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A Retrospective Study Of The Elementary School Experiences, Influences, Skills, And Traits Of Talented Engineers

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AC 2009-693: A RETROSPECTIVE STUDY OF THE ELEMENTARY-SCHOOL EXPERIENCES, INFLUENCES, SKILLS, AND TRAITS OF TALENTED ENGINEERS

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Abstract

By 2012, an estimated 1.6 million engineers will be needed to support the U.S. job market. Based on the current pipeline, there is clearly a shortage of American engineers. This shortage is due to 2 factors: a substantial number of baby boomer engineers are retiring, and there are not enough U.S. students studying engineering today. The engineering field and characteristics of engineers are not well understood by children, teachers, guidance counselors, and parents. In order to identify students who may be a good fit for a future in engineering, the characteristics of today's talented engineer, one who acquires specific knowledge and a professional engineering license, need to be investigated.

For this project, one research question was considered: What are the common childhood skills, traits, influences, and school experiences of talented engineers?

This retrospective study piloted an instrument designed to identify the influences, skills, and traits that drew talented engineers to engineering. Participants were solicited via a link to an on-line survey included in an email sent to 7,000 engineering students, faculty, and practicing and retired engineers; over 1,000 responded. The demographics of the participants and the frequency of their responses were tabulated.

The primary influencers identified were family, teachers and counselors, and friends, although several respondents stated that they made the decision to pursue engineering themselves without someone else's influence. The results of this survey identified the skills and traits of individuals who chose engineering study: skills in math, science, thinking, problem solving, and analytic reasoning, and traits of being focused, persistent, ambitious, task-oriented, independent, and interested in many things. In addition to curriculum modifications to increase student awareness of engineering, parents, teachers, and counselors need a familiarity of degrees and careers in engineering in order to knowledgeably discuss this field with their children and students.

Introduction

The U.S. Department of Labor forecasts that by the year 2012, the United States will need approximately 1.6 million individuals who are engineering educated and trained to fill the engineering employment demand[27]. The purpose of this paper is to understand the characteristics of individuals who pursued engineering.

In order to meet this future market demand and address the concern of an engineering shortage, an intervention is necessary to increase the likelihood that students with STEM-based talent will choose engineering as a college major and pursue engineering as a career. Is this nation in a place of possible future inadequate supply? There has always been a demand for engineers, however different reasons for the fluctuation in the supply[11].

During WWII, more engineers worked in the armed forces, giving the illusion that there was a shortage, albeit only in the private sector[11]. In the late 40s and early 50s, it was considered a fad to hire an individual with an engineering degree for a job that should have more appropriately been filled by an individual with a Bachelor of Arts degree. Engineers were in great demand, but there was not a shortage[11]. High school-aged male students in the early 50s stated that it was cool to be smart and fashionable to be nerds[6]. They enjoyed taking shop class where they could sketch, measure, design, and create projects. Shop class teachers were often the boys' coaches so students formed close relationships with them, and oftentimes they provided crucial direction to their students regarding their continuing education and future careers. Following their parents' experience with the great depression, and sometimes having come from working class or blue collar families, these young men were encouraged by their teachers and their parents to go to college, study engineering, and get a good-paying job[6]. As such, the U.S. experienced a healthy and continuous supply of talented engineers, those who acquire specific knowledge and a professional engineering license, for many years until recently.

Based on the current pipeline, it is unlikely that this country can meet the demand of 2012 because there a shortage of American engineers. This shortage is due to 2 factors: a substantial number of baby boomer engineers are retiring[13], and there are not enough U.S. students studying engineering today[29] to meet this future employment estimate. Concepts that may be related to the solution to the engineering shortage will be explored: (1) the historical fluctuations in education focus and the current STEM presence in education legislation that may prompt younger talented students to study engineering, and (2) the needed integration of engineering into the current curriculum and deeper understanding of the engineering field by the individuals, such as teachers, counselors, and parents, who influence and counsel students on their studies and career direction.

In order to identify students who may be a good fit for a future in engineering, the characteristics of today's talented engineers, those who acquire specific knowledge and a professional engineering license, need to be investigated.

Literature Review

Educators, government agencies, and employers recognize the need to engage the next generation of potential engineers at earlier ages[31]. This Literature Review discusses the role of Education and attempted implementation through legislative policy and accreditation standards in order to increase student pursuit of engineering through early education awareness.

Fluctuations in Education Legislation and Reports

In the midst of the world's recognition bestowed on the scientific, technological, engineering, and mathematical minds of Russia for their launch of Sputnik in 1957, this outstanding accomplishment immediately brought to light the deficiencies in the educational system in the United States. Much was published about the STEM deficiencies and the neglected minds of the nation's talented students, which prompted a whirlwind of short-lived legislation and programs, and published reports.

For a period of 16 years, several definitions of giftedness were developed in an effort to provide clarity and focus to the educational needs of talented students. In 1972, the U.S. Commissioner of Education proposed a definition of gifted students in the Marland Report[18]. In 1978, the US Congress revised that definition. In 1988, the Jacob K. Javits Gifted and Talented Students Education Act was introduced and issued this definition of gifted and talented:

> children and youth who give evidence of high performance capability in areas such as intellectual, creative, artistic, or leadership capacity, or in specific academic fields, and who require services or activities not ordinarily provided by the school in order to fully develop such capabilities[16].

Although most states have adopted this definition into legislation and have provided funding for education programs for their talented children[10], most schools do not provide technology and engineering programs for their STEM-talented students.

In 1983, the National Commission on Excellence in Education published *A Nation at Risk: The Imperative For Educational Reform.* The report primarily assessed "the quality of teaching and learning" in our public schools and claimed that "the educational foundations of our society are presently being eroded by a rising tide of mediocrity that threatens our very future"[1]. Educational researcher Paul Hurd stated "We are raising a new generation of Americans that is scientifically and technologically illiterate"[1]. The report did not seem to address K-8, but did provide one recommendation for STEM content: "to provide a sound base … in such areas as … computational and problem solving skills, science…"[1]. In the past 15 years, most schools still do not provide a sound base in science for their K-8 STEM-talented students.

A Quiet Crisis in Educating Talented Students, the first chapter in the 1993 U.S. Department of Education's *National Excellence* report, provided another focus on the educational needs of talented students. The report recommended that these students receive higher-level learning opportunities and that teachers receive training on how to implement this high-level curriculum[25]. One opportunity would have been to provide STEM-talented students with project-based engineering problems, however many teachers state that they have not integrated engineering in their curriculum.

In an effort to reform education in 1994, with some emphasis on the sciences, Clinton signed the Improving America's Schools Act of 1994, which extended or reauthorized the 1965 Elementary and Secondary Education Act. The purpose of Title III--Technology for Education, Part E--Elementary Mathematics and Science Equipment Program, is "to raise the quality of instruction in mathematics and science in the Nation's elementary schools by providing equipment and materials necessary for hands-on instruction through assistance to State and local educational agencies"[14]. Although this Act provided much needed materials in the classrooms, this focus of math and science didn't improve the scores of U.S. students on international math and science tests over the next several years.

The results of the Third International Math and Science Study in 1993, 1999, and 2003 indicated that American students consistently performed worse in math and science than students from several other countries, including Singapore, Republic of Korea, Hong Kong, Japan, Netherlands, and Hungary[23, 24]. Concurrently in January 2002, the *No Child Left Behind Act of 2001* was signed into law, making education and promoting educational excellence top priorities. This pledge, to leave no child behind, suggested that *every child* would be provided appropriate educational interventions in order to achieve success in school and in turn, life[28]. One of the concerns with NCLB is that it focuses on Read First; it will be 5 years before the American Competes Act is passed that focuses on math and science.

Three introductions followed in 2006 and 2007 in an attempt to bolster the nation's leadership role in science and technology and "build on [the nation's] successes"[4]. The first, the American Competitiveness Initiative (2006), designated substantial funding for cutting-edge research and development; world-class education focused in science, technology, engineering, and mathematics (STEM); professional development for teachers; and workforce training systems[4]. Second, the Carl D. Perkins Career and Technical Education Improvement Act of 2006, a reauthorization of the original Act in 1984 and 1998, was targeted to improve the quality of technical education programs[9]. Last, the America Creating Opportunities to Meaningfully Promote Excellence in Technology, Education, and Science Act of 2007 provided additional funding for STEM education and teacher preparedness[3].

For many years, legislation repeatedly brought the educational issues of American youth to the forefront of its peoples' minds. While legislating improved educational practices and providing a continuum of educational programs that meet all students' needs, including talented students, it seems that in the last fifty years, the U.S. would by now have a plethora of bright graduating college students preparing to be employed in the fields of science, technology, engineering, and mathematics. However this does not seem to be the case as "other countries are demonstrating a greater commitment to building their brainpower"[8]. Consider these facts and projections:

- In 2004, 350,000 engineers graduated from India's colleges; 70,000 from U.S. colleges"[15].
- In the 2003 Program for International Student Assessment (PISA), the U.S. ranked 27th out of 39 countries. This assessment measures 15-year-olds' ability to solve real-life math problems[22].
- South Korea, with one-sixth of the U.S. population, graduated more engineers than the United States in 2001 and in 2002[27].
- From 1985 to 2002, the number of first university engineering degrees awarded in China was up 245%, Japan was up 43%, South Korea was up 176%, and the U.S. was down 22 %[27].
- U.S. 12th graders ranked almost last in both mathematics and science in TIMMS[20].
- Since 1983, U.S. engineering colleges awarded more than 50% of all engineering doctoral degrees to foreign nationals[27].
- In 1970, 50% of the people in the world who held science and engineering doctorates were Americans; by 2010, projections show that figure will drop to 15%[30].

Based on these data, a new focus on engineering education for students in the U.S. is paramount[26]. Students need to be taught the principles of engineering and be given positive experiences that may encourage them to pursue an engineering career[5]. Engineering education needs to begin in elementary school while student interest in mathematics and science is still high. About 80% of fourth graders report positive attitudes toward mathematics and science compared to an estimated 33% of eighth graders who report positive attitudes toward mathematics and science[21]. Integrating engineering concepts, practicing related skills, and exploring associated careers in the elementary and middle school classrooms may increase the number of students who pursue engineering.

Influences in the Pursuit of Engineering

Besides teachers increasing awareness of engineering in students' classrooms, outside the classroom, guidance counselors and parents need a more solid understanding of the field of engineering as well as the fit of engineering study with students who show STEM-based strengths.

The Extraordinary Women Engineers Project (EWEP) is lead by the WGBH Educational Foundation in conjunction with a coalition of 55 professional engineering associations. This group is interested in understanding why more female students are not pursuing an engineering degree and do not seem to be interested in a career in engineering. Their initial premise is that it is a perception problem in that the primary influencers on female students' degree program recommendations and career choices do not understand engineering. WGBH conducted a qualitative research study and their results indicated that teachers, school counselors, parents, peers, and the media are "key influencers and resources for information gathering"[12]. The priority order of influence is parents, friend and peers, teachers and siblings, school counselors and professionals.

The survey further showed that "many teachers and counselors do not feel prepared to help their students explore the engineering profession, with one quarter of respondents reporting that they don't know enough to help students learn more about engineering"[12]. Their recommendations when asked about engineering were to use the internet or read about engineering on university websites. Parents were also not comfortable recommending engineering because of their lack of knowledge in the field. The exception was parents who studied or worked in the science field.

The EWEP coalition recommends that training opportunities be created "to promote engineering education and careers to girls, their parents, and educators … school counselors and teachers"[12].

Skills and Traits of Engineers Described by Professional Organizations

"The word *engineer* has its roots in the Latin word *ingeniator*, which means ingenious, to devise in the sense of construct, or craftsmanship. Several other words are related to ingeniator, including *ingenuity*"[19]. An engineer is defined by her own set of attributes, skills, traits, and educational accomplishments.

Three well-known engineering-affiliated organizations, representing an independent agency, a national manufacturer, and an accreditation bureau, offer a listing of preferred attributes of engineers:

The National Academy of Engineering developed a list of specific attributes of engineers that are key to the success of the engineering profession: strong analytical skills, practical ingenuity (skill in planning, combining and adapting), creativity, good communication, master of business and management, leadership, possess high ethical standards, strong sense of professionalism, dynamism, agility, resilience, flexibility, and lifelong learners[19].

The Boeing Company, manufacturer of commercial jetliners and military aircraft combined, is a long-standing supporter of K-12, college, and university programs, and because of its business, takes an interest in employing engineers that possess a specific set of attributes: a solid understanding of engineering science fundamentals, of design and manufacturing processes, of the context in which engineering is practiced, of a multi-disciplinary, systems perspective; good communication skills; high ethical standards, an ability to think both critically and creatively, independently and cooperatively; flexibility; the ability and self-confidence to adapt to rapid or major change; curiosity and a desire to learn for life; and a profound understanding of the importance of teamwork[7].

Accreditation Board for Engineering and Technology (ABET) was originally established in 1932 as an accreditation agency. Over the years, it expanded to evaluate engineering and engineering technology degree programs. The organization is a "federation of twenty-eight professional and technical societies" with practicing professionals from "academe, government, and industry" as its individual members[2]. ABET issued engineering program outcomes that are "statements that describe what students are expected to know and be able to do by the time of graduation. These relate to the skills, knowledge, and behaviors that students acquire in their matriculation through the program" [2]: apply knowledge of mathematics, science, and engineering; design and conduct experiments, and analyze and interpret data; design a system, component, or process to meet desired needs within realistic constraints; function on multidisciplinary teams; identify, formulate, and solve engineering problems; communicate effectively; use the techniques, skills, and modern engineering tools necessary for engineering practice; demonstrate professional and ethical responsibility; understand the impact of engineering solutions in a global, economic, environmental, and societal context; engage in life-long learning; and have a knowledge of contemporary issues[2].

The majority of the traits, skills, and attributes listed by these three organizations are very similar; the differences may be attributed to the varying purpose of each organization. A clear gap in the literature is the linking of National Academy of Engineering, Boeing Company, ABET to the skills and traits of individuals who pursued engineering.

Preliminary Investigation of Degreed Engineers' Beliefs of their Skills and Traits

In order to refine the categories and questions for this study's piloted instrument, one question was emailed on September 21, 2007 to a convenience sample of twelve practicing and retired 40-

75 year old engineers. The question sent to the engineers was: *Please describe the school experiences, influences, skills, and traits that impacted your decision to become an engineer***.**

The top characteristics that were revealed in this mini-study were: a family member or family friend persuaded the individual to pursue engineering, and that the individual really enjoyed math and science, enjoyed learning new things**,** liked to design and draw, enjoyed building models, was an analytical and logical thinker, understood how things worked, was creative, involved in gifted program, was a high achiever, persistent, tenacious, and ambitious, and liked to solve problems. Despite the fact that there are hundreds of fields of engineering, this small study identified some of the core skills and traits that engineers typically exhibited regardless of the field they choose.

Although engineering content is being introduced in the classroom, the missing piece is the context of who becomes an engineer, or in other words, an understanding of the specific skills and traits that are indicative of talented engineers that need to be nurtured and encouraged in children. This retrospective study piloted an instrument designed to identify common childhood characteristics of talented engineers with a mini-study first conducted to refine the primary instrument. The research question guiding this work was: *What are the common childhood skills, traits, influences, and school experiences of talented engineers?*

Method

Participants

The sample in this study consisted of three groups: engineering students, engineering professors, and practicing and retired engineers. The engineering students and faculty were based at a large STEM-based university. The director in the Undergraduate Engineering Recruitment Office facilitated anonymously identifying the students and professors. The practicing and retired engineers were targeted using several avenues: personal contacts, and degreed engineers identified from internet searches, alumni organizations, and referrals. It was necessary that this third group meet the qualifications of having completed a degree from an engineering program, so choosing this specific portion of the sample was deliberate. The sample total based on emails sent was 7,382 engineering students, engineering professors, and practicing and retired engineers. The breakdown of the three group sizes was 6,379 students, 343 professors, and 660 practicing or retired engineering professionals.

Instrument

This study piloted a new instrument that identified common childhood experiences, influences, skills, and traits of talented engineers. The choice of attributes offered in this new instrument was based on the refinement of the pilot survey. This instrument was an electronic survey that was developed using Qualtrics© survey software. A link to the survey was established by Qualtrics© after the survey development was completed.

The survey was designed into three groups of a total of 14 questions, although these groups should have been transparent to the participant:

- Demographics: the participant was asked three demographic questions regarding location (city, state, and country), gender, and age (fill-in-the-blank); and to provide initials in order to distinguish between duplicate submissions by the same individual from identical submissions by different participants.

- Status/education: the participant was asked a question relative to school and employment status (check-all-that-apply); to identify each major for each degree earned or in-progress (fill-in-the-blank); and, to rank order the favorite four subjects in High School.

- Influences: the participant was asked to identify the people who influenced the decision to pursue engineering (check-all-that-apply); the skills and attributes that may have influenced the decision to pursue engineering (check-all-that-apply); the traits that may have influenced the decision to pursue engineering (check-all-that-apply); the toys/games/items the participant enjoyed playing with that might have inspired engineering study (check-all-that-apply); and the participant was asked to rank in order what and/or who influenced the decision to study engineering.

Several questions had an option for the participants to fill in their own answer just in case the choices provided did not include their preferred answers. The survey was developed in November and December 2007.

Procedures

During the first two weeks of January, messages were emailed to the targeted individuals asking for their participation in the survey. A brief statement was provided explaining that their input identifying their childhood experiences, influences, skills, and traits that drew them to pursue engineering would be helpful in the development and implementation of engineering curriculum in grade school. The Qualtrics© link to the survey was included in the email message that was sent to the participants. Another statement in the email explained that participation in the survey was voluntary, the survey was anonymous, and that the participant had to be 18 years old to participate. A final statement assured the participant that the survey was estimated to take less than 10 minutes to complete.

The Qualtrics© survey did not require any special computer hardware or software. Once the participant clicked on the link provided in the email message received, she was immediately directed to the survey page. The participant had the option to back up and change answers. Once the participant completed and submitted the survey, a final thank you message was displayed.

A count of the emails initiated by this author was tracked. However in the email, the recipients were invited to forward the survey link to their colleagues, so getting an accurate total count was not possible as any survey invitations forwarded by the original participants could not be tracked.

Data was collected in real-time. At any time, this author logged into the Qualtrics© website and viewed and analyzed the results. Qualtrics© provided a substantial offering of data management. The data collected from the survey could be exported into standard statistical analysis software packages. Participants' data could be viewed individually or in groups; data trends could be viewed through a filter; and a variety of graphics options were available.

Results and Discussion

The survey was emailed to 7,382 individuals; however the number of people who were forwarded the survey was unknown. The Qualtrics© software provided the statistical results based on the software's criteria for completed surveys, which totaled 1,008 surveys. Of these, 777 were undergraduate students, 59 faculty, and 172 practicing or retired engineers (see Table 1). Based on the emails this author sent, the group with the largest proportion (26.1%) of respondents was the practicing and retired engineers.

Table 1

Participants by Status

	Emailed	Responded	Proportion
Undergraduate Students	6,379	777	12.2%
Faculty	343	59	17.2%
Practicing/Retired	660	172	26.1%
TOTAL:	7,382	1,008	13.65%

The responses to these questions were ordered by age group because the number of participants varied greatly between the younger group and the four older groups. The younger group represented 75% of the participants so the responses were separated to insure that all the choices of each group would be accurately reported.

The largest age group was the 16 to 23 year old group, represented by 524 males and 235 females. The smallest age group was the over 65 year old group, represented by only 25 respondents and all were male. The middle 3 groups, 24 to 36, 37 to 49, and 50 to 65 years old, were similarly represented by about 20% females and 80% males (see Table 2).

Table 2

Gender Data of Participants by Age Group

	AGE GROUPS					
Count	16 – 23	24 – 36	37 – 49	50 – 65	>65	Totals
Female	235	15	17	11	0	278

GENDER	Male	524	57	68	51	25	725
	Totals	759	72	85	62	25	1,003

Participants could select more than one individual who influenced their decision to pursue engineering (see Table 3). The top nine choices of individuals who influenced the participants' decision were ordered by age group. The primary influencer for all of the age groups was a parent who was not an engineer. The next influencer was the other parent who was not an engineer or the participant decided to pursue engineering without anyone's influence. All age groups listed their science and math teachers but in different positions of influence. Friends or neighbors who were engineers were identified in all age groups, and a relative who was an engineer was identified in four of the five age groups. The participants' guidance counselor was identified as influential in the three higher age groups, but not identified in the lower two age groups' lists of the top nine influencers. Today, Guidance Counselors seem to be focused on the social and emotional needs of their students, and do not have much time to guide their students with career counseling (K.E., personal communication, 2/6/08).

Table 3

Influencers on Individual's Decision to Pursue Engineering

AGE GROUPS				
16 – 23	24 – 36	37 – 49	50 – 65	>65
Mom not Engineer	Dad not Engineer	Dad not Engineer	Dad not Engineer	Dad not Engineer
Dad not Engineer	Mom not Engineer	no influence	no influence	Mom not Engineer
Science Teacher	Science Teacher	Dad Engineer	Guidance Counselor	Other
Dad Engineer	no influence	Mom not Engineer	Friend Engineer	Dad Engineer
no influence	Relative Engineer	Math Teacher	Mom not Engineer	Math Teacher
Math Teacher	Math Teacher	Science Teacher	Relative Engineer	Science Teacher
Relative Engineer	Dad Engineer	Guidance Counselor	Dad Engineer	Friend Engineer
Friend Engineer	Other	Friend Engineer	Math Teacher	Relative Engineer
Technology Teacher	Friend Engineer	Other	Science Teacher	Guidance Counselor

Note. Descending order

This table indicates that parents were the largest influencer on the individual's decision to pursue engineering. Therefore exposing parents to engineering education and career information could have a significant influence on the future pipeline.

In Table 4, the top eight skills and attributes that the participants selected were ordered by age group. There were 26 skills listed on the survey from which to choose. More than one skill and attribute that influenced their decision to pursue engineering could be selected. All five age groups chose being good at math as the primary skill that influenced them. In the lower two and higher two age groups, the next two choices included being good at science. For the middle age group, being good in science was the sixth skill in order of importance. The top four age groups chose analytical reasoning and problem solving in their top eight selections, however the youngest age group picked neither.

Table 4

Skills and Attributes that Influenced Decision to Pursue Engineering

AGE GROUPS				
16 – 23	24 – 36	37 – 49	50 – 65	>65
good at math	good at math	good at math	good at math	good at math
good at science	enjoy math	enjoy problem solving	enjoy science	good at science
enjoy science	good at science	good at analytical reasoning	good at science	think about how things work
like learning new things	good at analytical reasoning	logical thinker	good at problem solving	enjoy problem solving
enjoy math	enjoy problem solving	good at problem solving	enjoy math	enjoy math
think about how things work	good at problem solving	good at science	good at analytical reasoning	enjoy science
logical thinker	enjoy science	think about how things work	enjoy making/ building things	good at analytical reasoning
enjoy challenge	like learning new things	enjoy science	enjoy problem solving	like learning new things

Note. Descending order

As the National Academy of Engineering indicated, the need for strong analytical skills is one of the key attributes to the success of the Engineer of 2020[19]. Life-long learning was a key attribute listed by the National Academy of Engineering[19], Boeing Company[7], and ABET[2].

The most important traits that influenced the participants' decision to pursue engineering were detailed by age group in Table 5. There were 25 traits listed on the survey from which to choose. The participants could check more than one trait. Each age group selected, but ordered differently, the same nine traits out of their top twelve traits:

-interested in a lot of things -need for logic -focused

-need for accuracy -ambitious -honest
-task-oriented -independent -persistent

Table 5

Top Traits that Influenced Decision to Pursue Engineering

AGE GROUPS				
16 – 23	24 – 36	37 – 49	50 – 65	>65
interested in a lot of things	interested in a lot of things	need for logic	task-oriented	self-directed
need for logic	task-oriented	persistent	focused	task-oriented
focused	need for logic	focused	persistent	focused
persistent	persistent	self-directed	self-directed	independent
ambitious	ambitious	task-oriented	honest	persistent
honest	focused	interested in a lot of things	interested in a lot of things	honest
task-oriented	need for accuracy	independent	need for logic	ambitious
independent	perfectionistic	need for accuracy	ambitious	interested in a lot of things
sense of humor	honest	ambitious	independent	need for accuracy
need for accuracy	independent	honest	ethically-oriented	ethically-oriented
perfectionistic	keen observer	keen observer	need for accuracy	good self concept
keen observer	sense of humor	perfectionistic	sense of humor	need for logic

Note. Descending order

The majority of the attributes listed by the National Academy of Engineering, Boeing Company, and ABET are skill-based, so a study further identifying traits may be key in understanding the complete make-up of a talented engineer.

Conclusion

The responses from this survey provided both a fuller picture of the characteristics of talented engineering students, academic engineers, and practicing engineers, and a clearer understanding of the individuals who influenced the participants in their various stages of pursuing engineering. Since these participants represented a span in time from the 1950s to today, many witnessed the exploration, attempts, and advancements in every field of engineering that took place during the 20th century. These life experiences may have influenced their responses. This was evident in the participants' choices of popular toys and games which seemed representative of the technology at the time.

The National Academy of Engineering, Boeing Company, and ABET stated that thinking skills, analytical skills, and problem solving skills were key for engineers. They explain that these skills were used in every step of the design process, so it was imperative that engineers developed and honed these skills. These three organizations also stated that having a desire for lifelong learning was an important attribute for engineers. This data was substantiated in the results of this survey. Society's needs change frequently and technology advances rapidly; both drive an engineer to adapt to constant learning. The participants' responses were similar to the needed attributes listed by the National Academy of Engineering, Boeing Company, and ABET.

There are certain traits that engineers exhibit during the various steps of the design process used to solve problems and invent solutions. These traits are inherent in the engineer's personality, ingrained in their thinking, part of their core. All five groups of engineers chose the same top nine traits, although in different orders, because these traits are essential to those in the profession.

The results of the qualitative research study that WGBH conducted indicated that the priority order of influence was parents, friend and peers, teachers and siblings, school counselors and professionals. In this study, parents were unanimously the primary influencer, but the surprising high-ranked response was the participant, who stated that the decision was made without anyone's influence. Follow-up studies with the participants could help clarify the circumstances behind this unilateral decision to pursue engineering. With the guidance counselor absent in the choices of the younger-aged groups, follow-up studies could investigate if the issue also included that guidance counselors are unfamiliar with the engineering field.

Engineering concepts are beginning to be incorporated in some schools' curriculum; however it is clearly missing in most. As teachers become more familiar and comfortable with the concepts of engineering, follow-up studies could assess teachers' willingness to raise engineering awareness in their classroom. Based on the results of this survey, engineering content and concepts and associated engineering skills and traits should be integrated into the curriculum. In order to create interest in students to pursue engineering study, it would be beneficial to bring this same awareness and education to the students' influencers identified in this survey: parents, teachers, and guidance counselors. Integrating engineering into the mindset of children and adults may help bring this country back into the position of technological focus, advancement, and leadership.

The opportunities in engineering are growing at the same rate as the exploding technological advancements. Most children with STEM-based strengths have interests or passions that can be discovered and realized with exposure to the different fields of engineering. Any student who dreams of being an engineer can fulfill her goals; those in the field of engineering don't want to leave any child with these kinds of dreams behind.

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