Global Engineering: What do We Mean by It and How are We Preparing our Students for It?

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Global Engineering: What it Means at University of Colorado Boulder, and How We are Preparing our Students for It

Introduction

The world's increasingly global economy has created a steadily growing market for engineers who can work in a globalized environment (Jesiek & Beddoes, 2010). The need for such engineers has increased even more rapidly in developing nations where population growth outpaces technological solutions. To be competitive both at home and abroad, American engineers must learn how to interact productively with people from a range of cultures and customs (Ball, Zaugg, Davies, Tateishi, Parkingson, Gensen, & Magleby, 2012). American education must produce global engineers.

Unfortunately, there is no standard definition of *global engineer*. A recent literature review reveals the extensive debate about this term. (See Jesiek, Zhu, Woo, Hompson, & Mazzurco, 2014; also see National Research Council, 1999).

A small group of faculty and staff at the University of Colorado Boulder (CU Boulder) has adopted a functional rather than an essentialist definition. For them, a global engineer is someone who practices engineering in the following way:

1. with forethought of its far-reaching consequences, both physical and social;
2. with an appreciation of international colleagues and/or in international offices; and
3. with cultural sensitivity, so that personal interactions are both pleasant and effective.

People who practice this kind of engineering must have tremendous personal and intellectual flexibility. In order to consider (1) the far-reaching consequences of their actions, they must step out of the present and into the future—and yet they must be willing to study the past for the lessons it can impart. To evaluate consequences fully, they must consider both physical and social contexts—not just local and national, but also international and, indeed, global. Evaluating far-reaching consequences will be easier for those who engage (2) the joint efforts of an internationally diverse team—one that includes both local and non-local participants. Such a team will be effective if its members work with (3) international cultural awareness and sensitivity.

A global engineer is thus an intellectually flexible, highly evolved individual who is completely at home wherever engineering is practiced: a person who creates effective solutions by considering problems in multiple contexts and through multiple lenses. Such a person has learned how to negotiate engineering complexity as well as cultural complexity, and can therefore arrive at solutions that are physically robust, economically feasible, aesthetically pleasing, ethically sound, and culturally sensitive.

But can this nexus of characteristics be taught? And if so, how?

At CU Boulder, faculty and staff have decided that the answer lies not in a single course or semester, but over several semesters, in a new Global Engineering Minor (GEM). They believe that this new minor can prepare students for the extreme versatility and universal effectiveness

that global engineering requires. The present paper describes this new minor: its origins and evolution, its current design, and its newly designed gateway course. The paper ends by anticipating the influence of this course within the minor and on the students who take it. That is, the paper will address what "global engineering" means at CU Boulder, and how we are preparing our students for it.

Origins of the Global Engineering Minor, or GEM

The current GEM is the merger of two earlier certificates: one in *international engineering* certificate and one in *global engineering*. Those two certificates had very different goals: the former emphasized foreign language and culture, whereas the latter emphasized the skills needed to practice engineering domestically or abroad with a multicultural team. The story of their merger must begin with the certificates themselves.

In 2003, the College of Engineering and Applied Science attempted to implement the International Engineering Program developed by the University of Rhode Island: one originally envisioned to lead to dual degrees in engineering and a foreign language (University of Rhode Island, 2017). At CU Boulder, the dual degree option did not gain a foothold, and since language minors were not offered at that time, the CEAS International Engineering Certificates (IECs) were offered primarily as an alternative academic credential in language. The first IECs at CU Boulder were offered in French, German, Italian, and Spanish and required specified third-year language courses and culture courses (University of Colorado, n.d.). These Certificates, however, remained completely separate from engineering; they did not require any engineering coursework and were in no way integrated into the engineering curriculum.

A decade later, in fall 2013, faculty and staff of CU Boulder's Mortenson Center in Engineering for Developing Communities decided to create a new certificate to support professional skills development for the international practice of engineering. Guided by the research cited in the Introduction above, they created the Global Engineering Certificate (GEC). It still required advanced study of some language, but its goal was to develop student understanding of global economics, governance, history, and culture. To this end, this new certificate guided students towards pre-approved social science and humanities courses relevant to the practice of global engineering (University of Colorado, 2016). The certificate required the following:

- one upper-division course in world language;
- one course in intercultural communications, development, economics, or history;
- two courses in international culture, sociology, or governance;
- and a technical elective course generically described as "focused on global engineering" (University of Colorado, 2016).

During the next two years, however, this second certificate, the GEC had very limited success: it attracted only a dozen students. In retrospect, the reasons for this are clear. The Certificate lacked a strong unifying theme and it did not initiate students into what global engineering meant. It recommended courses based on their relevance to the practice of global engineering, but it offered no context within which students had to reflect seriously on global engineering itself. Consequently, students did not connect their coursework to global engineering and to their identity as engineers.

Besides suffering a lack of focus, the GEC suffered a severe identity crisis, in that students, faculty, and staff repeatedly confused it with the IEC. There was no obvious difference between the terms “International” and “Global.” The contrast was further blurred with the opening of a new Global Engineering Residential Academic Program, since it highlighted the importance of world language acquisition by engineers, rather than professional skills for navigating intercultural workgroups (Anas, 2013; Sieber, 2013; Zurier, 2014). It did no good for the GEC faculty to emphasize that their new Global certificate did *not* focus on foreign culture and language, when the new Global RAP did exactly that!

In spring 2015, the staff managers of both the GEC and the IEC decided to combine the two certificates. The then-Dean of the College of Engineering and Applied Science suggested that they be merged into a global minor, on the supposition that minors held more academic credibility than did certificates. So began a nine-month process to examine the true goals of the two certificates and to create consensus about how to meet those goals. This was a truly remarkable instance of collegial creativity, where there might have been a turf war. The result of this merger of two pre-existing Certificates was the new Global Engineering Minor, or GEM—the real subject of this paper.

This new minor, the GEM, unifies many features of the two certificates, while also creating its own identity. It requires the completion of 15 to 18 semester credit hours plus an immersive international or intercultural experience for every student. The following list of requirements gives more detail:

- elective courses in foreign culture and foreign language. This requirement echoes the IEC, but it includes the stipulation that culture courses must include both national and regional cultures. (International students have some different requirements, since they are already studying a foreign culture and language—to wit, American culture and English language.)
- a suitable technical elective. This echoes the original GEC, but the GEM’s electives must explicitly combine technical and non-technical aspects of engineering.
- a global experience typically involving an international study or work project. This was an option associated with the original IEC, and proposed as the post-graduate goal of the GEC, but now it is an integrated and essential requirement for the new Minor.
- a new gateway course to give GEM students a common focus. This course orients students towards the program’s definition of global engineering. It encourages students to gain cultural awareness, not just by taking non-STEM courses, but by synthesizing non-STEM courses into a more “global mindset” based on “appropriate cultural and historical knowledge” (Jesiek et al., p. 3).

Collectively, these requirements can be considered as antidotes to the typical undergraduate curriculum of disconnected coursework. (These requirements resemble those at other engineering colleges across the US; they were determined after benchmarking similar programs at other institutions, such as Carnegie Mellon University (n.d.), Clemson University (2016), Drexel University (2016), and Purdue University (2016). Considerations included curricular and extracurricular content as well as student outcomes.)

Although the new Minor differs from both antecedent certificates, many courses identified as Certificate options continued as options for the new Minor. Some certificate students thus found that they had already made significant progress towards the Minor prior to its official initiation in fall 2016, and they were willing to fulfill the additional requirements in order to get the Minor. Other students chose to stay on-course for their Certificate and not switch to the new Minor.

There was some discussion about requiring GEM students to take a first-year projects course. Like many other engineering colleges, CU Boulder has established a strong first-year projects experience to introduce students to the varied contexts of engineering, including consulting, design, and manufacturing. The projects course also initiates first-year students into group-based design experiences where the individual student does not control group formation (Knight, Sullivan & Louie, 2007), and where all groups follow the design/build/test process that requires teamwork skills. All of these features help to ground first-year students in actual practice—relevant to the GEM but hardly unique to it. Beyond that, though, several sections of the course assign projects that address developing community problems. Such projects have included re-use and re-purposing of waste material as fuel briquettes, simple ways to purify water, or methods to recharge cell phones in remote regions. Students working on these projects often become deeply committed to bringing positive change to developing communities. At the end-of-semester public design expo, such projects attract excitement and public admiration; they also generate a certain envy from students who worked instead on 'first-world problems.' Even though such projects courses dovetail with the goals of the GEM, it seemed pointless to make the projects course a GEM requirement: most students would take a projects course anyway, and many students gained interest in global engineering only after their projects experience.

Aside from the projects course, though, lower-division engineering courses—packed with foundational STEM concepts and formulas—do not offer students much opportunity for the complexities of engineering decision-making. It is only later that students begin the judicious weighing of conflicting desiderata. Even in the purely material realm, this activity poses significant design challenges; making a car both fast *and* roomy, for example, requires critical evaluation of technical trade-offs.

The GEM includes at least one *technical elective* that goes beyond the purely technical, however, to include evaluation of social trade-offs. For example, making a car fuel-efficient and *safe* involves more than a physical analysis. It raises questions about risk-tolerance and risk-aversion; it obliges designers to weigh cost against danger to human life. The GEM designers want students in the minor to get plenty of practice with this kind of complex analysis. The GEM-approved technical electives thus include both social and technical considerations. Examples include *A Systems Approach to Global Engineering; Water, Sanitation and Hygiene; An Interdisciplinary Approach to Energy and Climate Change,* or *Energy and the Environment*. Such courses encourage students to appreciate the technical and social complexity of actual engineering practice in these fields.

Social complexity increases exponentially when engineers practice outside their native cultures and languages. This complexity is vividly conveyed in the immersive *global experiences* required as part of the GEM. In these, complexity does not detract or distract from the educational content; rather, complexity *is* the educational context. Global experiences can include involvement with transnational non-profits such as Engineers Without Borders-USA

(EWB-USA) and Bridges to Prosperity (B2P). CU Boulder has strong chapters in both programs. GEM students are encouraged to join these groups, even if they cannot travel abroad (due to limited student funds or to limited project size). CU Boulder is the birthplace of Engineers Without Borders-USA. In fact, founder Dr. Bernard Amadei teaches here and continues to advise and inspire members of the local chapter. He is also the faculty director of the GEM and his presence generates tremendous interest in global engineering.

The GEM offers considerable flexibility by accepting a variety of immersive activities as global experiences. For example, it accepts international internships or the more conventional study abroad programs. The latter might not offer hands-on engineering experience, but they abruptly throw students into the deep end of cultural difference. The GEM also requires cultural courses with a local, regional, or global focus, including topics such as exploring non-Western cultures and introductions to various civilizations and cultures. In this respect, the GEM transcends the earlier IEC, with its emphasis on only one language and one culture, and it transcends the GEC by making international experience part of the undergraduate experience.

The GEM also offers flexibility in terms of timing: it enables students to take their courses and immersive global experiences when these are most convenient. This is especially important for students who must earn money for their college education, or who have other internship opportunities here in the United States. The downside of such flexibility is that the Minor risks losing cohesion. The various GEM students might never meet each other; their experiences of the program and of cultural study could be widely different; they would not even share the same definition of 'global engineering.' That is why the Minor includes a gateway course—one that can impart the three components of global engineering described earlier in this essay:

1. a sense of engineering's far-reaching physical and social consequences,
2. an appreciation for working with colleagues from other cultures, and
3. cultural sensitivity, for collegial interaction and for effective outcomes.

The GEM designers wanted this gateway course to accomplish at least the first and third of these goals. (The second seemed difficult to accomplish in a classroom, unless it had a multi-cultural enrollment, and this could not be guaranteed.) The gateway course could do more than offer a common curriculum; it could inspire a sense of community among the GEM students. This gateway course, *A Global State of Mind*, debuted in fall 2016. This paper will now address the gateway course in detail: its origins, its components, and its impact.

Developing a gateway course for the Global Engineering Minor

What kind of course would the GEM gateway be? There were many possible options. A course in cultural communications would be fascinating, though it would lack the historical context necessary for true global awareness. A course in cultural difference would be fun, but not deeply challenging or clearly connected to the professional skills engineers need. A course in international finance would be immensely valuable, but not if it were dissociated from politics, history, and the environment. The GEM founders, primarily engineers, asked a humanist for advice: Dr. Leland Giovannelli, of the Herbst Program of Humanities, within the College of Engineering and Applied Science. Her strong interdisciplinary background in humanities and the history of STEM, plus her life-long interest in other cultures led her to accept the challenge of

creating the gateway course. In the spirit of Ball et al. (2012), she designed a course that had as its primary goal inviting students to explore *their own* cultural practices.

The course was designed as an interactive, three-credit-hour interactive lecture format. The syllabus had 15 weekly units, outlined here in brief.

- Units 1-3 offered a brief history of the world through about 1600, grounded in Jared Diamond's (1999) thesis on the rise of agriculture.
- Units 4 and 5 introduced the themes of comparative religion and cultural conventions.
- Units 6-8, the second historical segment, included the Industrial Revolution, 19th-century imperialism, and post-colonial nationalism.
- The previous historical and cultural units laid the groundwork for Units 9-14, five weeks on economics, 20th-century politics, the environment, and 21st-century global forces.
- The last week was spent on review.[i]

The course texts included Steger's *Globalization: A Very Short Introduction* (2013), the Rand McNally *Historical Atlas of the World* (1994), Daniel Quinn's *Ishmael* (1995), and various online sources.[ii] The main text, though, and the one designed exclusively for this course, was a *Course Reader* (Giovannelli, 2016) of 123 pages, with 125 short texts from history, religion, philosophy, literature, anthropology, and so on. Dr. Giovannelli chose these texts for their capacity (a) to inform readers about other perspectives on ordinary life or on the human condition and (b) to reveal the reader's own cultural preconceptions. The following examples will illustrate these characteristics.

On the first day of class, the students read a *Course Reader* (Giovannelli, 2016) text from Augustine, a North African theologian from roughly the year 400 CE. This brief selection runs as follows:

> Ambrose was a great man, but not an arrogant one; anyone could approach him freely. Since his guests were not commonly announced, they often came upon him reading in his study. When he read, his eyes scanned the page and his heart sought out the meaning, but his voice was silent and his tongue was still. Yes, he read *in complete silence*. (Augustine, 1963)

Dr. Giovannelli asked students to discuss this in pairs or trios. At first, there seemed nothing to discuss, since reading "in complete silence" is the norm in American schools and colleges. Then the students realized the implication of Augustine's surprise: in his world, apparently, *reading* meant reading aloud.

This text not only presented cultural difference, but also revealed to students their own strong preconceptions, and raised questions about the cumulative effect of such differences. The whole class was intrigued by Augustine's text—even the few seniors and juniors who had switched from a certificate program and were taking the class as a GEM requirement. Thus engaged and challenged on the first day, these older students felt reassured that this final requirement was not going to be a waste of their time.

This text was important for another reason: it offered a very concrete cultural difference without a correlative sense of cultural comparison, reproach, conflict, or guilt. There was no right and wrong here. This cultural difference, precisely because it was neutral and unthreatening, could safely become emblematic in the class for all cultural differences—seen and unseen, large and small, ours or theirs.

Other *Course Reader* texts offered similar new insights on similarly unthreatening subjects, such as whether one should hang a painting, and if so, where, and whether the French revolution was a recent or a distant event. These texts were interesting and engaging without being particularly provocative. They were risk-free, safe, and gentle.

Other texts addressed social injustices; though their age rendered some of these apparently harmless, they often carried a sting. At first, for example, students felt insulated from a late 19th-century argument that marriage was a sex-contract conducted in a one-sided marriage market (Gilman,1898). They believed that no American woman followed the antiquated code of waiting around for a man to propose marriage. Then, to no apparent purpose, Dr. Giovannelli related that she had proposed to her husband. The students laughed—until she asked them to deconstruct their own laughter. What was so funny, after all? This question forced students to confront their preconceptions; it shattered their complacency about American gender liberation. This critique of courtship, though over a century old, was not merely "still relevant," as they had somewhat smugly supposed; it was disquieting and painfully instructive. This episode, by exposing and helping to break down presumptions of cultural superiority, was crucial to student intellectual growth and self-awareness.

Still other *Course Reader* texts addressed cherished American values. When Sitting Bull (c. 1882) declared that he would rather die than be restricted to a reservation, the students warmly embraced his love of liberty. When he described white men as *slaves* to their cities and farms, they felt a definite chill; he was indicting all post-agriculturalists. This invited serious discussion of liberty as a cultural imaginary. Another unsettling text was Rabindranath Tagore's (1917) early 20th century indictment of American materialism. Though deeply challenged by these texts, the students yet remained receptive to them. Dr. Giovannelli credits this to that first unthreatening text on day one: to Augustine's observation of a silent reader.

The *Course Reader* (Giovannelli, 2016) also provided a list of *cultural dimensions* (from Geerte Hofstede, 2005), i.e., of over-arching cultural characteristics. These include, for example, how a culture deals with time or space; how a culture regards honor, power, or identity; whether the members of a culture operate as a collective or as individuals; and to what extent the culture practices long-term or short-term planning. Each week featured one specific cultural dimension, strategically paired with that week's content.

For example, the week on the Industrial Revolution featured the cultural dimension of time, or chronemics. British industrialists of the 19th century prized punctuality and efficiency, and they brought these values to their colonies around the world, whereas non-industrialist cultures continued to judge experiences by quality rather than by duration. The industrialist attitude towards time thus arose out of specific socio-cultural forces and became part of the imperialist narrative of justification; it was not merely a neutral way of describing sequential events.

The week on comparative religion was paired with the cultural dimension of uncertainty avoidance. For many students, this pairing seemed obvious: a person *seeking to avoid uncertainty* would "naturally" turn to God. They were surprised by Francis Bacon, co-founder of the modern scientific method, when he urged that science should be conducted "with a religious care." Only then could observation eliminate uncertainty (Bacon, 1978, p. 26). By contrast, the unit's texts on Taoism and Buddhism welcomed uncertainty and ambiguity. The texts in this unit, too, invited discussion of the human condition, while also revealing students' assumptions about religion and uncertainty avoidance.

The same unit on comparative religion helped illustrate the variety of human experience on a single topic. An online chart of world religions included a wide range of faiths—and, with an even hand, reduced them all to a few sentences each. In the Reader, students encountered Francis of Assisi conversing with birds (Francis of Assisi, 2003) and also Jonathan Edwards threatening imminent damnation (Edwards, 2005). Finally, this unit demonstrated the historical relevance of religion and the inter-connectedness of the course: the theme of religion surfaced in conjunction with trade along the Silk Road, the Iberian conquest of the Americas, Tagore's (1917) denunciation of nationalism in post-colonial India, and Benjamin Barber's (1992) provocatively titled essay, *Jihad vs. McWorld*.

The lessons of these cultural dimensions were thus spread over the entire semester, not only because each week brought a new dimension, but also because each new dimension was inevitably linked to dimensions already discussed. Consequently, the dimensions were absorbed gradually, and thus had a good chance of being retained. Collectively, these cultural dimensions provided a valuable introduction to cultural difference in general, making students feel less like detached tourists and more like participants. Each week brought new analytical skills, and successive weeks brought new opportunities to use those skills and gain deeper insights. By becoming aware of chronemics, for example, students could reflect on their own habits related to time. In the subsequent week, they retained their perception of chronemics as they explored proxemics, or physical proximity. They then advanced to new units capable not only of recognizing chronemic and proxemic differences, but also of assessing how these contribute to their own sense of reality, to cross-cultural misunderstanding, and to organizational dysfunction.

Linguistic cultural difference proved to be an especially intriguing case. Of the 29 persons in the room, at least one spoke French, Spanish, German, Italian, Arabic, Japanese, Chinese, Hindi, and Tagalog. The students eagerly sought information from each other, and each answer led to a new question. For example, once they knew how to express respect in a particular language, they wanted to know how a rebellious teenage might express *disrespect*. They contemplated the metaphor that vanishing languages are like endangered biological species. They then studied the argument that linguistic extinction is worse than eco-extinction, since world-views that might diminish eco-extinction might be contained in those vanishing languages (Mühlhaüsler,1994). To make this less abstract: some languages do not make a strong distinction between active and passive verbs. The people who speak these languages tend to see action as *interaction*, and therefore tend not to divorce actions from their consequences. These people are less likely to dissociate themselves from the natural environment—and to that extent, so the argument goes, are far less likely to destroy it. This is food for serious thought, and it reflects the spirit of the course as a whole: information not for curiosity's sake, but for its potential to provide insight into a greater subject.

Extensive use of the Rand McNally *Historical Atlas* (1994) helped students piece together a continuous narrative when other readings made sudden leaps: geography was the common ground, literally, that connected empires and eras. The *Atlas* certainly economized explanations of political history by showing the growing and shrinking size of various successive empires. It also revealed, with painful clarity, some consequences of *Realpolitik* from the late 19th century: African nations are today living out the bloody consequences of European boundaries that were made without regard to local ethnicities.

Discussing these boundaries led to considerations of physical distance as a dehumanizing factor in making political decisions from one continent to another. The discussion of territorial distance led to the discussion of the cultural dimensions of physical distance and of power distance. These dimensions, in turn, illuminated the potential for grievous cultural clash: in some cultures, one shows respect by standing for a superior; in others, one shows respect by sitting. This and other short case studies did not merely inform students about varieties of "otherness." Rather, these examples confronted students with the practically inevitable prospect of unwittingly violating social conventions in other cultures. They realized that, while mere apologies could not mend such breaches of etiquette, increased awareness might serve as a guide to negotiating uncertain terrain. Just knowing enough to ask might save much cross-cultural tension.

Students encountered post-colonial echoes in the film *When We Were Kings* (Gast, 1996), about American boxer Muhammad Ali's "Rumble in the Jungle." When heavyweight champion George Foreman took his German shepherd dog to Kinshasa, he unwittingly offended his hosts who remembered all too well the Belgian militia's use of these dogs. This one example very effectively alerted students to the dangers of cultural insensitivity; they do not know all of the cultural details of every nation of the world, but they now know, acutely, that even the slightest gesture can be fraught with meaning.

The thread did not end there, though. Discussion of another cultural dimension—high vs. low context—revealed that the innocent request for information or procedure might be counter-productive. A well-intentioned American, eager to reach a simple resolution, might ask, "Is there anything wrong with what I am doing?" The gracious host *must* reply to this question in the negative. This leaves the well-intentioned American reinforced in error, and that much further from understanding.

This issue hit close to home for the students in the class who had participated in EWB-USA or B2P. These students related some triumphant experiences. They also related some painful and uncomfortable questions: *Do I know what this community regards as the problem? Does this community want help from <u>me</u>, an American? To what extent does my cultural background undermine my chances for communication?* And even: *To what extent is my desire to help a function of my own need to be helpful?* In sharing their self-doubts, these students gave their classmates a powerful lesson in understanding oneself: the Socratic command to know the Self must include knowing one's motives with respect to the Other.

Such questions underscore an important feature of the course: its goal was not universal praise for all things international. It was not possible or even desirable to embrace all cultures. It was important, however, to try to *understand* them, and to try to understand the self *in relation to them*. Once again, the methods of this course were tied to the global competencies of Ball et al.

(2012) who reported that "it is highly unlikely that individuals can find agreement among all cultural differences, but rather it is almost certain that there will be elements that differ among cultures about which there is disagreement" (p. 158).

The ideas of Donella Meadows (2008) proved extremely helpful in trying to understand all of this cultural difference and dissonance. Key ideas from her *Thinking in Systems* gave students the tools they needed to parse out factors in cultural encounters that went awry. Cultural difference could be understood as an input to a system of misunderstanding, in which subsequent cultural miscommunication could be seen as contributing to a feedback loop of increasing divergence and even hostility.

The students

It is impossible to give a full account of the course without speaking of the students in this class. They were astonishing: widely travelled, broadly interested, consistently engaged, and full of good will. Their enthusiasm, energy, intellectual excitement, and frank appreciation were vitally important to each class meeting—and these all contributed to the feedback loop of the course's increasing success over the semester. Consequently, each student was able to report tremendous educational gains. Meeting one-on-one with Dr. Giovannelli, especially when planning the final essay, students stated that they now saw how complicated and interconnected everything was, and not just in terms of physical or environmental repercussions. They now realized that surrounding *each physically and technologically complex engineering problem* was a web of historical, social, political, economic, and cultural complexities. Seeing themselves as culturally determined beings, they began to understand their own reactions to others.

Anonymous course evaluations were filled out in the penultimate week of the semester, and Dr. Giovannelli received them six weeks after the end of the semester. The course evaluations were extremely positive, giving the course a 5.9 out of 6.0 final rating. Twenty-one students submitted final course evaluations, and each of them wrote individual comments. The eleven most relevant comments follow here—but these are by no means the only favorable ones.

1. This was my favorite class this semester, I loved the reading and articles and topics that we discussed, which forced me to challenge my own ideas. This course made me excited for a future in engineering and made me want to stick with it.
2. …You made me excited about things I used to find trivial or boring...
3. I really had no idea what this class was going in. I expected something more like analyzing cultures from around the world, but this class gave me the tools to do this, and I think that's what's most important.
4. Favorite class in college so far. You encouraged me to think deeper and learn more.
5. …This course to me overall is perfect for students who are looking to develop and forge a global mindset. Getting more empathy by understanding that all the cultural dimensions are alive in every culture…
6. …We learned about interesting and applicable concepts and the course material was extremely valuable to my personal growth.
7. I absolutely loved this course. The material challenged me to become aware of myself and my perspectives and how they differed from others…
8. …Thanks for an amazing semester and opportunity to challenge my thoughts/biases!

9. …This course taught me how to learn more than any class I have taken in the past. Keep up the good work.

The next two comments deserve special notice. In the first of these, the student truly embraced the diversity in the classroom. With no disrespect to Dr. Giovannelli, this student simply regretted not having learned more from the other resources in the room:

10. …This course attracts the most interesting students in the college. I wish I heard more about their lives and passions. Maybe 5 minutes of each class, a student should go up, introduce themselves, and describe an element related to global engineering that they are passionate about. Student interaction is crucial to the course, so keeping class numbers small would be wise. Thank you!

Finally, this student offered a powerful statement about cultural awareness, and one fully endorsed by the authors:

11. Awesome class…. I loved the extremely varied readings… As a senior in a gateway course, I still felt mentally stimulated and took away a lot from the course… Anybody who wants to go abroad should enroll in this class.

This student felt that *any* engineer seeking to study, travel, or work abroad, must study globalization, not merely as an academic subject, but as a discourse between the Self and the Other: from one's own perspective as a member of an individual culture within a multicultural world.

Attaining the course goals

Experientially, the course was a complete success. To give a more critical evaluation of its impact, however, it is worth revisiting the goals of the GEM. These were to instill in engineering undergraduates the following three outcomes:

1. a sense of engineering's far-reaching physical and social consequences,
2. an appreciation for working with colleagues from other cultures, and
3. cultural sensitivity, for collegial interaction and for effective outcomes.

The gateway course was designed to contribute to the first and the third of these goals. The evidence suggests that the course encouraged students to think about far-reaching consequences, both physical and social, and inspired a deep cultural sensitivity.

The course accomplished more than was planned, however, by being a sort of immersive experience right here at home. In this internationally diverse classroom, within a college and university that aspire to be ever more ethnically diverse, students felt strongly cooperative, both intellectually and culturally. As the discussion on language revealed, diversity enhances greater understanding, and sometimes *urgently needed* understanding. Students thus could explore course material in the personal and cultural contexts that they themselves provided. Through this, they increased their cultural sensitivity towards others—both towards their classmates, and towards that distant and unknown Other.

They also gained cultural sensitivity *towards themselves*—though this might seem a strange concept. As Ball et al. (2012) suggest, "An individual must know and understand his or her own culture before they can compare and contrast it with another." Part of understanding is accepting. This enabled them to confront themselves both more objectively, i.e., less defensively, and also more sympathetically, as when viewing any human being shaped by culture. Moreover, many students indicated in their final essays their intentions to approach cross-cultural encounters with greater patience and creativity: patience in teasing out complex layers of meaning, and creativity in responding as flexibly as circumstances permit. Thus, the course did more than create a sense of culture and a sense of academic community; it created a sense of cultural community, and it created a desire to work with and learn from people from other cultures.

From global awareness to an appreciation of the complexity of global engineering

One of the course's major themes was the search for unintended consequences—not just locally, regionally, or even nationally, but globally. Although Dr. Giovannelli, not being an engineer, had not intended to make that case for engineering practice, the students applied this search to engineering itself. They needed no coaxing to see the connection between this course and their future professions; they needed no coaxing to see that *global* complexity included engineering complexity. They themselves saw that global engineering was practiced in a nexus of conflicting influences, desiderata, and consequences. They saw that global engineering included global complexity, as well. Complexity itself proved to be a feedback system. Indeed, complexity proved to be the hallmark of this gateway course, even though this was not its purported content.

Looking ahead

In light of these successful outcomes, Dr. Giovannelli and the designers of the GEM do not feel compelled to make any major revisions of the course design. On the other hand, there is room for improvement.

Dr. Giovannelli intends to include student and guest presentations on initiatives in global engineering. These could include:

a. reports from older GEM students who have already completed their global experience in *B2P*, *EWB-USA*, or in similar programs;
b. presentations on projects being carried out by professors and graduate students at CU Boulder or at other universities;
c. presentations on various enterprises in global economy, art, music, etc.
d. presentations on various movements in global politics, human rights, religion, etc.
e. presentations on global ecology, including topics such as the Great Pacific Garbage Patch, the life-cycle of various objects, international ecological initiatives, etc.
f. opportunities for each student to give a 2-minute autobiographical introduction with explicit reference to global interests and experiences.

All of these would greatly enhance the content of the course as well as accomplishing two additional functions: (i) they would increase the opportunity for individual students to make their mark on the class as a learning experience, and (ii) they would model one of the core values of

the course: that solutions emerge from the contributions and shared expertise of all members of a community.

Another plan for the future is to create a robust interactive community from the successive cohorts of Global State of Mind students—that is, a thriving and interconnected community of GEM students. The gateway course helps current students create a coherent, integrated, and personally relevant definition of global engineering. The discussion generated in that course can continue whenever the various cohorts meet and mingle. Of the initial cohort's 27 students, most are lower division students who will be at CU Boulder for several years to come. Their participation would be instrumental in creating and continuing a GEM community. Social gatherings at the outset of the fall semester and at the end of the spring semester could bring new and prospective GEM students in contact with continuing GEM students. At such events, GEM students with "global experiences" could share them with the group. Alumni could be invited back to discuss the long-term impact of their work with B2P or EWB-USA. Positive communication and collaboration, mutual appreciation, and global awareness would be essential features of all such events. In short, the admission price would simply be a global state of mind.

Summary

The Global Engineering Minor was heir to two certificate programs: one, focused on a particular culture and language, and the other a list of courses useful to practicing global engineers. The narrow nationalism of the first and the diffuseness of the second were their drawbacks. They did not provide the students with a perspective at once global and coherent, and they did not challenge the students' own cultural beliefs.

The GEM combines their virtues and also exceeds them. It requires language study, but encourages reflection on linguistic difference and its consequences. It requires study of a national culture, but does not allow students to rest in just that one culture; rather, it includes coursework at the local, regional, national, and global levels. The GEM student cannot float as a world tourist, above and equally distant from all cultures; rather, she must negotiate the territory between these levels.

The GEM's gateway course systematically challenges students to become aware of their own cultural beliefs and practices, and to see them in relation to the beliefs and practices of other cultures. The Reader's texts, starting with Augustine's silent readings, offered repeated opportunities to come upon oneself by surprise, as it were, and each unit gave students new skills by means of which to scrutinize that newly revealed self. Each unit's skills prepared for the challenges of the next unit, so that, by the end, each student felt equipped to grapple with the complexity of global engineering and also to reflect on its many meanings, consequences, complications, and personal connections.

The GEM does not simply push students towards lists of Humanities and Social Sciences courses in the hopes that students will eventually understand their relevance to global engineering. Rather, the GEM offers the gateway course as a means of approaching these fields and exploring their relevance to global engineering. The skills learned in this course will enable students to synthesize later Humanities and Social Science coursework into an increasingly rich and

complex “global mindset” (Jesiek et al., 2014). This seems the appropriate outcome for the course, and the right kind of gateway for the GEM as a whole.

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[i] Assessment included daily discussion of reading/viewing assignments, three in-class tests, five written assignments (including a final essay on the impact of the course), and a final exam.

[ii] Secondary sources were listed in the weekly assignment sheets and posted on the university's learning management system platform. These included scholarly and popular articles (in full or in part) in anthropology, psychology, intercultural communications, global studies, economics, etc.