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The Attributes of a Global Engineer: Results and Recommendations from a Multi-Year Project

Dr. Stephen Hundley, Indiana University-Purdue University Indianapolis (IUPUI)

Stephen Hundley is Chair and Professor in the Department of Technology Leadership and Communication at Indiana University-Purdue University Indianapolis (IUPUI). He also serves as IUPUI's Associate Vice Chancellor for Strategic Initiatives. Stephen holds a Ph.D. from American University in Washington, D.C., and has published and presented on the topics of workforce engagement, adult learning, STEM education, and higher education administration.

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Abstract

For the past several years, the American Society for Engineering Education's Corporate Member Council, reflecting the voice of industry, developed a series of attributes representing the desired competencies needed by engineers in order to effectively live and work in a global context. A global online survey was launched to validate the performance and proficiency levels of each attribute, and a series of global focus groups in every major region of the world have been held for the purpose of clarifying and refining the attributes. In 2015, the Attributes of a Global Engineer Project formally concludes its work, having benefitted from prolonged engagement with and input from globally-representative stakeholder groups of academicians and industry partners. This paper will describe the process to develop attributes of a global engineer; present a summary of key results; discuss how attribute outcomes can assessed in engineering education globally; and provide recommendations for a variety of stakeholders, with particular emphasis on lessons learned from the multi-year Project.

Introduction and Context

The American Society for Engineering Education (ASEE) Board of Directors established the Corporate Member Council (CMC) to convey the ideas and views of corporations to ASEE. With over 120 corporate and non-academic institutional members, the CMC's mission is to foster, encourage, and cultivate the dialogue between industry and engineering educators. The CMC has several Special Interest Groups (SIGs), which exist to share information and advance key priorities of the CMC. The International Engineering Education SIG is the CMC sponsor of the Attributes of a Global Engineer Project. The Attributes of a Global Engineer Project grew out of an expressed need by CMC members to identify and validate specific knowledge, skills, abilities, and perspectives that would be required of an engineer living and working in an increasingly global context. Specifically, the goal was to refine a list of attributes that would be applicable to engineers regardless of specialty, location, or background. The Attributes of a Global Engineer Project's principal goal is to "Enhance the employability of engineering graduates and increase the international competitiveness of ASEE's corporate members, so that engineers can effectively live, work, and perform anywhere in the world." (Diane Matt, Chair ASEE-CMC, 2014)

Initial Attribute Development and Refinement

The process of initially developing the Attributes of a Global Engineer began in 2008, led by the International Engineering Education Special Interest Group (SIG), and involved CMC members developing a list of competencies derived from representative job descriptions, literature reviews, and other reports. This initial list was consolidated through a series of SIG meetings and events throughout 2008 and 2009. At the ASEE Annual Conference in 2010, SIG stakeholders attempted to translate the attributes into specific competencies that could be identified by levels of importance and proficiency at certain intervals of an individual's education and professional development. The initial list totaled forty-eight; however, through in-

person meetings at the Conference, and through bi-weekly telephone conference calls and other electronic communication, the list was ultimately synthesized and consolidated. After further review and validation from CMC members, a total of twenty attributes of a global engineer emerged. These are:

1. Demonstrates an understanding of engineering, science, and mathematics fundamentals
2. Demonstrates an understanding of political, social, and economic perspectives
3. Demonstrates an understanding of information technology, digital competency, and information literacy
4. Demonstrates an understanding of stages/phases of product lifecycle (design, prototyping, testing, production, distribution channels, supplier management, etc.)
5. Demonstrates an understanding of project planning, management, and the impacts of projects on various stakeholder groups (project team members, project sponsor, project client, end-users, etc.)
6. Demonstrates an understanding of the ethical and business norms and applies norms effectively in a given context (organization, industry, country, etc.)
7. Communicates effectively in a variety of different ways, methods, and media (written, verbal/oral, graphic, listening, electronically, etc.)
8. Communicates effectively to both technical and non-technical audiences
9. Possesses an international/global perspective
10. Possesses fluency in at least two languages
11. Possesses the ability to think both critically and creatively
12. Possesses the ability to think both individually and cooperatively
13. Functions effectively on a team (understands team goals, contributes effectively to team work, supports team decisions, respects team members, etc.)
14. Maintains a positive self-image and possesses positive self-confidence
15. Maintains a high-level of professional competence
16. Embraces a commitment to quality principles/standards and continuous improvement
17. Embraces an interdisciplinary/multidisciplinary perspective
18. Applies personal and professional judgment in effectively making decisions and managing risks
19. Mentors or helps others accomplish goals/tasks
20. Shows initiative and demonstrates a willingness to learn

Survey Research on the Attributes of a Global Engineer

After completing a stakeholder-driven process to develop the attributes of a global engineer, SIG members sought to validate the list of attributes with stakeholders beyond the CMC. Given the global dimensions and emphasis of the attributes, SIG members were desirous of a mechanism to receive widespread feedback from a truly global audience of engineering-oriented stakeholders. The CMC partnered with the International Federation of Engineering Education Societies (IFEES) to accomplish the goal of widespread global stakeholder input and validation. IFEES consists of nearly 50 member organizations, representing engineering education associations and corporations from around the globe. Dr. Hans Hoyer, who serves Secretary General of IFEES, facilitated connections between the SIG leading the attributes of a global engineer project and IFEES stakeholders around the globe. This purpose was two-fold: (1) to garner assistance in translating the survey into multiple languages (including validation of the survey once

translated); and (2) to secure assistance in marketing the survey opportunity to IFEES stakeholders worldwide.

From July-September 2010, the survey was translated from English to the following languages: Chinese (Simplified and Traditional), French, German, Italian, Japanese, Korean, Polish, Portuguese, Russian, Spanish and Turkish. Translators also assisted in validating the survey with a small representative audience of likely survey responses. This was done to ensure that the intent behind attribute meanings was preserved across all translations. Translators were asked to make appropriate substitutions to words or phrases in the translated context to accomplish this goal. Using SurveyMonkey as the data collection platform, the survey was launched in October 2010; a work-in-progress paper was presented at ASEE's 2011 Conference in Vancouver; additional responses were received by and the survey was closed for additional responses in September 2011.

The survey yielded 1,027 usable case respondents reflecting the following demographic profile:

- 70% English; 30% non-English; responses were received from all languages except French
- 80% Male; 20% Female
- 50% between ages of 40-60; balance over other age ranges
- 46% Academicians; 40% Practitioners; 10% Students; balance preferred not to answer
- Aerospace (17%); Computer Science (13%); and Electrical/Computer (13%) are largest Engineering Discipline response categories
- 64% reported having graduate-level Engineering degree

Data analyses revealed the following attributes were most important and proficient overall:

1. Communicates effectively in a variety of different ways, methods, and media
2. Possesses the ability to think both critically and creatively
3. Shows initiative and demonstrates a willingness to learn
4. Functions effectively on a team
5. Possesses the ability to think both individually and cooperatively
6. Demonstrates an understanding of engineering, science, and mathematics fundamentals
7. Demonstrates an understanding of information technology, digital competency, and information literacy
8. Maintains a positive self-image and possesses positive self-confidence

When analyzing above attributes at each stage of an engineer's development (upon completion of high school/secondary school; university; early-career professional), the importance and proficiency levels of each attribute varied, as follows:

The most important/proficient attributes for the *secondary school graduate* are:

1. Demonstrates an understanding of engineering, science, and mathematics fundamentals
2. Maintains a positive self-image and possesses positive self- confidence

For individuals at this stage, the need to have sound preparation in the disciplinary fundamentals is needed for successful transition to and success in university-level engineering education programs. Furthermore, student retention and success in most first-year university engineering curricula requires resiliency and the positive self-image/self-confidence.

The most important/proficient attributes for the *university/post-secondary graduate* are:
1. Demonstrates an understanding of engineering, science, and mathematics fundamentals
2. Demonstrates an understanding of information technology, digital competency, and information literacy.

For individuals at this stage, the need to have master of the disciplinary fundamentals upon departure from university-level engineering programs is most important. Furthermore, the ability to be proficient in and up-to-date with the tools and technology of the field are also needed.

The most important/proficient attributes for the early-career engineering professional are:
1. Functions effectively on a team
2. Possesses the ability to think both individually and cooperatively

For individuals at this stage, the need to work as part of an engineering-oriented team are most important, as is the ability to make both individual and collective contributions to engineering-oriented work.

After analyzing, summarizing, and disseminating results from the survey, SIG members felt it was necessary to conduct focus groups and workshops related to the attributes. The next section highlights the process and findings from those endeavors. In order to garner additional input into the Attributes of a Global Engineer, a series of focus groups and workshops were conducted in several venues. From 2012-2015, events were held at engineering-related conferences, symposia, and workshops in the United States, Finland, Belgium, Colombia, Argentina, Japan, U.K., Spain, U.A.E., and India. In all but one event, the principal attendees were university-level engineering educators or industry partners. The October 2013, San Antonio, Texas, event provided an opportunity for K-12 and community/technical college stakeholders to have input into the Project. Each event was structured as both a *focus group* (to seek stakeholder input) and a *workshop* (to permit the dissemination of findings and encourage integration of attributes into the engineering curriculum).

During the focus group portion, highlights from the survey findings were shared and discussed, and participants had an opportunity to provide reactions or contribute additional information related to the attributes. A summary of the attributes the collective stakeholders from all events felt were needed for engineers to be successful in the global context included the following:
- ultural sensitivity
- Tolerance to other people and perspectives
- Open-minded and ability to adapt
- Ability to behave ethically across cultures
- Social responsibility
- Research and analytical thinking
- Problem-solving and improvement capabilities
- Entrepreneurship

Stakeholders at each event were also queried as to the best uses of the attributes, which they identified as:

- Teaching and learning processes and student preparation
- Business/industry involvement as vocal advocate for attributes
- Linkages to other initiatives

Finally, while focus group and workshop participants uniformly expressed appreciation for the Attributes of a Global Engineer Project, there was widespread agreement that a framework of twenty attributes seemed daunting to remember, explain, or champion. Thus, stakeholders provided useful guidance on helping SIG members develop a revised framework.

Revised Framework for the Attributes of a Global Engineer

To facilitate greater utility of explaining the purpose of the Attributes of a Global Engineer, and to encourage their integration into the engineering curriculum, SIG members have revised the framework based on feedback from focus group and workshop participants. The new framework retains the twenty attributes, yet organizes them more effectively around five broad categories needed for global engineering effectiveness: Technical; Professional; Personal; Interpersonal; and Cross-cultural. Descriptions of each category and corresponding attributes are listed below:

Technical: Engineering-related knowledge, skills, and abilities needed for success

- Demonstrates an understanding of engineering, science, and mathematics fundamentals
- Demonstrates an understanding of information technology, digital competency, and information literacy
- Demonstrates an understanding of stages/phases of product lifecycle (design, prototyping, testing, production, distribution channels, supplier management, etc.)
- Demonstrates an understanding of project planning, management, and the impacts of projects on various stakeholder groups (project team members, project sponsor, project client, end-users, etc.)

Professional: Workplace related competencies for global performance

- Communicates effectively in a variety of different ways, methods, and media (written, verbal/oral, graphic, listening, electronically, etc.)
- Communicates effectively to both technical and non-technical audiences
- Maintains a high-level of professional competence
- Embraces a commitment to quality principles/standards and continuous improvement
- Applies personal and professional judgment in effectively making decisions and managing risks

Personal: Individual characteristics needed for global flexibility

- Possesses the ability to think both critically and creatively
- Possesses the ability to think both individually and cooperatively
- Maintains a positive self-image and possesses positive self-confidence
- Shows initiative and demonstrates a willingness to learn

Interpersonal: Skills and perspectives to work on interdependent global teams

- Functions effectively on a team (understands team goals, contributes effectively to team work, supports team decisions, respects team members, etc.)
- Mentors or helps others accomplish goals/tasks

Cross-cultural: Society and cultural understanding to embrace diverse viewpoints

- Demonstrates an understanding of political, social, and economic perspectives
- Demonstrates an understanding of the ethical and business norms and applies norms effectively in a given context (organization, industry, country, etc.)
- Possesses an international/global perspective
- Possesses fluency in at least two languages
- Embraces an interdisciplinary/multidisciplinary perspective

Future dissemination concerning the Attributes of a Global Engineer Project will use the revised framework as the means of organizing and communicating the attributes.

Conclusion

The Attributes of a Global Engineer Project has enjoyed several strengths, challenges, and opportunities. *Strengths* include corporate voices reflected in origin and concept development; mixed method approach for attribute development and refinement; and prolonged engagement with global stakeholders. *Challenges* include the large number of attributes identified; competing and co-existing "outcomes" frameworks exist; and engineering curricular tightness, which makes additive educational work impractical. *Opportunities* include the ability to offer corporate perspectives on related initiatives; integrating the attributes with curricular and other efforts possible; and adaptation to local contexts, versus superimposing the attributes on others. The SIG members look forward to continued evolution, dissemination, and improvement of the Attributes of a Global Engineer Project, and to seeing this effort scale and sustain over time.