Supporting global competence learning for engineering students: Four key lessons (to be) learnt

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ABSTRACT

Global competence is an essential attribute for engineering graduates working in an interconnected and culturally diverse world, and higher engineering education needs to adapt to ensure that their students will acquire it before entering the labor market. For universities, the only way to ensure comprehensive global competence learning for all students is the holistic integration of related learning outcomes throughout curricula – which requires engineering educators to be able to (re)design their courses and programs accordingly. Considering that most engineering educators are subject experts of their discipline – but lay people when it comes to such competencies – we set out to compile a practical guideline for those wanting to integrate global competence learning within their disciplinary courses.

Following a participatory action research approach, we connected our own insights as global competence educators at a technical university with those of several cohorts of engineering educators and students enrolled in global competence courses. Synthesizing these insights, we could identify four essential lessons for integrated global competence learning: 1) learning opportunities can be found (nearly) everywhere, 2) relevance and authenticity must be emphasized, 3) theory and practice need to be integrated and 4) global competence cannot be taught, but it can be learnt. These lessons are illustrated with practical examples for fostering global competence learning in regular engineering courses.

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1 INTRODUCTION

Professional demands on engineers are evolving, and global competence has recently emerged as a key factor for ensuring that graduates can succeed in our interconnected and culturally diverse world. Following calls from industry to instill global competence – described typically as the knowledge, skills, and attitudes needed to collaborate with diverse others appropriately and effectively (e.g., [1]) – numerous institutions have begun efforts to introduce such learning into their curricula. While the exact competencies constituting global competence are still under debate, several authors have attempted to identify those relevant to engineering contexts. Some of the most frequently quoted and used conceptualizations are those developed by Downey and colleagues [2], Lohmann and colleagues [3], and Ball and colleagues [4]. While their ideas of competencies differ slightly, e.g., in how individual aspects are named, they all appear to revolve around the same dimensions: intercultural communication skills, openness and appreciation for others' perspectives, teamwork and leadership skills, adaptability to living and working in different contexts, as well as global awareness, and an understanding of how culture may affect engineering work.

Despite an increased attention to global competence learning in technical curricula, scholars still emphasize that engineering education needs to catch up to equip graduates with those practical competencies so demanded in industry [5, 6]. There is no denying that technical expertise constitutes the basis for engineering students' future employment, but for the time being, global competence is what will make graduates stand out among their highly-trained competitors on the global labor market [7]. For universities, well-known approaches thought to enable such learning are international mobility experiences such as studies, internships, service learning, or research abroad, or in some cases specific courses or modules on the issue. However, as typically only a small minority of students take advantage of such offers, and considering the need to foster global competence in *all* students, calls for more comprehensive global competence strategies have been made [8-10]. Key agents to achieve this goal are engineering educators who sensibly design their courses for integrated disciplinary and global competence learning.

This is, however, easier said than done; global competence learning is different from much other engineering learning, and any attempt to comprehensively integrate it with disciplinary technical contents requires careful consideration. A recent study by Passow and Passow [11] identified three principles for such curriculum design in engineering: 1) engineering practice extends beyond science-based tasks to both technical and social tasks critical to project success, 2) non-technical skills should be taught in context rather than in isolation, and 3) engineering education should display a greater connection to practice including authentic problem-solving, iteration, working towards a bigger picture, and realistic social dimensions (p. 501). Their work clearly shows how the traditional differentiation between hard and soft skills is outdated and an integrative approach to teaching competencies in context is needed. Considering that those aspects are interconnected in the professional world, such an approach should certainly be of interest for engineering teachers, as they are responsible to prepare their students for their future life as professionals.

However, with engineering educators themselves often being educated in a hard-science teacher-focused tradition, rather than an integrative student-focused pedagogy, these ideas of global competence learning may appear foreign, and can be perceived of as potentially troublesome ad-ons rather than as easily integrated aspects that ought to be part of their discipline. Additionally, considering the vagueness of the concept, its complex and multifaceted nature, and the fact that global competence goes beyond knowledge and also comprises attitudes and skills [12] educators wanting to practically work with it are faced with a daunting task.

Looking more closely at specific classroom environments that could support global competence learning, Mullins and Wood [13] suggested that lessons should be student-centered, authentic, contain continuous feedback, and provide students with clear expectations and opportunities to be in charge of their learning. Other important factors were pointed out by Atadero and colleagues [14], who proposed that academic activities fostering appreciation of diversity in engineering should be explicit in their intent while relevant to engineering, have a longer-term focus for sustained engagement with such issues, and measure the students' perceived links between engineering and diversity. While these suggestions provide useful contributions for global competence learning in engineering classrooms, they may still be too vague for non-experts, such as engineering educators, to practically implement

This paper aims to illustrate practically applicable guidelines for global competence education including crucial questions that educators need to reflect on when wanting to integrate global competence learning. Based on our own background as global competence educators and the practical insights and experiences from engineering educators and students at our home institution, this paper synthesizes insights from theory and practice and presents key lessons for the successful introduction of global competence learning within disciplinary engineering courses.

2 METHODOLOGY

We followed a participatory action-based research approach, which is characterized by the collaborative co-creation of knowledge with stakeholders to solve practical problems [15].This approach connects theory with practice and reflection, and, in our specific case, combined our own insights and experiences as global competence educators with those from engineering educators and students as stakeholders and experts of their discipline and classroom settings. Accordingly, we collected and synthesized both insights and best practices from literature with discussions and reflections of several cohorts of engineering educators and students enrolled in elective global competence courses at a large Swedish engineering university. This helped us in connecting the rather general insights from internationalization literature with the real-life contexts of engineering education. The result of our efforts is a practical and broadly applicable set of guidelines for integrative global competence learning in regular disciplinary engineering classes.

3 RESULTS AND DISCUSSION

Finding ways to instill global competence in students is already a challenging endeavor, but finding ways to ensure that engineering educators – whose teaching expertise lies in the technical rather than the social realms – can do that is on a whole different level. To support this process, we have connected theoretical and practical insights to create the four most essential lessons learnt for those wanting to foster global competence learning in their students: 1) learning opportunities can be found (nearly) everywhere, 2) relevance and authenticity must be emphasized, 3) theory and practice need to be integrated, and 4) global competence cannot be taught, but it can be learnt. In the following, we will elaborate on those four lessons and provide examples of how they can support the practical implementation of global competence learning within a wide range of disciplinary engineering classes.

3.1 Learning opportunities can be found (nearly) everywhere

The first lesson to be learnt – something that may otherwise be a perceived obstacle for engineering educators – is the fact that global competence learning might happen nearly everywhere. When thinking of global competence learning opportunities, many might first think of the classics: studies, internships, or field trips abroad or potentially even specific courses for students. While those certainly are great learning opportunities, they are not the only ones, and may in many cases only reach a small subset of students. A common misconception of many engineering educators and students is the idea that global competence just does not fit to, or into, specific engineering courses, particularly when it comes to highly logic- or science-based courses. However, we would like to introduce Kahn and Agnew's [16] poignant conclusion that "[n]ot all coursework needs to include global learning outcomes, but it is increasingly understood that all courses can be internationalized, including the hard sciences" (p. 58). When looking more closely at certain typical global competence learning outcomes, it becomes clear that even highly logic-based or technical courses provide opportunities for developing at least some competencies. To illustrate this better, we will take a deeper look at popular global competence learning outcomes, such as intercultural communications skills, openness and appreciation for others' perspectives, team-working and leadership skills, adaptability for living and working in different contexts, as well as global awareness and an understanding of how culture may affect engineering work.

Most of these competencies can be directly practiced through collaborations with diverse others, prime examples for such would be intercultural collaborations with other student groups (in person or virtually), as well as collaborations with industry partners or other stakeholders of engineering work, which is the focus of several service learning courses. Such learning opportunities bring students together with others from diverse backgrounds (e.g., national/regional, university, discipline) and introduce them to different perspectives, and in some cases even allow glimpses into different professional context, with their own rules and standards. For all these reasons, it is no surprise that such activities are often first thought of when it comes to integrative global competence learning. While invaluable chances for competence development, it must be considered that setting up courses including such activities involves much planning and resources, and the majority of these examples is only feasible for some courses and not others. The Covid-19 pandemic has proven that many courses could move to the virtual sphere, which in some cases attracted more external course participation – which would be very advantageous for especially those courses that otherwise would not allow much interaction with external actors.

Relatedly, another obvious learning opportunity potentially touching several of the social or interaction-focused competencies are cooperative learning, or group exercises, where diverse students will have to collaborate on problems together. Here it is important to note that in their everyday usage at engineering universities, some of the concepts we talk about are easily misunderstood or overgeneralized: *culture* may be interpreted as "people from different countries," and *diversity* may be equated with "people of different genders" or in some cases "people of different abilities." It should be clear that such isolated factors are not the sole defining aspects making up a person's perspective, and when global competence scholars talk about culture or diversity, they typically refer to a wide variety of factors potentially affecting one's viewpoint, including the aforementioned aspects, but also ethnicity, religion, education, discipline, professional background, and many others. Following this line of thought, it is easy to see that all classrooms – even those consisting of students having similar nationality, gender, or abilities, can be inherently diverse.

During discussions and the exercises themselves, students will have the chance to practice communication, teamwork skills, and conflict management, and they are likely introduced to diverse perspectives. By mixing student teams, and ensuring they interact with diverse others, a first step for global competence learning can be laid. Considering that the majority of engineering subjects allow for group exercises of some type, they are an easily implemented and non-disruptive addition to many courses. The engineering educators we talked with had at minimum small in-class group assignments or discussions, and several had students collaborate in labs or longer projects. They generally acknowledged the value of bringing students with different values, backgrounds and skills together to work on common problems, both for the potential for new perspectives and more creativity, and believing that working with others will prepare the students better for their professional life. This was, however, not always unproblematic, and conflict within groups was something both the educators and students were familiar with. A particular issue repeatedly highlighted was certain team members' lack of contributions, which the students found particularly frustrating when such behavior affected grades. Educators, aware of such conflicts, had different approaches to deal with this: some allowed students to choose their own groups in order to reduce conflict potential, others implemented group work reflection exercises to find out whether they should intervene, and others believed that students should learn to navigate such situations by themselves since they will have to do that later in their jobs.

For especially the knowledge-based competencies, a fruitful way to introduce new perspectives and widen students' horizons is by careful selection of course materials – for one, course readings or case studies could be chosen to represent the perspectives from authors from around the world. Additional discussions on how engineering is done differently around the world, examples could be the introduction of different engineering cultures and, if applicable, professional standards and regulations. The mutual interaction between historic, socio-cultural, or economic aspects and developments of the field may also be easily integrated in a variety of different subjects. For almost all disciplines, the history of how the field developed – and where it may be headed – may also comprise relevant knowledge and support a deeper understanding of the subject. If planned carefully, also insights into historical or societal contexts affecting the field could be incorporated in this regard. Another very contemporary approach could be in illustrating the potential connections of the basic science concepts of the field and local, international, or global challenges [16].

3.2 Relevance and authenticity must be emphasized

The second lesson for integrative global competence learning revolves around its perceived relevance and authenticity. The importance of global competence for professional practice has been acknowledged by universities, but the longstanding approach to solving that – the classic distinction between hard and soft skills – is now recognized as outdated, as it both differentiates between aspects that are connected in practice, and wrongly implies little diligence or depth to the "soft" aspects of the profession [7]. From a linguistic perspective, competence notions on the other hand may appear more pertinent to engineering education, but that should not distract from the fact that students, who may have a certain image of engineers as pure technologists in mind, may not immediately recognize their importance.

To ensure students recognize the value of such learning and develop the necessary motivation to hone their competencies, it is imperative that their disciplinary of professional relevance is *explicitly* clarified by the educator [10]. Many of the educators we spoke to had clear ideas and motivations behind the assignments they gave to students, particularly in terms of communication and collaboration, but did often assume the students' understanding of these benefits rather than being explicit about these goals. Moreover, if global competence learning is to be integrated with regular disciplinary learning, an additional factor to consider is authenticity. An effortless way to achieve authenticity is to let students work with real-world cases or issues, or let them relate what they are learning with potential areas of application. Showing students the potential and importance of course contents for real life contexts is not only great for motivation, but also enables them to look at the bigger picture and work on their systematic thinking skills. Regardless of whether students have to analyze or work themselves on case studies, they can provide wonderful examples for good – or problematic – implementations. By actively reflecting on the processes or decisions leading to final outcomes, they are a great opportunity for working on critical reasoning skills. Similar to case studies are also critical incidents, potential real life situations characterized by misunderstandings or conflicts, which can be used for reflections and discussions on how such situations could be handled appropriately.

Another simple way to convey relevance and create authenticity, while simultaneously offering the students another perspective, is the invitation of guest speakers. Depending on what makes sense regarding course contents, these may be researchers or experts from industry or other institutions for rather theoretical subjects, or industry partners, stakeholders, or alumni for the more practical subjects. The topics these guest speakers address may even be subject for later follow-up assignments or exercises. The educators we spoke to that did incorporate some kind of industry partners did typically have guest speakers, primarily for motivational purposes, or used their connections to provide case studies for the students to work on, the output of which would later be presented to the industry partners. In some cases, industry partners also took up supervisory or mentor roles. However, it was also pointed out that forming and maintaining relationships with such external partners was very time-consuming for the educators.

An approach we took in our own global competence course for students was to have themselves identify, approach, and then interview a person that could function as a mentor for them. While something like this might not be a common assignment within engineering subjects, it gave students a chance to reflect on their future professions and what type of person could function as mentor, to get out of their comfort zone, gain relevant insights into questions they had about professional life, and at the same time network and form connections for their future.

3.3 Theory and practice need to be integrated

The third lesson is that theory is a good starting point for much learning, but students should also have the opportunity to practice what they are learning. While hearing that certain competencies are invaluable in professional settings can be useful, experiencing their merit firsthand is even better. Related to this is experiential learning theory, originally proposed by Kolb [17], which rests on the idea that “learning is a continuous process grounded in experience” (p. 27). With the undeniable advantages of integrative learning through experiences, it is not surprising that also the CDIO guidelines for engineering education [18] are strongly informed by such an approach. By actively applying their knowledge, small issues that may otherwise be undetected come to the forefront, and the students are eased into using a holistic perspective to make theory work. The approach of having students apply their theoretical knowledge to projects was very common amongst the educators we spoke to. Only one of them, teaching a very fundamental theoretical science course, emphasized difficulty doing this due to their course contents being based on theoretical models with “little direct connection to application.” After reflecting on the issue and the feedback of other educators taking the global competence course with them, this educator did however propose emphasizing links to sustainability, i.e., how concepts could be used to solve problems, in order to show students potential areas for practical application.

A special tip related to competence learning is to also balance discomfort with support – students should have a chance to break out of their comfort zone, but at the same time do so in a safe environment where they can try, fail, and learn from failure. In the real world, mistakes can have costly consequences, but the engineering classroom can be a safe space to learn from trial and error. As a matter of fact, it has been pointed out that mistakes may be very valuable for learning [19] – assuming that they are properly introduced as a learning experience rather than a failure. This experiential approach does not necessarily mean students really have to go out of the classroom and practice engineering – several of the examples mentioned before, such as case studies, roleplays, or critical incidents – may function well for gaining such experience. They even have the advantage that they can be specifically targeted at common or extremely challenging situations that can be used as learning experiences. As soon as practice is involved, peer or teacher feedback or self-reflections can be used to revisit the learning experience and potentially gain an even deeper understanding of the subject. However, as stated earlier, it is crucial for the students to understand this reasoning in order for the exercises to fulfill their full potential. Many of the students we talked to saw their grades as important for getting a good job, hence the frustration with team colleagues potentially dragging their grades down. In an attempt at self-serving comradery, they might also for this reason be tempted to be overly positive when giving each other feedback in front of the teacher, which both runs counter to the idea behind the exercises and can easily be interpreted by the teacher as a lack of critical thinking.

3.4 Global competence cannot be taught, but it can be learnt

Our final lesson is that global competence cannot be taught, but that it can be learnt. Becoming globally competent is a lifelong, continuous process, which requires the learner to actively hone their competencies. A simple course, yet alone one only seeing competency development as additional informal learning outcome, will hardly be able to lead to globally competent students. It can, however, create the basic knowledge, skills, and attitudes – and the motivation – needed for students to continue the path to become globally competent individuals. The prior points have already hinted at the fact that the student – and not the teacher – should be the focus of such activities. Indeed, in creating globally competent students, educators should act as facilitators supporting their students – they can show them the basics, but the students have to do the work themselves. In a similar regard it is also important to view the educators as learners themselves. Every engagement with diverse perspectives can support them in becoming more globally competent educators, which in turn allows them to create more globally competent students.

4 SUMMARY

Addressing the great industry demand for globally competent engineers, universities have begun to look for ways to foster those competencies in their students, and the engineering educator is an essential key player in those efforts. With global competencies appearing foreign to traditional hard science teaching, there is always a risk of institutional efforts meeting hesitation or resistance from educators feeling top-down pressures to having to redesign their well-tried courses without seeing additional value in doing so. Connecting the insights from our own background as global competence educators with those of engineering educators and students, we have shown that technical and global competence can easily be integrated in a way that also mirrors professional practice without putting much additional strain on educators. We identified four key lessons for the integration of global competence in engineering courses; these related to the identification of vast opportunities for global competence development, the importance of emphasizing relevance and authenticity, the integration of theory and practice, and the fact that any approaches to global competence learning need to be centered around the learner. The latter lessons show obvious overlaps with what can be seen as good pedagogical practice in general, which also highlights how a good educator should – given the right training and support – be able to effortlessly tweak their course contents to increase the potential for global competence development. While our lessons are a first starting point for those educators wanting to do so, the institutional support given them for such endeavors – both in the provision of relevant training opportunities as well as encouragement and other incentives for redesigning their courses for additional global competence learning – will be the deciding factor to whether a *comprehensive* institutional approach to global competence development can have the desired effects.

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