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Drawing Connections: Exploring Global Engineering Perspectives Through an Arts-Informed Approach

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ABSTRACT

BACKGROUND & CONTEXT

Engineering education continuously emphasizes the development of global engineering competency, including intercultural competence, cultural awareness, and a global mindset alongside technical skills. Research suggests that engineers should be prepared to operate across cultures and address complex global challenges. Despite this, many engineering students have a limited understanding of what global engineering entails beyond working abroad or on international projects. The context of this paper is in a global engineering course created to intentionally expose students to these topics.

PURPOSE OR GOAL

This study explores how students' conceptualizations of global engineering evolve through participation in a global engineering course. The goal was to understand how structured curricular experiences contribute to the development of global engineering competencies. The central research question asked how students visually represent their understanding of global engineering before and after the course.

APPROACH OR METHODOLOGY

Using an arts-informed approach, 47 engineering students created drawings at the start and end of the semester in response to the prompt, "What is global engineering?" Thematic analysis was applied to identify shifts in visual content, focusing on themes such as technical emphasis, collaboration, cultural awareness, and sustainability.

OUTCOMES

Post-course drawings reflected increased complexity, socio-technical thinking, cultural awareness, and ethical sensitivity, contrasting with the simplified, technical non-humanistic focus of pre-course images.

CONCLUSIONS

The course was effective in fostering global engineering competencies among students as expressed by how their perception of "What is global engineering?" changed. Arts-informed methods captured meaningful shifts in students' thinking, demonstrating the value of creative assessment in global engineering education.

KEYWORDS

Global engineering, arts-informed methods, global engineering competency.

Introduction

Engineering continues to become a global profession. Global engineering refers to applying engineering principles and knowledge in an interconnected, international, and multicultural context, to address global challenges and create a more sustainable world for everyone (Thomas, 2020). Engineers are expected to be prepared to collaborate across borders, address global problems that transcend frontiers, and design solutions that consider cultural, environmental, and political contexts (Duderstadt, 2008). Whether developing sustainable infrastructure, managing global supply chains, or innovating in health and energy systems, engineering work demands a global mindset (Jesiek et al., 2014; Downey et al., 2006). As such, industry, academia, and accreditation boards agree that engineering graduates must be equipped with global competencies (ABET, 2022; Parkinson et al., 2009).

According to Johri and Jesiek (2014) global engineering competency, is defined as those competencies and qualifications that hold distinctive importance for effective engineering practice in international and global context. Engineering education research has focused on understanding the importance and the ways to develop globally competent engineers. However, engineering programs struggle to develop these competencies effectively. Engineering students are usually unaware of the cultural, social, and global dimensions of engineering, and they preconceived perception that the profession is purely technical (Capobianco et al., 2011). Usually, they believe problem-solving is a technical process, with minimal recognition of the social aspects of engineering decisions and their impact on people across global contexts.

Universities have been developing global awareness, and intercultural and professional skills through international exposure, like study abroad programs (Davis et al., 2022; Wrobetz et al., 2023). However, access to these opportunities is often constrained by cost, a packed engineering curriculum, and institutional capacity. This creates challenges and limits the reach of global engineering education.

In response, educators have begun integrating globally focused experiences into the core engineering curriculum—through virtual collaborations, intercultural modules, and reflective pedagogies (Davis et al., 2019, Schneider et al., 2024). In this study, there was a particular interest in unpacking how engineering students' understanding of what it means to be a global engineer changes during a semester. A global engineering course was developed with the intention of promoting global engineering competency in undergraduate engineering students.

Hence, we examined student-created drawings as a visual expression of their understanding of global engineering competency at the beginning and the end of the semester. By analyzing these drawings, we aimed to uncover changes in how students conceptualize global engineering practice. This arts-informed approach offers a unique, non-textual window into students' mindsets, potentially revealing aspects of their learning and shifts in their perspectives that traditional surveys or written reflections might miss.

Literature Review

This literature review aims to synthesize prior research around the development of global engineering competencies, highlighting how intercultural competence and global mindsets are cultivated through various educational pathways. It also examines emerging arts-based approaches as alternative ways of capturing students' perceptions of engineering, establishing the foundation for this study. Downey et al. (2006) introduced the idea of the globally competent engineer, an engineer who is able to work with people who define problems differently, who have different contextual experiences, and engineers who consider the global impact of engineering decisions. Hence, beyond technical proficiency -which is also important, global engineers are expected to have different problem-solving approaches, cultural norms, and an understanding of the impact of solutions. Research has subsequently focused on understanding how global engineering competency is developed in terms of specific skills. For example, Parkinson, Harb, and Magleby's (2009) survey focused on ranking global

competence attributes, finding that cross-cultural communication, understanding the global context of engineering work, and the ability to collaborate with international partners were considered most critical. These attributes align with most accreditation standards in Australia, Europe, and the United States.

One key dimension of global engineering is fostering intercultural competence in future engineers. Intercultural competence is considered the capability to shift one's perspective and behavior to bridge cultural differences and work effectively with people from other cultures (Leung et al., 2014). In an engineering context, this might translate to understanding cultural aspects of design requirements, communication across borders, contextual user needs, and global ethical considerations of engineering projects (Mahadevan, 2014). Engineers often learn intercultural skills through direct exposure. For example, participating in study abroad, engaging with international teams or collaborative online international learning (COIL) experiences, or working on international design teams. However, research suggests that there are other ways to develop a global mindset (Schneider et al., 2024); for example, students can be exposed to interventions to recognize that a technical solution successful in one country could fail in another due to social or environmental context, or understanding how global supply chains and markets influence engineering design. Engineering educators have been designing interventions to cultivate these traits without necessarily requiring travel; for example, virtual global team projects and on-campus intercultural training have successfully improved students' global mindsets and communication skills (Munoz-Escalona, 2024).

While prior research has quantified gains in global competencies (e.g., via surveys) (Davis et al., 2018; Paradise et al., 2022), there is a need to also unpack this phenomenon using a different approach. In fact, arts-based approaches have been gaining traction in engineering education research. For example, Capobianco et al. (2011) used the Draw-an-Engineer Test to explore elementary school students' understanding of engineering work. The authors analyzed the data using content analysis and statistical testing. They identified that students described engineers as mechanics, laborers, and technicians. Similarly, Ganesh et al. (2009) used the Draw-an-Engineer Test to collect data from Junior High-School to understand their individual perceptions of engineers. They were able to describe engineers in action, the occurrence of gender, and engineers' clothing. Similar to Capobianco et al., Ganesh et al. found that students had a lot of preconceived notions about associating engineers with men. However, this type of thinking shifted at the end of the academic year. Finally, Murzi et al. (2022), used an arts-informed approach by asking students to draw a response to the question "What is engineering?" Results provided a representation of students' preconceptions about the discipline in terms of human, technical, process-based, and holistic/global aspects; the authors suggested there was evidence that arts-based methods are effective in capturing students' deep perceptions of the engineering discipline.

Taken together, the literature supports our arts-informed methods to explore how the course impacted students' conceptualizations of global engineering. Therefore, the following section describes the methodological approach adopted in this study.

Methods

We employed an arts-informed qualitative research design to explore changes in students' conceptualizations of global engineering. Arts-informed methodology leverages creative inquiry as a means of expression and data (Özkan et al., 2018). Visual representations -via engineering students' drawing to the prompt "What is global engineering?" provided insights into student understanding and the evolution of such understanding in a way that might not be captured through words or quantitative data alone. Since we wanted to understand any possible impact of the course on students' understanding of global engineering, we collected drawings at two points in time (before and after the educational intervention, i.e., the course). We conducted a qualitative thematic analysis to identify changes in content and complexity.

Course Context and Participants

The study was conducted in the context of an elective course titled “Global Engineering Practice.” This course is part of one of the core general education requirements of the university and was taken by engineering students from different years (from 2nd to 4th). The course enrolment for the semester of study was 47 students, mainly comprising engineering majors across various disciplines (e.g. mechanical, electrical, civil). Students had diverse backgrounds and had been exposed to different internships or cooperative educational opportunities in industry. However, the majority had limited prior international exposure. The course curriculum covered topics intended to develop global engineering competencies: intercultural communication, case studies on engineering projects in different countries, discussions on global ethical issues (such as sustainability and social responsibility), and leadership exercises for multicultural team settings. Students’ projects focused on understanding problems contextualized in different countries and developing strategies to operate effectively in a multinational team. Students presented their work to their peers, were involved in at least 2 different teams, and developed individual reflections, individual assignments, and team projects. The objectives of the course were to understand global engineering practice and the professional skills needed to function successfully in a range of different cultural settings, and to identify global challenges, technological problems, and business opportunities and their implications for engineering professionals.

Data Collection

On the first day of class (pre-course), students were given an open-ended prompt to draw a response to the question: “What is Global Engineering?” They were provided blank paper and colored pencils and given about 10 minutes to sketch any images, symbols, or scenarios that came to mind. We emphasized that artistic skills were not important and that the goal was to visually express their current understanding of global engineering without using words, although many of them asked to include words as labels. Many students produced relatively simple drawings at this stage, often composed of a few basic elements (as described in the results section). At the end of the semester (post-course), the same drawing activity was repeated with the same prompt on the last day of class. By this time, students had engaged with the course material for 16 weeks. Notably, the second drawing session allotted a bit more time (around 15 minutes), and students were encouraged to be reflective and comprehensive in illustrating their concept of global engineering practice. We collected a total of 46 pre-course drawings and 45 post-course drawings, pairing them by student IDs.

Qualitative Analysis

We analyzed the drawings using thematic analysis. We followed the six-phase process of thematic analysis outlined by (Braun & Clarke, 2006), which includes 1) becoming familiar with the data, 2) generating initial codes, 3) searching for themes, 4) reviewing themes, 5) defining and naming themes, and 6) reporting themes using selected excerpts (in this case, drawings). As part of this process, a codebook was developed that included initial coding, definitions of codes, example drawings, and final themes. Themes were examined for any patterns emerging in comparison between pre and post-data. Two researchers independently reviewed the entire set of images and generated initial codes based on recurring visual elements or ideas depicted. Examples of codes that emerged in this open-coding phase included: “technology focus” (for drawings emphasizing tools, machines, or technical diagrams), “global symbols” (e.g., depictions of globes, world maps, flags), “teamwork” (multiple people or figures working together), “cultural representation” (visual cues of different cultures such as national flags, traditional attire on figures, languages), “communication” (symbols like speech bubbles, communication lines, satellites), “environment/sustainability” (nature elements or pollution symbols), “ethics” (e.g. justice scales, warning signs), and “complexity” (drawings with many interconnected parts or systems). We then compared and discussed our coding to resolve discrepancies and arrive at a consensus codebook. The codebook was iteratively refined by

grouping related codes into higher-level themes. For instance, codes like teamwork, cultural representation, and communication were grouped under a broader theme of “Global Collaboration & Awareness,” whereas codes like technology focus and complexity related to a theme of “Technical vs. Holistic Focus.” We also had a theme for “Ethical and Societal Considerations.” Throughout this process, we remained open to emergent themes rather than forcing data into preconceived categories.

Results

Our findings suggest clear differences between the pre-course conceptualizations of global engineering and the post-course conceptualizations. The pre-course drawings tended to reflect a narrow and technical-centric view of global engineering, often missing explicit global or cultural context. In contrast, the post-course drawings were generally more complex and holistic, incorporating social, cultural, and ethical dimensions of engineering practice on a global scale. Also, a significant difference was that in the pre-course drawings, most draws did not include people, as opposed to the post-course where most of them did.

Pre-Course Drawings: Initial Conceptualizations

In the pre-course drawing, students focused on sketching draws that were less complex, highly focused on technical aspects, and with more traditional engineering objects. People were usually not present. The main themes that emerged from the pre-course drawings were:

- **Technical Focus with Minimal Context:** In the pre-course sketches, students overwhelmingly depicted global engineering regarding technology or infrastructure, often in isolation. About half of the drawings featured objects like globes overlaid with gears or circuit patterns or a specific engineering project (e.g., a bridge, a skyscraper, a satellite). These drawings emphasized tangible outputs (bridges, machines, etc.) and technical processes. Notably, they generally lacked any human or community presence aside from a singular engineer icon. For example, one student drew a plane, as shown in Figure 1.

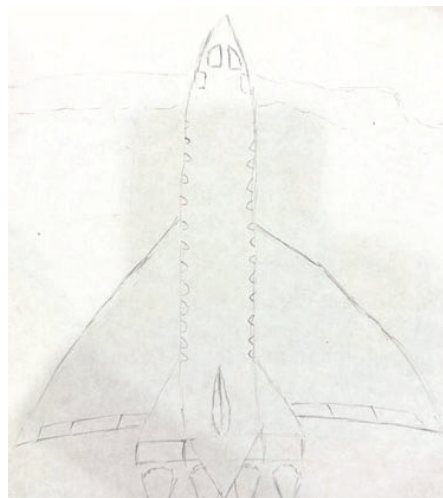


Figure 1: Pre-Course Student 33

Overall, these drawings suggest that initially, many students equated “global engineering” mostly with engineering big things around the world (a kind of literal interpretation) rather than with collaboration or cultural exchange.

Simplified, less complex: The pre-course drawings tended to be relatively simplistic. Many drawings contained a few bold elements (like a single globe, a national flag, or a simple gear) with little elaboration. This simplicity likely reflects the students’ initial understanding. In some

cases, the drawings also betrayed underlying stereotypes. For example, if a flag appeared, it was usually the United States flag (drawn perhaps to indicate the student's context rather than multiple nations). No student explicitly drew multiple national flags; thus, the “global” aspect was usually only implied by a globe graphic (Figure 2), not by depicting different countries or cultures. The absence of richer cultural context in these early drawings suggests that students had not yet internalized what intercultural or international collaboration in engineering looks like. Instead, global engineering was seen as engineering that happens to take place internationally but is still conceived through a single-culture lens (often their own).

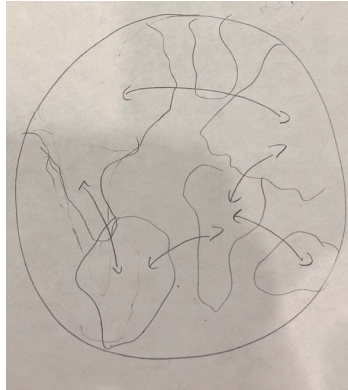


Figure 2: Pre-Course Student 33

- **Few Social or Ethical Considerations:** Themes related to the social impact of engineering or ethics were nearly completely missing from the pre-course sketches. None of the early drawings depicted communities or end-users of technology, nor references to issues like sustainability, inequality, or ethics. This indicates that initially, students' conceptual model of “global engineering” was largely apolitical and ahistorical – not connecting engineering work to its societal consequences globally.

The pre-course drawings portray global engineering as students initially understood it: technologically oriented, somewhat abstract or simplified, and lacking explicit multicultural or human elements.

Post-Course Drawings: Complexity, Culture, and Holistic Views

Data collected at the end of the semester showed a significant shift in both content and complexity. Students' post-course visualization of global engineering were more comprehensive and nuanced, including social and cultural elements, collaboration and people, and holistic views. Several emergent themes illustrate how their understanding evolved:

- **Incorporation of Social and Cultural Elements:** A significant change in the post-course drawings was the prominent inclusion of people and cultural symbols, indicating that students came to see global engineering as inherently social and intercultural. In contrast to the solitary figures (or no figures) in the pre-course draws, the majority of post-course drawings featured multiple human figures with the inclusion of cultural aspects. For example, Figure 3 represents two drawings from students that not only included people, collaboration, interconnectedness but also it is interesting to see the flags represented. Cultural symbols were constant in the post-course drawings. The presence of these elements demonstrates that students now recognized cultural awareness as a core component of global engineering practice. Engineering was no longer portrayed as a culturally neutral technical pursuit; instead, the drawings acknowledge that global engineering involves engaging with people of different backgrounds and that solutions must be culturally informed.

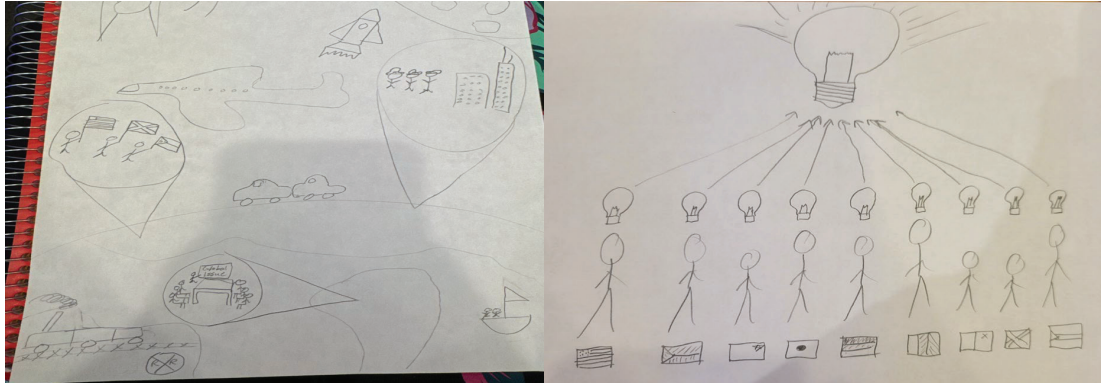


Figure 3: Post-course students 18 and 36

- **Emphasis on Global Collaboration and Communication:** several drawings explicitly visualized collaboration across distances, highlighting teamwork and communication across borders as essential to global engineering. We saw numerous representations of communication technologies and connectedness: globes encircled by orbiting satellites or arrows, dotted lines linking stick figures on different continents, and even depictions of video conference screens connecting engineers. One particularly evocative drawing is the one presented in Figure 4, effectively illustrating how different engineers posed their ideas and they realized ideas became effective when they understood their counterpart points and merged into a solution for all. These images suggest that after the course, students viewed global engineering as inherently cooperative – a contrast to the earlier individual-centric perspective.

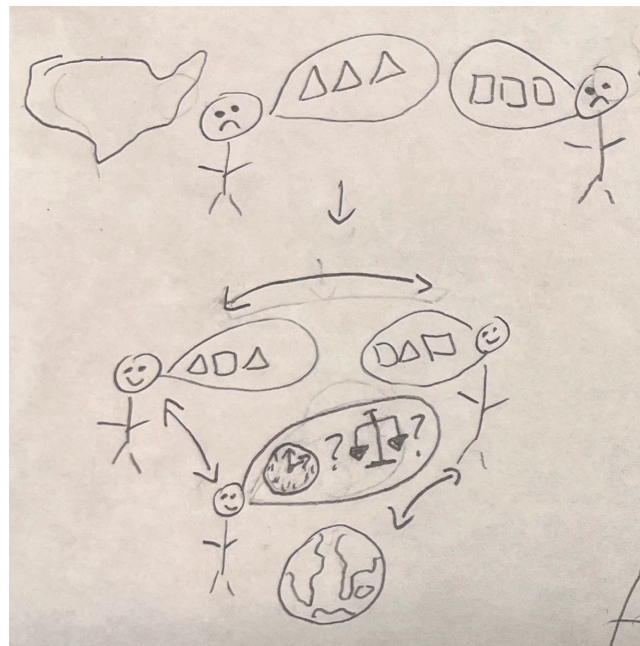


Figure 4: Post-course student 09

- **Holistic and Complex Depictions:** Something evident in the post-course drawings was the overall increase in complexity and holism. Students incorporated many more elements into their illustrations, suggesting a broader systems view of what global engineering entails. Where a pre-course drawing might have one or two symbols (e.g., Figure 1), a post-course drawing often had a rich scene or interconnected diagram. Several students attempted to show the wider impact of engineering on society and the

planet. For instance, one drawing portrayed a city skyline with factories and wind turbines on different continents, alongside images of happy communities, implying that engineering contributes to society globally. Another students represented a multi-country team working together to solve issues in a community (Figure 5), the draw included several different aspects and disciplines. They were recognizing that global engineering involves communication, discussion, understanding of implications, ethical and societal impact (e.g., firefighters) beyond the technical (tools, etc.).

- **Inclusion of Ethical and Environmental Considerations:** Several of the post drawings contained some representation of environmental stewardship or ethical responsibility. Common items included: recycling symbols, trees, and green energy technology (solar panels, wind turbines) indicating sustainable engineering, and warning signs or exclamation marks near depictions of potential hazards to denote safety and ethics. For example, one student drew a series of small scenes in a cycle: mining raw materials, manufacturing in a factory, product use, and recycling – essentially mapping a global supply chain and lifecycle with an arrow going in a circle to emphasize sustainability. They grew to understand that global engineering practice must reckon with ethical implications and environmental limits in the global context. This is supported by the presence of such symbols and by contrasts in some drawings (e.g., showing both positive and negative outcomes).

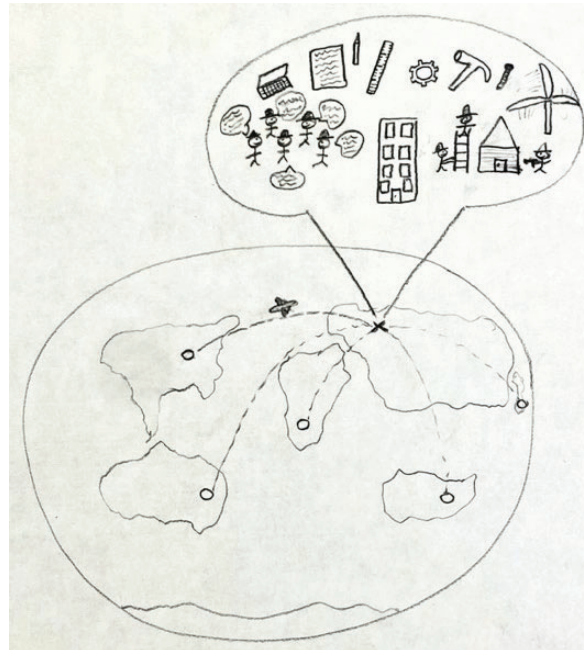


Figure 5: Post-Course Student 26

To provide a concrete example of how a student's conceptualization evolved over the course, consider one student (ID #45) as represented in Figure 6. Pre-course, the student drawing showed a plane, a boat, and a gear. Post-course, the student's new drawing was richer, more complex, and more detailed. It featured the world, people working together, a symbol for ideas, but also a question mark asking why, a peace sign including labels of morality and ethics, a supply chain, and different modes of transportation. It evidences a shift from a technocentric view to a people- and planet-centric view of engineering. Not every student change was as dramatic, but all showed some broadening. Even the few that remained technical on their focus often appended a nod to global context (such as a small flag) and included at least an element of collaboration, communication, and people, which was previously missing. No student drew fewer global or social elements in the second round than in the first – the change was uniformly towards more inclusion of global aspects.

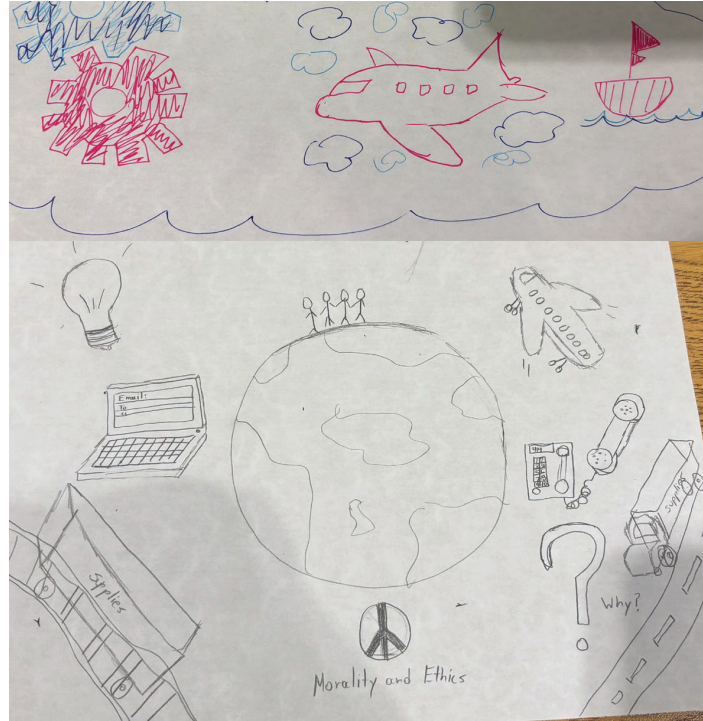


Figure 6: Pre-and-Post-course Student 45

In summary, pre-course themes centered on technical focus simplified mechanical objects, and the absence of culture, social aspects, and people. Post-course themes encompassed global collaboration, cultural awareness, holistic impact, and ethical and sustainable engineering. The evolution observed aligns with the course's intended learning outcomes – students moved from a somewhat narrow vision of global engineering to one that is multifaceted and considers social, cultural, human, economic, and political aspects. They came to see engineering as not just building things globally but as working with people globally for the benefit of society while being mindful of cultural differences and ethical obligations. These findings corroborate and enrich prior research on global competence development. For instance, Dare (2011) found that students often overestimate their global skills but later become aware of what they did not know; our results suggest that they eventually understand the importance of those dimensions (teamwork, culture, etc.) that were initially lacking in their perspective. Moreover, using drawings allowed us to see the integrated nature of their learning – how they simultaneously depicted technical and non-technical elements together in one picture, reflecting a synthesis of competencies.

It is worth noting that the arts-informed approach provided a unique window into student learning. Some of the subtleties in the drawings – like the use of specific cultural symbols or the depiction of a balanced scale – might not have been readily captured through standard course evaluations or surveys. Yet these visuals speak volumes about the internal conceptual shifts in the students. By qualitatively coding these, we understood which aspects of global engineering were most salient to students after the course (for example, teamwork and cultural awareness were extremely salient, as evidenced by their frequent appearance).

Conclusion

This study set out to explore how engineering students' understanding of global engineering evolved through participation in a dedicated course on global engineering. By using an arts-informed approach – specifically analyzing student-created drawings from before and after the course – we were able to qualitatively capture shifts in conceptualization that might have been otherwise difficult to articulate.

Students' pre-course drawings revealed a baseline perception of global engineering as primarily a technical endeavor with international scope, but without much cultural, social, or humane context. In contrast, students' post-course drawings depicted more holistic and complex, portraying engineering as a collaborative, multicultural, and socially conscious activity. They visualized global teams, cross-cultural interactions, and considered impacts on communities and the environment reflected a deeper understanding of what it means to be a "global engineer."

The Global Engineering Practice course appears to have been effective in broadening student perspectives. The changes in the drawings align closely with the course's objectives. Where initially a student might not have considered culture or ethics relevant to engineering, by the end of the course they explicitly depicted those as integral.

This study demonstrates that even a single, semester-long course, when intentionally designed, can significantly reshape how engineering students understand global engineering. The course helped students move from simplistic, tool-centric definitions to a broader, culturally aware, and ethically grounded view. The arts-informed approach was instrumental in revealing these shifts, capturing layers of understanding that traditional methods might overlook.

Similarly, the arts-informed approach provided a form of rich feedback on the course's impact: it shows not just that students know more about global engineering (cognitively), but that they can envision and value it in practice. This kind of outcome is particularly important for education aimed at attitude and mindset change, not just technical knowledge.

There are several implications from this study. First, incorporating arts-based assessments can be highly beneficial in engineering programs. The drawings yielded insights into student learning that complemented traditional metrics. Educators could consider using similar drawing exercises or creative reflection prompts to gauge students' evolving attitudes toward topics like critical thinking, communication, or teamwork, which are hard to measure, and quantitative measures might not provide the full picture. It provides students an opportunity for reflective expression and provides instructors a window into student thinking that might otherwise remain hidden, which also ultimately leads to learning gains. Second, the success of the course in expanding students' conceptual horizons underscores the value of explicit global engineering curricula. Programs looking to produce workforce-ready engineers should invest in courses or modules that tackle global issues, intercultural training, and collaborative projects. The evidence suggests students are receptive to these topics early in their studies; even by the end of freshman year, they can appreciably grow in these dimensions. Third, our findings highlight certain areas that might need reinforcement. For example, while many students did include ethical and environmental concerns after the course, not all did, indicating some variability. Future iterations of the course might place even greater emphasis on, say, global engineering ethics to ensure every student grasps its importance. Additionally, the persistence of some technical-centric views in a few post-course drawings reminds us that integrating technical and social understanding is an ongoing process; curriculum designers should strive to weave global perspectives throughout technical courses as well, so that students continually practice thinking in this integrated manner. Future studies could incorporate quantitative analysis to identify patterns, test relationships, and generalize findings for specific global competencies in larger courses.

In conclusion, this research demonstrates how engineering education can cultivate students' global collaboration skills and cultural awareness as essential components of the engineering profession. It also highlights the value of an arts-informed qualitative approach as a powerful way to capture and evidence student learning in the development of global engineering competencies. It reinforces the idea that educating engineers for the 21st century must go beyond technical training to include global competencies and the ability to understand and work within the diverse human contexts, an aspect that defines today's engineering challenges. It also provides a call to emphasize the importance of socio-technical thinking as

a way of integrating both fundamental principles with real-world societal, cultural, and political issues. Incorporating global competency, intercultural understanding, and ethical leadership in the engineering curriculum can enhance the way we prepare students not only to be better engineers but to be problem-solvers who can contribute positively on a global stage. This study revealed that students' visual conceptualization of global engineering is a testament to the transformative potential of a well-crafted educational experience, encouraging educators to continue innovating in pedagogy to develop the next generation of globally competent engineers.

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