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ABSTRACT

A qualitative research approach was used to investigate the National Aeronautics and Space Administration's (NASA) educational efforts in achieving scientific literacy through mass media and other communication technologies. Six in-depth telephone interviews were conducted with various NASA education and public affairs officers throughout the country. Findings revealed a distinction between public information and educational efforts. Face-to-face interaction was identified as the most effective information delivery system; however, the Internet and mass media play a prominent role in NASA's educational outreach plan. Future research should examine the mass media's perspective on achieving scientific literacy. Another area of exploration should target teachers and students to see whether they are benefiting from NASA's educational efforts. (Contains 26 references; interview questionnaire is appended.) (Author/NKA)

Achieving Scientific Literacy Through the Mass Media and Other Communication Technologies: A NASA Perspective

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Abstract

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INTRODUCTION

The United States is the most powerful nation in the world. Much of its power can be attributed to scientific and technological discoveries and advancements. However, there is a distressing level of public ignorance about science (Ziman, 1991). A survey by Jon Miller of the National Science Board (1990) indicated that most adults do not understand fundamental scientific concepts. According to University of Virginia physicist James Trefil, "[t]he general level of scientific knowledge, even among educated people, is very low. There are a lot of people who don't know the sun is a star" (Detjen, 1995, p. S-60). A survey by Northern Illinois University reported that one-third of the respondents did not know what a molecule is, two-thirds did not understand what radiation is, and five-sixths did not grasp the basics of genetic engineering. In addition, 57% believed electrons are bigger than atoms, 63% said dinosaurs and humans occupied the earth simultaneously, and 73% thought lasers focus on sound waves rather than light waves (Detjen, 1995). These findings suggest the need for an increase in the level of scientific knowledge among the general public.

The significance of examining the quantity and quality of scientific information that reaches the general public rests in the demand for more public participation in the decision-making process about social issues and in the growing technical complexity of the issues involved (Cronholm & Sandell, 1981). These two trends are at odds because scientific research is a vital part of the development and evaluation of public policies, but in order for the public to be more active in decisions, research on complex issues must be accessible and comprehensible to them (Cronholm & Sandell, 1981).

President Bill Clinton and Vice President Al Gore (1994), in the foreword of their report, Science in the National Interest, reminded Americans that science helps us solve our problems, learn about life's mysteries, and inspires and enriches us. They called for an investment in scientific research as well as science and mathematics education. Through education our children will be better equipped to live and work in the twenty-first century (Clinton & Gore, 1994).

Fifty years ago Vannevar Bush said,

> The Government should accept new responsibilities for promoting the flow of new scientific knowledge and the development of scientific talent in our youth. These responsibilities are the proper concern of the Government, for they vitally affect our health, our jobs and our national security (Clinton & Gore, 1994, p. 1).

The top executive officers of the United States have taken Bush's statement to heart and outlined several goals for science in the national interest:

- Maintain leadership across the frontiers of scientific knowledge
- Enhance connections between fundamental research and national goals
- Stimulate partnerships that promote investments in fundamental science and engineering and effective use of physical, human, and financial resources
- Produce the finest scientists and engineers for the twenty-first century
- Raise scientific and technological literacy of all Americans (Clinton & Gore, 1994, p. 7).

While all of the goals have an inherent connection, perhaps the one most important to the nation as a whole is the last one. It is imperative to make Americans more aware of science and technology and how they affect their lives. Thus, the burning question is "How do we make the public more scientifically literate?"

President Clinton and Vice President Gore believe the goal of raising the level of scientific literacy can be achieved in several ways. First, research and educational communities must raise education standards in math and science to foster higher achievement, make students competitive for high quality jobs of the future, and develop an appreciation of science. Second, teachers must continually work to develop professionally. Through partnerships with researchers, teachers can bring the excitement of science and its discoveries into the classroom. Third, research scientists must present their experiences and findings to foster public understanding and appreciation of science. Fourth, alliances among industry and state and local governments must be developed in order to provide educational institutions at all levels with telecommunications and other information resources. "We must educate our children for the twenty-first century workplace in a twenty-first century setting" (Clinton & Gore, 1994, p. 29).

Rationale

It is clear from the guidelines set forth by the President and Vice President that an improvement in science education is key to raising the level of scientific literacy among Americans. In order to improve the quality of science education, it is important to analyze and evaluate the current status of science education. However, such a task is a major undertaking and far beyond the scope of this paper. Therefore, this paper focuses on a specific organization's attempt to achieve a more scientifically literate public.

This paper is designed to be one of several studies that suggests answers to the fundamental research question discussed in the introduction: "How do we make the public more scientifically literate?" The relevant literature, which will be reviewed below, identifies a myriad of research that already suggests possible answers. However, there is a need for a complete answer. In an attempt to draw us closer to a solution or identify further questions for exploration, this paper is guided by the following question: "What educational efforts are being used by NASA to promote scientific literacy among Americans?"

As one of the leaders in the scientific community, NASA has called for research that will help increase the level of scientific knowledge among the public. For example, in 1995 NASA granted $100,000 to the Imaging Node of NASA's Planetary Data System at the United States Geological Survey in Flagstaff, Arizona, to help distribute NASA educational and informational resources through proactive video, graphic and CD-ROM materials to educators, science service organizations, museums, planetariums and the commercial sector (NASA, 1995). NASA also took steps to expand its use of new communication technologies by working with Wheeling Jesuit College in West Virginia to create a Classroom of the Future program. In addition, NASA awarded grants for the development and application of technologies that would provide science information to designated user communities on the Internet (NASA, 1995).

In light of previous research and scholarship as well as calls from the scientific community and our nation's leaders for additional investigations, it seems appropriate to explore how NASA, arguably the leader in science exploration, is currently promoting scientific literacy among the general public and within the educational community. Key to this investigation is establishing the role of mass media and other communication technologies in NASA's educational efforts.

In order to understand the research design and methodology, a review of the relevant literature is necessary. Following this review, a detailed description of this study's methodology, a summary of the findings, and general conclusions will be provided.

LITERATURE REVIEW

Communicating science to the public

The process and effects of communicating science to the public and the public's understanding of science have been the focus of several research endeavors.

Cronholm and Sandell (1981) reviewed a wide range of studies that focused on the dissemination of scientific material and the intended audience and found that "education plays the determining role in both the level of interest and effect among the general public" (p. 85). The authors also concluded that the public is at a disadvantage because scientists and science journalists do not always report the information the public needs to make informed decisions. Some journalists see science as stimulating, but inconsequential, others view it as a societal menace, and still others see it as "the salvation of humanity" (Cronholm & Sandell, 1981, p. 87). Scientists may view their research as exclusive to a select few, while others freely report their findings. All of these views dictate what information will reach the public (Cronholm & Sandell, 1981).

Despite the uncertainty of what gets published or broadcast, the mass media are the channels through which the public, including scientists, receive scientific information (Cronholm & Sandell, 1981). However, it may be that the mass media do not affect directly the public's understanding of science, rather they only make the public aware of scientific issues. The public chooses to seek further understanding or not.

Cronholm and Sandell (1981) suggest "the agenda setting function of the mass media may be a useful concept in understanding what role the mass media play in making certain scientific areas and issues salient, and what the consequences are for the contribution and distribution of grants and the recruitment of students and scientists to be" (p. 92). Unfortunately, the agenda setting function of the mass media may hinder the media's ability to thoroughly answer the public's questions about science. Scientific jargon and limited space or time constraints may contribute to the superficial level of scientific information in the media.

Cook, Tyler, Goetz, Gordon, Protess, Leff, and Molotch (1983) applied agenda setting to their experiment involving communication of scientific information. They randomly assigned subjects in Chicago to watch either a report on NBC that exposed fraud in home health care or another program on a different channel. An agenda setting effect was found for NBC viewers; they evaluated health care as an important issue after watching the report. No attitude change was found for those watching different programs.

Detjen (1995) reported that a recent Roper survey found that most of what people know about their environment comes via the media, especially television and newspapers. In the past few years there has been an increase in environmental reporters and environmental coverage, although recently newspapers have significantly reduced their coverage of science (Detjen, 1995). Various polls continue to indicate environmental news is important to readers (Detjen, 1995). A 1993 Harris poll found that Americans want more news about children's health risks, AIDS development, recycling, women's health, genetics, endangered animals, and the impact of global warming. In addition, the survey found that in all age groups, all races, and all demographic areas, the public is interested in science (Detjen, 1995). Detjen also reported that environmental issues permeate the educational system.

As noted earlier, the public's level of scientific knowledge is quite low. Leaders in the scientific community charge that the mass media can help raise the level of knowledge through effective communication. Robert M. White, president of the National Academy of Engineering, believes there is a partnership between the public media and the scientific and technical community. This partnership is important because agents of the media have a significant role in interpreting messages from the scientific community and informing the public. It is vital for the public to understand scientific information because of its effects on daily living and "because governmental policies are ultimately shaped by public attitudes" (White, 1994, p. 431). The scientific community needs to develop new methods of message dissemination that extend beyond the press release because with each passing year there is a greater need for public understanding of science and technology (White, 1994).

Mass media and science education

Science educators report an undeniable connection between the mass media and science teaching. However, this connection is not always used to its fullest extent. Johnson (1993) called for the educational use of the popular media as an instructional and informational resource in lower-level general education courses. Inherent in this plea for the use of the media in the classroom is the desire to help students see the social implications of course content.

Through student-centered education (Morse, 1951) and a focus on integrative thinking (Cleveland, 1985), students relate to content better and become motivated to learn (Mallow, 1986; Strauss & Fulwiler, 1989/90). The connection and application of subject matter to the real world is the key to making students scientifically literate (Yager, 1989). Johnson (1993) stated that "it is vital that we do more than just call a science course 'general education science.' It must provide the student with a strong sense of connection" (p. 55).

The strong sense of connection is found in the popular media, ranging from newspapers and news magazines to special interest and hobby magazines to radio and television (Johnson, 1993). These information sources often are easier to understand than textbooks, and they highlight the impact of scientific knowledge on personal and social levels (Johnson, 1993).

Johnson (1993) described how he enhances general education science courses through written logs on popular media. In an introductory course on weather and climate, Johnson requires students to find additional information about the atmosphere in the media and write a brief critique or log. Students answer nine specific questions about the article or broadcast presentation including source, possible bias, and advantages. The logs are evaluated for thoroughness, timeliness, and quality (Johnson, 1993).

Moreover, popular science helps students learn material that is difficult or omitted in the course textbook, and it fosters critical thinking skills when information is inaccurate or biased and is used to influence public opinion (Johnson, 1993). Gregory (1992) reported that students became acutely aware of the print media's effect on the public's opinion of science and scientists when such popular media were used as a primary resource. Media sources help students "appreciate and understand the relatedness of knowledge and to be impressed with its impact on their life" (Johnson, 1993, p. 55).

It has been established that the mass media play a role in the dissemination of scientific knowledge to the public, which includes students. Therefore, the media provide scientific information to students. However, students, like other members of the public, may not understand the concepts presented in the media. Some teachers have capitalized on scientific presentations within the media. The presentations become part of the classroom experience and are used as a way to get students involved in the learning process.

Dubeck, Moshier, Bruce, and Boss (1993) explained that watching and analyzing concepts within science-fiction films help students gain a better understanding of science as a discovery process and improve their attitudes towards science. Dubeck and his colleagues proposed that science-fiction films help students learn in four ways. First, films help students understand abstract concepts in familiar and attractive ways. Direct visualization of abstract principles is a key to understanding. Second, students learn science is a rational process as well as a discovery process when they view and discuss a film. They learn to recognize scientific and pseudoscientific approaches. Third, science-fiction films make science more relevant to students because they place science in dramatic settings and relate it to socially significant issues. Fourth, films allow students to experience science within interdisciplinary settings, which is more like the "real world."

Allen (1993) uses science-fiction material in the classroom as well. She uses one of popular culture's best known science-fiction television series, "Star Trek," along with its derivatives "Star Trek: The Next Generation" and "Deep Space 9." Use of all three television series allows Allen to capitalize on the use of stories to illustrate educational theories and practices. She explained that students appear more attentive and focused when she tells a story.

The most appealing aspect of using "Star Trek" and its off-shoots in the classroom is that the shows provide common ground for the teacher and students. Allen noted it is important to relate her teaching to student experiences and interests. "Making connections is vitally important for making learning come alive" (Allen, 1993, p. 2).

"Star Trek" is among other media-books, movies, magazines, other television shows-utilized by Allen. She emphasized that the media have an important influence on students' lives and has called for educators to take advantage of the media's valuable resources. "The knowledge we want to teach, the skills we want to develop, and the attitudes we want to instill can all be accommodated by utilizing the media" (Allen, 1993, p. 18).

Scientific ignorance may continue unless new goals are set in science education. Penick (1995) suggested that educational reform will occur only if instructional reform comes first. He believes teachers must be able to communicate scientific knowledge to students in fun and exciting ways. Through innovative teaching, students learn to like science, feel confident in their scientific abilities, find science useful, and yearn to learn more about science. According to Penick, discussions with teachers of all grades throughout the United States have yielded student goals that differ from traditional textbook objectives. Outstanding teachers want students to "use science knowledge, identify and resolve problems, communicate effectively, like science and feel successful at it, be creative, and continue learning science" (Penick, 1995, p. S-53). The focus in education should be on creating an environment that is conducive to learning (Penick, 1995).

Research indicates that scientifically literate people often have a positive attitude toward science; therefore, it is important to foster a positive attitude in students. Penick argued that students with positive attitudes are successful in science. He calls for the need to ensure such success for everyone. By cultivating a positive attitude towards science, students are more likely to be active citizens who use their scientific knowledge to identify and solve problems (Penick, 1995).

A positive attitude is a result of an active classroom (Penick, 1995). Effective teachers create an active classroom by relating the material to students personally and having students do more than listen. Students have to talk, take action, do the science (Penick, 1995). Outstanding teachers run "laboratory-centered, student-active classrooms. The most effective teachers in the

United States do some kind of hands-on activity every single day" (Penick, 1995, p. S-55). This is often the exception rather than the rule.

The review of the literature clearly indicates that mass media play a vital role in the dissemination of scientific information. Used properly, popular media can enhance the educational experience of students and contribute to an increase in scientific literacy. Given the important role mass media can play in creating a more scientifically literate public, this study will explore, in part, how NASA uses the mass media in its efforts to raise the level of scientific knowledge among Americans.

RESEARCH DESIGN

This study's research question--"What educational efforts are being used by NASA to promote scientific literacy among Americans?"--was answered using a qualitative research approach. Such an approach is consistent with some previous research designs in this area (Penick, 1995; David, 1993); however, the majority of previous studies were based on quantitative designs using surveys and experiments to assess public knowledge and understanding of science. While quantitative measures have their place in communication research, this study's research question dictates the need for qualitative research methods. Lindlof (1995) explains that qualitative inquiry helps answer questions like: "What is going on here? What is the communicative action that is being performed? How do they do it? How does it change over time? How do they evaluate what they do?" (p. 6). This study addresses these general questions in terms of scientific literacy and the mass media and other communication technologies. Changes in science, education, the media, and communication technology make it necessary to assess the state of affairs in each of these areas in order to understand NASA's present efforts in achieving scientific literacy as well as design future studies that focus on relevant issues. This study provides a personal assessment by a select few of what scientific literacy means among NASA education officers and how it is being achieved. In addition, this line of research generated suggestions for achieving such literacy in the future.

Methodology

McCracken (1988) declares that "the long interview is one of the most powerful methods in the qualitative armory. ... The long interview gives us the opportunity to step into the mind of another person, to see and experience the world as they do themselves" (p. 9). By using interviews, which are a staple of the qualitative approach, we will be able to learn about things we cannot observe directly (i.e., thoughts and feelings) and understand differing perspectives (Lindlof, 1995).

Given the advantages of the long interview, six in-depth, telephone interviews were conducted with various NASA education and public affairs officers throughout the country. Initially eight research centers were identified as potential sources; however, schedule conflicts prohibited the completion of all eight interviews. One education officer declined to participate.

Participants included NASA Headquarters (Washington, DC) education director Frank Owens, geologist and education officer Julius Dasch, and public affairs outreach officer Terri Hudkins; Ames Research Center (Moffett Field, CA) special assistant for educational programs Garth A. Hull; Marshall Space Flight Center (Huntsville, AL) education programs office director James Pruitt; and Lewis Research Center (Cleveland, OH) technical assistant William Nyerges. Dasch and Hudkins were asked to participate in the project by Owens because of their expertise in the fields of science and communication. Dasch and Owens were interviewed at the same time. All others were interviewed separately.

A question guide (see Appendix A) was used to draw out information about scientific literacy and the mass media and other communication technologies. McCracken (1988) reminds us the interview is designed to "allow respondents to tell their own story in their own terms. The investigator seeks to keep as 'low' and unobtrusive profile as possible" (p.34). Therefore, initial "grand tour" questions were used to get the respondents talking without leading them in a specific direction (Werner & Schoepfle, 1987). These included "what is science?" and "What does it mean to be scientifically literate?" When elaboration or clarification was needed "floating prompts" were utilized. The prompts included items like "What makes you think that? or "Can you give me an example?" "Planned prompts" were employed when informants failed to discuss relevant issues spontaneously. Questions such as "What is NASA doing to educate the public about science?" and "What restrictions exist in achieving scientific literacy?" were used. Finally, "category" questions were used to ensure all aspects of the topic of interest were discussed (McCracken, 1988). These queries ranged from "What is the role of the mass media in science education?" to "How does the media fit into NASA's educational efforts?"

The interviews were tape recorded and professionally transcribed. Transcriptions were coded and analyzed by the principal investigator using analytic induction and comparative analysis (Glaser & Strauss, 1967). Analytic induction involves scanning interview transcripts for common themes and categories. These themes and categories are further refined and modified as new patterns emerge from subsequent reviews of the transcripts (Goetz & LeCompte, 1984). Analytic categories and themes are identified in the next section.

FINDINGS

Science defined: Knowledge through experience

Most interviewees suggested science is knowledge that is gained through experience. "I would define it as knowledge and knowledge gained through experience. ... (t)hat would be through observation, through experiments, through investigation. Sort of like an explanation of natural phenomena," said Marshall Space Flight Center Education Director James Pruitt.

Julius Dasch, a geologist at NASA headquarters, corroborates Pruitt's definition.

> I would define science as the formulation and testing of hypotheses based on data collection. Usually it is related to natural phenomena - rocks, stars, water, life. That's the basic essence of the definition, and if you define it that way it really differs from things like faith and religion and scientific creationism. So, it's based on a collection of data and usually natural phenomena, and it's based around the ability to analyze hypotheses and then test them. Testing is very important. And, science can be falsified. Unlike faith and religion, it can be distorted either on purpose or not, but you can't do that with faith. So you have to be careful. There are all the time problems with science and creation of data that are not very good.

Garth Hull of Ames Research Center described science as a subset of knowledge. "The word science itself means knowledge. ... (S)cience is a subset of the larger body of knowledge. Science is the study of the natural world and all its various subsets."

William Nyerges, technical assistant in the education office at Lewis Research Center, defined science simply as "systematized knowledge. Systematized in the sense of there being an orderly and intellectually honest way of moving through answering questions and defining results." Nyerges' definition is broad-based like public affairs outreach officer Terri Hudkins'. Hudkins agrees with the standard textbook definition of science offered by her colleagues at the National Academy of Sciences; however, she believes science "encompasses what we often call technology."

Traditional categorization of science

Most respondents agreed that the traditional break down of science found in the educational system, i.e., biology, chemistry, and physics, is most reasonable. Dasch commented, "(t)he basic fields within science have always been physics, overwhelmingly, number one, chemistry, and then biology." He noted that a lot of sub-disciplines of science exist, like oceanography, geology, and forestry. Hull agreed with the classification of physical sciences and biological sciences. He also suggested a break down of organic versus inorganic sciences. He considered other classifications as well:

> I think there are various other ways in which science is categorized. For example, when you talk about curriculum and so forth, you talk about the earth sciences. And, in our kind of business, of course, you know we are using space as a domain. Now space for me is just that; it's a domain and, of course, in that context then it embraces all of the sciences that have been categorized in the past.

NASA's past categorization is at the heart of Nyerges' classification of the sub-categories of science. He broke down science into life sciences, physical sciences, earth science, chemistry, math and included social science, economics, and political science. "All of those naturally have a different kind of bent to them as far as the value-laden content, but they can be specific in that way," said Nyerges.

Pruitt offered another perspective. He suggested science be placed under the category of research and development. He believes that "through research and development knowledge is gained and you actually do science in that process."

Assessing public interest in science

All interviewees felt people want to know about science, but the level of interest varies. Some people are interested in science because they want to understand as much as they can about the world around them. Hull described individuals in this group. He said:

> People by nature are explorers. That's very evident in the very young. I mean just the nature of the fact that they're developing in all aspects of their physical and mental being and the fact that they're walking in a world that they know so little about. They're explorers. ... (w)e are all explorers. And if we're truly explorers, of course we're going to try to understand where we're at and then push it a little bit further.

Nyerges' suggested public interest in science exists, but he qualified his response.

> (A)ny time you're in a certain kind of organization such as ours or in the educational community, you can sometimes get blinders as to those kind of things ... overall, I'm sure there's a number of people who may not be interested, but I think ... it's definitely there.

Hudkins and Pruitt suggested that some individuals show an interest in science when it is applicable to their lives, but they only seek a surface level understanding. Hudkins said:

> I think the American public is exceptionally interested in things that pertain to them, particularly health and medicine. And, I think that they tune in to things that are relevant to them. I think that they're intrigued by planetary science, earth sciences, but how much detail they are willing to explore I don't think is very deep.

Pruitt echoed this sentiment. "They're interested in how it can improve the quality of life, how it can benefit them say from a medical perspective." However, Pruitt speculated that the public was not interested for the sake of basic research.

> The public seems to be more interested in direct benefits or applications of the science to their lives. The American public, I believe, holds generally positive attitudes toward science, but I don't believe as a whole they're very familiar with specifics.

Dasch agrees there is a fundamental lack of scientific understanding. In addition, he suggested that people expect too much of science. They don't realize some scientific topics take many years to understand. The public expects quick and dirty fixes often. This is not possible in science. Searching for life on Mars is not a six-month endeavor. It takes years of exploration and testing. The public, though, expects fast results, especially when large sums of money are dedicated to such research.

Hull offered an interesting perspective about scientific interest in terms of younger members of the public. He explained that effective leadership is a key component to sparking interest in youngsters. According to his own experiences with students as well as teachers he has worked with, a small percentage of students need little leadership because they actively seek knowledge on their own. "(Y)ou just get out of their way really. You really don't have to provide leadership. You don't have to push or prod and that sort of thing." There is a larger percentage of students who "don't make you laugh and they don't make you cry," Hull said. This means they are ready to respond to good teaching and strong leadership. "They're hard-working people. They'll go as far as they're led in many cases." Finally, there is a third group that falls by the wayside. "It's a very difficult group to ever raise to a point where they're explorers," said Hull.

Scientifically literate: To understand and appreciate scientific knowledge

At the heart of this study is an attempt to determine what communication channels are effective in creating a scientifically literate public. In order to identify effective communication channels it is necessary to define what it means to be scientifically literate. The interviewees suggested that a scientifically literate person was one who had a common understanding and appreciation of scientific knowledge. Pruitt explained that "being scientifically literate would be to have an appreciation or to be able to appreciate and understand the benefits of science." He also believes "that the general public would even appreciate basic research if they were scientifically literate as a whole more than what they do now." Dasch offered a practical definition:

> To me, it's the ability for someone to read the newspaper and be able to understand some of the issues involved in scientific subjects and be able to vote with some degree of knowledge about issues effecting science like dam sites and nuclear reactors.

Hudkins cited a similar definition. "I think it's an ability to understand issues of the day and be able to be a responsible citizen and make informed decisions." NASA Headquarters education director Frank Owens concurred with Dasch's and Hudkins' definitions and added:

> It's perhaps not necessarily getting an A on a test that has certain kinds of questions on it, but it's more of a thought process and reasoning process and at least a familiarity with a number of broad areas in which the average citizen then can go search out additional information to make a clearer understanding or a projection of what he or she wants to do.

Nyerges defined being scientifically literate in terms of education.

> [To be scientifically literate] I think that simply means to be reasonably conversant in the methods and content of science as part of one's basic education ... and understand its impact on society. It's so much at the heart of and cutting edge of what drives societal progress as well as societal problems. I think anybody who earns a high school diploma or bachelor's degree should at some level or another have that kind of awareness and developed understanding.

NASA's public education outreach efforts

All respondents referred to *outreach* in some form or another. NASA's outreach plan is a direct result of the National Aeronautics and Space Act of 1958[1] that mandated the wide dissemination of information about NASA's missions and discoveries. Hudkins addressed this mandate from a public affairs perspective.

> It's always been ingrained in our culture since we were established in 1958. That was a major mission and priority of the agency ... to share with the public the good, the bad, the results, the mishaps of everything that we do. Everyone within the agency feels an ownership to that whether it's going out and doing public speaking or to a project manager that has to be accountable to the public; whether it's through the news media, or going and talking to organizations and different groups. So, I really think we're exceptionally unique as a government agency.

Nyerges reiterates Hudkins' comments and speaks to the role of the academic community in the outreach plan.

> One (a reason for increasing interest level) is that inherent in its mission from the very beginning has been this matter of outreach and provision of information to the public and to the educational community as a specific part of that public because of the very close ties we would have with that community for reasons of the research interest. ... So there's been a strong relationship with the academic community from the start and that has spilled over right up and down the line as far as encouraging a lot of interaction in mentoring and in student internships and that sort of thing.

Education vs. information programs

Owens and Hull distinguished between education programs and information programs. Owens suggested that education (designated by a lower case e) in a public affairs context is the notion that "we're educating and providing information to the general public for some good purpose." Education (designated by an upper case E) deals with the agenda and objectives that the educator is trying to achieve. This type of education is driven by strategies designed to meet specific objectives. Assessments are made according to various criteria to determine if the objectives are met. Hull made the distinction in the following way:

> Now the difference between those two programs, in my view, is the fact that if you are in an educational program first and foremost you have to understand the person that you're communicating with. And if you're an educator, then you have to help that person go to the next level or the next step. Now information programs, by and large, are associated

[1] The National Aeronautics and Space Act of 1958 states in section 203. (a) (3) that "The Administration, in order to carry out the purpose of this Act, shall--provide for the widest practicable and appropriate dissemination of information concerning its activities and the results thereof."

> with the mass media. ... (Y)ou recognize they're (the mass media) the common denominator.

Owens made it clear that NASA's educational efforts must be put into context. NASA is only a small element in a large society that is quite diverse. There are members of society who do not know what NASA means. There are others who would disagree with the fact that the United States landed people on the moon. Given such diversity, NASA is only able to do so much, but it is making a concerted effort to demonstrate the vision that NASA is an investment in America's future.

NASA's delivery systems

NASA efforts to interact with the educational community are varied and diverse. Hull of Ames Research Center categorized the center's educational efforts in terms of "delivery systems." He suggested the most effective delivery system is "one-to-one, people-to-people." This face-to-face interaction is a part of NASA's educational programs that bring students, teachers, and the general public to the various centers throughout the country. "They come to our living room," said Hull. In the Ames living room, scientists and students become partners in learning. This partnership is created at other centers as well. One-to-one interaction also occurs when NASA scientists go out into the community to work with teachers and students in the schools and talk with the media.

The second delivery system is electronic interaction. Examples of this type of delivery system include the Internet and NASA TV. Through Space Link, a world-wide computer information system that is maintained by Marshall Space Flight Center on the Internet, teachers have access to numerous curriculum supplements for classroom instruction in science, math, and technology. In addition, the Internet provides an opportunity for individuals to "attend" scientific conferences electronically. They are able to see and hear what is going on and ask questions like the live audience. NASA TV links classrooms throughout the country for live interactive video conferencing and allows the general public to access through their cable or satellite provider recorded presentations and documentaries that are in NASA's archives.

The third delivery system, according to Hull, is "the printed version of our knowledge and then also video and slides and so forth." Owens summed up NASA's communication efforts in the following way:

> Our primary activity or way of communicating with them (the customer) goes anywhere from face-to-face and personal interaction to the development of curriculum materials that can be print, multimedia, or Internet based to advanced technologies ... I mean it's the whole array of activity. The key to that, however, is first of all understanding the customer that you're dealing with and secondly then delivering and interacting with that customer in a way in which makes sense for the objectives you're trying to achieve.

Science education and the Internet

The Internet has assumed a major role in the dissemination of information, according to the participants. Home pages contain up-to-the-minute information about recent findings, shuttle missions, and scientific break-throughs. Everything from press releases to fact sheets to budget briefings to the latest pictures of the most recent shuttle mission are on the various NASA centers' home pages.

Compared to the traditional mass media, Nyerges suggested the Internet has a life of its own. He said the Internet is considered a key media player, albeit a multimedia player. The Internet is "a way of approaching gathering information together and putting it in a useable form. ... It's a very rich area and certainly very prominent area," said Nyerges. However, he cautions that the Internet is not a cure-all medium for educating students and the general public about science because all those who have access are not at the same level of understanding.

> The one proviso, the limitation that needs to be kept in mind is that not everybody is at the same place when it comes to that (Internet), and it's not a cure-all answer for everything, especially in educational reform. I mean, a lot of things are geared now toward government money and so forth to get kids on the Internet and get the computers out there, and that's fine. In most cases it's something that should work pretty well, but there's a down side to that and there's a limiting side to that as well. You don't assume that the answer to every educational problem is a computer or the Internet necessarily. There's some other things that go with it that are important, too.

Science education and mass media

All participants suggested mass media have a role in science education. Nyerges said, "the media is just like the air we breathe." Both the educational programs office and the community and media relations office use the media to disseminate its information. However, Nyerges made a distinction between the role of the media in each office.

> Their (media relations office) role would be more in terms of the broadest reaches of the general public, and ours (education office) might be more in terms of educational publications or newspapers and that sort of thing as well because things like education are to going to have an impact and interest out there. Most people are interested in it. It affects things. It's valued, so it's going to be covered that way. And the media is also part of the commercial technology area where they're getting out to various, maybe sometimes, more technical or business oriented publications where they're sharing NASA technologies.

Pruitt believes it is important to develop a media outreach plan that allows education offices and public affairs offices to work hand in hand. Hull echoes this belief. He said that originally education and public affairs were not separate entities; both were housed under public information programs. However, with the Space Act of 1958, the public affairs office was established. Several years after the establishment of the public affairs office, the education office at headquarters moved to the human resources side of the organization. The philosophy behind this move, according to Hull, was that human resource representatives were responsible for training agency employees, and, therefore, education and training should be together. Other centers made this change, but Ames Research Center did not. Hull believes this was wise.

> In my view, that is probably in our best interests, and I would even suggest it might even be in NASA's best interests to stay like we (NASA) were and like we (Ames) now are. I think education can benefit a great deal from the people that have a responsibility to gather information for the benefit of mass media.

Pruitt explained that media play a vital role in helping to inform the general public and young people of science. He said:

> (M)ore than a teaching role, the media can serve a role of creating awareness and generating a desire on the part of the general public to learn. You know, stimulating interest through the production capabilities that they have to make science somewhat entertaining and to create a teachable attitude on the part of the viewer to want to learn more. So collaborating, I think, with the media can be very helpful.

According to Hudkins, there is a great deal of collaboration between NASA and mass media outlets. One of the key media players in cable television is the Discovery Channel. Hudkins explained:

> (W)e courted them heavily because we saw the great potential in their medium of sharing the neat, wonderful things that we do because we do exceptionally interesting things here. ... We talked for a about a year or so, and all of a sudden, they understood what we did. And, I guess, their industry was taking off, so there was a natural marriage between the two organizations.

In addition to the Discovery Channel, NASA has worked with the Learning Channel, Lifetime, Arts & Entertainment, MTV, Nickelodeon, and Disney, according to Hudkins. Public broadcasting is also a major media outlet for NASA. Owens and Dasch cited PBS programs like "NOVA" and "Bill Nye the Science Guy" as useful outlets that foster scientific literacy. Owens said:

> From an education standpoint, ... we seek people like Bill Nye the Science Guy. Bill's a tremendous supporter of space. We have taken a lot of efforts to ... let him have access to our information, our site, and so he knows where all the NASA and education information is. We've looked at getting him access to some of our facilities. But, that's an example of a very popular science delivery program in which we've tried to have interaction and support his efforts.

Feature films like "Apollo 13," starring Tom Hanks, also contribute to an increase in public awareness about science. Although NASA did not pay for the movie, it was instrumental in providing a lot of technical support and facilities, according to Owens.

Pruitt suggested that a more proactive distribution of NASA's research and mission products would be beneficial. He called for increased coverage of NASA activities by broadcast television, cable, and radio. According to Pruitt, "(J)ust making producers and the media gurus aware of what's going on may very well be the secret to getting more coverage and more involvement."

Besides commercial and public television and feature films, print media also serve an important role in the dissemination of scientific information. Newspapers, specialty magazines, and news magazines are active in relaying scientific information to the general public. Hull explained that the major newspapers he typically reads (San Jose Mercury, San Francisco Chronicle, Los Angeles Times) used to have top-notch science writers. However, there was a period of time when there seemed to be less emphasis on effective science reporting. More recently, though, there has been a return to quality science writing. As for specialty and news magazines, Hull said:

> My view on the printed word in general is that there's been a watering down of some of these (specialty) magazines that I thought in the past had a much richer, more depth approach to them. Magazines like Scientific American, I think that's been watered down. I think the New Yorker's been watered down. National Geographic, I think, has been pretty much the same. The news magazines, in my view, are not the same in terms of depth as they used to be, magazines like Time and Newsweek.

Constraints and restrictions

Achieving scientifically literacy is not without obstacles. Often these obstacles manifest themselves as personnel and budget constraints. However, most of the participants accepted such obstacles as part of any organization. Hudkins said, "I don't know anyone who wouldn't say that they have those restraints. I just think that's just endemic of every agency, of every company." Nyerges also suggested that a lack of time, money, and energy are normal and usual constraints, but believes it does not have to be restricting. He said:

> In general, with the government role and the government resources on the shrinking mode rather than expanding, there's a lot of scrambling, you might say, to make sure that we're doing the right things with the limited resources we have because things are getting tighter and tighter all the time. So, in a way, that's a healthy process because it does tend to refine and narrow what you can do best and what you need to do rather than just trying to do everything.

Other restricting factors highlighted by the respondents ranged from language problems to legal constraints. Hull remarked that in the Northern California area there is the problem of English as a second language. Many young people in the area have a limited knowledge of English. This makes it difficult for them to interpret the printed word as well as television, much less complex scientific information.

As for legal restrictions, Pruitt said, "Congress has limitations on the agency, and we cannot market new programs that have not been approved by Congress or try to sell new programs to the public if Congress has not approved those programs." Hudkins explained that as a federal agency NASA cannot fund television programming, advertise, or lobby.

Despite the various obstacles that exist, Owens chooses to see the situation in more optimistic terms.

> (T)he personnel and budget constraints are not limiting. We could have more money and that's all well and good. I guess I just don't feel constrained. I feel right now in education ... we have more going on than ever before. Our budget's flat, but that's okay. Part of it is an investment in people doing things - understanding what education is, what is important in education, and then aligning their interest to the national agenda. I just don't feel constrained. I don't feel like I can keep up to be honest with you.

DISCUSSION

This research revealed that NASA education officers are generally consistent in their views about achieving scientifically literacy. All participants define science in a similar manner and suggest that being scientifically literate involves understanding and appreciating scientific knowledge. In addition, all respondents recognize the agency's obligation to distribute scientific information and make it available to the general public. In order to foster greater understanding and appreciation, NASA utilizes several delivery systems to disseminate scientific knowledge. Among these delivery systems are face-to-face interaction, on-site visits, mass media, and the Internet. These channels of communication are used by the education and public affairs offices, but often to achieve different purposes. The role of public affairs offices is to increase awareness of science among the general public. The role of education offices is to work with the educational community to stimulate a learning environment that teaches youngsters about science. Therefore, in order to understand the role of mass media and other communication technologies in achieving scientific literacy one has to distinguish between a public information objective and an educational objective.

Using the mass media to inform the general public about science has been a common practice for several years. Public broadcasting continues to provide science-related programming that is informative and entertaining. The Discovery Channel and the Learning Channel offer excellent cable programming that helps raise public awareness of scientific applications and discoveries. Newspapers and magazines also provide stories that expose readers to NASA's latest research efforts. However, the depth of understanding that is achieved from these delivery systems is suspect (Cronholm & Sandell, 1981; Elliott and Rosenberg, 1987; National Science Board, 1990). Hull believes that those in the mass media underestimate how much their audience wants to understand about scientific discoveries and applications. He said the media should go into much greater depth, but he thinks they do not because producers and reporters lack the background necessary to write and communicate effectively. This lack of training may be a contributing factor to the "watering down" of selected print media that Hull discussed.

Does this mean that mass media are ineffective delivery systems for achieving scientific literacy? Based on participants' responses, one could argue that mass media are one part of a larger outreach plan that involves several delivery systems that together contribute to increasing the level of scientific literacy among the public. Mass media have their place in informing and educating the public about science, but they are not as effective in isolation. It is clear from the participants that NASA does not allow mass media channels to operate in isolation. NASA recognizes the need to complement and supplement mediated communication with face-to-face interaction.

NASA also recognizes the value of the Internet in its attempt to increase scientific literacy among the public. The Internet has the ability to combine the traditional mass media into one medium. "There's more of a blending of the traditional media and the emerging technologies of multimedia," according to Pruitt. With this merging of technologies there must be "more linkages and synergy with the media outlets," said Pruitt. He suggested that all forms of media should be involved in NASA's outreach plan. By identifying ways to collaborate with all the different media outlets, instructional tools that affect more of the senses can be designed. The learner is more apt to remember what he/she is exposed to when more senses are involved in the learning process. Pruitt called for collaboration among scientists and media specialists in order to effectively package and communicate the new science and technology of the agency.

One of the driving forces behind this study is the notion that achieving scientific literacy among the general public must start with younger members of society. Clearly, the respondents are committed to providing the most effective and useful resources available to educate, not just inform, students about science. It may be that the youth of America can serve as teachers for adults, or at least both parties can engage in a stimulating dialogue that will further their understanding of scientific concepts. Such a dialogue may be the result of a fascinating documentary about the space shuttle program shown on the Discovery Channel. Or, the Internet might provide the opportunity for children to show their parents what they are working on in school. In either case, there is an opportunity for both groups to further their understanding of science and move toward scientific literacy.

Creating a scientifically literate public is not an easy task. One of the biggest barriers is the simple fact that science is hard. Dasch made this point several times throughout his interview. He suggested that the problem of scientific illiteracy would not be as great if more people understood that scientists are fallible and science itself is fallible. White (1994) addressed this issue and emphasized the need for public understanding of scientific purposes and goals because the success of science and engineering efforts is contingent upon it.

> We have a real self-interest in communicating well. ... There is an obligation on the part of scientists, as well as reporters, to make sure that the public understands that many of these issues are encrusted with uncertainties and, that reputable scientists can have differing views on many critical issues (White, 1994, p. 432, 434).

NASA's educational efforts to raise the level of scientific literacy in America are numerous and diverse. It is clear from the respondents that the majority of the public is interested in scientific applications that relate to daily life. As more discoveries are made it is imperative that NASA identify how such findings will make a difference in the lives of the general public. It is also important for media outlets to cover scientific issues more thoroughly. NASA can help contribute to greater depth by training its scientists to communicate more effectively with the media. Scientific jargon needs to be put into lay terms and coupled with practical examples and illustrations. Finally, NASA education and public affairs offices must continue in a collaborative relationship. The public affairs office is vital in creating scientific awareness that can be cultivated into scientific literacy by the education office.

Future research

Future investigations should examine the mass media's perspective on achieving scientifically literacy. Participants suggested some media channels are not as effective in developing scientific understanding as they could be. Perhaps the media players see it differently. Another area of exploration should target teachers and students. Are they benefiting from NASA's educational efforts? If so, which delivery systems are most effective? Further research into these and other areas will only draw us closer to determining how to effectively create a more scientifically literate public.

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Appendix A

Science Education and the Media
Question Guide

1. How do you define the field of science?

   Would you categorize the field of science in any specific way?

   If so, what are some of the categories?

2. Do you think the public is interested in science?

   What makes you think that?

   Are students interested in science? (compared to other subjects)

   Which grade levels?

3. What does it mean to learn about science?

4. What does it mean to be scientifically literate?

5. In your view, what is the purpose or mission of NASA's education centers?

6. What is NASA doing to educate the public about science?

   To educate students?

   Where are the directives coming from? NASA Headquarters? Individual centers?

7. What restrictions/constraints exist in achieving scientific literacy?

   Personnel constraints? Budget constraints? Legal restrictions?

   Ex. NASA is prohibited from soliciting commercial networks to produce programming in its interest.

8. Do you think the media have a role in science education?

   Do you feel the media teach/educate the public about science?

   What about students? In what way?

   Does the media's role differ for the two populations? Or, do you see the two groups as the same?

   Are the media being used effectively as teaching tools?

   For the public? For students?

   Are they being used to their fullest potential?

   How so? Which media?

9. In the scope of NASA's educational efforts how does the media fit in?

10. Are there key media players in science education?

    Who are they? What are their roles?

11. Can the media and NASA work more closely to achieve scientific literacy? In what ways?

    Can a commercial network solicit NASA to help produce science-based programming?

    Has this happened?

    What were the circumstances? Is this common?

    How might this help achieve scientific literacy?

    What about PBS? Is solicitation prohibited?

    Which media outlet(s) does NASA seek initially if it wants to produce a program?

12. Do you make a distinction between traditional media and emerging technologies/ multimedia?

    If so, what are the differences?

    How do you use them?

    Do you categorize your educational efforts based on the use of traditional media vs. emerging technologies?

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