The Recognition of and Increasing Value of Professional Engineering Skills

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Abstract

Studies by EAC/ABET have identified skill gaps engineers and engineering technologists lack upon graduation. Some of the skills identified were project management, teamwork, engineering economics, organizational behavior, decision-making, and communications. Hundreds of ASEE conference attendees, in 2003, listened to keynote speaker, Shirley Jackson, discuss the increased importance of “soft skill” education for engineers today. Dr. Jackson, president of Rensselaer Polytechnic Institute, stressed the importance of leadership education for engineers and engineering technologists. A few of the many “soft skills” in which Dr. Jackson focused was leadership, ethics, teamwork, integrity, appreciation of diversity, the value of cooperation and respect for others, and the ability to gain a wider and broader perspective. Norman Augustine, in 1994, coined the term, “Socioengineering” to describe the combination of the contextual and process skills with the elements of traditional engineering education needed for the twenty-first century. This paper will focus on ABET Accreditation and how it has expanded in recognizing “socioengineering” by including soft skills, or professional skills, in the quality assurance of engineering higher education. It is when we all recognize the changes needed, prepare for the future, and become systems thinkers that we will meet our goals of preparing well-rounded engineering graduates for the workplace. ABET recognized the needed changes years ago and this is why future employers recognize accreditation as assurance of a well-educated and well-prepared entry-level employee.

Introduction

A recent study by the American Society for Engineering Management listed seven socioengineering areas where there are “perceived gaps in the value of the organization versus preparedness for new BS engineers.” Studies by EAC/ABET have identified skill gaps engineers and engineering technologists lack upon graduation. Some of the skills identified were project management, teamwork, engineering economics, organizational behavior, decision-making, and communications. Thousands of ASEE conference attendees in 2003, listened to keynote speaker, Shirley Jackson, discuss the increased importance of leadership education for engineers today. Dr. Jackson, president of Rensselaer Polytechnic Institute, stressed the importance “soft skill” education for engineers and engineering technologists. A few of the many “soft skills” in which Dr. Jackson focused was leadership, ethics, teamwork, integrity, appreciation of diversity, the value of cooperation and respect for others, and the ability to gain a wider and broader perspective.
Why is there such an emphasis on professional skills for entry-level engineers today? One example was found when the National Science Foundation collected data on U.S. engineers in 1997 and found 58% of the people trained as engineers spend major part of their work in management, sales, and administration. In addition, with the recent economic downturn, many engineers, with research and development funds cut, have found themselves thrust into business and leaderships roles for which they were ill-prepared. Norman Augustine, in 1994, coined the term, “Socioengineering” to describe the combination of the contextual and process skills with the elements of traditional engineering education needed for the twenty-first century. This study will focus on ABET Accreditation and how it has expanded in recognizing this “socioengineering” by including professional skills in the quality assurance of engineering higher education.

**ABET Defined**

To be ABET (The Accreditation Board for Engineering and Technology) accredited is to be recognized as an institution or program with high standards. This accreditation is important as it provides prospective students and their parents assurance of a quality, best practice, education. In addition, future employers recognize accreditation as assurance of a well-educated and well-prepared entry-level employee. ABET was established in 1932 to establish a quality assessment program for engineering, technology and applied science programs. The condensed eleven criterion for an effective engineering or engineering technology program begins with the following: Engineering or engineering technology program student be able to demonstrate they have an appropriate mastery of the knowledge, techniques, skills, and modern tools of their disciplines, an ability to apply current knowledge and adapt to emerging applications of mathematics, science, engineering, and technology, an ability to conduct analyze and interpret experiments and apply experimental results to improve processes, the ability to identify, analyze, and solve technical problems, and a commitment to quality, timeliness, and continuous improvement.

In Manufacturing Engineering Technology, for example, the objective of an accreditable baccalaureate degree program in manufacturing engineering technology will prepare graduates with the technical skills necessary to enter careers in process and systems design, manufacturing operations, maintenance, technical sales or service functions in a manufacturing enterprise. Graduates, in this program, must demonstrate the ability to apply the technologies of materials, manufacturing processes, tooling, automation, production operations, maintenance, quality, industrial organization and management, and statistics to the solution of manufacturing problems.

ABET, faculty, and institutions continually search for meaningful ways to allow for student mastery of their discipline. For example, in April 2000, Standards for Technological Literacy: Content for the Study of Technology was published by the International Technology Education Association. The document provides rationale and recommendations for encouraging technology literacy. Faculty at ABET accredited institutions have and should continue to be searching for learning outcomes of mastery in
related disciplines through capstone courses, portfolios, reverse engineering and industrial experience. However, the focus of this paper includes a study, not of the aforementioned critically important criterion for student technical skill outcomes, it will define the remaining evolving criterion described as “socioengineering” or the soft engineering skills which, coupled with the technical skills, makes the student work ready for the 21st century. This paper will particularly focus on creativity, team membership, communication, lifelong learning, appreciation of diversity, and ethics.

Creativity ([an ability to apply creativity in the design of systems, components, or processes appropriate to program objectives)]

Interviewer: “Give me some examples when you utilized your creative skills to get a project or assignment completed.”

Every year the National Collegiate Inventors and Innovators Alliance (NCIIA) offer grants for creative student projects. Faculty and students alike submit creative proposals in hopes of winning the prize. Innovation and creativity should come naturally to a technologist or engineer but this is not always the case. But as more and more students realize, especially when asked these types of interview questions, an entry-ready future employee will be expected to be creative and innovative. Students are competing for jobs with engineers and engineering technologists from all over the globe. The generation of knowledge is the lifeline of global businesses. For example, while a manufacturing engineer graduate will indeed be involved with some form of production of goods, the generation of knowledge and the creative skills needed to generate new knowledge allows for manufacturing to compete in a global marketplace.

Many universities find creativity is best encouraged through team activities. Many institutions have adopted multidisciplinary E-teams. These teams, composed of multidisciplinary team members, are charged with rapidly developing new technologies and products. In addition, with these projects, team member will enhance communication skills as they make oral and written proposals and presentations throughout. Not only will engineers need to demonstrate creative abilities, engineers of the future will be tasked to lead creative consensus-building regardless of the discipline. This skill is one closely identified with teams and team skills have become a requisite for any engineering position in today’s global work environment.

Team Membership ([an ability to function effectively on teams)]

A definition of team would be a small group of people with complementary skills who are committed to a common purpose, performance goals, and approach for which they hold themselves mutually accountable. In today’s complex work environment, engineers are required to solve current, complicated problems that require teamwork. GE, Intel, Motorola, Xerox, Ford, and GM are just a few companies publicly stating their commitment to team-based environments. Teamwork, utilizing complementary skills in industry, typically refer to functional roles such as engineering, finance, manufacturing, sales, etc. In the book, Wisdom of Teams, the authors stressed that simply placing
students into groups does not automatically lead to superior performance. Instead team performance is related to effectiveness in the building of the teams. In most cases, students do not come to university with the social skills needed to collaborate effectively so the appropriate communication, leadership, decision-making and conflict management skills should be provided in order to understand how groups function effectively. Because the “building of team” is the most important function of a team, engineering students must not only be encouraged to develop the social skills need to function effectively, they must be encouraged to value and utilize complementary skills found in diverse team development. It is the faculty’s responsibility to recognize future workplace needs and help students develop their skills to participate and lead teams and one way to do this is to encourage the development of communication skills.

Communications (...to be able to communicate effectively)

ABET’s 2000 criteria flag included the all-important, but vague term, “communication skills.” Why are communication skills so important to engineering today? Many corporate leaders would name several critical reasons:

- The ability to explain what you are doing throughout a project to people who are not engineers and get them involved in the process
- The ability to work in the early stages of a project to obtain feedback from various teams impacted by the potential changes
- The ability to explain your actions and how you got there
- The ability to make an oral presentation to a group of clients or co-workers
- The ability for leading creative consensus building

As an article in the May-June, 2003 Prism shared, Dr. Jerry Bischof, director of nuclear engineering for Dominion Resources recently visited an engineering university in an attempt to fill ten engineering positions for his corporation Of the one-hundred resumes that had made the cut-off for an on-campus interview, approximately 50% were immediately rejected for lack of communication skills.

In a recent study conducted with 301 former engineering graduates from Southern Illinois University-Carbondale, it was found that listening was the most important non-technical skill needed to function in team-based work environments. While decision-making ranked second, verbal communication was ranked third in perceived importance for graduate skills. Dr. Norman Augustine, as far back as 1994, warned the ability to communicate is increasingly important today because of the growing complexity of systems and cross-disciplinary team approach to engineering.

There are many ways to develop communication skills in future engineers. The typical oral reports and team reports will certainly enhance oral communication skills. However, to develop the most important listening skills, instruction should include activities in dynamic listening and detection of speaker feelings and speaker perceptions. While, one can include exercises in listening and recitation, to teach future engineers to dynamically listen and to become skilled in FPIs (Feelings-Perceptions Identifiers) is to develop the...
team skills needed to function effectively a team environment. An example of a dynamic listening activity may include a situation where you have students respond to statements without sharing opinions, solving problems, or offering judgments (see Appendix 1 and 2). A worksheet can be used wherein students complete a response section responding to possible team member responses to suggested changes. The student shall be prompted to recognize the FPIs or the Feelings-Perception Identifiers and to respond accordingly. Appendix 1 offers a worksheet that can be used to develop communication skills for engineers. Appendix 2 shares appropriate response and explains the FPIs and Dynamic Listening examples. The development of these higher-level communication skills, coupled with the technical skills needed to function effectively, will make the student a well-rounded and prepared entry-level worker. These activities will also allow for students to be prepared for the diverse and multicultural workforce they will encounter when entering the 21st century workplace.

Respect for diversity (a respect for diversity and a knowledge of contemporary professional, societal and global issues)

Diversity wears many faces. The engineer or the engineering technologist will enter a workforce that is diverse in many ways. There are differences in gender, race, ethnicity, sexual orientation, religion, and even diversity in educational level, socioeconomic background and age. Additionally, one has to consider the multicultural impact in today’s global environment. One patent attorney was quoted in Prisim as warned that technical competence can only get you so far. A critical element necessary for success today is the ability to work alongside and report to people from other cultures. This patent attorney, Loria Yeadon, warned, “It’s a multifaceted engineering candidate that will fare well in today’s corporate environment.” (p. 19) The educational institution plays a role as well, observed in the cries and demands of corporations for higher education to focus on commitment in providing quality, diverse and work-ready candidates. Corporations and higher educational institutions alike, are seeing more and more that investing in diversity is a social responsibility.

Teaching busy students to seek understanding of contemporary, professional, societal, and global issues is a hard sell. Most students are focused on the current paper due, the current examination to study for, and the latest campus social affair. To adequately prepare students faculty must encourage systems thinking. It is when students are taught to see the system and the interacting parts of a system that they develop a more global viewpoint. A system is anything that takes its form from the interaction of its parts. Systems usually have common purposes and behaviors because they are interrelated toward that purpose. Just as an engineer is taught to understand system dynamics, that same understanding can be applied to other systems such as information flow, social systems, and living systems. It is when a student gains an understanding of the interrelationships of systems that they grow to understand the effect of contemporary, professional, social and global issues. All of these issues are part of systems that interact with other systems and each professional, social and global decision made by the student in a future workplace will have an effect on the system. Once systems thinking is
introduced, another ABET criterion, ethics, is easily introduced to students as one recognizes the actions of individuals and organizations affects all interrelated systems.

Ethics (an ability to understand professional, ethical, and social responsibilities)

The American Society for Engineering Education (ASEE) annual conference proceedings for the 2003 Nashville conference contained several papers on the topic of engineering and engineering technology ethics, professionalism, and social responsibility. Understandably, these issues are important to engineering education as engineers have a major impact on public safety and health. David Haws, in the April 2001 Journal of Engineering Education, labeled engineering thinking “convergent thinking.” This author described engineers as focused on small aspects of problems, isolated thinkers, and mesmerized by the majesty of engineering science and engineered design (p. 223). He noted that ethical behavior requires “divergent” thinking which is considering options and impacts beyond the narrow realm of engineering. Many higher educational institutions have introduced professional code of ethics aiding in this divergent type of thinking. A hands-on method of divergent thinking would include assignments in service learning. Appendix 3 offers a quick and personal assessment to aid engineering students in evaluating their ethics and moral decision-making. This model is designed with the assumption that there are some givens in our institutions and society. Our institutions may have a Code of Ethics similar to the Professional Engineer’s Code of Ethics included in some coursework. Some corporations have Value Statements and Statements of Integrity stressing the importance of ethical decision-making. Our society holds all of us accountable for certain norms and expectations, reflecting our requirements of being a good citizen. This model also considers personal values, attitudes, principles, and perceptions as powerful influences on decision-making. However, this model is designed to show that most decision-making is made in a split second, a moments notice, or in a self-defining time period. Personal ethics are tested when engineers are engaged in convergent thinking and not paying attention to the sudden dilemma facing them. It is then we conduct an “Unanticipated Moral Query.” There are several questions to be asked of students when they feel they have to make a major decision in their engineering careers. Questions such as: If this was my business, would I make the same decision? If my action faced public scrutiny, would I be ashamed? Would it be acceptable for someone else to treat you in the same manner? How would you handle this situation if you knew the other person would find out? Would you treat this person this way if he/she were a family member or friend? If you were going to purchase and use this product, would you make the same decision?

Ethical decisions are made consistently when guided by the Unanticipated Moral Query. For we all are aware of social and institutional expectations but it is in an environment of uncertainty, in an engineering decision-point, that our students learn to evaluate, diverge their thinking and consider their personal moral stance. We operate in a global marketplace and ethical decision-making is only one criterion to consider when considering contemporary professional, societal, and global issues.
Lifelong learning (a recognition of the need for, and an ability to engage in lifelong learning)

The Wingspread Group on Higher Education recently reported that, “We must redesign all of our learning systems to align our entire education enterprise with the personal, civic, and workplace needs of the 21st century.” The workers of the 21st century must possess cross-functional, inter-disciplinary knowledge, skills, and attitudes, which extend well beyond the traditional scope of technological training. In addition, they will need to understand the very nature of the organization and their contribution to its performance. In a study gathered from data from two groups of business leaders and managers, it was found that today’s business leaders and managers expect graduates to possess the knowledge, skills and attitudes of contemporary business concepts. The workplace changes continuously, there are continuous improvement initiatives, and there is a need to recognize global aspects of a boundaryless marketplace. In the educational marketplace, there is a movement towards learner-centered approaches wherein learners becomes an active part of the process of discovery based in intrinsic motivation rather than consumption of facts. There is a growing need in society for further education, where the learners must have the ability to combine studies with their ordinary work. And the view of education is changing in that it is viewed as a lifelong process rather than a non-recurring investment. It is a need, not a choice. In today’s knowledge or information society, lifelong learning is a necessary tool for successful participation. The educator’s role includes a move towards learning rather than just teaching, a focus on active involvement rather than recitation of data, and one of action rather that passivity. As more and more students become involved in their educational process, it is the faculty who is tasked to offer the tools of learning rather than the tools of fact consumption.

Conclusion

The curriculums at many colleges, universities, and corporations have been tweaked and even overhauled in some cases in response to ABET’s criteria. A recent (May-June, 2003) Prism cover title warned, “The Graduate: Educators struggle to prepare well-rounded engineers for today’s workplace.” In an article of the same name, an Exelon corporate vice-president, is quoted: “I think universities are honestly trying to change and work closely with corporations to do so, but I am not sure that the process has been set up to allow them to change as fast as business is.” This article continues by saying while success in engineering curriculum depends on ability to complete problem sets and exams, success in business classes depends on ability to analyze case studies, succeed in group projects, and develop and conduct effective presentations. Well ahead of the curve, ABET warned years ago of the need for socioengineering skills or professional skills in engineering and engineering technology education. Transferring educational knowledge and experience to the ever-changing workplace is a matter of learning to learn, learning to play nice with others, learning to think creatively, learning to respect diversity, understanding ethics an social responsibility, and a willingness and unsatisfied yen for lifelong learning. Faculty and curricula must also change in order to adequately prepare future leaders by including socioengineering into the curriculum, allowing for team participation, and allowing for the process of discovery. It is when we all recognize
the changes needed, prepare for the future, and become systems thinkers that we will meet our goals of preparing well-rounded engineering graduates for the workplace. ABET recognized this years ago and this is why future employers recognize accreditation as assurance of a well-educated and well-prepared entry-level employee.

References

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Biography

Beverly Davis is an Associate Professor of Organizational Leadership in the School of Technology at Purdue University in South Bend, IN. She is a member of the ASEE, IEEE, International Leadership Association, American Society for Quality, The National Literacy Institute, The American Psychological Association, and The World Future Society. She is the Program Chair for the ASEE Manufacturing Division.
Appendix 1

As a new engineer in a manufacturing corporation, you have been thrust into a leadership position in a team setting. You have shared a new idea for a project you are working with. This project would impact each of the team member’s job in minor to major ways. Each of the statements below reflect a team member’s remarks to you in a team meeting. Write the proper response to demonstrate dynamic listening and the person’s feelings and perception identifiers (FPI’s) when making the statement.

<table>
<thead>
<tr>
<th>Team Member’s Statement</th>
<th>Feeling and Perceptions Identifiers (FPIs) of the speaker detected</th>
<th>Your response to this statement</th>
</tr>
</thead>
<tbody>
<tr>
<td>“I don’t think I like this idea, I don’t see what is in it for me.”</td>
<td></td>
<td></td>
</tr>
<tr>
<td>“I am tired of new engineers coming in here and trying to change everything.”</td>
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<td>“I am willing to do whatever it takes to make our team successful but I am not sure I will be much of a contributor because I don’t have any skills to add.”</td>
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<tr>
<td>“We tried something similar to this in another team I was on and it failed miserably, I don’t trust the changes.”</td>
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<td>“We will have to train people in the new process, I will be glad to help in that way.”</td>
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<td>“I have work to do, may I get back to it?”</td>
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<tr>
<td>“I am willing to try this new process, however, I wish to contribute some ideas before jumping on board.”</td>
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Developed by Beverly Davis, Purdue University: 2003
Appendix 2: Answer Key

The key to dynamic listening and utilization of Feeling and Perception Identifiers (FPIs) is practice, practice, practice. Dynamic Listening means one does not judge, one does not solve the problem, one does not react, one does not share opinions, and one “listens” for feelings perceptions. By listening for feelings and perceptions and soliciting more information by dynamic listening, one will increase communication skills and become a more effective leader and team member. By making these statements below, you are opening the door for understanding the statement by soliciting more information in a non-threatening manner. An example of a proper response is listed below with explanation.

<table>
<thead>
<tr>
<th>Team Member’s Statement</th>
<th>Feeling and Perceptions Identifiers (FPIs) of the speaker detected</th>
<th>Dynamic Listening Response</th>
</tr>
</thead>
<tbody>
<tr>
<td>“I don’t think I like this idea, I don’t see what is in it for me.”</td>
<td>Fear, discouraged, frustrated</td>
<td>“You feel the project idea is unwarranted.” *** You are allowing for the opportunity for the team member to share frustrations. You do not show emotions, judge nor offer unsolicited opinions</td>
</tr>
<tr>
<td>“I am tired of new engineers coming in here and trying to change everything.”</td>
<td>Unimportant, threatened, Fearful</td>
<td>“It’s frustrating to not understand the reason behind change.” *** Has this person had a negative experience with a new engineer’s project? Has this person been disrespected in some way?</td>
</tr>
<tr>
<td>“I am willing to do whatever it takes to make our team successful but I am not sure I will be much of a contributor because I don’t have any skills to add.”</td>
<td>Low self-esteem, self-doubt</td>
<td>“You feel unsure about how you will contribute.” ***This person could need skill development or just be full of self-doubt. Either way, one must find the reason this person feels this way.</td>
</tr>
<tr>
<td>Statement</td>
<td>Emotion, Concern</td>
<td>Response</td>
</tr>
<tr>
<td>----------------------------------------------------------------------------</td>
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<td>---------------------------------------------------------------------------</td>
</tr>
<tr>
<td>“We tried something similar to this in another team I was on and it failed miserably, I don’t trust the changes.”</td>
<td>Doubt, Resentment</td>
<td>“You had a bad experience and don’t trust this change.”</td>
</tr>
<tr>
<td>“We will have to train people in the new process, I will be glad to help in that way.”</td>
<td>Excitement, motivated</td>
<td>“You like training others in new processes.”</td>
</tr>
<tr>
<td>“I have work to do, may I get back to it?”</td>
<td>Disgusted, bored, unconvinced</td>
<td>“You feel contributing to this project would be a waste of your time.”</td>
</tr>
<tr>
<td>“I am willing to try this new process, however, I wish to contribute some ideas before jumping on board.”</td>
<td>Leery, control concerns</td>
<td>“You have specific ideas to share.”</td>
</tr>
</tbody>
</table>

Problems can be solved, decisions made, and progress obtained more effectively if everyone is on board. One must learn to listen effectively and practice human relation building when communicating with team members in today’s team-oriented environment. Remember, practice, practice, practice. Utilizing FPIs and Dynamic Listening methods will open many doors for more effective team functioning.

Developed by Beverly Davis, Purdue University: 2003
Appendix 3

Unanticipated Moral Query

**Personal:**
- Attitudes
- Values
- Perceptions
- Principles

**Societal:**
- Expectations
- Norms

**Institutional:**
- Code of Ethics
- Value Statements
- Statements of Integrity

- If this were my business, would I make the same decision?
- If your action faced public scrutiny, would you be ashamed?
- Would it be acceptable for someone else to treat you in the same manner?
- Would you treat this person this way if she/he were a family member or friend?
- If you were going to purchase and use this product, would you make the same decision?
- How would you handle this situation if you knew the other person would find out?