

AC 2008-908: MESSAGES FOR IMPROVING PUBLIC UNDERSTANDING OF ENGINEERING

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Messages for Improving Public Understanding of Engineering

Abstract

Every year, hundreds of millions of dollars are spent in the United States to improve the public understanding of engineering. Despite these efforts, educational research shows that K–12 teachers and students generally have a poor understanding of what engineers do. Polling data show that the public believes engineers are not as engaged as scientists with societal and community concerns or as likely to play a role in saving lives. At the same time, policy makers and others are concerned about the state of STEM education in the United States, low enrollments of women and certain minorities in engineering schools, threats to U.S. competitiveness in the global economy, and the degree of technological literacy of Americans. This paper reports on research to develop and test messages that communicate a more accurate and positive image of engineering to the public. The results suggest that public understanding of engineering could be improved if engineers recast the way they presents themselves in outreach efforts and the engineering community uses the tested messages in a systematic way. Enhanced public understanding of engineering may be an important tool for addressing economic, education, and literacy concerns in the United States.

Introduction

Considerable efforts have been undertaken in the United States to improve the public understanding of engineering (PUE). A survey by the National Academy of Engineering (NAE) in 2002 of 177 organizations involved in PUE activities revealed that they spend an estimated \$400 million annually.¹ However, the actual national investment can be assumed to be much higher, because the survey is believed to have reached only a fraction of the institutions that have PUE initiatives.

Despite these efforts, the impact of engineering on our daily lives, the nature of what engineers do, and the opportunities available through an engineering education are still largely unknown to most Americans. Educational researchers have found that K–12 teachers and students generally have a poor understanding of what engineers do.^{2 3 4} Polling data comparing scientists and engineers show that the public sees engineers as being more responsible for creating economic growth and preserving national security than scientists, as well as more likely to make strong leaders. However, engineers are not perceived to be as engaged with societal and community concerns or to play as great a role in saving lives.⁵ And when the relative prestige of all professions is tallied, engineering falls in the middle of the pack, well below medicine, nursing, science, and teaching.⁶

Although engineers, engineering educators, and the organizations that represent them want people to have more accurate and positive impressions of them, there are more important reasons for improving the public understanding of engineering. Some

knowledge about how engineering work is done, for example, is fundamental to technological literacy. To be fully capable and confident in a technology-dependent society, citizens should understand something of the process of engineering and how engineering and science, among other factors, lead to the development of technologies.^{7 8}

Improved public understanding of engineering may also support U.S. efforts to maintain its capacity for technological innovation, an issue that has received considerable attention.^{9 10 11} Although there are many aspects of this challenge, two important conditions for sustaining U.S. innovative capacity are improving undergraduate engineering education and increasing investment in basic engineering research. Effective action in both areas will depend partly on how well policy makers and the public understand what engineering is and how it contributes to economic development, quality of life, national security, and health—information that could be conveyed through effective messaging.

Women, African Americans, Hispanics, Native Americans, and some Asian American groups are significantly underrepresented in engineering, based on their proportions in the population at large. If current demographic trends continue, by 2050 almost half the U.S. population will be non-white.¹² In the future, engineering solutions will have to be acceptable to this increasingly diverse population, and the engineering profession will have to draw more heavily on underrepresented groups for the country to maintain, let alone increase, its technological capability.¹³ Thus messages that effectively encourage girls and underrepresented minorities to consider careers in engineering could be crucial to U.S. success and leadership in the future.

This paper reports on messaging research conducted by the National Academy of Engineering (NAE) with support from the National Science Foundation.

Message Development

In the lexicon of marketing, messages are a key component of branding. A brand associates specific traits in a person's mind that induce behavior. At one time, brands were associated only with consumer products, such as dish soap, cereal, or new cars. Branding is now applied more broadly, to organizations, to entire industries, and even to professions, like engineering. Messages, usually a complete sentence, articulate the “brand promise.” For example, the message for the British painkiller Anadin is, “Nothing acts faster than Anadin.”

To develop messages about engineering, the NAE committee overseeing the research hired a communications firm, BBMG (www.bbm.com), experienced in brand development. The firm first reviewed the landscape of past and present engineering outreach initiatives. The review confirmed much of what has been previously reported,¹⁴ namely

- Such efforts have been mostly ad hoc,
- There are few data on outcomes,

- There is little or no coordination among efforts,
- Most efforts have targeted older (high school) students,
- Most efforts are local in scope, and
- The use of a variety of tactics has made it difficult to deliver consistent messages.

The review also determined that most messages related to engineering have been direct, rational statements emphasizing either (1) the benefits and challenges of being an engineer or (2) the skills required to be an engineer, particularly in mathematics and science. Other research has found these sorts of messages to be in conflict with many of the career and academic motivators for high school girls.¹⁵

In consultation with the NAE committee, BBMG created a positioning statement (Box 1) that recasts engineering from a profession that yields personal *benefits* and requires certain *skills* to a profession based on creative *ideas* that have a beneficial *impact*. Positioning statements are not usually shared with the public. Rather, they serve as the point of reference for all public communications (e.g., advertising, PR campaigns), encourages a consistent message (i.e., staying on message), clarifies the aspects of engineering that set it apart from other professions, and makes a clear case for why engineering matters.

BOX 1 A Positioning Statement for Engineering

No profession unleashes the spirit of innovation like engineering. From research to real-world applications, engineers constantly discover how to improve our lives by creating bold new solutions that connect science to life in unexpected, forward-thinking ways. Few professions turn so many ideas into so many realities. Few have such a direct and positive effect on people's everyday lives. We are counting on engineers and their imaginations to help us meet the needs of the 21st century.

BBMG developed a set of preliminary messages consistent with the positioning statement and shared these messages in telephone interviews with a cross section of educators, opinion leaders, and engineers. The preliminary messages were also shared in focus group settings with pre-teens, teenagers, and parents with teenage children in two different U.S. cities. The interviews and focus groups were also used to gather information about teen and adults perceptions of engineers and engineering; this paper will focus on the findings related to the messages.

As a result of this qualitative research, and again in consultation with the NAE committee, BBMG crafted five final messages (Box 2) that were then tested in a more quantitative way through the use of online survey techniques.

BOX 2 Messages Tested in Online Surveys

Engineers make a world of difference.*

From new farming equipment and safer drinking water to electric cars and faster microchips, engineers use their knowledge to improve people's lives in meaningful ways.

Engineers are creative problem-solvers.

They have a vision for how something should work and are dedicated to making it better, faster, or more efficient.

Engineers help shape the future.

They use the latest science, tools, and technology to bring ideas to life.

Engineering is essential to our health, happiness, and safety.

From the grandest skyscrapers to microscopic medical devices, it is impossible to imagine life without engineering.

Engineers connect science to the real world.

They collaborate with scientists and other specialists (such as animators, architects, or chemists) to turn bold new ideas into reality.

* This message was inspired by a similar message used to promote National Engineers Week.

Online Survey

The online survey instrument contained nine questions, in addition to several screening items. Five of the substantive questions probed participants' views about engineers and engineering, three sought opinions on the messages, and one question asked about a small number of engineering "taglines."¹⁶

The survey was fielded three times, the first time by Polimetrix (www.polimetrix.com) in late 2006 among a group of 666 adults and 568 teens, ages 14 to 17. Relatively few African Americans or Hispanics took part in this first survey, making it statistically impossible to draw valid conclusions about the responses of these groups. Because African Americans and Hispanics are a key audience for engineering messaging, the NAE committee decided to repeat the survey in two populations of underrepresented minorities.

The follow-up surveys, conducted in late May and early June 2007 by Harris Interactive (www.harrisinteractive.com), returned 605 surveys from African American adults, 608 surveys from Hispanic adults, 535 surveys from African American teens, and 566 surveys from Hispanic teens. All three surveys relied on pre-recruited panels of respondents, and

all three were statistically weighted to adjust for potential demographic differences between the final sample and the general population.

Attributes of Engineers

In answer to the survey's only open-ended question, respondents were asked to type the first word or words that came to mind when they heard the word engineering. The words mentioned most often (22 to 30 percent of the time) by adults were "builders," "building," and "construction." The second most frequent associations for adults in the general-population survey were "math" or "science" (mentioned by 12 percent) and "design" (mentioned by 11 percent). Among African American and Hispanic adults, "math" and "science" were the second most frequent words associated with engineering. Teens across the board typed "math" or "science" most often (between 21 and 31 percent of the time).

The prominence of math and science in the minds of the public was reinforced by responses to a second question in which respondents were asked to decide how well each of 25 attributes described engineering and/or engineers. Adults and teens chose "high skill level in mathematics and science" as the most distinguishing attribute of engineering (Table 1). A majority of adults and teens also chose "designers," "builders," and "problem solvers." More teens than adults chose "hard workers."

Although in the telephone interviews, engineers said they believed the public viewed them as "boring" and "nerdy," fewer than 15 percent of adults or teens in the surveys described engineers this way, although teens in the general population survey were three times as likely as adults in that group to consider engineering "boring" and twice as likely to consider engineers "nerdy."

Hispanic girls were significantly more likely than Hispanic boys to think engineers were nerdy and boring. When answer choices "very well" and "somewhat well" were combined, Hispanic girls were also significantly less likely than Hispanic boys to consider engineering fun. Hispanic girls were also significantly less likely than Hispanic boys to believe engineering has a positive effect on people's lives.

TABLE 1 Words That Describe Engineering “Very Well,” by Percentage (Rank)

	First Survey			African American Survey			Hispanic Survey					
	Adults	Teens		Adults	Teens		Adults	Teens				
		All	Boys		Girls	All		Boys	Girls	All	Boys	Girls
Good at math/science	86 (1)	84 (1)	85	84	77 (1)	71 (1)	59	81	72 (1)	76 (1)	74	78
Designs, draws, and plans things	61 (2)	63 (2)	64	61	67 (2)	59 (3)	60	59	60 (3)	56 (4)	61	50
Problem solver	59 (3)	62 (3)	68	57	60 (6)	52 (5)	58	47	64 (2)	50 (7)	47	53
Builds, constructs, and makes things	53 (4)	59 (5)	59	59	63 (3)	59 (3)	60	59	54 (4)	61 (2)	64	58
Creative	45 (5)	47 (7)	55	41	62 (4)	50 (6)	50	50	47 (6)	52 (5)	52	53
Get results	44 (6)	41 (10)	44	40	51 (8)	45 (8)	39	50	45 (8)	47 (8)	56	38
Well paid	44 (6)	46 (8)	48	44	61 (5)	45 (8)	32	56	53 (5)	51 (6)	52	51
Must be smart	43 (8)	56 (6)	58	54	46 (9)	37 (12)	35	38	45 (8)	42 (9)	38	45
Original thinkers	43 (8)	45 (9)	44	45	41 (12)	46 (7)	36	54	38 (13)	37 (12)	39	35
Hard working	42 (10)	62 (3)	56	66	56 (7)	64 (2)	63	65	47 (6)	58 (3)	58	58
Well respected	39 (11)	34 (14)	35	32	40 (14)	35 (14)	36	34	42 (10)	36 (14)	40	31
Work is rewarding	36 (12)	32 (15)	39	26	41 (12)	31 (17)	32	30	38 (13)	35 (15)	39	30

TABLE 1 (cont'd) Words That Describe Engineering “Very Well,” by Percentage (Rank)

	First Survey						African American Survey						Hispanic Survey					
	Adults			Teens			Adults			Teens			Adults			Teens		
	All	Boys	Girls	All	Boys	Girls	All	Boys	Girls	All	Boys	Girls	All	Boys	Girls			
Mostly men	35 (13)	37 (12)	38	40 (14)	41 (11)	45	31 (15)	36	45	30 (16)	31	28	31 (15)	30 (16)	31			
Have a positive effect	32 (14)	36 (13)	29	44 (11)	36 (13)	36	39 (12)	36	36	37 (12)	51	22	39 (12)	37 (12)	51			
Inventors	28 (15)	41 (10)	44	46 (9)	43 (10)	45	40 (11)	45	40	42 (9)	40	43	40 (11)	42 (9)	40			
Leaders	23 (16)	22 (16)	24	30 (17)	33 (16)	31	31 (15)	31	35	42 (9)	44	40	31 (15)	42 (9)	44			
Often work outdoors	17 (17)	20 (17)	22	29 (18)	35 (14)	30	21 (18)	30	38	30 (16)	33	27	21 (18)	30 (16)	33			
White	12 (18)	11 (23)	10	34 (16)	14 (21)	15	22 (17)	15	12	10 (23)	9	10	22 (17)	10 (23)	9			
Entrepreneur	12 (18)	18 (18)	18	21 (19)	22 (19)	15	14 (21)	15	28	24 (18)	29	19	14 (21)	24 (18)	29			
Too much school	10 (20)	15 (19)	15	16 (20)	14 (21)	17	18 (19)	17	11	13 (21)	12	15	18 (19)	13 (21)	12			
Fun	7 (21)	9 (24)	6	15 (22)	15 (20)	12	13 (22)	12	17	19 (20)	24	14	13 (22)	19 (20)	24			
Start new companies	7 (21)	14 (20)	16	16 (20)	23 (18)	23	18 (19)	23	24	21 (19)	20	22	18 (19)	21 (19)	20			
Nerdy	5 (23)	14 (20)	13	13 (23)	10 (23)	10	12 (23)	10	10	12 (22)	4	18	12 (23)	12 (22)	4			
Boring	4 (24)	12 (22)	7	6 (24)	10 (23)	10	9 (25)	10	11	10 (23)	4	15	9 (25)	10 (23)	4			
Sits at a desk	2 (25)	6 (25)	5	4 (25)	3 (25)	1	12 (23)	5	5	5 (25)	7	4	12 (23)	5 (25)	7			

NOTE: Pairs of shaded cells indicate responses where differences exceeded the sampling tolerance. Yellow = adults vs. all teens. Gray = boys vs. girls.

Message Testing

As noted, three survey questions addressed responses to the messages. The first asked respondents how appealing the messages were and, separately, how believable and personally relevant they were (how much they cared about the message). By triangulating among appeal, believability, and relevance, one can get an accurate sense of the validity of the appeal ratings.

All five tested messages were rated at least “somewhat appealing” by an overwhelming majority of adults and teens, a finding that reinforces the validity of the underlying positioning statement. The message with the highest “very appealing” rating—the most favorable category—among all adult and teen groups was “Engineers make a world of difference.” This message was also considered the most believable and most relevant in most groups (Table 2). However, once again, girls were generally less enthusiastic than the boys about all of the messages.

TABLE 2 Appeal, Believability, and Relevance of Messages among Adults and Teens, by Percentages (Rank)

	First Survey		African American Survey		Hispanic Survey	
	Adults	Teens	Adults	Teens	Adults	Teens
Engineers Make a World of Difference						
Very appealing	55 (1)	43 (1)	53 (1)	40 (1)	48 (1)	46 (1)
Very believable	57 (2)	54 (1)	57 (1)	40 (3)	49 (1)	47 (1)
Care very much	41 (1)	31 (1)	46 (1)	32 (2)	39 (1)	37 (1)
Engineers Help Shape the Futuree						
Very appealing	48 (3)	37 (3)	48 (2)	37 (2)	44 (2)	40 (2)
Very believable	56 (4)	48 (4)	53 (3)	46 (1)	45 (3)	46 (2)
Care very much	33 (3)	25 (4)	41 (2)	31 (3)	34 (3)	31 (2)
Engineering is Essential to Our Health, Happiness and Safety						
Health/Happiness						
Very appealing	48 (3)	35 (4)	45 (4)	35 (3)	40 (3)	36 (4)
Very believable	57 (2)	50 (3)	49 (4)	35 (5)	47 (2)	39 (4)
Care very much	38 (2)	31 (1)	40 (3)	33 (1)	35 (2)	31 (2)
Engineers Connect Science to the Real World						
Very appealing	42 (5)	35 (4)	42 (5)	31 (5)	34 (5)	35 (5)
Very believable	49 (5)	46 (5)	49 (4)	41 (2)	38 (5)	39 (4)
Care very much	28 (5)	21(5)	39 (4)	23 (5)	29 (5)	27 (5)
Engineers Are Creative Problem Solvers						
Very appealing	52 (2)	42 (2)	48 (2)	33 (4)	40 (3)	39 (3)
Very believable	58 (1)	53 (2)	54 (2)	39 (4)	44 (4)	44 (3)
Care very much	32 (4)	26 (3)	38 (5)	27 (4)	33 (4)	30 (4)

NOTE: Pairs of shaded cells indicate responses where differences between adults and teens exceeded the survey sampling tolerance.

The message that received the lowest percentage of “very appealing” rankings by respondents in all groups was “Engineers connect science to the real world.” This message was also the least personally relevant to all but African American adults. The

lack of resonance with this message was confirmed when survey participants were asked to choose the single “most appealing” message of the five.

Boys in the first survey found “Engineering makes a world of difference” and “Engineers are creative problem solvers” equally appealing. This second message did not appeal nearly as much to girls. The second most appealing message for girls across the board was “Engineering is essential to our health, happiness, and safety.” Girls age 16 and 17 in the African American sample and all girls in the Hispanic sample found the “essential to health and happiness” message significantly more appealing than did the boys in those groups.

As a check on both adult and teen preferences, respondents were also asked to choose a single “least appealing” message. “Engineers connect science to the real world” was the least appealing message for all but African American boys, who found the “Engineering is essential to our health, happiness, and safety” message least appealing, and Hispanic girls, who found the “Engineers help shape the future” message least appealing.

Caveats to the Research

There are several aspects of the survey method that might affect generalizability of the results. First, because the survey required respondents to have Internet access, we could not include people who did not have access. Currently, about 73 percent of American adults report having regular access to the Internet.¹⁷ The number of teen users is higher, 87 percent in 2005.¹⁸ It is possible that people who do not have Internet access might have different views about engineering than those who do have access.

A second issue that may have affected generalizability was that the NAE was identified as the sponsor of the research in the materials provided to survey respondents at the beginning of the questionnaire. This was necessary for securing fully informed consent from respondents, but it may also have influenced the responses to one or more questions.

Finally, in any survey, some people choose not to participate. The reasons for non-responses vary but can include disinterest in or aversion to the survey topic or discomfort with the survey methodology (e.g., keyboarding in an Internet-based survey). Because non-responses change the representativeness of a sample, the rate of non-response can affect generalizability. Some surveys—but not ours—try to correct for non-responses by contacting non-responders outside of the survey process to determine their reasons for not participating.

Discussion

One of the most important outcomes of this research is the positioning statement’s recasting of engineering. Rather than a profession that yields personal benefits and requires certain skills, our research present engineering as an endeavor based on creative ideas and having beneficial impacts on humanity. This repositioning and messages that

align to it could be very effective tools for future public outreach by the engineering community.

The research data demonstrate how much perceptions of mathematics and science have shaped perceptions of engineering. Evidently, messages from the engineering community linking success in engineering to skills in mathematics and science have reached a wide audience. Although this message is correct, our research suggests that it has not been effective in improving the appeal of engineering.

The research also strongly suggests that boys and girls have different reactions to messages and different perceptions of engineering. The focus groups confirmed other research showing that girls are much more comfortable with images of engineering that include people, especially women, whereas boys tend to gravitate to “things.” Boys also appear to have a more positive outlook toward engineering as a career choice than girls, who are less confident that engineering can be a rewarding profession that will have a positive effect on people’s lives. This relatively negative view of engineering has been documented in other research.¹⁹

The research also exposed a “disconnect” between the engineering community’s self-perception and the public perception of engineers. The image of a nerdy, dull person, as popularized in the comic strip “Dilbert,” is widely accepted as a given by the engineering community. However, our research shows Dilbert is not the public’s image of an engineer. Neither adults nor teens in our study correlated Dilbert’s characteristics with real engineers. This means that messaging resources that might have been invested in efforts to counter the “nerdiness” image can be spent in more productive ways.

Finally, the research shows there are few significant ethnicity-based differences in the way adults and teens perceive engineers, engineering, and messages and taglines meant to improve the image of engineering. This does not mean, however, that messaging efforts, particularly the use of taglines, should not take ethnicity, culture, language and other factors into account. For optimum effectiveness, messaging needs to be contextualized for the target population.

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¹³ NAE. 2004. The Engineering of 2020—Visions of Engineering in the New Century. Washington, D.C.: The National Academies Press.

¹⁴ NAE, 2002.

¹⁵ EWEP (Extraordinary Women Engineers Project). 2005. Extraordinary Women Engineers—Final Report, April 2005. Available online at http://www.eweek.org/site/news/Eweek/EWE_Needs_Asses.pdf. (July 16, 2007)

¹⁶ This paper discusses results from two questions related to public views of engineering and all of the results related to the messages. A fuller discussion of the survey results, including those related to taglines, can be found in the NAE’s final report, which should be published in late 2008.

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