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A Literature Review of Global Competencies for Engineering Students

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A Literature Review of Global Competencies for Engineering Students

Abstract

With the growing need for an interconnected workforce, there is an increasing demand for college graduates to develop global professional skills. This paper reviews existing literature to identify core global competencies essential for engineering students and examines the evidence supporting their importance in today's workforce. It synthesizes key frameworks, research findings, and industry perspectives to clarify which skills are most critical for success in global and intercultural work environments. These global competencies encompass technical, interpersonal, and intercultural abilities that enable engineering students to work effectively across diverse settings. In this review, particular attention is given to professional skills such as adaptability, cross-cultural communication, ethical awareness, and problem-solving. Drawing from a combination of scholarly research and industry reports, the paper highlights the global competencies most relevant to engineering education and analyzes their impact on students' academic, professional, and personal development. Results of this study identify common themes and global competencies for continuous course and program improvement in the Global Engineering Fellows program in the College of Engineering at the Pennsylvania State University. The Global Engineering Fellows program aligns with broad institutional goals of fostering diversity, equity, inclusion, and cultural competency, aiming to produce engineers with global leadership capabilities. This study will help ensure program content and student outcomes remain current, relevant, and aligned with the literature.

Introduction

Global competence is widely defined as the capacity to examine local, global, and intercultural issues; understand and appreciate the perspectives of others; engage in open, effective interactions across cultures; and act in ways that support collective well-being and sustainable development [1]. In engineering, this definition takes on additional importance because the profession increasingly involves collaboration across national boundaries, cross-cultural teams, and global supply-chain environments. Engineering students are therefore expected not only to understand the technical aspects of their discipline but also to demonstrate adaptability, cultural awareness, and effective communication with colleagues of diverse backgrounds and perspectives [1].

Within engineering education specifically, global competence is often framed as the ability to work effectively with individuals who define problems differently, providing additional perspectives and expertise [2]. This definition emphasizes the types of collaboration engineers face in multinational industries and the need to engage ethically with diverse communities all around the world. Across studies, several traits repeatedly emerge as fundamental to global competence. Communication, cultural appreciation, and teamwork are consistently ranked as

essential for engineers operating in international and multicultural settings [3]. Clearly defining these competencies is essential, as employers frequently report that engineering graduates enter the workforce with strong technical preparation but limited intercultural and interpersonal skills, which can hinder effective communication and collaboration. Findings from the Tools for Enhancing and Assessing the Value of International Experience for Engineers (TA VIE) study underscore this gap, showing that engineers who studied or worked abroad demonstrated significantly higher levels of adaptability and intercultural awareness than peers without international experience [4].

As engineering continues to evolve within global supply chains, multinational teams, and culturally diverse communities, these competencies are no longer optional [4]. They shape an engineer's ability to navigate ambiguous problems, develop into leaders, collaborate across differences, and apply technical knowledge in real-world global contexts. This review synthesizes research that showcases which competencies matter most and examines how educational programs can more effectively support the development of globally prepared engineers across different institutions.

Identifying Engineering Global Competencies

Competencies represent clusters of skills, attitudes, and behaviors that enable individuals to perform effectively in specific contexts [1]. In higher education, competencies are often categorized as technical, interpersonal, or professional skills; however, global competencies extend this framework by emphasizing the dispositions needed to work within diverse cultural and international environments. As the Organisation for Economic Co-operation and Development (OECD) [1] notes, global competence involves the ability to understand global issues, appreciate different perspectives, communicate effectively across cultures, and contribute to collective well-being. We selected this definition as it provides a broad view of how engineers can consider these skills. These competencies prepare students to interact meaningfully with the world around them and engage in ethical decision-making that considers the needs of global communities.

In engineering education, the concept of global competence is grounded in the understanding that professionals must be able to collaborate with people who define and solve problems differently. Downey [2] argues that globally competent engineers have the capacity to work with diverse stakeholders and navigate differences in communication styles, cultural expectations, and ethical reasoning. This requires skills that are relational and contextual rather than solely technical. For example, Klein-Gardner [3] emphasizes that communication, teamwork, and cultural appreciation consistently emerge as the most essential competencies across engineering programs and international contexts.

Global competencies in engineering typically fall into several major categories. The first is intercultural communication, which includes the ability to adjust communication styles, interpret

nonverbal cues, and express technical ideas clearly to people with different linguistic and cultural backgrounds [5]. The second is cultural awareness, or the ability to understand that problem-solving approaches and professional norms drastically vary across cultures [6]. A third essential competency is adaptability, which describes the ability to function effectively in uncertain or rapidly changing environments [4]. Additional competencies include ethical reasoning in global contexts, the ability to collaborate in diverse teams, and a global mindset characterized by curiosity, eagerness to connect with others, and openness to new experiences [5].

These competencies are increasingly sought by employers as engineering work becomes more globally distributed and collaborative. Because these skills are complex and context-dependent, it is essential to clearly identify and define them within engineering education. Doing so helps clarify which foundational concepts should be introduced in coursework and which competencies should be emphasized and reinforced through global and experiential programs.

Unlike technical skills, global competencies cannot be mastered through lectures or homework alone. They develop through iterative practice, exposure to diversity, and reflection. Study abroad programs, global project teams, and multicultural engineering classrooms therefore play an essential role in helping students translate theoretical and technical awareness into applied skills. As research consistently shows, these experiences deepen cultural humility, enhance cross-cultural communication, and strengthen students' ability to navigate unfamiliar professional environments [7].

More narrowly, we found that several skills emerged as more salient across multiple sources. In the literature, global competencies typically fall into several recurring categories:

1. Interpersonal and Communication Skills

These include the ability to communicate clearly across cultural boundaries, adjust communication style, listen actively, and convey complex technical information to non-experts. Effective global communication also involves reading nonverbal cues, managing misunderstanding, and accommodating linguistic diversity. Miscommunication and misinformation may lead to conflicts in the workplace when communicating across cultures. Learning how to manage these in a different scenario than what one is accustomed to, strengthens interpersonal relationships and reduces misunderstandings, leading to a healthier and more productive working environment.

2. Cultural Awareness and Perspective-Taking

Students must be able to understand and appreciate different cultural norms, values, and ways of thinking. This does not require full cultural fluency, but rather the willingness to suspend judgment and consider how others approach problems and decision-making. Understanding

cultural beliefs promotes a diversified work environment, which allows everyone to express their ideas, perspectives, and concerns more freely without the fear of judgment.

3. Adaptability and Flexibility

Global work environments often require managing ambiguity, responding to unexpected challenges, and adjusting rapidly to new contexts. Adaptability is consistently cited in the literature as a key predictor of success in international roles. Learning to quickly navigate changing environments with resilience and patience strengthens overall productivity and fosters effective leadership.

4. Ethical and Social Responsibility

Engineering work increasingly intersects with global questions of sustainability, equity, and public welfare. Understanding how ethical issues appear differently across cultures and how engineering solutions may affect communities differently is an essential part of global competence. Engineers must acquire research and data before applying their work to challenging problems in a safe, ethical, and sustainable way without negatively impacting the community.

5. Global Mindset and Curiosity

A global mindset involves being open to learning from unfamiliar situations and being genuinely curious about how other cultures think and work. This mindset supports continuous learning, reflection, and improvement. By engaging with communities across the world, engineers develop empathy and eagerness to learn more about the world that surrounds them, which motivates more inclusive and innovative ideas.

6. Teamwork and Collaboration Across Differences

Modern engineering projects often involve multidisciplinary and multicultural teamwork. Engineers must be able to effectively collaborate across differences in expertise, cultural expectations, and work styles. This exposure creates the opportunity for meaningful relationships and connections that strengthen through collaboration and teamwork.

Together, these competencies form an interconnected network of skills that help engineers navigate global workplaces. They represent a comprehensive way of thinking rather than a checklist.

Competency Validation Studies

Framework validation studies have also contributed to the literature. For example, the American Society for Engineering Education (ASEE) has published multiple studies identifying and validating global competencies for engineers. One study identified 23 competencies grouped into

domains such as cross-cultural communication, world knowledge, and engineering-specific global skills [9]. Another study validated similar competencies based on feedback from academic and industry experts, emphasizing the importance of adaptability, ethical reasoning, and cultural understanding. [10].

Application of Competencies

The relevance of global competencies becomes most apparent when examining how engineers apply these skills in real-world contexts. In today's globalized engineering profession, students routinely encounter situations that require intercultural communication, cross-disciplinary collaboration, leadership skills, and ethical decision-making.

One of the most visible applications is global teamwork. Engineering teams often operate across time zones and cultural boundaries, requiring students and professionals to navigate differences in communication norms, leadership structures, and expectations for collaboration [5]. For example, approaches to conflict resolution or decision-making may differ significantly between teams in Europe, Asia, and North America. Engineers who possess strong global competencies are better able to adapt to these differences, build trust, and sustain productive working relationships [1]. These skills enhance communication between teams from different cultures; thus, enhancing productivity in meetings, projects, and everyday tasks.

Global competencies are also essential in international engineering disciplines, where engineers must consider global regulations, cultural norms in negotiation, and the ethical implications of manufacturing decisions [6]. Ethical concerns including environmental sustainability and labor practices vary across regions, making cultural awareness and ethical sensitivity critical components of responsible engineering practice.

Similarly, global competencies are essential for effective practice in humanitarian and community-based engineering, where engineers often work in regions facing shared challenges such as limited resources, infrastructure constraints, and environmental vulnerability. Addressing these challenges requires close collaboration with local communities, culturally informed design, and a focus on long-term sustainability. Engineers must understand local practices, values, and social structures to develop solutions that are appropriate, effective, and accepted by the community [2]. Without these competencies, well-intentioned interventions risk being misaligned with local needs or causing unintended harm. In addition, engagement in global engineering programs exposes engineers to the lived realities of underrepresented communities, deepening their understanding of how global challenges manifest differently across contexts. This exposure can motivate innovative, context-sensitive design approaches that are adaptable across regions and capable of supporting communities worldwide.

Global competencies also influence engineering leadership, where team diversity offers both opportunities and challenges. Leaders must be able to communicate clearly, manage ambiguity,

and cultivate inclusive work environments [3]. Engineers with international experience often demonstrate stronger leadership potential because they have practice navigating unfamiliar environments and working with diverse perspectives [4]. Those with a wide range of global competencies face diversity with courage and inspire others through their leadership, adaptability, and resilience.

Finally, engineers with strong global competencies often excel in innovation and problem-solving. Exposure to diverse perspectives broadens cognitive flexibility and fosters creative thinking, which is increasingly valuable as engineering challenges become more complex and interconnected [6]. These competencies enhance both technical outcomes and team performance, reinforcing their importance in modern engineering education. Learning how to navigate life in a completely new country builds global competencies by promoting problem-solving skills that allows engineers to easily tackle challenges.

Literature Review

Global Competence Frameworks

The OECD [1] framework defines global competence broadly in terms of knowledge, skills, and values that promote intercultural understanding and engagement. This definition serves as a foundation for many higher education institutions seeking to internationalize their curricula. In engineering specifically, global competence is often described as the ability to work effectively with people who define problems differently and share diverse perspectives [2]. This view highlights the importance of understanding not only cultural differences but also differences in how engineering problems are framed and approached.

Ortiz-Marcos [6] expands on this definition by identifying competencies needed for a sustainable global world, including collaboration, adaptability, intercultural communication, and the ability to address complex global challenges. Their framework emphasizes that engineering solutions increasingly intersect with societal needs and environmental concerns, making global competence essential for responsible innovation.

The Erasmus and TA VIE Studies

One of the largest sources of evidence on global competence development comes from mobility programs such as Erasmus+. According to the European Commission [8], Erasmus+ supports over 1.3 million mobility experiences annually, offering students opportunities to engage with diverse cultures and academic environments. Research consistently shows that mobility programs enhance students' adaptability, self-confidence, and intercultural communication skills [8].

Building on this work, the TA VIE project conducted a comprehensive study to determine which global competencies employers value most in engineering graduates. Through 37 semi-structured interviews with HR personnel across Spain, Italy, France, Sweden, and Hungary, the researchers found that employers strongly value interpersonal and relational skills, including communication, teamwork, cooperation, and willingness to face challenges [4]. These professional skills were frequently identified as missing among new engineers despite strong technical foundations and expertise in the field.

HR professionals emphasized that students with international experience demonstrate greater openness, adaptability, and social confidence than those without such experiences. Their ability to interact with people from different cultures impacts their interpersonal relationships and overall success in their work environments. These findings highlight the significance of international mobility in preparing engineering students for global workplaces [6].

BYU Study on Global Competence

Parkinson, Harb, and Magleby [5] conducted one of the most widely cited studies on global competence in engineering. Surveying engineering educators, industry representatives, and government professionals, the researchers identified and ranked 13 global competence attributes and their perceived influence on engineering graduates. The researchers sought to define what it truly means for an engineer to be globally competent and to determine which dimensions of this skill set are most essential in today's workforce. Participants included attendees of the NSF Summit on Globalization held at the University of Rhode Island, representing industry, academia, and government sectors who shared their perspectives on the cultural awareness of engineering professionals.

The results highlighted responses from 15 individuals representing 11 universities, 14 individuals from 12 companies, and two respondents from the government or ASEE [5]. As highlighted in Figure 1, of these 13 attributes, 12 were ranked as "desirable" with a score of 3.0 or higher, highlighting them as essential. Hence, the five most important competencies included the ability to appreciate other cultures, work with diverse teams, communicate across cultures, gain global engineering practice opportunities, and address ethical issues arising from cultural differences [5].

Understanding global competence and its impact on professionals is a central component in the engineering field. Emphasizing global competence equips future engineers to effectively communicate cross-culturally, navigate challenges, express their ideas in a respectful manner, and lead diverse teams with empathy and sensitivity. Thus, this study underscored the need for engineering programs to integrate global perspectives into technical education. It also

highlighted gaps between educational outcomes and industry expectations, particularly in the areas of communication and teamwork.

Intercultural Competence Development Through Study Abroad

Long-term research has further demonstrated the benefits of study abroad for engineering students. A study published by the European Journal of Engineering Education [11] found that engineering students who studied abroad showed significant improvements in intercultural competence, though the degree of improvement varied by gender and competency dimension. The findings support the integration of study abroad into engineering curricula and suggest that structured intercultural learning opportunities enhance student growth and motivation.

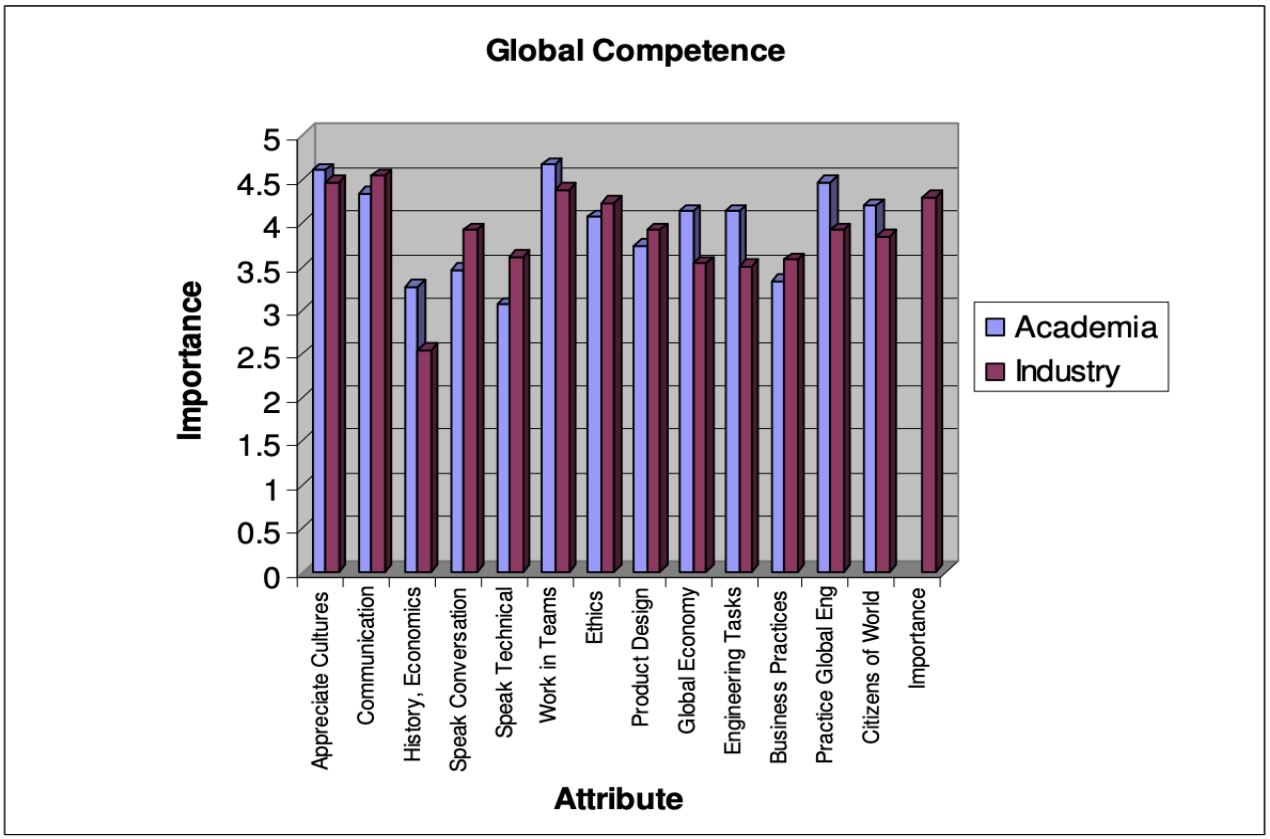

Figure 1. Rankings of the 13 global competence attributes by academia and industry [5]

Student Perspectives on Global Engineering

Research exploring student perspectives offers additional insight into global competence development. According to a study published by Tandfonline in 2023 [7], engineering students view global competence as essential to their professional success and emphasize traits such as open-mindedness, global awareness, and social skills. Students reported that transformative

learning occurred when they engaged with unfamiliar cultural contexts, indicating that experiential learning is essential for developing global competencies. These acquired competencies boost students' confidence in their diverse learning environments and further enhances their leadership, communication, and team-collaboration skills.

Challenges and Critiques

Despite strong agreement on the value of global competence, challenges remain and questions arise. Scholars argue that global competence is difficult to measure because many of its components, such as cultural humility, are not easily quantifiable [12]. Others critique the Western bias in existing frameworks, suggesting that definitions of competence should be more sensitive to local cultural values.

These critiques reinforce the need for multi-method assessment approaches and culturally inclusive frameworks that reflect the diversity of global engineering practice. Likewise, additional research and literature is needed to promote the benefits of global competencies and motivate universities across the world to modify their learning curriculum.

Recommendations

In light of the growing need for global competencies in engineering education discussed throughout this review, it may be useful to highlight key recommendations that emerge consistently across the literature. While individual studies offer a wide range of suggestions, several themes recur with notable frequency and significance. Rather than presenting an exhaustive set of recommendations, we distill the most prominent and impactful insights from the papers reviewed. These key takeaways reflect areas where engineering programs can focus their efforts to meaningfully support the development of global competence among students:

1. Integrate Global Competence into Core Engineering Courses

Courses should incorporate global case studies, international engineering examples, and cross-cultural communication modules. Embedding global learning into required courses ensures all students gain foundational competencies and explore their diverse interests [5]. Adding these into the already established curriculum allows students to build on their technical skills, while at the same time, expand cultural awareness, develop a global mindset, and become motivated to learn about different cultures around the world.

2. Expand Study Abroad and Virtual Exchange Opportunities

International mobility programs significantly enhance adaptability and intercultural communication [8]. Study abroad programs, of different durations, should be more accessible to students interested in gaining a global mindset. Yet, for students unable to travel, virtual

exchanges can replicate aspects of global teamwork. Likewise, virtual exchanges or internships motivate problem-solving skills, as these allow students to work with each other to solve a common goal through online platforms.

3. Strengthen Industry Partnerships

Collaboration with global companies can expose students to real-world challenges and expectations. Internships and project collaborations allow students to apply global competencies in authentic settings [4]. Encouraging internships abroad also promotes cultural exploration and a global mindset, as students become immersed in a new environment for a long period of time.

4. Promote Interdisciplinary and Multicultural Learning Environments

Courses in languages, global studies, or anthropology may complement engineering coursework. Mixed-discipline teams can aid students learning from diverse perspectives and ideas [3]. Student organizations and clubs, such as Engineers Without Borders, may inspire global communication by allowing students to interact with organizations from different universities through activities and mentorship opportunities.

5. Develop Structured Assessment Methods

Tools such as the Intercultural Development Inventory (IDI) and the Cultural Intelligence Scale (CQS) can provide meaningful feedback to students and universities about growth in global competence [12]. These instruments help programs move beyond general claims about cultural awareness by offering measurable indicators of a student's progress before, during, and after an international experience.

6. Ensure Equitable Access to Global Learning

Financial support, flexible program structures, and domestic intercultural opportunities can broaden participation among underrepresented students [1].

7. Support Faculty Training

Faculty need resources and training to integrate global learning into their courses. Professional development can improve instruction and mentor support for international projects [6]. Likewise, passionate and knowledgeable professors also serve as a way for study abroad programs to receive more traction and students to become more motivated to engage in these global experiences.

A nationwide study conducted by Brigham Young University (BYU) surveyed mechanical engineering alumni in 48 states and 17 countries to identify how colleges and universities can more effectively prepare engineers for the demands of a global engineering environment [10].

Sixty-six of 247 (26.5%) survey respondents participated in this particular study. As seen in Figure 2, 27% of the survey respondents chose professional skill development, which includes communication, presentation, and writing skills [10]. Further, 22.7% of the respondents indicated fostering international internships as a potential area for improvement, clearly highlighting the importance of global competencies and cultural experiences [10]. These results showcase that colleges and university engineering programs must reinforce two main areas: technical competence for engineers and the development of global competence.

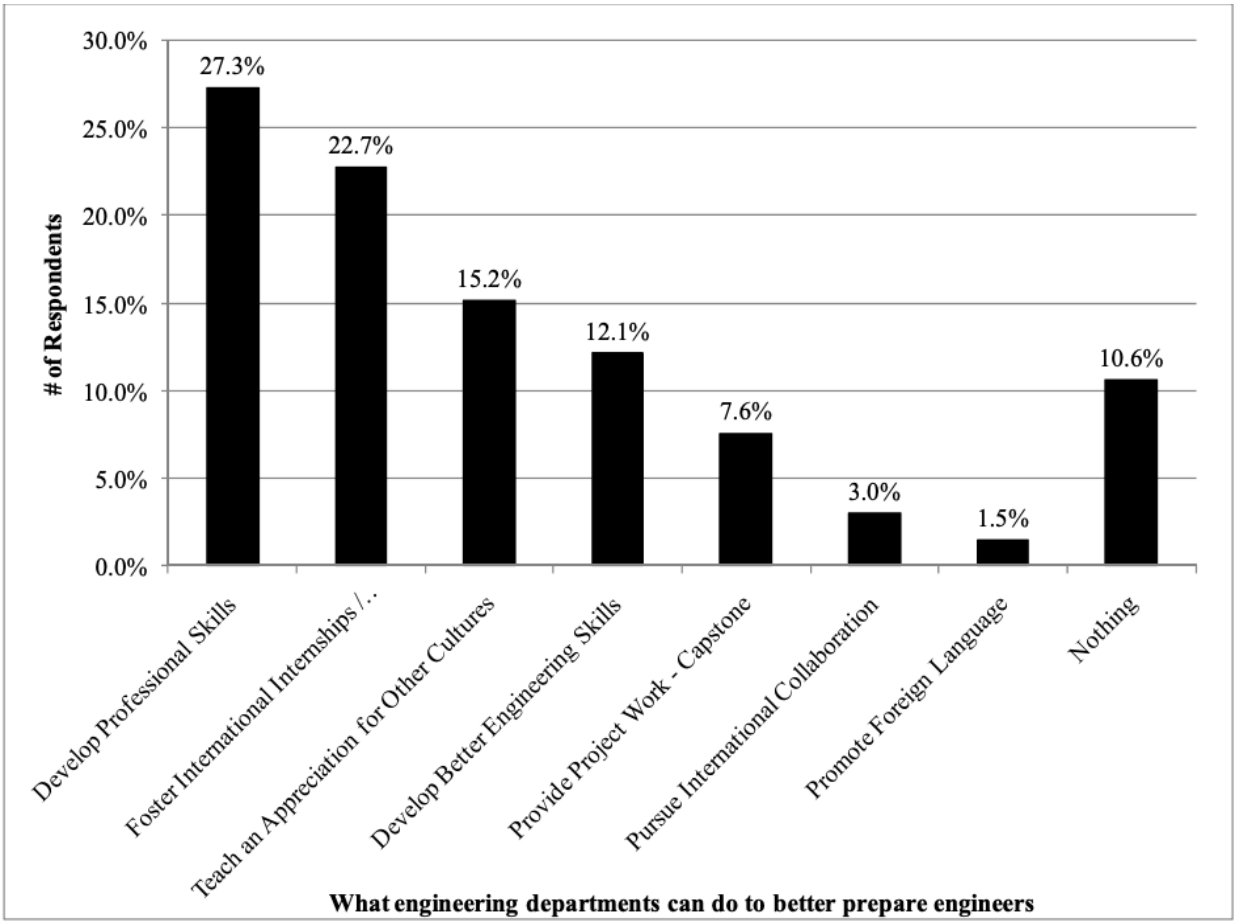

Figure 2. Survey results highlighting potential recommendations for engineering departments and programs to better equip engineers for global experiences [10]

Those who had previous experience working in a global environment answered the question, "What do you wish you would have known upon completion of college to better prepare you to work successfully in a global engineering environment?" [10] According to Figure 3, of 220 respondents, 51 (23.2%) indicated that they wished they would have had better cultural appreciation and understanding, 46 (20.9%) would have wanted to be more prepared in conducting business and engineering in an international environment, 34 out of 220 (15.5%) respondents believed they were prepared for a global engineering work environment, and 23 out of 220 (10.5%) believed language skills could have helped them significantly [10]. These results

not only reinforce the need to understand global competencies and their benefits, but they also highlight the growing need of developing these in universities and colleges across the world.

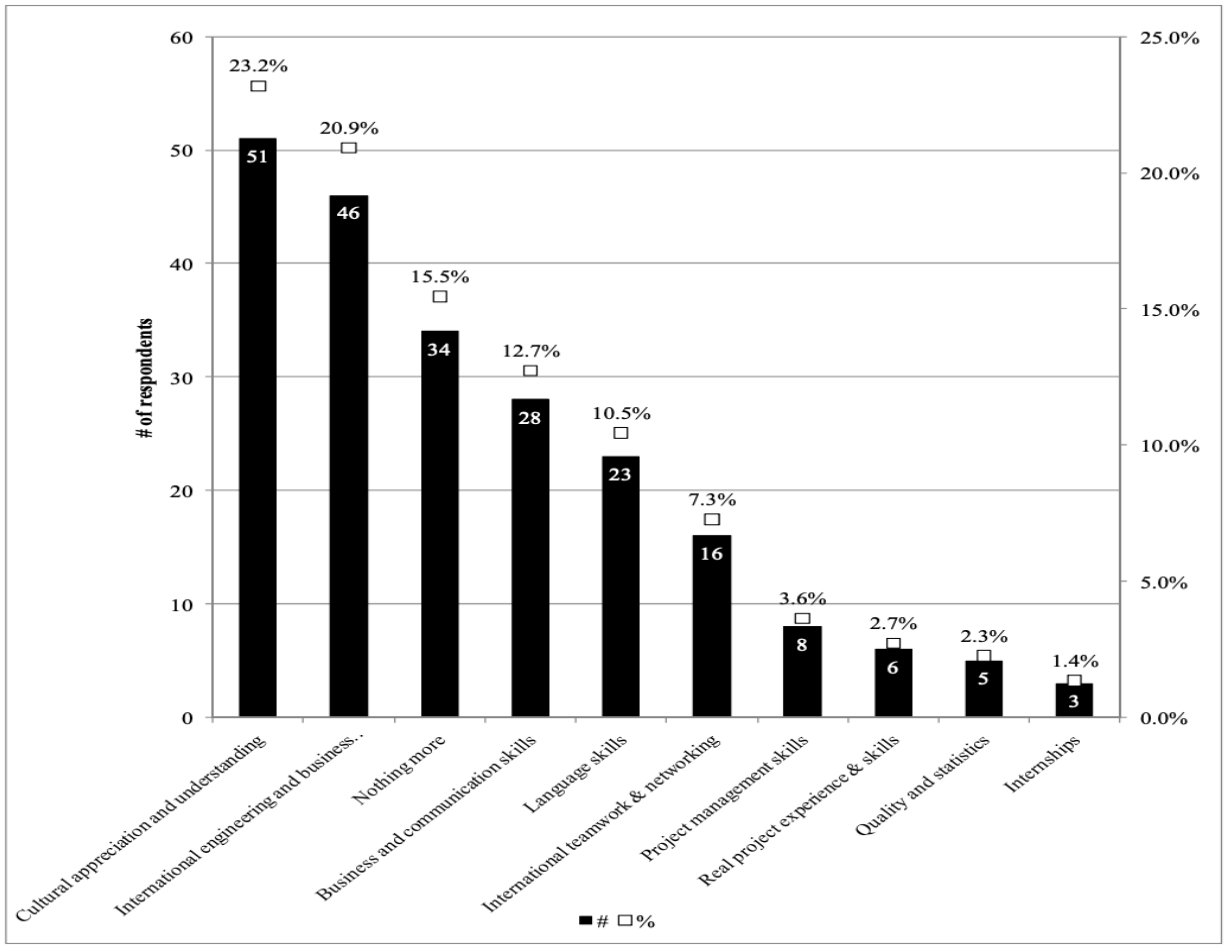

Figure 3. Survey results indicating what respondents wish would have known after finishing college to better prepare to work in a global scenario [10]

Discussion

The literature consistently demonstrates that global competence is essential for modern engineering practice. Although engineering programs traditionally emphasize technical skills, global competencies such as adaptability, communication, and cultural awareness are equally important in globalized work environments. Employers highlight these competencies as critical yet often insufficiently developed in new graduates [4].

International mobility experiences, such as study abroad, significantly improve students' intercultural competence and global mindset [7], [8]. These experiences encourage students to navigate unfamiliar environments, collaborate across cultures, and reflect on their own assumptions, which are skills essential for engineering in multinational settings.

However, access to global learning remains uneven, and challenges persist in assessing global competence reliably. Scholars suggest that global competence should be viewed as developmental rather than fixed, requiring ongoing learning throughout one's education and career [12]. Engineering programs must therefore create multiple, sustained opportunities for students to engage with global perspectives.

Ultimately, aligning engineering education with industry needs requires intentional curriculum design, expanded experiential learning opportunities, and support for both students and faculty. Programs that prioritize these changes will be better positioned to prepare graduates for the demands of an interconnected world.

Conclusion

Global competence is increasingly recognized as an essential component of engineering education. As engineers confront global challenges such as climate change, sustainability, public health, and international collaboration, they must be equipped with the interpersonal, intercultural, and ethical skills needed to navigate diverse contexts. This literature review synthesizes frameworks and findings that highlight communication, adaptability, cultural awareness, and teamwork as core competencies for global engineering practice.

Although many engineering programs prioritize technical knowledge, this review demonstrates that global competence cannot be developed through technical courses alone. Instead, experiential learning, study abroad programs, interdisciplinary coursework, and intentional curriculum design are vital for cultivating these skills. By adopting these strategies, engineering programs can better align with industry expectations and prepare students for successful global careers.

The findings of this review will guide future improvements in the Global Engineering Fellows Program at the Pennsylvania State University, ensuring that program content remains aligned with evolving professional demands and contributes to broader institutional goals related to diversity, equity, inclusion, and global leadership.

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