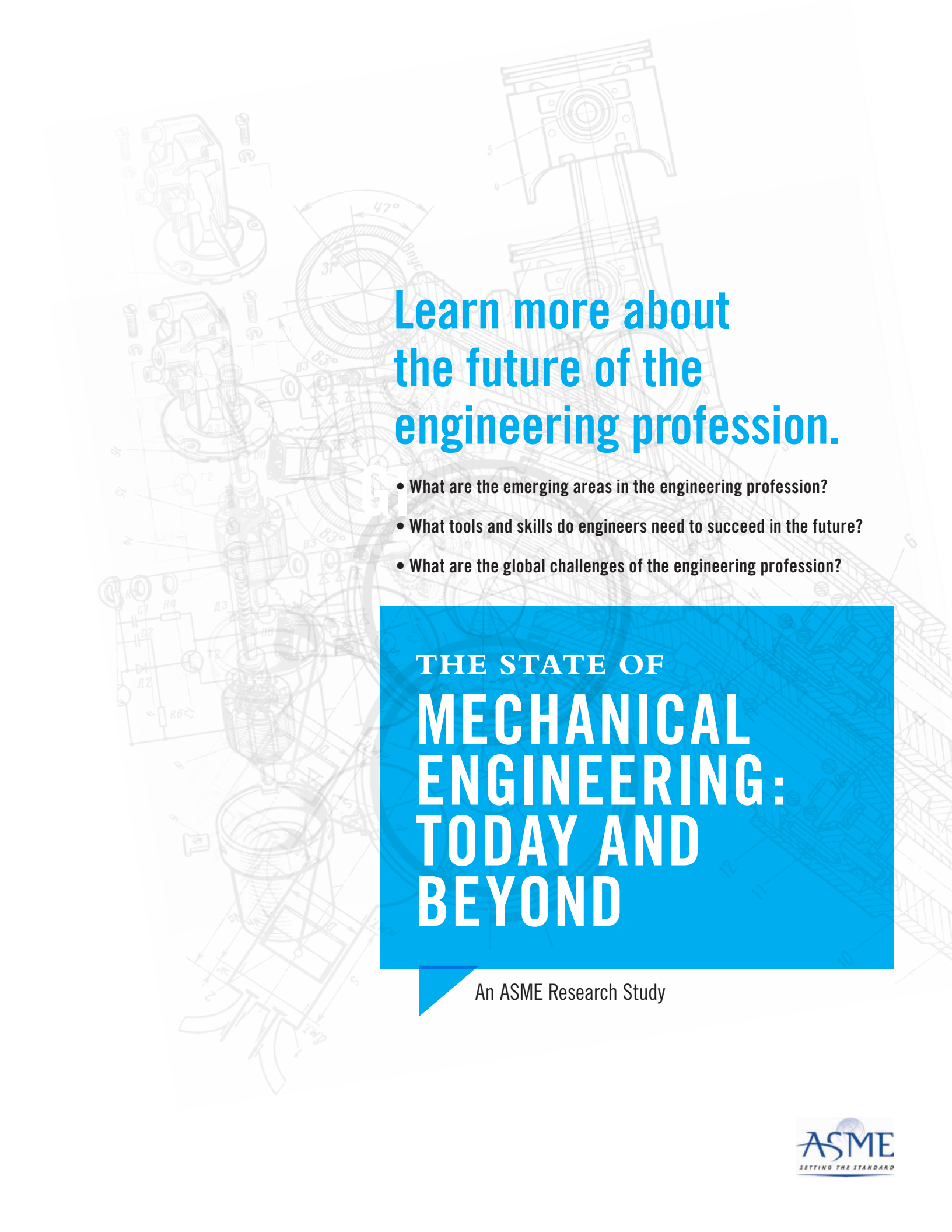


Learn more about the future of the engineering profession.

- What are the emerging areas in the engineering profession?
- What tools and skills do engineers need to succeed in the future?
- What are the global challenges of the engineering profession?

THE STATE OF MECHANICAL ENGINEERING: TODAY AND BEYOND

An ASME Research Study

ASME
SETTING THE STANDARD

ASME

ASME helps the global engineering community develop solutions to real-world challenges. Founded in 1880 as the American Society of Mechanical Engineers, ASME is a not-for-profit professional organization that enables collaboration, knowledge sharing, and skill development across all engineering disciplines while promoting the vital role of the engineer in society. ASME codes and standards, publications, conferences, continuing education, and professional development programs provide a foundation for advancing technical knowledge and a safer world. For more information, visit **www.asme.org.**

EXECUTIVE SUMMARY

ASME conducted a survey of engineers in June 2011 to learn about the current state of the engineering profession and the changes anticipated over the next 10 to 20 years. The survey addressed the following areas:

- Level of optimism toward the profession
- Changes they anticipate in the work environment
- Significant achievements they believe the engineering field could provide to meet global challenges
- Fields and disciplines most likely to gain prominence
- Tools and techniques that are becoming more important and to what degree engineers know about working with them
- Professional and personal skills likely to become increasingly fundamental to professional success

CONSIDER THE CONTEXT AT THE TIME OF THE SURVEY:

Consider the context at the time of the survey one year ago: Significant downsizing in aerospace, the final shuttle flight and the space program reorganizing, the U.S. had not yet begun the debt-ceiling debate, and the Fukushima Daiichi nuclear power plant had recently released radioactive material in Japan. The global economic and employment picture was still grim and though mechanical engineering was not as hard hit as other professions, unemployment was a major concern among engineers.

Significant results are highlighted below:

Moderate to significant levels of optimism exist about the ability of mechanical engineers to meet global challenges in the next 10 to 20 years.

An increasing number of engineers are predicted to have interdisciplinary training, working more frequently on interdisciplinary teams with both engineering and non-engineering professionals.

Future cutting-edge fields:

- Alternative energy
- Bioengineering/biomedical
- Computers
- Electronics
- Energy
- Nanotechnology
- Water

Top areas identified for increased knowledge enhancement:

- Nanotechnology
- Renewable energy
- Solar/wind

Most cutting-edge tools and techniques for the future:

- Motion simulation
- Animation/virtual prototype

Increasingly desirable skills:

- Multilingual capability
- Global team management

INTRODUCTION AND METHODOLOGY

As with most professions, the broadest factors driving significant change in the engineering profession are a mix of socioeconomic and political turbulence, together with the "shrinking world" of the global business environment. Rapid advancements in technology within the field, combined with increasing global connectivity, mean that a decade in modern times can be compared to a lifetime from ages past.

To understand the current state of the field and, more importantly, to better anticipate what might occur in mechanical engineering over the next decade, there is no better barometer than the views of those currently practicing in the engineering profession.

To that end, ASME conducted an online survey in June 2011. Invitations were sent to approximately 30,000 individuals, including ASME members and non-members with a minimum of two years of experience in mechanical engineering-related positions. The survey took approximately 15 minutes to complete and 1,222 engineers participated.

The experience level of respondents spanned the range of seniority, with 330 "early-career" engineers (two to 10 years of experience), 292 "mid-career" engineers (10 to 20 years of experience), and 539 "senior" engineers (20-plus years of experience). Note that not all respondents provided answers to the question regarding level of experience.

Nearly 60 percent of respondents—726—were in non-supervisory positions, with 496 having supervised other engineers.

Industry groups with substantial participant representation included energy, manufacturing, aerospace, and academia.

The survey asked participants to rate everything from the current levels of optimism around the field to their opinions of the hottest areas in mechanical engineering, along with the personal and professional skills they think are needed to succeed now and in the future. In compiling the results of this survey, the ASME sought to provide an accurate picture of the current attitudes of today's engineers as well as their expectations on the future of the engineering profession.

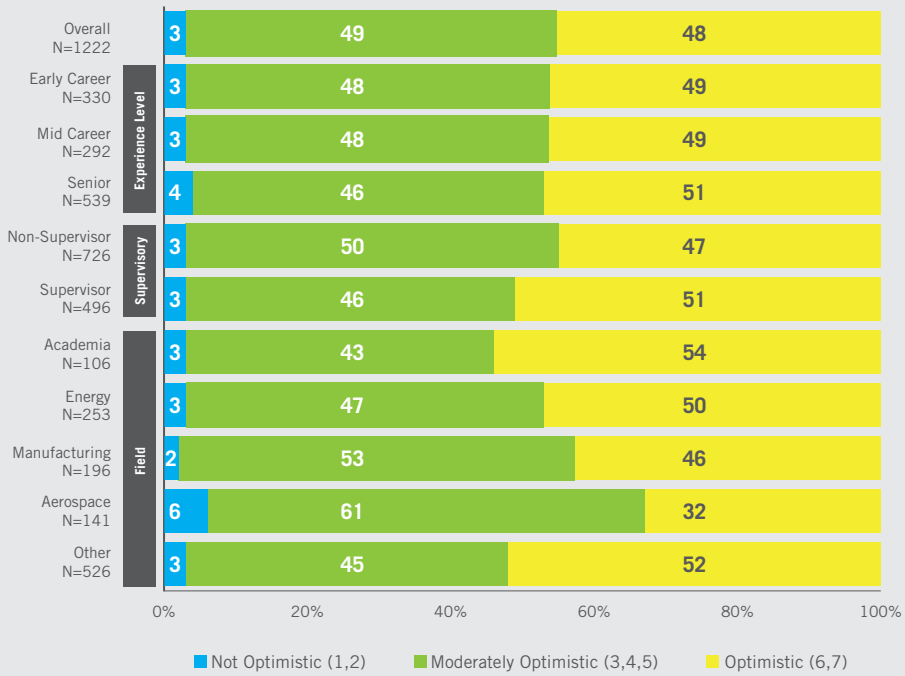
OVERALL ENGINEER OPTIMISM

Engineers were asked if, given the current state of the world economy and the present levels of investment in research and development, they were optimistic about the ability of the engineering profession to meet global challenges over the next 10 to 20 years. A seven-point scale was used in which a 7 indicated "optimistic" and a 1 represented "not optimistic."

With a majority of respondents choosing either "optimistic" or "moderately optimistic," we can conclude that most engineers believe their profession can provide significant achievements to meet global challenges. About half of the respondents were optimistic (responses of 6 or 7), with roughly an equal number moderately optimistic (3-5), and a very few (just 3 percent) not optimistic.

This degree of optimism is shared equally at all career and supervisory levels. However, it is not equally shared among those employed across all industries. Engineers in the aerospace industry, for example, are considerably less optimistic than those in other areas, with only 34 percent in this field reporting that they are very optimistic and 6 percent indicating not optimistic. Given the timing of the survey relative to the winding down of the space shuttle program and the resultant downsizing in the aerospace industry, this type of response was not unexpected.

Overall Optimism for the Future of the Engineering Profession



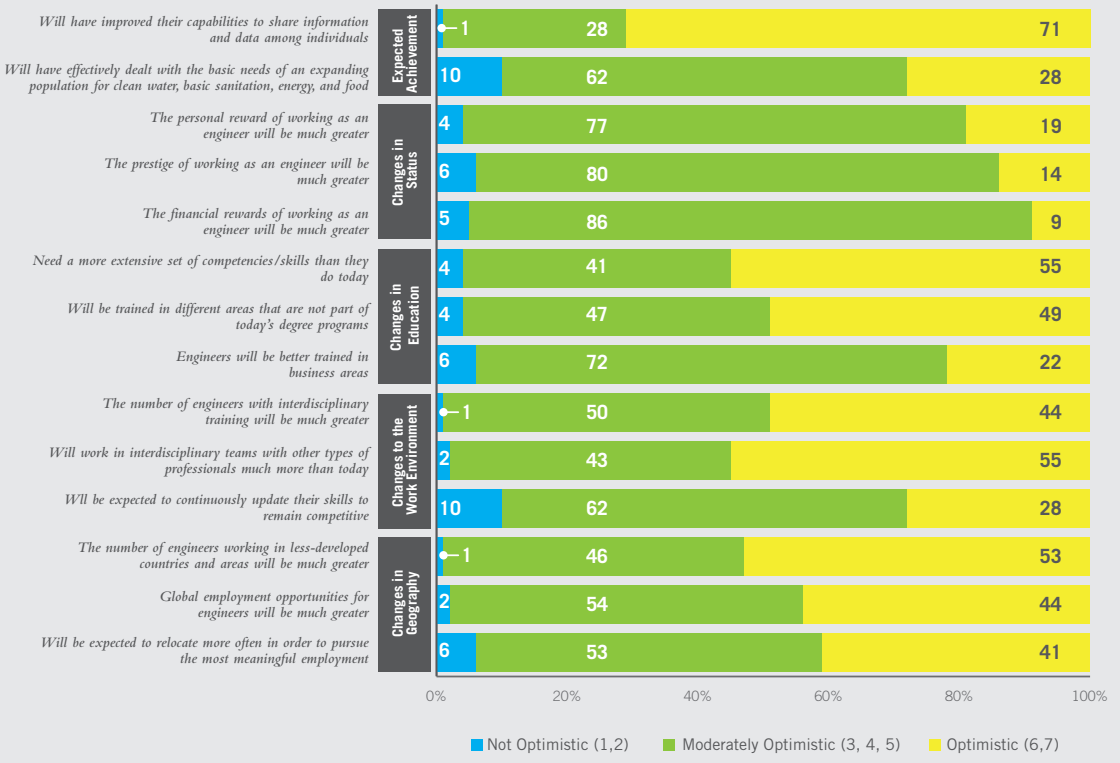
FUTURE VIEW OF ENGINEERING

Using a seven-point scale where a 7 indicates "optimistic" to 1 representing "not optimistic," respondents were asked to provide their expectations on major accomplishments, and anticipated changes to the work environment, globalization, professional status, and engineering education.

Over the next one to two decades, engineers strongly believe that they will improve the capabilities to share information and data among individuals. However, they are considerably less certain about how they will effectively deal with meeting the basic needs of an expanding world population for clean water, sanitation, energy, and food.

Respondents also expect that an increased number of engineers will have interdisciplinary training and will be working on interdisciplinary teams with members from outside the engineering profession. This will require engineers to continually update their interdisciplinary skills to remain competitive.

Future View of Engineering



While there is a belief that overall global opportunities will increase along with the number of engineers working in developing countries, survey respondents for the most part do not expect they will need to relocate in order to pursue the most meaningful opportunities. This finding reflects the belief that the growth of locally trained mechanical engineering talent is predicted to provide the needed expertise.

In terms of "prestige" and compensation, respondents expect that the esteem in which engineers are held and the professional and personal rewards of being an engineer will change little over the next 10 to 20 years.

Regarding education and training, respondents predict that engineers will require additional competencies and skills. They will also need to be trained in areas outside of current degree programs. Overall, they foresee the need for training in general business competencies to be much the same as it is today.

"Business and engineering will continue to merge."

"Engineering will become more global with the lack of face-to-face interaction."

"All of the basic engineer types, i.e., mechanical, electrical, civil, and chemical, need more training in other areas of engineering. For example, a mechanical engineering student needs to minor in chemical or electrical or civil engineering. A chemical engineering student needs to minor in electrical or mechanical or civil engineering."

"There is a need for engineers to acquire a more thorough knowledge of the business world, and not just the technical side of the societal development of a country or the world's infrastructure."

"I think engineering will become more collaborative both within multiple disciplines and with other fields."

CUTTING-EDGE FIELDS

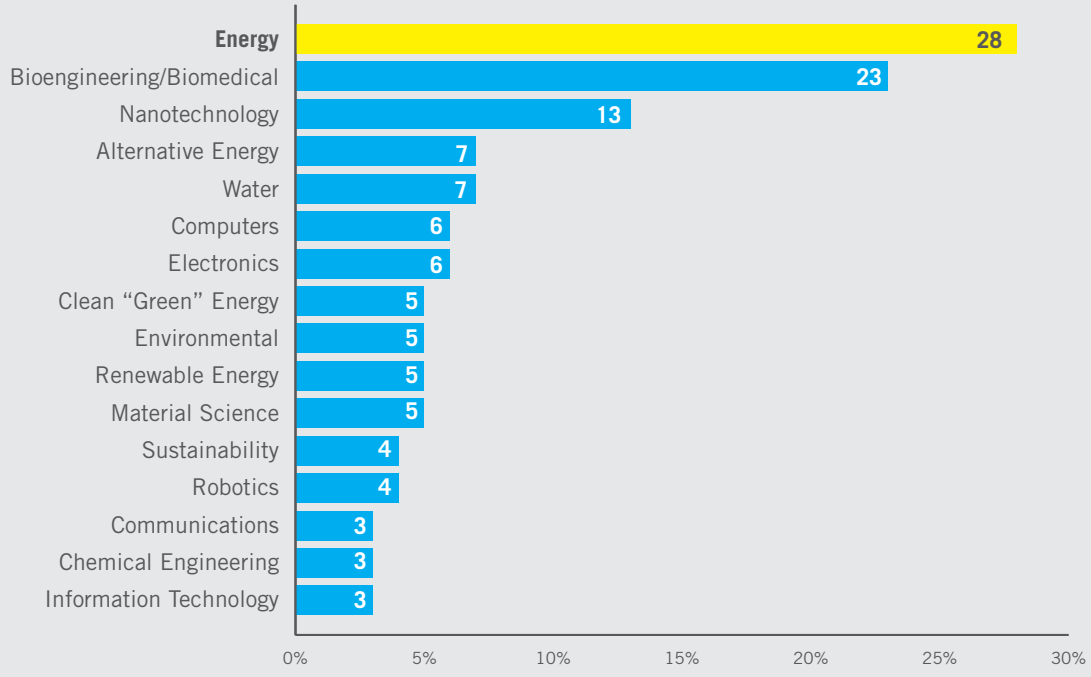
Engineers were asked an open-ended question on which disciplines or topics in engineering they thought would be considered the most cutting edge in the next 10 to 20 years.

"Energy" and responses on energy-related topics such as sustainability, renewable energy, and clean/green energy, when aggregated, were most frequently cited as the most cutting-edge disciplines or fields for engineering over the next 10 to 20 years.

Other oft-cited cutting-edge disciplines included bioengineering/biomedical, nanotechnology, alternative energy, water, computers, and electronics.

These responses were entirely consistent with other responses and data from the survey that probed the respondent's outlook for different disciplines and topics in mechanical engineering over the next 10 to 20 years.

Most Cutting-Edge Fields



"We'll need to be dealing with the population growth and balancing resources to meet the needs of the world."

"The future? Continued development of electronic communications media, alternative energy sources for vehicles and electric power generation, dealing with limited resources for a growing global population, and the global nature of business today."

"Sustainability must be integrated into daily design activities."

"Bioengineering and medical advances in hardware will help the handicapped walk and prolong a higher quality of life for the elderly."

"New ways to support the growing energy needs of the world's population will need to be developed. Though this won't be necessary to maintain our current way of life during the next 10 to 20 years, the areas researched/developed in the next 10 to 20 years will be crucial in meeting our energy demands in the next 30 to 40 years."

"Engineers will always be in demand in energy disciplines."

OUTLOOK FOR GENERAL FIELDS IN ENGINEERING

To help identify specific engineering disciplines and topics that are expected to become more prominent in the coming decades, respondents were asked to classify each into one of three categories: fading (days are numbered), enduring (has been and will continue to be around for a long time), or emerging (will be seeing more of this in the future).

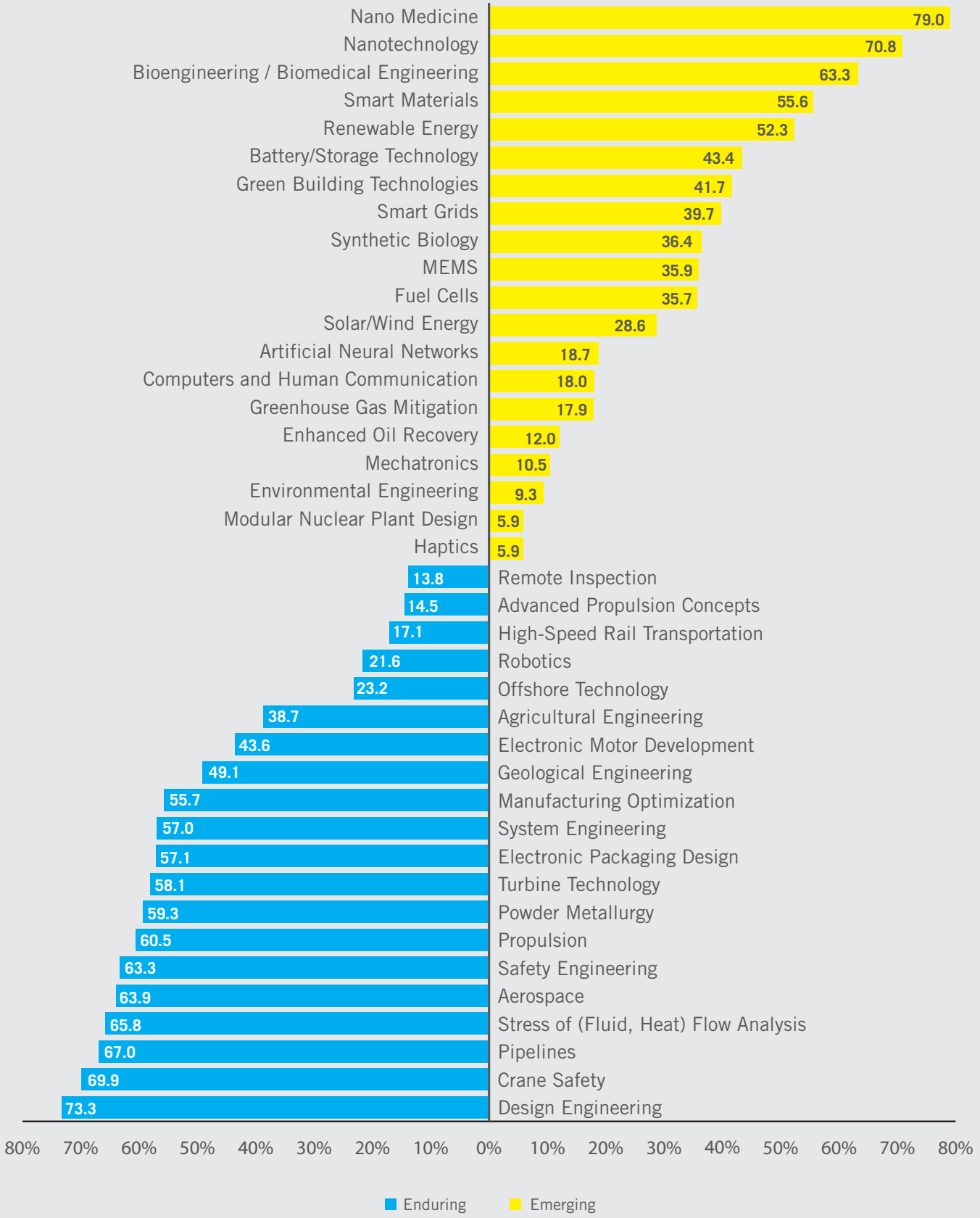
The first significant finding is that none of the disciplines and topics had "fading" scores above 24 percent. In fact, all of the fields had at least some responses in the "emerging" category. Consequently, the question became simply which fields were considered to be enduring and which were seen as emerging.

Topping the list of fields that respondents thought would enjoy the greatest attention in the future were nano medicine and nanotechnology. For the complete list in rank order, see the Emerging and Enduring Fields chart.

One interesting note is how the specific responses of this part of the research were, to a large degree, consistent with the survey's earlier open-ended questions.

Emerging and Enduring Fields

Note: This chart shows the difference between the "emerging" and "enduring" responses for each field.



AREAS IDENTIFIED FOR ADDITIONAL TRAINING

From the areas that they considered "emerging," engineers were asked to identify the ones in which they would like to acquire additional training or knowledge.

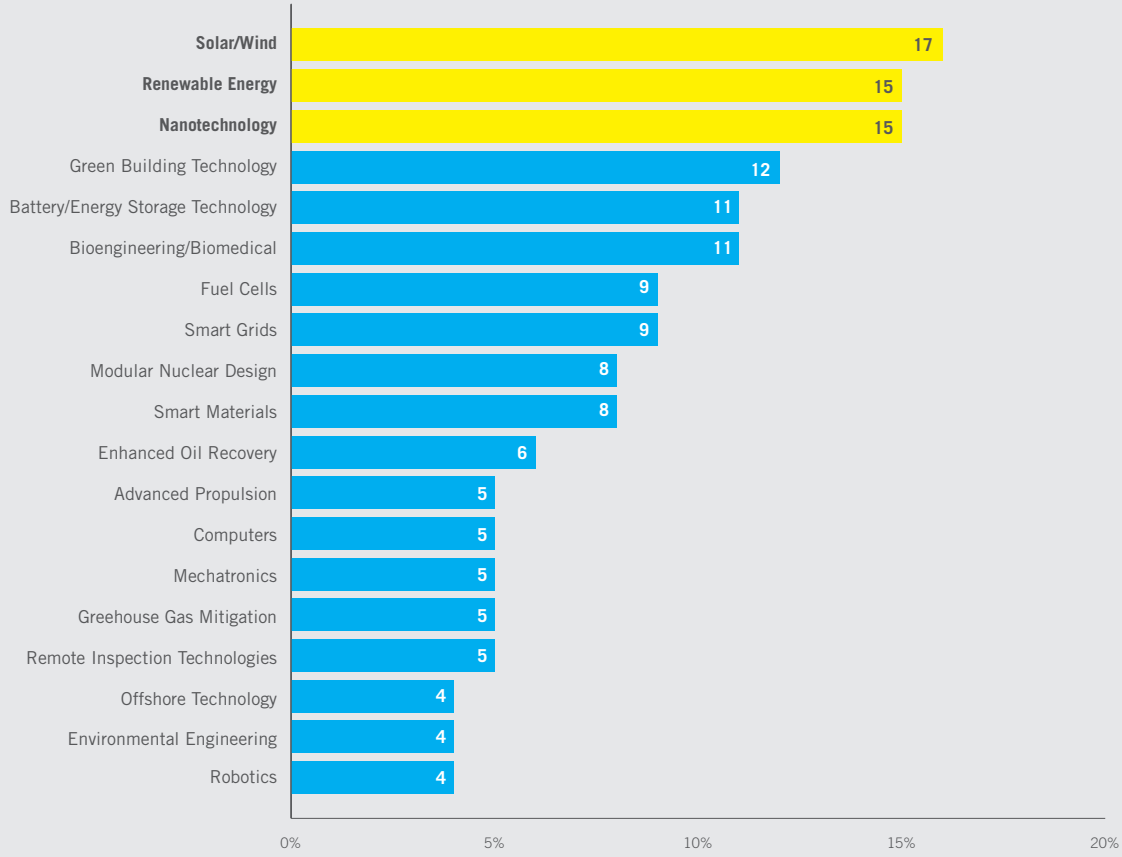
They cited solar/wind, renewable energy, and nanotechnology as the top three areas for acquiring expertise or knowledge.

"There's miniaturization of batteries and other energy storage devices. Or low-impact refurbishment of deteriorating infrastructure, like roads, waterways, the electrical grid."

Another significant finding in this area is that other industries related to broader energy and environmental subjects are also ranked highly. These industries include green building technology, battery/energy storage technology, fuel cells, smart grids, modular nuclear design, and greenhouse gas mitigation. Clearly the respondents recognize the role engineering is predicted to play in meeting the rising energy and environmental challenges that are expected in the coming decades.

"Engineers will always be in demand in energy disciplines. It does not matter whether fossil fuel is still being used."

Emerging Disciplines Identified for Additional Training



MEANS OF ACQUIRING KNOWLEDGE

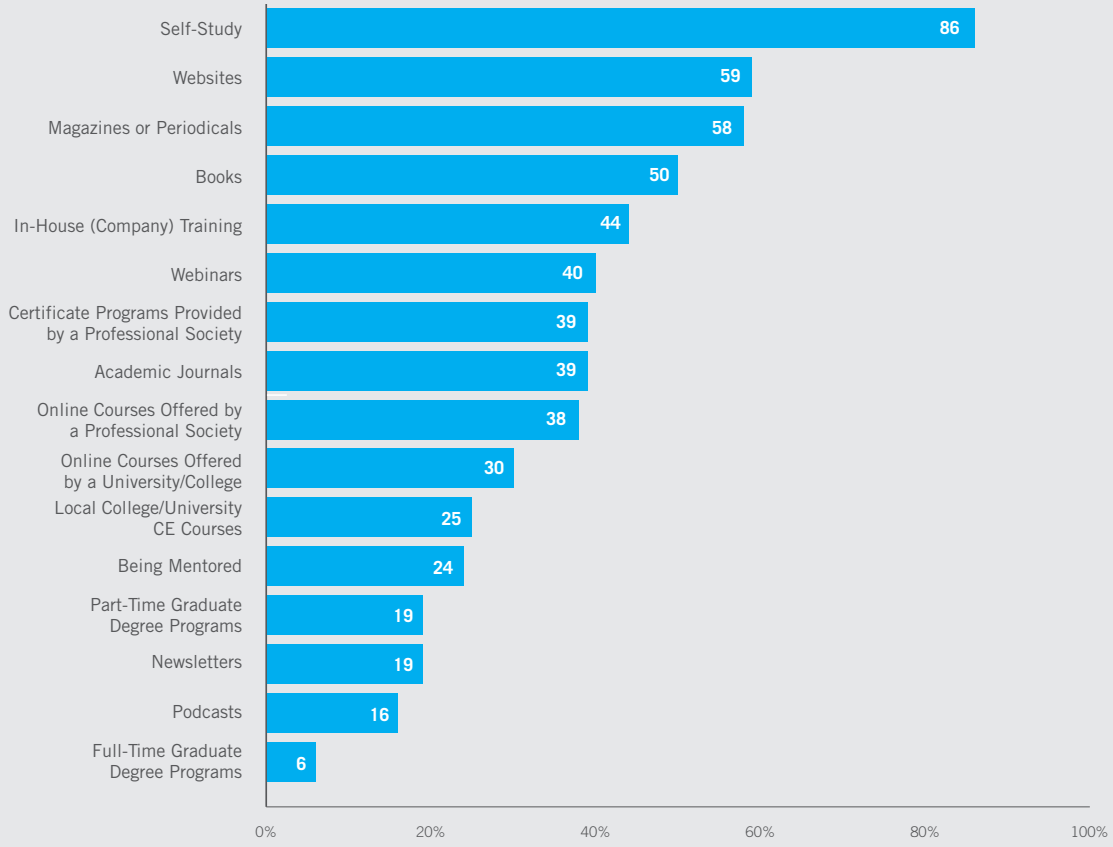
When asked how they would acquire the additional knowledge or expertise needed to address future challenges, almost all engineers said they would employ self-study.

Engineers cite websites, magazines and periodicals, and books as likely sources of knowledge.

Of note, early-career engineers prefer traditional face-to-face instruction for acquiring knowledge such as in-house training, mentoring, and part-time graduate degree programs. More experienced engineers, on the other hand, are more comfortable relying on magazines, books, and online courses.

Means of Acquiring Knowledge

Note: Multiple responses allowed



TOOLS AND TECHNIQUES – FUTURE VIEW

Survey respondents were presented with a list of engineering tools and techniques and asked to categorize them as fading, enduring, or emerging.

Much as with the responses in the prior "Outlook for General Fields in Engineering" section, few engineers were willing to categorize any of the tools and techniques as fading. This finding suggests that, in the opinion of the modern engineer, the current skill sets remain robust and relevant to meeting today's needs, and that those skills are expected to continue to serve them well in the future.

In citing more specific areas of expertise, respondents consider emerging techniques such as motion simulation, animation, and virtual prototype creation to be the most cutting-edge techniques and skill sets. The fact that they categorize them as "emerging" nearly as often as "enduring" indicates that the survey respondents think these techniques are likely to continue to play a strong role in the future of engineering.

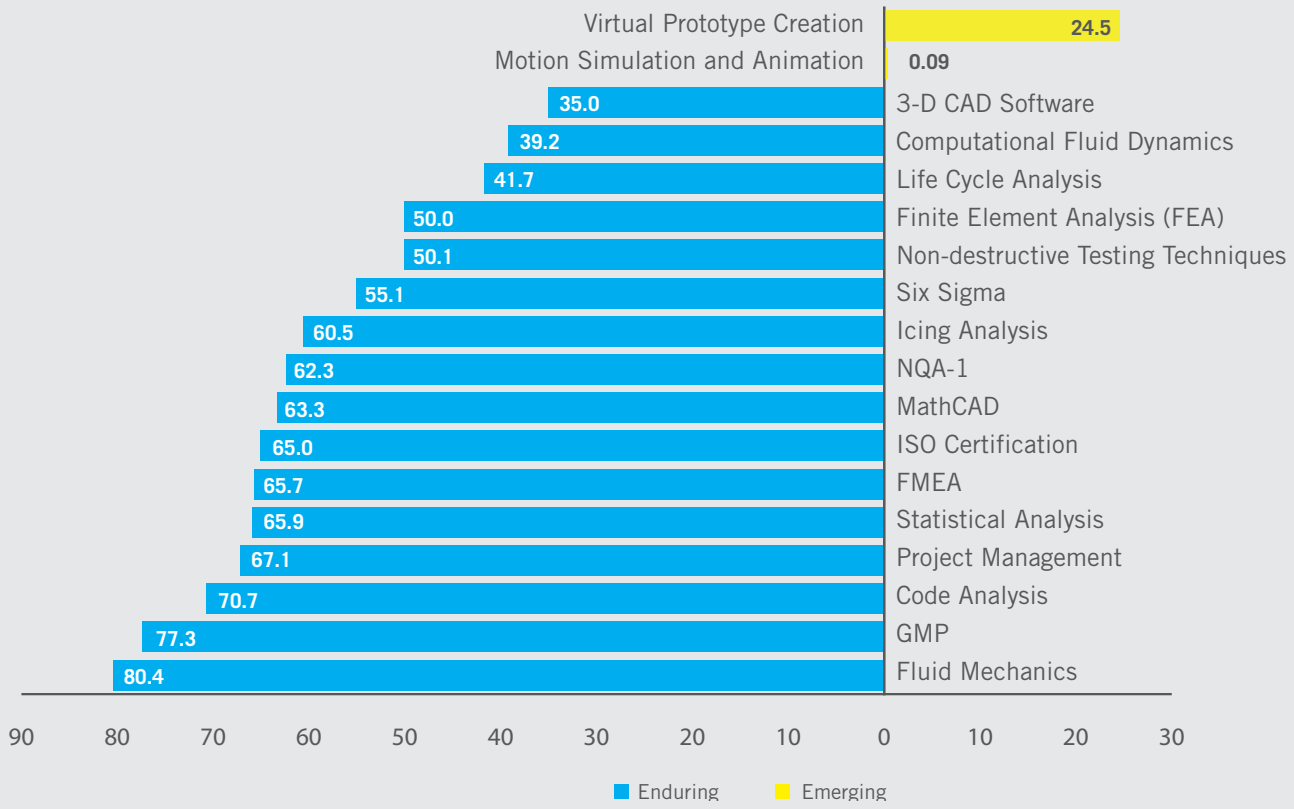
Foundational tools and techniques such as 3-D CAD, computational fluid dynamics, finite element analysis, life cycle analysis, and project management were all identified as growth areas.

In addition, a large percentage of engineers classify Six Sigma, MathCAD, ISO certification, and NQA-1 as "enduring."

"Engineers will still need a strong background in fundamental engineering science and engineering design. Communication skills (oral, written, and multimedia) will be very important. Software analysis tools will be prevalent; however, engineers will still need to develop models and interpret results."

Emerging and Enduring Tools and Techniques

Note: This chart shows the difference between the "emerging" and "enduring" responses for each tool/technique.



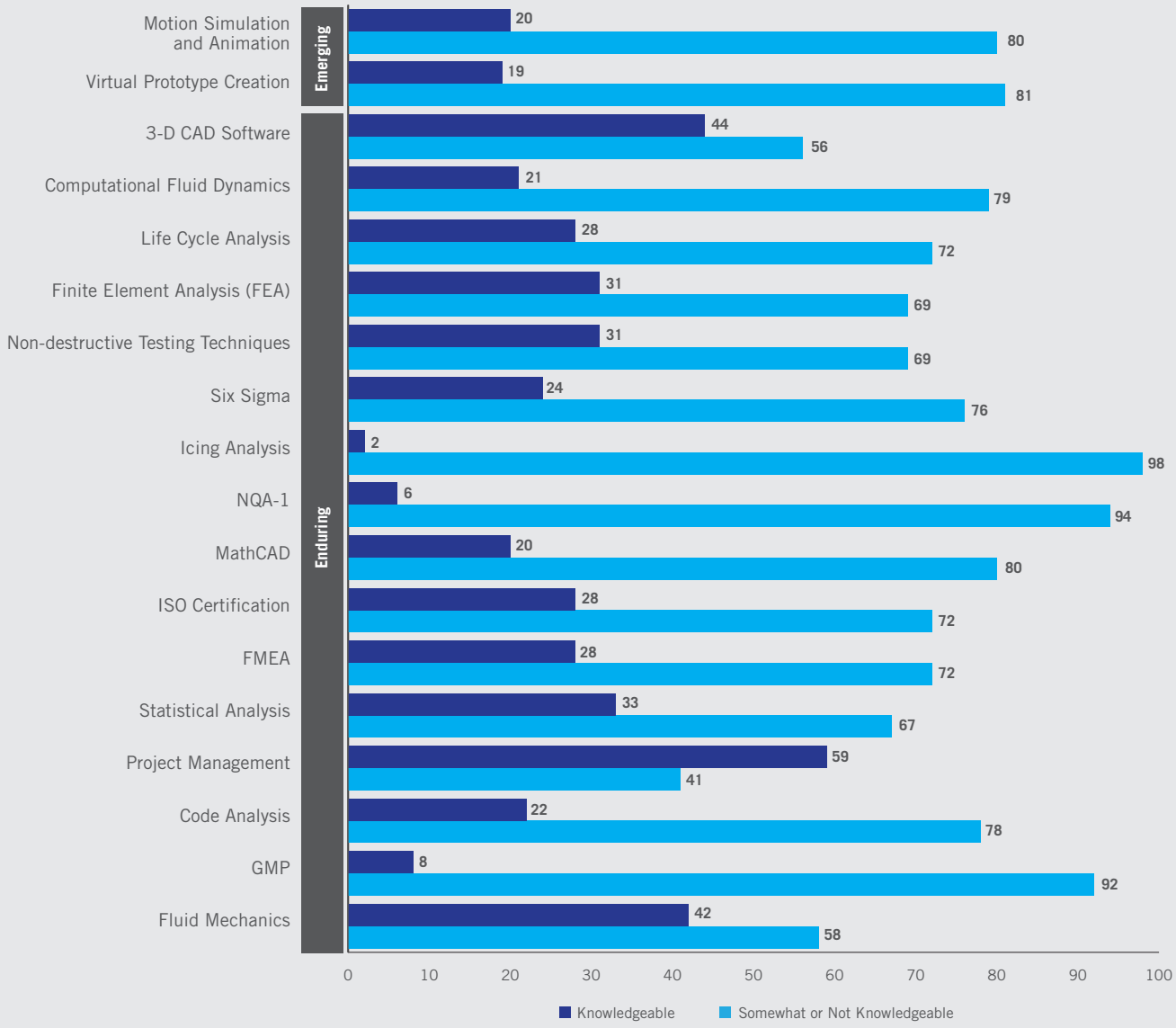
TOOLS AND TECHNIQUES – KNOWLEDGE LEVEL

Respondents were asked to rate themselves as either “knowledgeable,” “somewhat knowledgeable,” or “not knowledgeable” in regard to a variety of tools and techniques. Among the tools and techniques that had previously been identified as “emerging,” a large percentage of respondents indicate lack of knowledge.

There are a number of other tools and techniques where engineers believe their knowledge is somewhat limited. GMP, code analysis, MathCAD, NQA-1, icing analysis, and Six Sigma are tools and techniques where three quarters or more of the engineers in the study say they are currently either “somewhat” or “not knowledgeable.”

Many of the tools identified as most emerging by respondents are software based. Taking this into consideration, innovative approaches to training will be necessary going forward by having the tool developers more closely partner with training providers.

Tools and Techniques - Knowledge Level



SKILLS AND TECHNOLOGIES OVER THE NEXT 10 TO 20 YEARS

In response to an open-ended question, participants were asked to provide the "Most Needed Skills" for engineers to succeed.

At the top of the list of the skills and techniques are communications skills and computer/software skills, with one in five choosing communications and/or programming/software as the skills most needed in the future.

In breaking out the numbers, it shows that early-career engineers are inclined to place greater importance on computer programming/software skills, whereas senior engineers give greater weight to communication proficiencies.

Multidisciplinary skills also rank highly, with one in seven engineers identifying it as important for the future. Business competency is another skill area that is considered important.

The survey also reveals that basic engineering disciplines will continue to be indispensable. Abilities such as multilingual and multicultural skills will be essential in the anticipated increasingly global work environment. More experienced engineers additionally see a need for financial skills to equip them to handle budgetary responsibilities as they lead teams and projects.

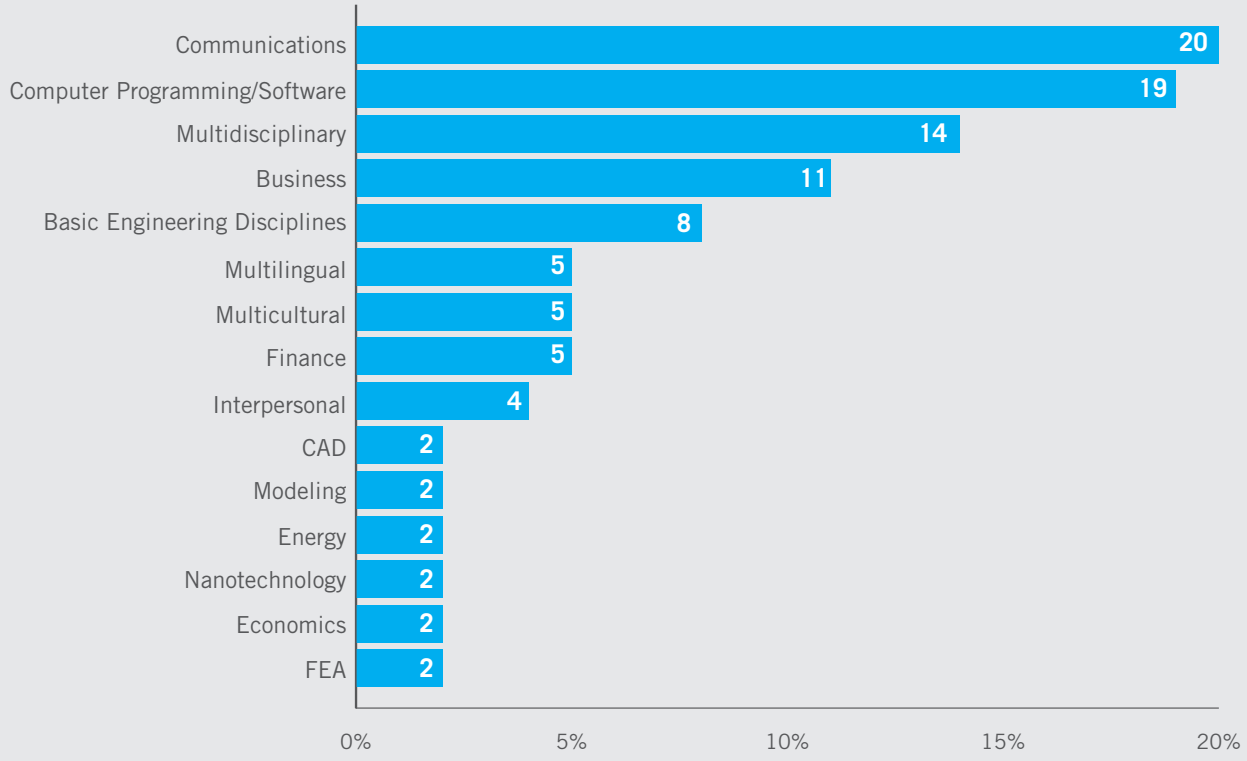
"Engineers will need to have the skills to communicate their designs through all types of electronic and data communication. The engineering world is becoming more electronic and digital every day."

"Interdisciplinary science and engineering is an example where engineering will meet chemistry, physics and biology to solve important challenges."

"Engineers will need to have a more cross-functional approach and group different areas of science/engineering/nature to have a more inclusive focus."

Most Needed Skills in the Future

Note: Multiple responses allowed



PROFESSIONAL SKILLS

The next set of questions provides a better understanding of the professional skill sets required today for success in mechanical engineering and to understand how they might change going forward.

In this case, engineers were asked to rank a set of professional skills as being either "Crucial," "Necessary," "Desirable," or "Barely Needed," both for today and for 10 to 20 years in the future.

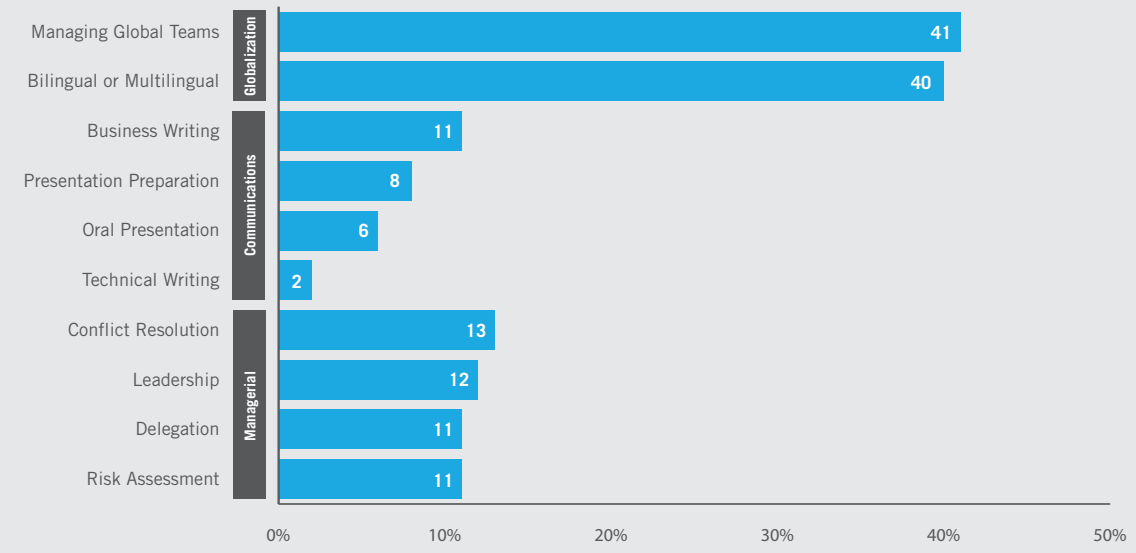
When considering the professional skills needed for the future, skills related to globalization, borderless markets, and economics, such as bilingual/multilingual proficiency and managing global teams, all rose by a large margin. This indicates a strong belief among respondents that these market trends will continue at a rapid pace or possibly accelerate, requiring engineers of the future to focus on developing what they see as crucial global relations skills in order to keep pace.

Communication skills such as business writing, technical writing, oral presentation, and presentation preparation are also considered important to engineers. The fact that all respondents indicated them as being "crucial" for future success demonstrates their belief in the critical nature of these skills.

And while different managerial skills, including conflict resolution, leadership, delegation, and risk assessment, rank lower for the present day than the communications skills mentioned above, they all saw similar increases, with at least a 7 percent jump in "crucial" responses for the future.

Most Needed Skills in the Future

Percent difference from today to future



"The obvious [need] will be computer skills. Next will be language. It is a global economy and multilingual skills will be mandatory. Thirdly will be political skills. We understand technology and need to help governing bodies make smart decisions."

"Globalization will require ability to manage team members in diverse locations and maintain quality."

"Engineers must be able to integrate whatever widget they are designing into fulfilling a business and policy model. Without that integration, design occurs in the dark and it is hit or miss if a product succeeds. To be successful, a need must be fulfilled. The challenge for today's engineers is to reach outside of their comfort zone to understand related issues."

"Engineering will become more global and teams of engineers around the world will be working on a single project."

"Communication, understanding of, and appreciation for other cultures, biotechnology, computational analysis, original thinking."

PERSONAL SKILLS

"Engineers will need more business and interpersonal skills."

In addition to professional skills, engineers in the survey were also asked to rate a series of personal skills as being either "Crucial," "Necessary," "Desirable," or "Barely Needed" for today and in the next 10 to 20 years.

The most crucial skills for engineers today, ranked in order of importance, are as follows:

- Ability to deal with the unexpected
- Collaborative
- Cost conscious
- Creative
- Flexible
- Open-minded
- Persistent
- Socially responsible

Over the next 10 to 20 years, respondents see the need to further develop all personal skills. The personal skills cited as being most important going forward, in order of importance, are as follows:

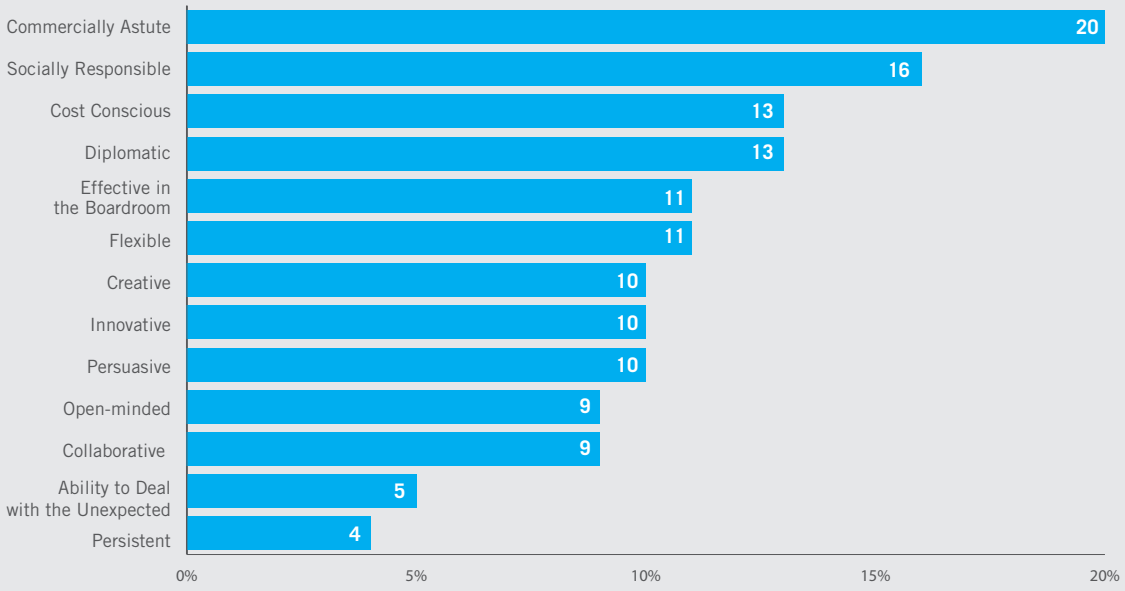
- Commercially astute
- Socially responsible
- Cost conscious
- Diplomatic
- Effective in the boardroom

"Engineers will need to see into the future. They will have to know what will happen to the world, if their project is completed. Will the project be good for the environment, will it offend anyone, and will I offend anyone? Engineers will have to show no bias toward anyone, but show emotion when needed. Engineers will have to design new things"

The results indicate that, among other results, engineers look forward to a greater leadership role in bringing socially responsible, commercially successful projects and products to market.

Most Needed Skills in the Future

Data shown equals Percent Crucial + Necessary in 10-20 years minus Percent Crucial + Necessary today



CONCLUSIONS

Overall, engineers have an upbeat view of the future for their profession.

One of the most significant needs in the future will be the sharing of data and other information among individuals.

Engineers are less certain that their skills are going to be adequate to provide sufficient clean water, sanitation, energy, and food for the world's growing population.

Globalization is predicted to have a significant impact on the mechanical engineering field.

Engineers foresee the need to increase their ability to communicate effectively as well as to increase language skills and manage global teams.

Looking ahead, survey respondents expect engineering to evolve in several ways:

- Becoming more interdisciplinary with the lines between traditional engineering disciplines fading or disappearing entirely.
- Increasingly requiring working with other types of professionals, necessitating improvement to their skill set.
- Even if they don't anticipate being the actual "boots on the ground" in remote areas, engineers expect to work more with people from different regions and cultures, including both developed and developing countries.

Engineers recognize the necessity of acquiring business skills, to become more commercially astute and to be more effective in the corporate boardroom, though they are uncertain if and how this can be integrated into their training.

Today's engineers want tools for better communication at all levels—with coworkers who might be close by, with colleagues far away, with other types of professionals, and with non-engineers making business decisions.

Engineers recognize that computers and software are going to play an increasingly important role in their profession. In addition, training to use emerging tools and technologies is likely to require collaboration between software vendors and training providers.

There is agreement that energy, bioengineering, nanotechnology, and topics relating to the environment are the emerging and expanding areas over the next 10 to 20 years. Engineers are therefore interested in seeking training and information in these areas. Much of the training would be self-study, but online resources would comprise a significant amount of the training and course-based training online, with in-person training playing an important role.