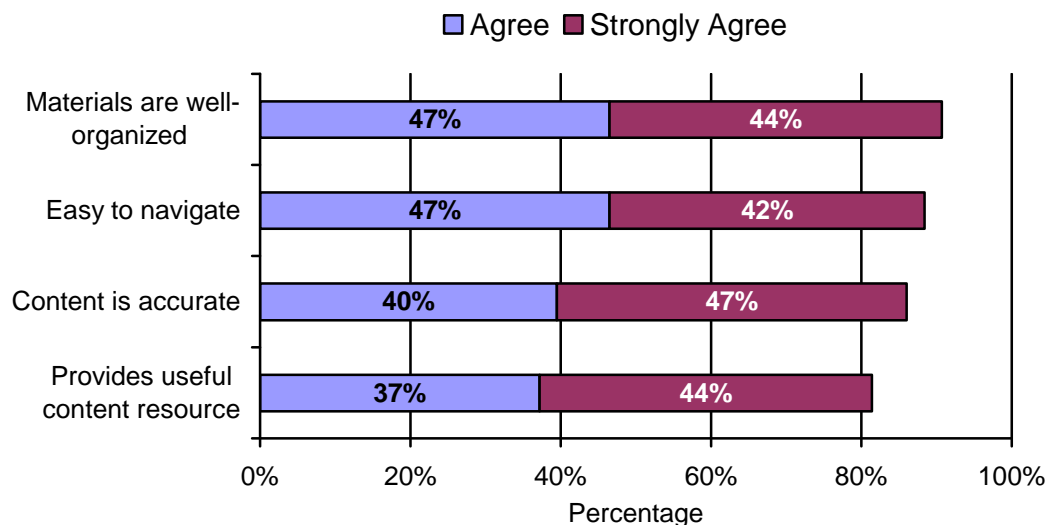


Figure 11. Percent of respondents who agreed or strongly agreed with statements about the Dawn Web site.

As shown in the figure, most (91%) respondents indicated that the materials on the Web site are well-organized. Of respondents, 89% found the site easy to navigate, and 87% found the content accurate. Finally, 81% indicated that the site is useful as a resource for Dawn Mission science content.

Respondents replied to a question about the degree to which the Dawn Web site had met their needs. Of respondents, 58% indicated the Web site met their needs completely; 28% indicated it met their needs mostly; 9% indicated that the Web site had met their needs somewhat; and only 2% indicated the site did not meet their needs. Some respondents requested more updates (n = 3) and additional information (n = 7). With regard to updates, participants requested updates to the Dawn Mission live shots and a list of bulletin updates to the Web site. Additional information requests included more details about the Mars Flyby, explanation of the major events of the program, “more coherent popular science presentation,” follow-up on whether the “ion engine will work as planned,” “short lessons that can be taught individually,” and “more scientific material.” Seven respondents felt the Web site provided a wealth of information that was both easy to find and layered. One participant explained,

*“Simply, the site satisfies all the essential criteria for delivering information to visitors in an easily navigable and straightforward way. Visitors such as myself, as well as young people, students and the general public, are all (so far) well served by your current approach, and I imagine they all look forward to a blossoming odyssey of discovery as Dawn closes in on her targets!”*

Others added that the Web site provided great information “suitable for people with diverse knowledge level in science” and was a “very informative and interesting way to satisfy my curiosity.”

Respondents also answered questions about the utility of each of the major sections of the Dawn Web site by indicating whether each section was “not useful,” “somewhat useful,” or “useful.” Figure 12 presents these results. More than three-quarters of those who responded to this question found the Science, Mission, and Technology sections of the Web site to be useful. In addition, greater than half of respondents found the Dawn Media, Education, People, and Multimedia sections to be useful. Two participants requested the addition of images on the Dawn Web site, including the “best pictures of Vesta and Ceres” and “images from the framing cameras and other instruments as the mission progresses.” Another participant requested more accurate information, writing, “When you tell someone that the angular momentum of Mars is ‘the speed at which it orbits the sun,’ this is not accurate.”

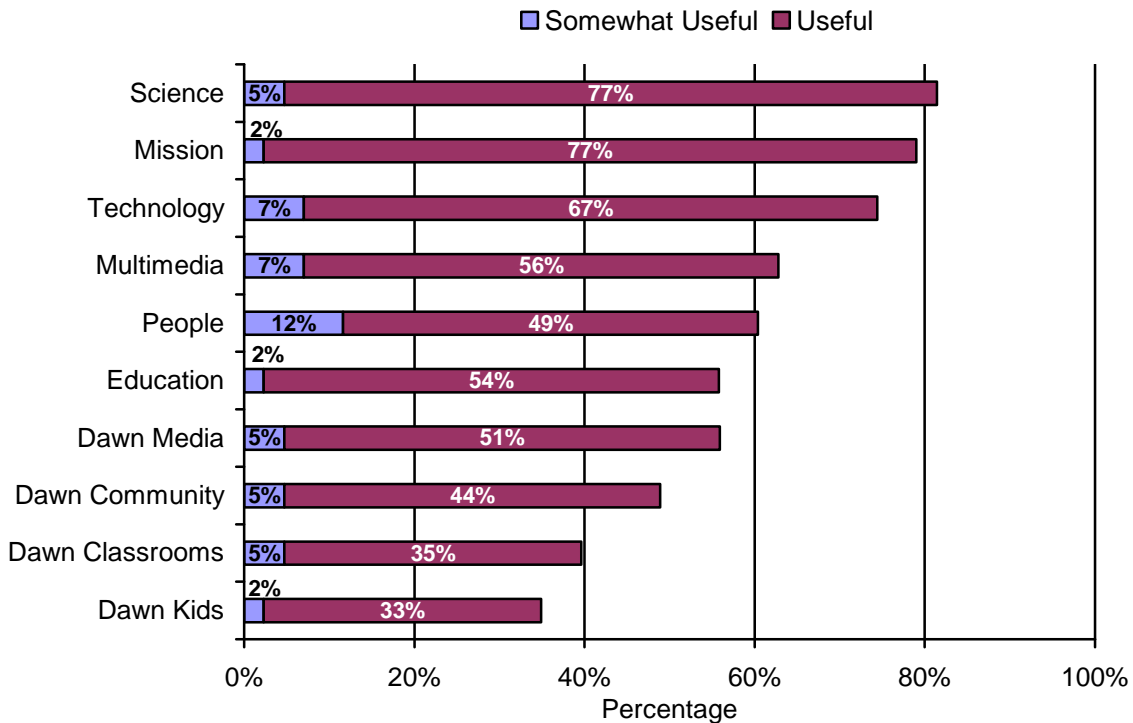


Figure 12. Percent of respondents reporting that the Web site was somewhat useful or useful (n = 43).

Survey respondents answered questions regarding how the Web site affected their interest in science and their awareness of science-related content. Figure 13 shows responses to questions related to increased interest in Dawn Mission science content and increased understanding of the formation of the solar system. As shown in the figure, 86% of respondents agreed that the Web site increased their interest in Dawn Mission science content, and two-thirds came away with a sense that they understood more about the solar system after looking at the Web site.

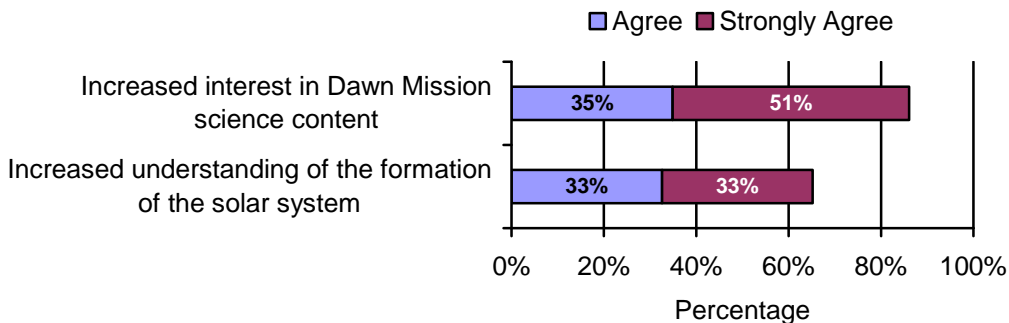


Figure 13. Percent of respondents reporting increased interest and understanding because of viewing the Dawn Web site.

After reviewing the Web site, several participants had additional questions about the solar system, indicating a high level of engagement. Among other questions, participants asked about the formation of planetoids and “their importance for overall understanding of formation of solar system,” how the Dawn Mission will study asteroids, why certain planets are solid and others gaseous, and “what the solar system is made of.”

In addition to items related to the quality and utility of the Web site, respondents replied to two questions related to their overall satisfaction with the Dawn Web site. Respondents indicated agreement or disagreement with a statement about whether they would recommend the Web site

to others. Of respondents, 98% agreed that they would recommend the site to others (see Figure 14). This is greater than in the past reporting period where 87% of respondents agreed that they would recommend the site to others.

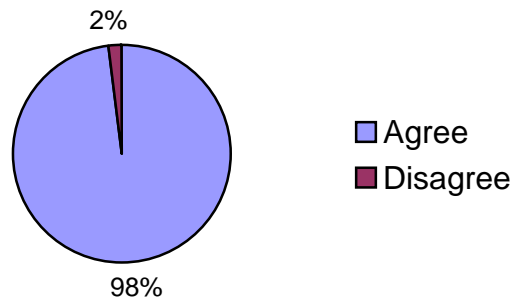


Figure 14. Percent of respondents agreeing or disagreeing that they would recommend the site to colleagues.

Respondents also rated the quality of the Web site on a five-point scale (5 = excellent; 4 = good; 3 = average; 2 = fair; 1 = poor). Most respondents (95%) rated the Dawn Web site as good or excellent (see Figure 15). Two participants mentioned items they would fix on the Web site, including the accuracy of information on the “Where Is Dawn” page as well as improving the overall look of the Web site to be more attention-grabbing. Overall, respondents were impressed with the Web site, with viewers noting the ease of use and excellent format (n = 6) as well as educational benefits (n = 4). One participant wrote that the Web site was professional and easy to use, adding that NASA “delivers on its promise to provide superior information to anyone who may want to find out about its projects and explorations.” Another added that the Web site provides a, “very good combination of technical, scientific and sheer excitement.” With regard to education, one participant noted that the site might “help promote NASA to the public.” Another added that the site “has everything ‘normal’ users need to know about the mission.”

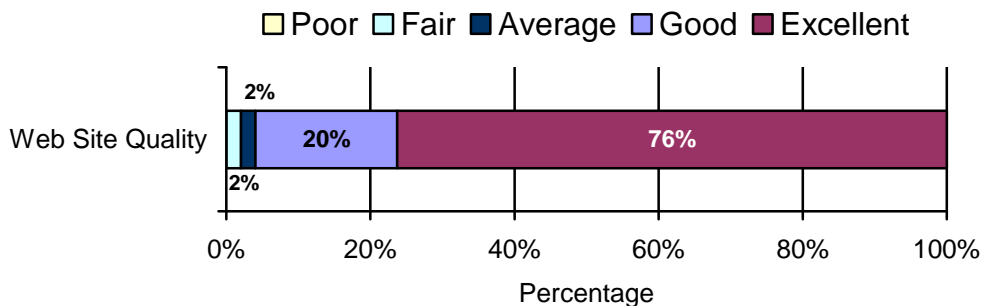


Figure 15. Percentage of respondents rating the overall Dawn Web site.

Respondents answered open-ended questions concerning what they liked most about the site and what they would improve. Participants were particularly pleased with several specific pages, including the Dawn Journal by Dr. Rayman (n = 2), Becoming a Dawn Young Engineer (n = 1), teacher and students session (n = 1), mission pages (n = 1), status reports (n = 1), mission intent (n = 1), detailed information about the beginning of the mission (n = 1), and references to other sites (n = 1). Viewers appreciated the multiple layouts and variety of pictures as well as audiovisuals (n = 5), the ease of access and site simplicity (n = 2), information sharing with the public (n = 1), and the encouragement of public participation (n = 1).

Respondents suggested including more images/videos (n = 4) and providing more detailed information (n = 4). Beginning with multimedia, viewers requested “more images from the Dawn spacecraft as the mission progresses” as well as 3D graphics of the Dawn orbits. One respondent wrote the following about improving the site from “basic to great”: “Go for great. I would love every classroom in the world to be hanging on Dawn’s great adventure. This is the first real spacecraft. Not just a probe. Tell the world.” Respondents also requested more information concerning what is happening in real time. One visitor wrote that such real time weekly or monthly updates “would substantially enhance the visitor’s experience,” allowing for the user to experience a more “active connection on current operations.” Additionally, respondents desired more in-depth science coverage, including information that is both “technical as well as educational.”

Lastly, respondents indicated the types of materials or information they would like more of on the Dawn Web site. Figure 16 presents the results to this question. Respondents chose simulations and technical data most frequently (67% and 58%, respectively). Of respondents, 9% chose “other” materials or information in response to this question and indicated specific things they would like to see. Respondents requested more chat rooms, family and youth participation links, and in-depth articles.

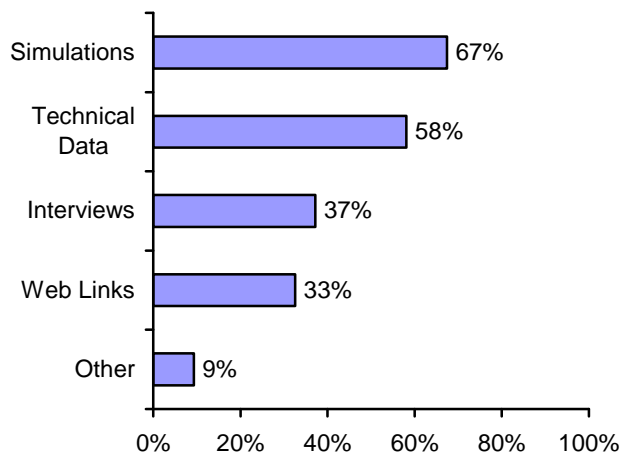


Figure 16. Resources respondents would like to see more of on the Dawn Mission Web site.

## 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, afterschool, and summer school settings; and independent learners who access the activities on the Dawn Mission Web site.

The Dawn science education 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 cycle<sup>8</sup> 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 because of using E/PO materials?
5. Do participating students have an increased understanding of the formation of the solar system?

Six teachers participated in the field test of the *Ion Propulsion* content module in formal classroom settings. One teacher field-tested the materials in the spring of 2008 with 28 students. Five teachers field-tested the module in the fall of 2008 with 181 students for a total 209 participating students across both field tests. Field-test teachers implemented the module with students in Grades 9–12.

### **Characteristics of Participating Students**

The students participating in the spring 2008 field test completed a post-module questionnaire providing feedback on the module. All 28 participating students completed the post-module questionnaire. Students in the fall 2008 field test completed pre- and post-module questionnaires to provide feedback on the module and gauge the impacts of the module on student interest and attitudes toward science. Of the 181 students participating in the fall field test, 166 completed both pre- and post-questionnaires. Of the students who completed questionnaires in both field studies, 43% were female and 57% were male. Of the students, 57% identified themselves as White, 10% as African American, 15% as Hispanic, 10% as Asian American, 3% as Other, and 5% did not respond.

### **Increasing Student Interest in Solar System Science**

Students in the spring 2008 field test responded to items on the post-questionnaire about impacts of the *Ion Propulsion* module on interest and engagement in the activities on a four-point scale (4 = strongly agree; 3 = agree; 2 = disagree; 1 = strongly disagree). Figure 17 presents results of these items.

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<sup>8</sup> The learning cycle for each module is divided into the following five components: briefing, exploration, development, interaction/synthesis, and assessment.

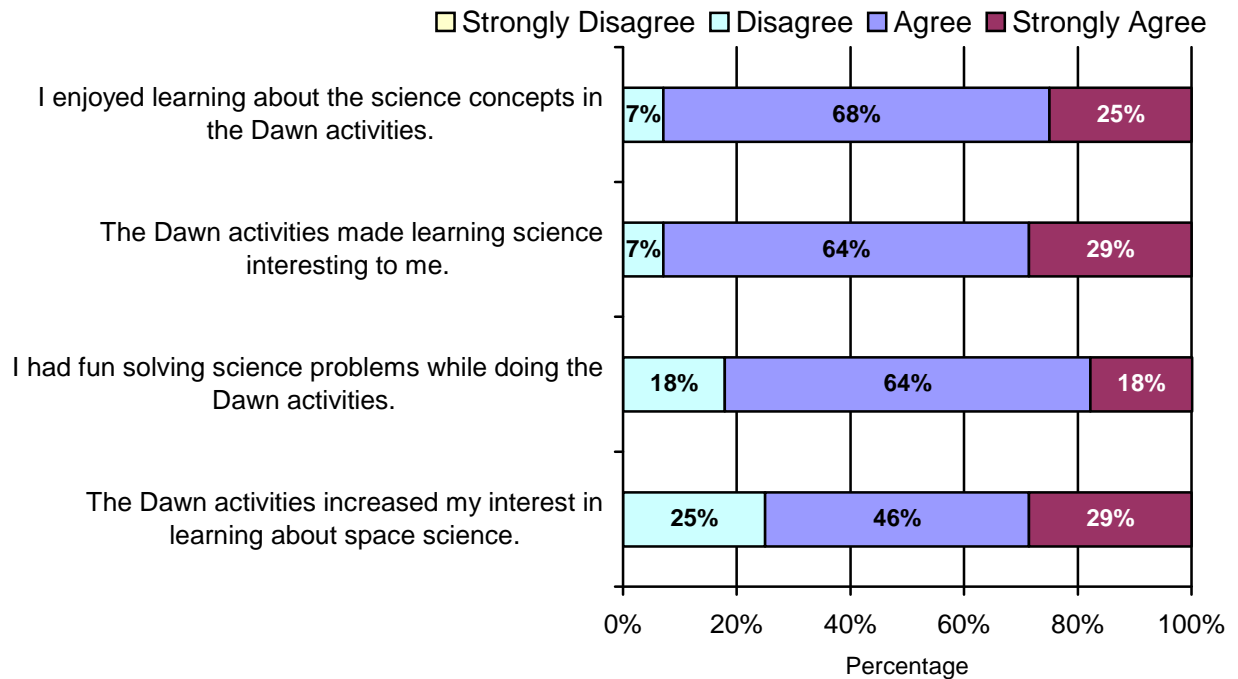


Figure 17. Percentages of students in the spring 2008 field test agreeing and disagreeing with statements related to interest and engagement (n = 28).

As shown in the figure, most students (93%) indicated that they enjoyed learning about the science of the Dawn activities and that the activities made learning science interesting to them. Of the students in the spring field test, 82% indicated that they had fun while doing the activities. Three-fourths of students felt that the activities increased their interest in learning about space science. In addition to the findings in Figure 17, 82% of the spring 2008 students agreed that they would like to learn more about careers in space science, while 58% indicated that the activities sparked their interest in pursuing a job that uses science.

Students in the fall 2008 field test indicated their level of agreement with twelve statements on the pre- and post-questionnaires intended to measure changes in attitudes after completion of the Dawn *Ion Propulsion* activities. The items were measured on a four-point scale (4 = strongly agree; 3 = agree; 2 = disagree; 1 = strongly disagree). Results of the 12 items indicated that students had a moderate level of agreement before and after the module with items related to understanding of ways to conduct science investigations, interest in pursuing a job that uses science, and enjoyment of solving science problems. Students had a high level of agreement pre- and post-module that they enjoy conducting science experiments. Responses to 4 items showed statistically significant change from before to after module completion at the .05 level. Figure 18 presents the mean ratings of students' responses before and after participating for the items that showed significant change.

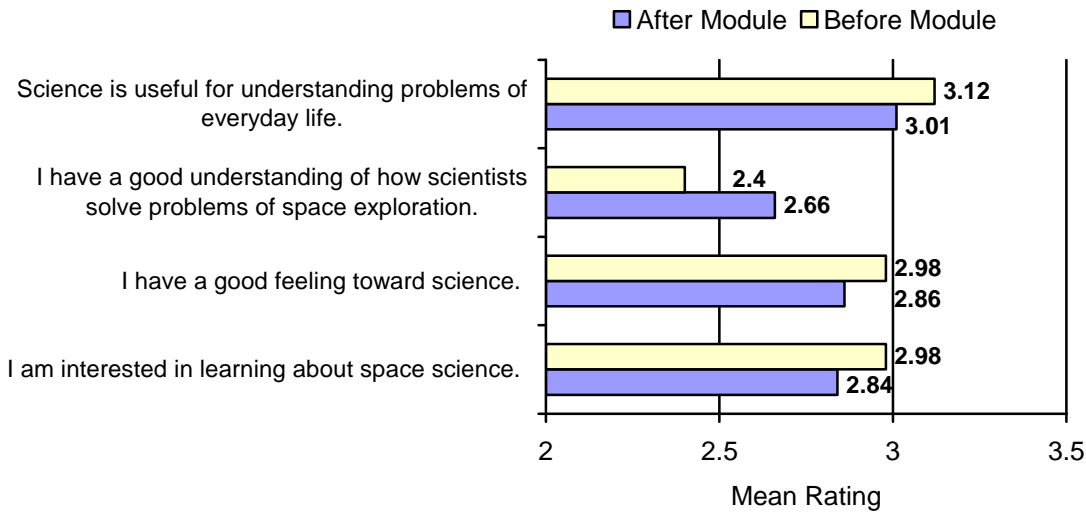


Figure 18. Mean ratings for students' level of agreement with statements regarding their perceptions of and experiences with science (n = 164-165).

Figure 18 indicates that students gained an understanding of how scientists solve problems related to exploration of space through participation in the *Ion Propulsion* module,  $t(164) = 3.07$ ,  $p = .003$ . Teacher observations and assessments discussed in the following section of this report corroborate these results.

Student ratings decreased for having a good feeling about science,  $t(163) = 2.22$ ,  $p = .028$ ; interest in learning about space science,  $t(164) = 3.07$ ,  $p = .003$ ; and understanding the usefulness of science to everyday life  $t(160) = 2.034$ ,  $p = 0.44$ . Interpretation of these results is difficult, given that experiences beyond the Dawn activities also influence student perceptions and attitudes, and it is difficult to interpret student survey responses without observation and interviews to clarify findings. Teacher feedback indicated that students perceived the reading portion of the module as too much and difficult and this may have influenced their perceptions related to interest and attitude toward space science. Student comments revealed they most liked the computer simulations and "learning about the ion propulsion engine and how it works." When asked what would make the *Ion Propulsion* module activities more interesting and fun, the most common responses were "to have more simulations," "have hands-on labs," and to "build or see a model of a spacecraft."

### Increasing Student Knowledge and Skills

Students participating in the spring and fall field-testing responded to a series of Likert scale items (4 = really agree; 3 = agree; 2 = disagree; 1 = really disagree) about their learning because of the *Ion Propulsion* activities. Students indicated their level of agreement with five statements beginning with "As a result of this Dawn module, I learned much about ...." Figure 19 presents the results for these items.

## As a result of this Dawn module, I learned much about...

□ Strongly disagree □ Disagree □ Agree □ Strongly Agree

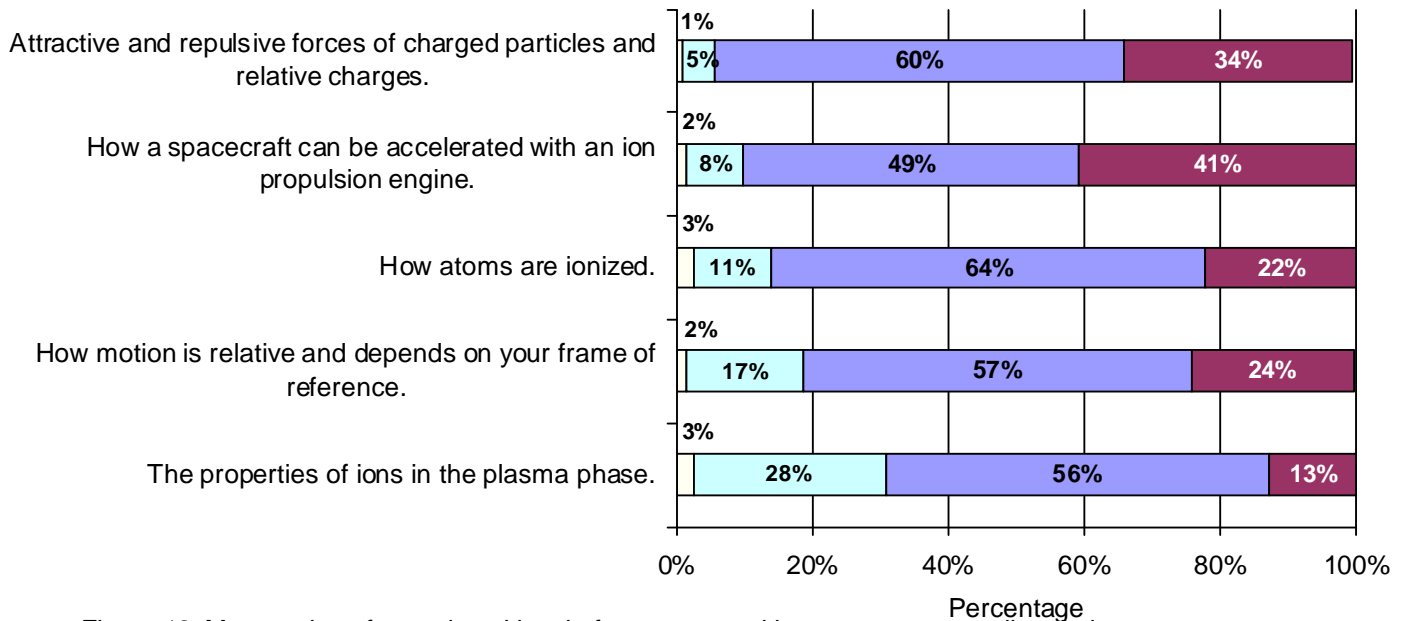


Figure 19. Mean ratings for students' level of agreement with statements regarding their learning (n = 193).

As shown in the figure, students indicated on average that they had learned most about attractive and repulsive forces of charged particles and relative charges (94%). Most students (90%) also agreed that they learned much about how an ion propulsion engine works to accelerate a spacecraft, how atoms are ionized (86%), and the relationship between motion and frame of reference (81%). In addition, 70% of students indicated that they had learned much about the properties of ions in the plasma phase (Figure 20). Written comments from students supported these findings. The following four student responses are typical of what students wrote:

*"I learned how exactly an ion engine works and the components that are involved in doing that. It made it a blast."*

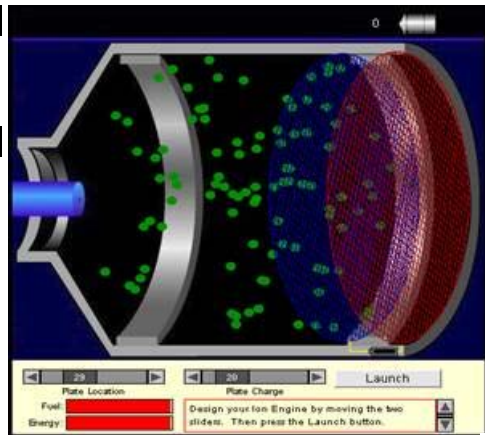
*"I have learned a lot more about what ion propulsion is, especially by observing the ion simulations where I moved the screen to see how far I could make my rocket go."*

*[I learned about] "the design of an ion engine and the history of positive and negative charges from Ben Franklin thinking it was a fluid."*

*"I learned the basics of an ion propulsion engine and a new alternative to using conventional onboard fuel."*

Students commented that in addition to learning about ion propulsion engines, they also learned about the Dawn Mission. One wrote, "It shows our knowledge of space, that we can venture that far into our solar system." Related to this, 93% of students indicated that the Dawn *Ion Propulsion* activities helped them to understand the "real-life" uses of science, and 86% agreed that the activities helped them to understand how to solve science problems.

Based on observations and informal assessment, 83% of educators agreed that the activity improved student learning about science concepts. On a scale of 1 to 7, 1 being "no learning" and 7 being "a great deal of learning," educators overall indicated that students demonstrated a high level of learning ( $\chi = 6.33$ ). One educator offered the following written comment,



*"... I think the final assessment really captured their interest and intrigued them. And, remarkably, they had learned enough along the way to think in a fairly sophisticated fashion about the problem scenario with which they were faced."*

Another wrote,

*"[We had] excellent discussions regarding ionization of atoms. The classes (with guidance) roughed out the basics of an ion drive prior to the reading. Students effectively manipulated ion simulations by changing the size of the charge and location of the charge."*

Figure 20. Ion Propulsion computer simulation.

These findings indicate that students learned much about significant physical science concepts by doing the *Ion Propulsion* activities, and that the computer simulations were particularly effective in increasing student understanding of attractive and repulsive charges and the design of ion propulsion engines. Students were highly engaged by the computer simulations; they enjoyed the challenges presented by manipulating the variables in the simulations.

### History of the Telescope Calibrated Peer Review Lesson

In January of 2009, NASA Education and Public Outreach (E/PO) team members piloted a lesson titled *The Invention of the Telescope: An Astronomical Revolution* with 21 middle-school students in a private school in the Denver, Colorado, area. The lesson used the Calibrated Peer Review (CPR) process to teach students about the history of the telescope while developing their writing skills. The CPR process involves information gathering on the topic, writing an essay on the topic, learning a process for evaluating essays, and finally, self-assessment of writing on the topic. The lesson was originally developed as an adapted activity for Content Module #1 during the CPR teacher workshops in 2004. The lesson was revised by McREL and formatted for inclusion with the CPR interface. Students completed the lesson over three class periods.

The pilot test was an exploratory study to examine the feasibility of using the CPR telescope lesson with middle school students. Prior to this pilot, the CPR lesson had not been used at the middle school level, and a primary purpose of the study was to determine if the use of the CPR process was developmentally appropriate for this age group. The study was conducted in a single classroom for the purpose of providing information to Dawn E/PO team members. Findings are not generalizable beyond the study sample and are solely intended for formative use.

#### *Characteristics of Participating Students*

Twenty-one students participated in the CPR telescope lesson. Of the participating students, nine were in seventh grade, and twelve were in eighth grade. Of the students, eleven were female, and ten were male. Twenty students (95%) classified themselves as white, and a single student indicated Hispanic ethnicity. Students responded to a survey after completion of the lesson to gather feedback on the impact of the lesson on learning, interest, and the CPR process. Researchers also conducted observations and interviews with students during the three class periods.

#### *Student Interest and Engagement*

On the survey, students indicated their level of agreement with statements about their interest in science related to the CPR telescope lesson on a four-point scale (4 = strongly agree; 3 = agree; 2 = disagree; 1 = strongly disagree). Figure 21 presents results of these items.

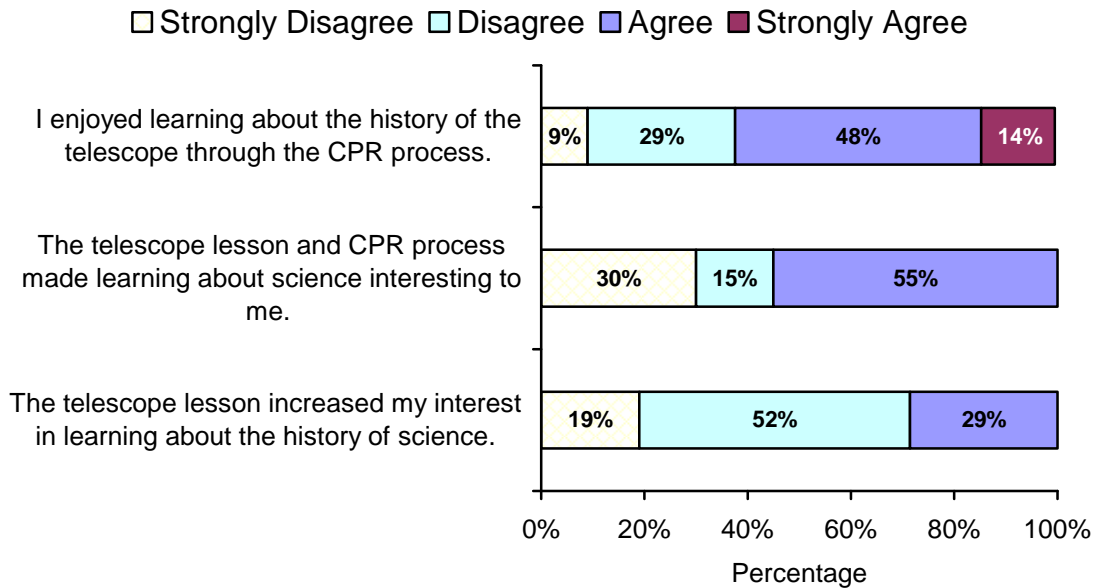


Figure 21. Percentages of students who agreed or disagreed with statements regarding interest in science related to the CPR telescope lesson (n = 21).

As shown in the figure, nearly two-thirds of students (62%) *agreed or strongly agreed* that they enjoyed learning about the history of the telescope through the CPR process. More than half indicated that the lesson made learning science interesting to them. Most *disagreed or strongly disagreed* with statements regarding the impact of the lesson on their interest in science. Observations revealed a higher level of student engagement and interest than indicated by students in interviews and questionnaires. Observations and an interview with students and the classroom teacher revealed that students were highly engaged in the lesson but became frustrated as they began to get feedback from the computer program on the calibration essays and on their own writing. In interviews, students expressed confusion about the calibration process, particularly in understanding their scores. The classroom teacher felt that the low scores students received from the CPR program tainted their perceptions of the lesson. The classroom teacher gave students a grade on the assignment, which added to student frustration as this was a high achieving group of students who place a high degree of importance on their grades. In a follow-up self-assessment questionnaire given by the classroom teacher, students expressed a more positive view of the lesson, with many indicating it was worthwhile and that they would like to do similar lessons in the future.

#### Impacts on Student Learning

Students indicated their level of agreement with statements about their learning because of the CPR telescope lesson. Figure 22 presents the results for these items.

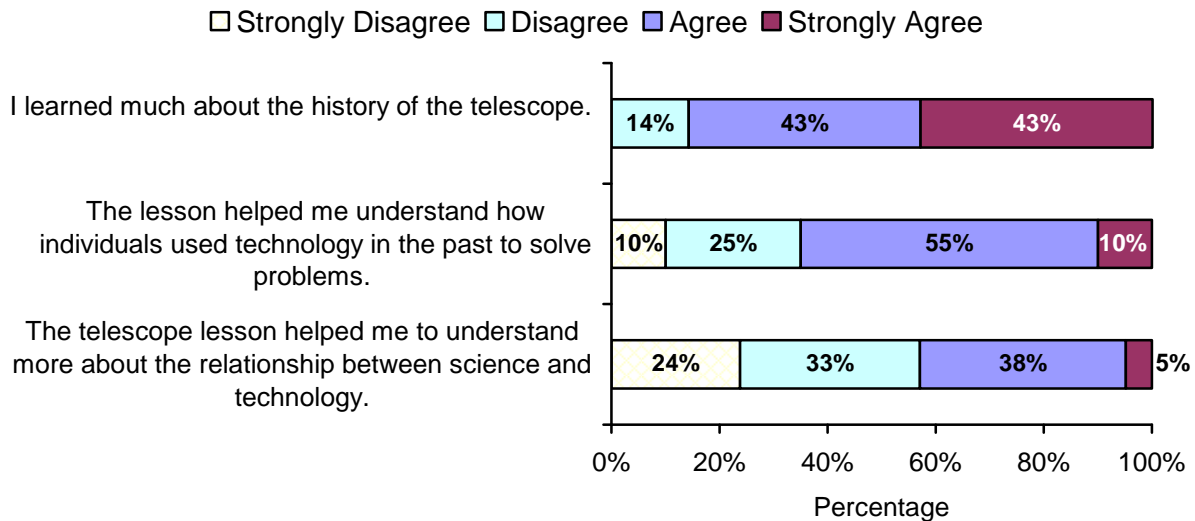


Figure 22. Percentages of students who agreed or disagreed with statements regarding increased learning related to the CPR telescope lesson (n = 21).

Nearly 86% of students *agreed* or *strongly agreed* that they learned much about the history of the telescope. On the follow-up self-assessment, 20 of the 21 students indicated that they knew more about the history of the invention of the telescope after completing the CPR lesson than before, and 19 indicated that they knew more about how a telescope works after completing the lesson. Focus groups and student surveys revealed that students learned specifically about conflicting stories concerning the origin of the telescope, how the telescope was invented, the types of telescopes (refractor and reflector), and how the telescope works. One student commented in the focus group interview, “I thought Galileo invented the telescope, but when I was reading today, I realized he didn’t, at least the lens part. He used the lens in cool ways.” Sixty-five percent of students agreed that they learned how scientists used technology in the past to solve problems. Most students *disagreed* or *strongly disagreed* with statements concerning an increased understanding about the relationship between science and technology. It is important to note that this item did not define “technology,” and therefore it is not known if students’ conceptualizations of technology expanded beyond computers to include telescopes and other science-related tools and equipment.

With respect to the Calibrated Peer Review process, students most enjoyed the chance to grade other students’ work. Typical comments included, “I liked grading because I love editing other people’s work. I want to be a teacher when I grow up, so I loved grading!” and “I enjoyed be able to read other text samples and comment on them, I learned most from that.”

Students expressed frustration with the word limit imposed on their essays by the program and with the inability to edit their essays after initial scoring. The classroom teacher and writing teacher confirmed that for this age group, the editing and revision process is critical to developing writing skills.

Results of the pilot study indicate that students learned much about the history of the telescope from the readings and that they exhibited a moderate to high level of engagement in the process. However, the CPR process may not be appropriate for middle-school students who are in the early stages of both learning to write clearly and analyzing written text unless they have opportunities to edit their work and receive feedback from the classroom teacher. If the CPR telescope lesson is to be used with middle school students, it would need revising to allow for more practice with the CPR process, and the ability to edit work as students progress through the lesson.

## REACHING AND IMPACTING FORMAL 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 in science instruction. Through the Dawn outreach efforts, educators can access standards-based curriculum modules and activities, 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 reporting period, evaluators focused on collecting feedback data from educators in formal education settings who volunteered to implement the *Ion Propulsion* module with students. This report also presents feedback from participants across six professional development workshops that occurred during the study period.

### Ultimate Outcome

5. Educators have a better understanding of how to implement inquiry processes 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 involving pilot- and field-testing curriculum materials, providing evaluation feedback, and disseminating E/PO materials and resources to other educators. As E/PO products become available, educators also can access the materials without becoming a field associate. 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 workshop feedback 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 Web site evaluation form.

### Characteristics of Educator Participants

As previously noted, during this reporting period, outreach efforts reached educators through field-testing as well as through professional development workshops (Figures 23, 24). Participants in field-testing of the *Ion Propulsion* module included teachers from public high schools in Colorado, Florida, Texas, and California. The middle-school pilot testing of the CPR telescope lesson took place at a private school in Denver, Colorado. Of the six teachers who implemented the *Ion Propulsion* module, four held master's degrees while two held bachelor's degrees. Years of teaching experience ranged from 7 to 35 years ( $\chi = 18$ ).



Figure 23. Educators "In Search Of" an asteroid during the Mars Gravity Assist educator conference in West Virginia.

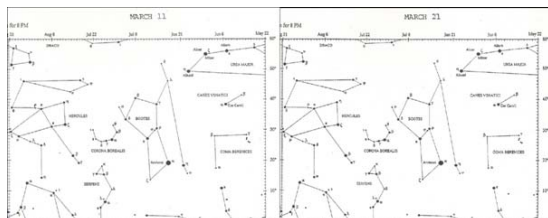


Figure 24. Star chart like that used in Figure 23.

### Reaching Formal Educators in Field-Test Sites

All six teachers who field-tested the *Ion Propulsion* content module reported a high degree of interest in science and enjoyment in teaching science. All teachers felt well-prepared to facilitate inquiry-based learning in their classrooms. As such, they indicated feeling comfortable using the *Ion Propulsion* materials and activities. One noted,

*“Although these materials were developed around an event and principle that I would not have thought to utilize on my own, the strategies are consistent with what I try to do with my teaching on a regular basis.”*

Several other teachers echoed this sentiment. These results suggest that the materials supported teachers’ existing pedagogical principles, thus enhancing their utility.

Teachers responded to several items related to the impact of the *Ion Propulsion* materials on their instruction. Figure 25 presents results for these items.

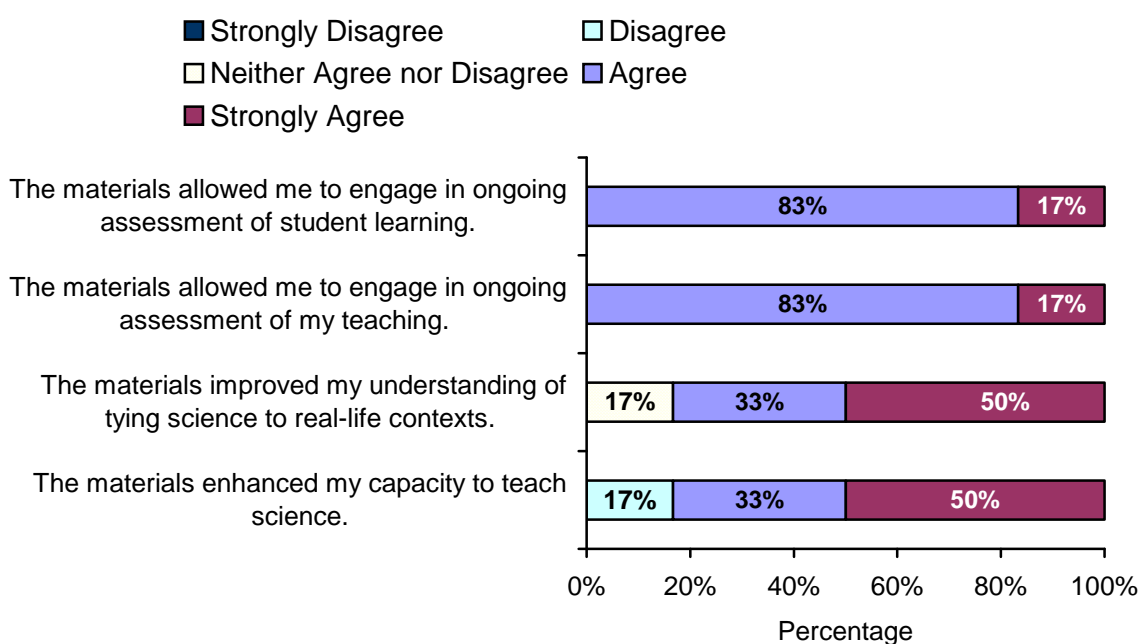


Figure 25. Percentages of teachers who agreed or disagreed with statements regarding impacts of the Dawn materials on their teaching (n = 6).

As shown in Figure 25, all of the field-test teachers perceived the *Ion Propulsion* materials to be effective in assessing their own instruction as well as student learning. Most teachers (83%) felt that the materials improved their understanding of tying science to real-life contexts and that the materials enhanced their capacity to teach science.

### Reaching Workshop Participants

During the project period, E/PO team members represented the Dawn Mission at several educator events to over 160 participants (Figure 26). Staff presented Dawn educator workshops at the National Afterschool Association Conference (New Orleans, Louisiana), the National Middle School Association Conference (Denver, Colorado) and the Kansas Association of Teachers of Science KATS Kamp (Junction City, Kansas). In addition, E/PO staff conducted four *Mars Gravity Assist* workshops on March 7, 2009 in Pasadena, California; Denver, Colorado; Portland, Oregon; and Fairmont, West Virginia. Workshops and presentations focused on E/PO activities and resources to promote further Dawn Mission education outreach. Presenters collected feedback



Figure 26. A participant at the Mars Gravity Assist educator conference in Denver designs an Ion Engine.

from participants during five workshops on the quality of workshop materials and activities, applicability of the sessions to classroom practice, and on the impact of the workshops on educator understanding of the topic presented. Thirty-eight participants provided feedback on the sessions.

Participants rated aspects of the workshops including materials, activities, presentations, and opportunities for participation and input on a five-point scale (5 = very good; 4 = good; 3 = fair; 2 = poor; 1 = very poor). Figure 27 presents participant ratings of session

activities and materials. As shown in the figure, all participants rated every aspect of the workshops as *good* to *very good*, with most rating all aspects as *very good*.

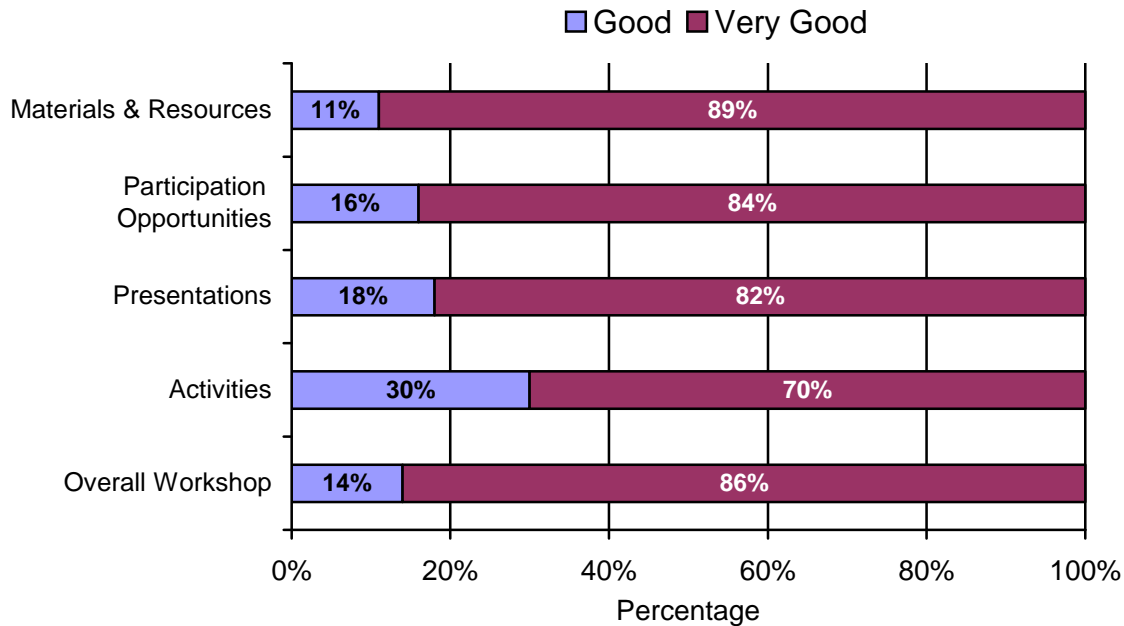


Figure 27. Participant ratings of aspects of workshop quality (n = 37–38).

Participants rated their level of agreement with statements about whether the sessions increased their knowledge of the topic and were applicable to their work as educators on a five-point scale (5 = strongly agree; 4 = agree; 3 = neutral; 2 = disagree; 1 = strongly disagree). Of participants, 97% indicated that the sessions enhanced their understanding of the topic, and the majority (89%) indicated that they expected to use what they had learned in their work. In addition, 97% of teachers indicated that they expected to share what they had learned with their colleagues. These results demonstrate that teachers found the workshops to be valuable, applicable, and relevant learning experiences.

When responding to a question about what they found most useful, participants in the *Mars Gravity Assist* workshops most frequently commented on the videoconferencing with NASA

Mission leaders. One noted, “the live broadcast by those involved with Dawn [was useful] for my overall understanding.” Another indicated that the video conferencing “was supported by great instruction, materials, and activities.” Participants appreciated the chance to “personally interact with the activities” during the workshops and found it useful to learn about activities they could use in their classrooms. Several participants also commented that it was helpful to see the Dawn Web site including activities and information for use with students.

In addition to these outreach efforts, Dawn E/PO hosted its first Webinar, entitled *Journey to the Bottom of the World*, featuring Dr. Lucy McFadden, on August 8, 2008, for educators across the country. Although evaluators did not collect formal feedback, the following testimonial was e-mailed to the E/PO team from a high-school teacher:

*“I really enjoyed the Webinar. I met Dr. McFadden last year at the DAWN workshop for educators and was very interested in hearing about what scientists do while they're waiting for the next stage of their mission to occur. For DAWN, we're looking at several years. I'm impressed. As a high school educator in a rural Montana community, the web tie-in is just super. I've done "on-line workshops" where we were on a simultaneous website and conference call. This was truly slick. Thanks for the invitation to attend the Webinar and the opportunity to get ideas to expand my student's horizons. I particularly noted the comment about 'female pilots.' I think I work hard at not allowing gender specific-ness to creep into my presentations.”*

## STUDY LIMITATIONS

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There are limitations to this evaluation study that the reader should take into account when interpreting findings. For the Ion Propulsion field test, budget constraints did not allow for classroom observations and student interviews. Without these data, it is difficult to know how teachers presented the module to students. It is also not possible to understand what experiences students may have had beyond the classroom that could have influenced their attitudes toward science and the module content. For some students, difficulty with some of the readings in the module may have also influenced their perceptions of science. The addition of classroom observations and interviews would contribute to a greater understanding of the student survey findings through triangulation of multiple data collection methods.

Dawn EPO staff conducted the CPR telescope lesson pilot test to explore the possibility of using the lesson with middle schools students. The study was conducted in a single classroom with high achieving students who became frustrated with the CPR process. Students had only this single exposure to the CPR process which did not give them enough practice to become adept at the peer and self-review process. Frustration with the process may have influenced their acquisition of content knowledge related to the telescope lesson and their interest and engagement in the content. Additionally, the classroom teacher graded students on the lesson which likely further influenced their perceptions as they found themselves not achieving at the level to which they were accustomed. The study design and contextual factors prevent the findings from the pilot to be generalized to a larger population.

## SUMMARY

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During the project period for this evaluation report, August 2008 through July 2009, E/PO efforts focused on increasing Dawn visibility, 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 Mission education materials, and reaching audiences through conferences and public events.

During the study period, the Dawn Mission Web site received 2,581,117 hits and 584,083 page views. People accessing the Dawn Web site visited the Dawn homepage and mission-related sections of the Web site most frequently as well as the education-related pages. Of the top 10 most frequently viewed PDF documents, more than 3,600 visitors accessed Dawn Teacher Guides, and more than 5,800 accessed student activities. Most visitors completing the Web site

survey agreed that the Web site is well-organized, provides accurate information, is easy to navigate, and is a useful resource. Visitors value the mission status updates, simulations, and technical data and would like to see more of this type of information on the Web site. Visitors find the Dawn Web site to be of high quality and utility with 95% of respondents rating the Web site as good or excellent.

E/PO field-test efforts for the *Ion Propulsion* module reached 209 students across formal education settings. Of these students, 38% represented minority racial groups. Student participation in the module activities resulted in a significant increase in their understanding of how scientists solve problems of space exploration. Overall, the students participating in the field test reported a positive attitude toward science before engaging in the activities, and consequently, findings reveal a slight downward shift in students' perceptions about their interest in learning about space science, their feelings toward science, and their view of science as useful for understanding problems of everyday life. Despite teachers' observations of students reporting that there was too much difficult reading in the module, students indicated that they learned much about significant physical science concepts by doing the *Ion Propulsion* activities and that the computer simulations increased their understanding of attractive and repulsive charges and the design of ion propulsion engines. Students also reported an increased awareness of and interest in the Dawn mission.

Classroom educators who used the *Ion Propulsion* module with students implemented it with ease and with few barriers. Educators resoundingly found the *Ion Propulsion* module to be of high quality and utility. Overall, they believed students exhibited great interest in the activities and a moderate amount of learning of the science concepts. Classroom teachers reported that the *Ion Propulsion* module increased their interest in science and improved their understanding of how to tie science learning to real-life contexts. Workshop participants indicated they learned a considerable amount about the science content and pedagogy associated with the Dawn outreach materials and would be able to apply their learning to their educational settings.

The pilot test of the Calibrated Peer Review (CPR) tools revealed that the writing process supported by the program might not be appropriate for the iterative writing and revision process in which middle-school students need to engage as part of their learning. Students also needed to experience the program multiple times to be more comfortable and competent in grading their peers' writing. As such, the CPR pilot test yielded helpful formative feedback regarding the developmental appropriateness and fit of this tool in middle-school classrooms. Based on student and teacher feedback, the tool was successful in helping students acquire the science content embedded in the lesson.

Through the dissemination of high-quality and utility information, resources, and materials, the E/PO team is effectively meeting its goals of increasing target audiences' understanding of and interest in solar system science, enhancing educators' abilities to implement scientific inquiry processes, and increasing student learning of solar system science within a real-life context.

## RECOMMENDATIONS

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Based on the evaluation findings from the reporting period of August 2008 to July 2009, 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.

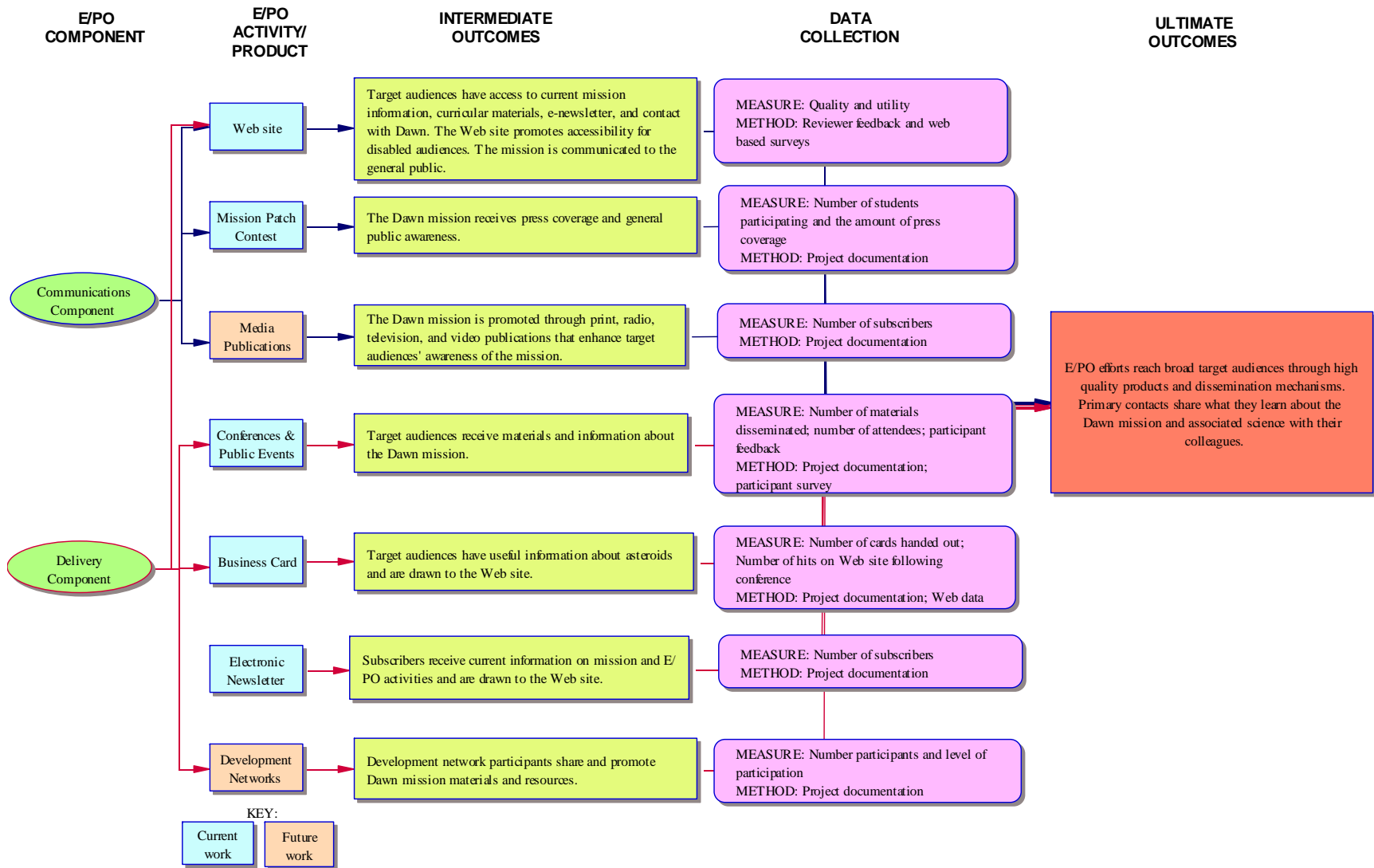
- With consideration of student feedback for how to improve the *Ion Propulsion* module, it is recommended that E/PO team members gather more information on the developmental appropriateness of the reading portion of the module for students that also takes into account student background knowledge before using the module. It is also recommended that the materials be enhanced to provide an opportunity for students to build or view a model spacecraft to allow hands-on opportunities to engage further with the materials.
- With consideration of teacher feedback on the *Ion Propulsion* module, further explore

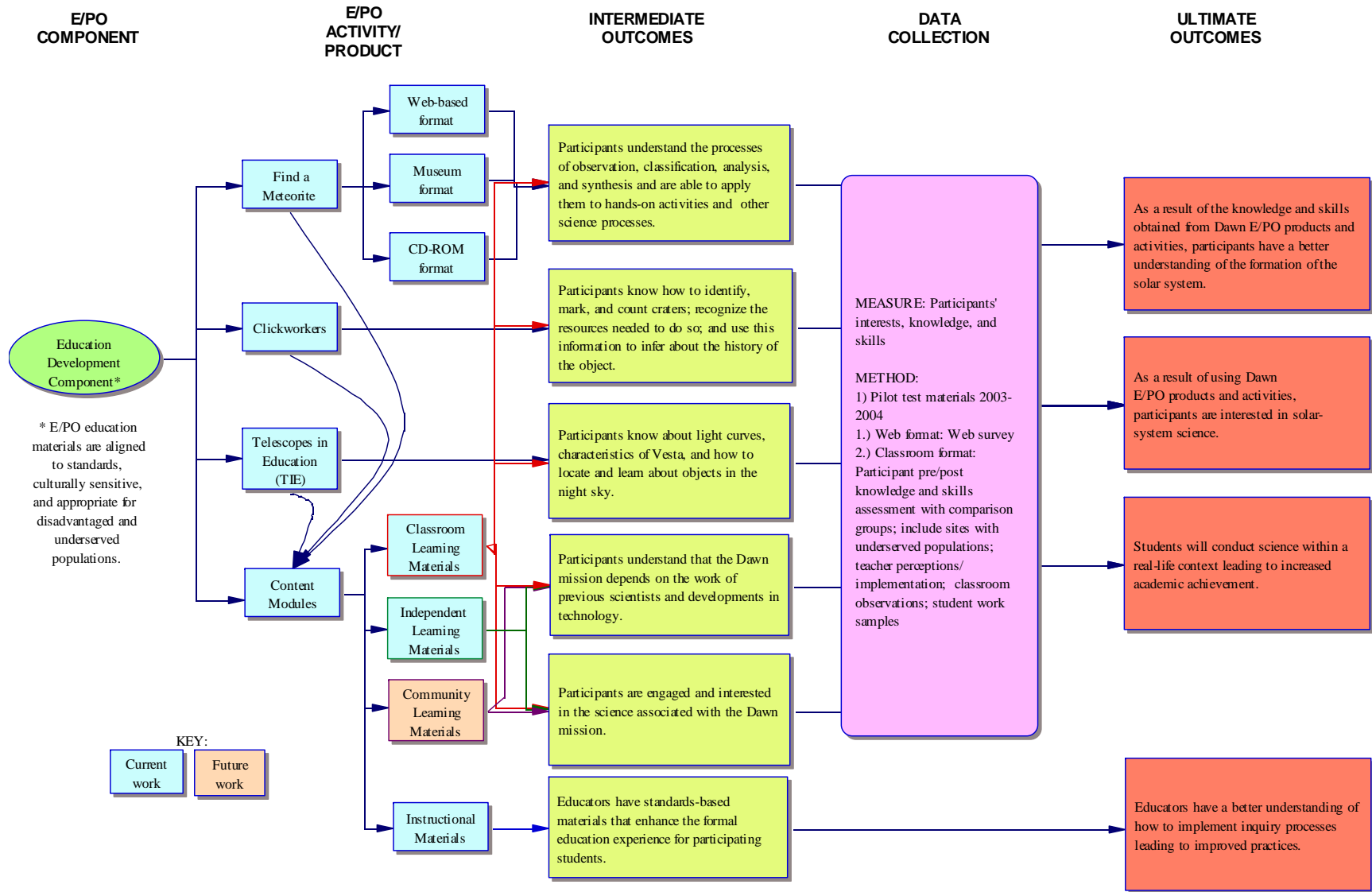
teacher perceptions of any issues as to the alignment of the materials to standards.

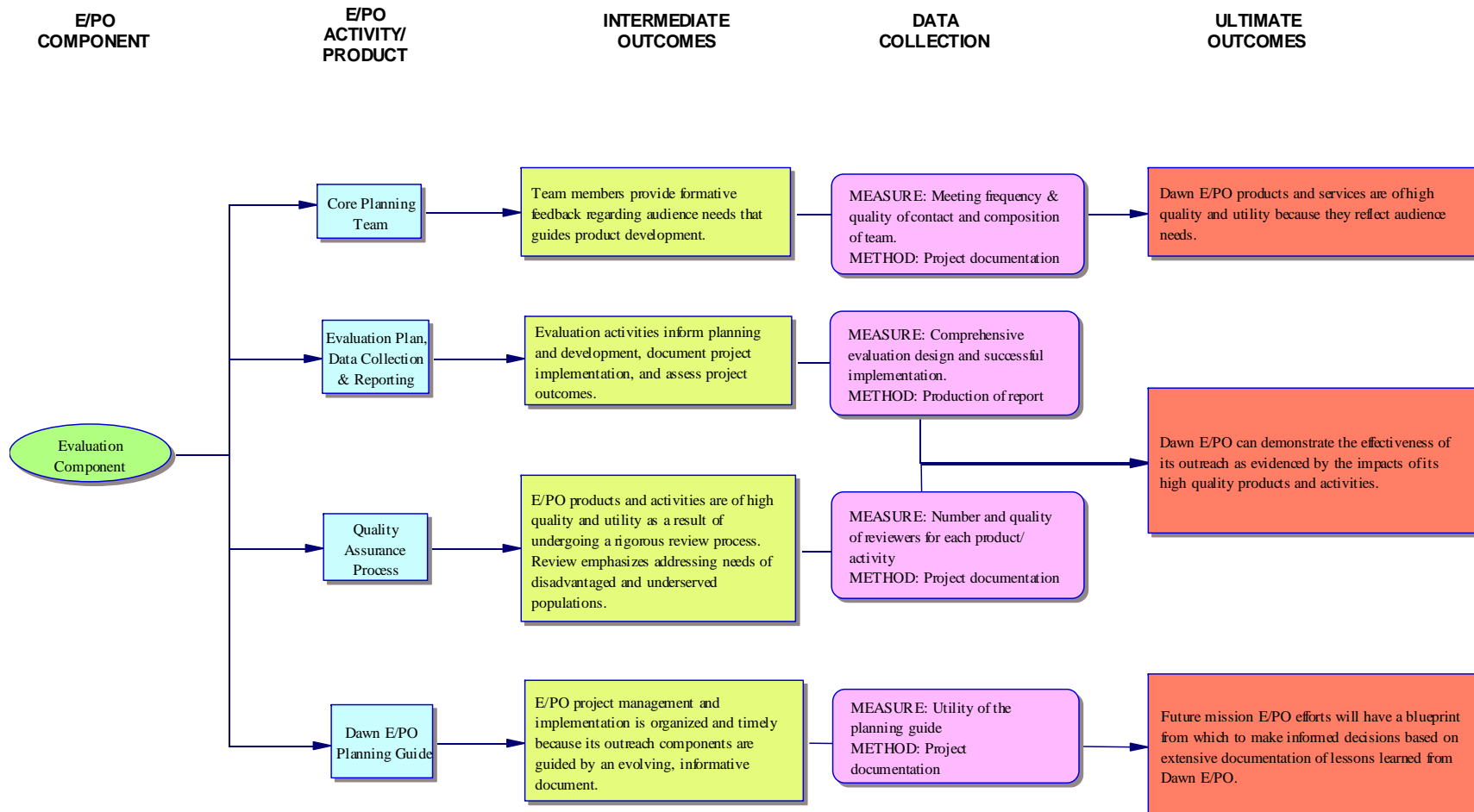
- Given that the students learned science content by using the CPR tool, it is recommended that E/PO team members revisit the program design to explore if modifications to the tool would be feasible to align it better with the middle-school writing process and learning context.
- Given the highly positive feedback from workshop participants, continue to offer ways to humanize the Dawn Mission through opportunities for the public, educators, and students to connect with the scientists behind the mission through Webinars and other experiences. These types of interactions act as a catalyst in creating excitement and enthusiasm for the science and work of the mission.
- Given the increase in users accessing the Web-based education guides and student activities, it is recommended that E/PO team members continue to offer the Dawn tools and activities as stand-alone, short learning opportunities as separate from the more comprehensive content modules.
- Given that Dawn E/PO educational activities increase student awareness and interest in science, it is recommended that E/PO continue to broaden participation to underrepresented groups along the K–12 continuum. One way to do this might be through partnerships with minority institutions. The E/PO team might also consider developing a diversity plan that articulates dissemination strategies for reaching underrepresented populations.
- Given the proven capacity of the Dawn Web site to reach public members, educators, and students, it is recommended that E/PO team members continue to identify ways to enhance the navigation of the site's most popular content to improve ease of access. Team members might also consider increasing the number of simulations and amount of technical information on the Web site, given the heightened interest among visitors.
- Both evaluators and E/PO team members should consider ways to increase the response rate to the Dawn Web site survey and participation in the field testing of curriculum materials.

## **APPENDIX A**

### Logic Models for Dawn Education and Public Outreach







## APPENDIX B

### Evaluation Matrix

EVALUATION QUESTIONS	DATA SOURCES	DATA METHODS
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.		
Objective 1: To increase the availability of E/PO products and services related to the Dawn Mission.		
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?	Internal and external reviewers Web site users Workshop participants Teachers Students Public members	Quality assurance process Online surveys Participant feedback Web statistics Dissemination data
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. Because 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.		
Objective 2: To increase student awareness, interest, and understanding of space science.		
4. a. Are participating students engaged and interested in the Dawn Mission science because 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?	Students in pilot- and field-test sites  Students who access online resources	Pre/post student performance data with non-equivalent comparison groups  Student survey (print/online)  Teacher reports
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.		
Objective 3: To increase teachers' use of hands-on, inquiry-based educational materials related to the Dawn Mission.		
6. To what extent has the Dawn E/PO effort enhanced participating teachers' capacity to teach space science?	Teachers in development networks Participants in workshops Teachers accessing Web site resources	Pre/post assessment of capacity Participant evaluations Web-based surveys
Public Ultimate Outcomes #2 & #3: Because of the knowledge and skills obtained from Dawn E/PO products and activities, participants better understand the formation of the solar system. Because of using Dawn E/PO products and activities, participants are interested in solar system science.		
Objective 4: To increase public interest in and understanding of the Dawn Mission.		
7. To what extent has the Dawn E/PO effort affected public interest in and understanding of the Dawn Mission?	Public members accessing Web site or museum resources	Web-based surveys

## APPENDIX C

### Dawn EPO Team Response to Recommendations

- With consideration of student feedback for how to improve the *Ion Propulsion* module, it is recommended that E/PO team members gather more information on the developmental appropriateness of the reading portion of the module for students that also take into account student background knowledge prior to using the module. It is also recommended that the materials be enhanced to provide an opportunity for students to build or view a model spacecraft to allow hands-on opportunities to further engage with the materials.

From the teacher feedback, we need to review the reading level of the materials to see if more explanation can be provided in readings (Charges and Pushing with Plasma) where we assumed some familiarity with the material. After follow up interviews with the teacher who created supplemental materials that she used during the field test, we will consider a teacher supplement handout for 9<sup>th</sup> grade students and/or students without any prerequisite chemistry.

We do not think that linking to the paper spacecraft model would add to the student conceptual understanding of ion propulsion. We will explore having the students build a paper spacecraft model and use this to model relative motion of the spacecraft relative to models of different bodies (Earth, Mars, Vesta, Ceres) along its journey of the spacecraft. This stand-alone activity could be combined with the reading on relative motion currently in Content Module 2.

- With consideration of teacher feedback on the *Ion Propulsion* module, further explore teacher perceptions of any issues as to the alignment of the materials to standards.

It is clear from figure 5 on page 12 that standards alignment was not useful for teachers using this module. We acknowledge that alignment to national standards may be of limited benefit of teachers who are required to align their curricular materials to state or local curriculum documents. However, since many state documents are built using national standards as a guide, we will continue to align Dawn materials to national standards documents.

- Given that the students learned science content by using the CPR tool, it is recommended that E/PO team members revisit the design of the program to explore if modifications to the tool would be feasible to better align it with the middle school writing process and learning context.

We will discuss the educational components of Calibrated Peer Review (CPR) and determine the essential components that made it effective. We will look at revising the CPR activity and also review other models that might be available to provide meta-cognitive review of student writing. We will also post the activity to the CPR library with an invitation for regular CPR teachers to provide feedback. Sharing the activity with a larger community provides feedback from teachers and students who frequently use CPR. We will also explore potential benefit of conducting a pilot test with University level Astronomy classes for non majors.

- Given the highly positive feedback from workshop participants, continue to offer ways to humanize the Dawn Mission through opportunities for the public, educators and students to connect with the scientists behind the mission through webinars and other experiences. These types of interactions act as a catalyst in creating excitement and enthusiasm for the science and work of the mission.

We will continue to use the workshop models that have been successful for us in the past. We are currently working with the Discovery Program EPO to develop more comprehensive thematic EPO workshops that are NASA/Space Science driven instead of specific missions driven. This plan will leverage our efforts and we hope increase numbers of participants.

- Given the increase in users accessing the Web-based education guides and student activities, it is recommended that E/PO team members continue to offer the Dawn tools and activities as stand alone, short learning opportunities as separate from the more comprehensive content modules.

We agree that web-based delivery is essential to providing quality materials for STEM instruction and outreach. Flexibility seems to be of value because of different styles of teaching and different levels of teacher experience. The Dawn Mission EPO continues to look for avenues available through the WWW including facebook, twittering, etc.

- Given that Dawn E/PO educational activities increase student awareness and interest in science, it is recommended that E/PO continue to broaden participation to underrepresented groups along the K–12 continuum. One way to do this may be through partnerships with minority institutions. The E/PO team might also consider developing a diversity plan that articulates dissemination strategies for reaching underrepresented populations.

The Dawn EPO team has responded to this recommendation by exploring collaborations with the Para Los Ninos Middle School in Los Angeles. This school is an urban school that serves the skid row region. We have also made contact with the Colorado Association of Black Professional Engineers and Scientists about connecting Dawn E/PO materials with their student programs. We will also renew our efforts at identifying Indian Nation and Rural Schools. We will engage Dawn Mackety at McREL who works with these Native Americans on other projects. In addition, we will follow up on our initial letters of support from various minorities/underserved associations as well as identify new ones to invite to participate.

- Given the proven capacity of the Dawn Web site to reach general public members,

educators, and students, it is recommended that E/PO team members continue to identify ways to enhance the navigation of the site's most popular content to improve ease of access. Team members might also consider increasing the number of simulations and amount of technical information on the Web site, given the heightened interest among visitors.

We plan to undertake a comprehensive review of our current website that includes navigatability, content, and feature structure.

Additionally, Figure 18 and its accompanying text caused our team concern. We were particularly troubled by the results for items 1, 3, and 4. Though item 1 was not statistically significant, we should look at avenues for doing better. We realize that this module was a brief interaction and that statistically significant outcomes due just to this treatment are not always expected. Still these results give us reason to pause and reassess the module for improvements in appropriate areas. The comment about the reading as a detriment to having a good feeling toward science recalls results of our first module. Students who enjoyed reading enjoyed the module. Students who did not like to read did not. We take these results seriously while realizing that we constantly balance students enjoy joy of the activity with presenting materials that address state and national standards.