GLOBAL COMPETENCE NEEDS: A COMPARATIVE STUDY OF STAKEHOLDERS' PERSPECTIVES ON ENGINEERING EDUCATION

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ABSTRACT

Upon graduation, engineering graduates will find themselves in diverse, interconnected, and fast-paced work environments. Global competence, which encompasses different types of knowledge, skills and attitudes, is what will help them navigate successfully through the variety of situations they may encounter. Accordingly, its development should be an integrated core aspect of today's engineering education. Acknowledging the problems with current approaches to doing so – in particular, the vagueness of the concept and the issues of prioritizing learning content in already crowded curricula - this paper compares the perceived need and value of specific competencies according to key stakeholders. Based on a previous literature review, a survey focusing on a set of 15 frequently mentioned competences was developed and distributed internationally. The perspectives of three types of stakeholders - engineering professionals (n=339), educators (n=200), and students (n=331) – were collected and broadly analyzed according to the perceived importance of the competencies. Overall, we found agreement among the stakeholder groups, and the majority of our proposed competences were perceived as either important or very important by the respondents. Among the competences, teamwork and collaboration and English language skills stood out, while other language skills were perceived as less important. Comparing the groups, we found that professionals tended to value several social competences more highly and subject-specific competences less highly than academic stakeholders. In our discussion, we offer possible explanations for these findings, which allow inferences for educational change towards a more globally competent higher engineering education.

KEYWORDS

Global Competence, Integrated Learning, Curriculum Development, Stakeholder Perspectives, Engineering Education, Standards 2,3,7,8,10

INTRODUCTION

Industry, accreditation bodies, and educational frameworks such as CDIO or ABET have repeatedly emphasized the need for several non-technical competences for engineering graduates. In addition to issues of employability and professional development (Craps, Pinxten, Knipprath, & Langie, 2020; Pais-Montes, Freire-Seoane, & López-Bermúdez, 2019), the issue of competence has also been repeatedly addressed in the context of education for sustainable development and global citizenship (Brundiers & Wiek, 2017; Quelhas et al., 2019). This scholarly discourse increasingly revolves around competence models that aim to unite knowledge, skills, and attitudes to complement and enable the optimal use of disciplinary technical skills. In addition to the core idea that competences have a behavioral impact, they are also envisioned to be flexibly applicable to different contexts (Bazgan & Norel, 2013; Garcia-Esteban & Jahnke, 2020; Jørgensen, 2012), making them crucial for graduates to navigate rapidly and unpredictably changing work environments. While technical expertise certainly lays the foundation for employment, additional competences that help to view one's work from a holistic perspective and the ability to communicate and collaborate with a variety of different stakeholders can have a significant impact on professional performance and success.

Despite numerous calls to move from long-established, yet outdated, teaching traditions towards new global realities, the wheels of educational progress appear to be turning slowly, and engineering education has been criticized for not sufficiently preparing graduates for the non-technical aspects of their work (Craps et al., 2020). While organizations, accreditation bodies, and scholars have created various lists and models for the specific competences future engineers will need, many of these – having names like generic, transversal, transferrable, global, sustainable, or engineering competences – can only be vaguely defined and are thus difficult to appropriately integrate within curricula. However, the different interpretations of such competences and their perceived importance are likely to affect how educators integrate them within their courses (Richter & Kjellgren, 2022). Additionally, there is the question of whether such “academic” perspectives match those of industry professionals – after all, engineering educators may have begun their academic careers right after their own studies and may have not worked in industry themselves.

Moreover, universities do not merely provide education and training for the profession – they also play an important role in forming the students' conceptions and ideas of their future careers (Garcia & Pinela, 2018). Students may well be affected by their experiences in their engineering classrooms where unintended, implicit messages could be conveyed to them, as the idea of the *hidden curriculum* (Leask, 2005) suggests. Even if educators have an industry background, preparing their students for all eventualities will be a daunting task, not only due to students choosing different career paths and likely changing positions several times, but also due to changing technologies, work environments, and professional demands. This makes it all the more important to identify crucial global competences that will equip graduates with the basic knowledge, skills, and attitudes needed to be able to flexibly adapt to a variety of different contexts and further develop their capabilities in a sense of lifelong learning.

RESEARCH AIM

This paper contributes to a clearer understanding of the perceived need and value of various crucial global competences for engineering graduates around the world. Through comparison of different stakeholders’ – engineering professionals, educators, and students – perspectives on the need and value of certain global competences, it addresses both the relative importance of certain competences as well as differences in opinion among these three groups. This compilation of differently perceived competence needs allows inferences for curriculum development in integrated competence learning.

METHODOLOGY

Empirical data was collected through surveys that were internationally distributed from July to December 2022. Contacts from the researchers' university networks were asked to forward the surveys to their institutions' educators, students, and alumni. Altogether, we received 870 responses: 339 professionals, 200 educators, and 331 students. Demographic data shows that respondents included individuals from 54 different universities currently located in 40 different countries, with the majority of them based in Europe. The surveys revolved around a previously identified set of 15 competences that were frequently in the center of relevant literature, and focused on different types of non-technical competences for engineers. Based on this, three slightly different surveys were developed for the individual target groups. Respondents were asked to rank the perceived importance of specific competences within their (or their students') professional field on a 5-point Likert scale, ranging from "not important" to "very important". For the purpose of this study, data was analyzed quantitatively.

RESULTS

Overall, we found a high level of agreement among professionals, educators, and students. Table 1 summarizes the response frequency in terms of mean and mode values and shows that the majority of the competences were perceived as either important (value 4 on the scale) or very important (value 5 on the scale).

Table 1. Frequency comparison of the competences' perceived importance (scale 1-5)

			Professionals		**Educators**		**Students**	
			Mean	*Mode*	Mean	*Mode*	Mean	*Mode*
Knowledge/ Awareness	Communication differences	Intercultural	4.29	*5*	4.25	*5*	3.95	*5*
		Interdisciplinary	4.36	*5*	4.37	*5*	4.14	*5*
	Professional differences	Engineering practice	3.71	*4*	4.04	*4*	4.07	*4*
		Standards/regulations/laws	3.81	*4*	4.01	*5*	4.00	*5*
Skills	Teamwork and collaboration		**4.76**	*5*	**4.66**	*5*	**4.55**	*5*
	Management and leadership		4.31	*5*	4.20	*5*	4.17	*5*
	Adapting to different audiences		4.26	*5*	4.31	*5*	4.08	*4*
	Information searching/analyzing/processing		4.45	*5*	**4.68**	*5*	4.41	*5*
	Language	Local	3.48	*4*	3.72	*5*	3.54	*4*
		English	**4.70**	*5*	**4.75**	*5*	**4.57**	*5*
		Other	2.64	*3*	3.36	*4*	2.83	*3*
Attitudes	Willingness to communicate	Interculturally	4.35	*5*	4.31	*5*	4.16	*5*
		Interdisciplinarily	4.46	*5*	4.43	*5*	4.36	*5*
	Open-mindedness towards others' opinions		**4.54**	*5*	**4.62**	*5*	4.49	*5*
	Sustainability commitment		4.09	*5*	4.41	*5*	4.26	*5*

Among the individual competence rankings, *Teamwork and collaboration*, *English language skills, and open-mindedness towards others' opinions* scored highest, with the most common assessment throughout all groups being "very important." Less importance was placed on *local* or *other language skills*, and *knowledge of differences in professional practices* and *standards/regulations/laws around the world.* Figure 1 on the next page illustrates the individual stakeholder groups' competence assessments in more detail.

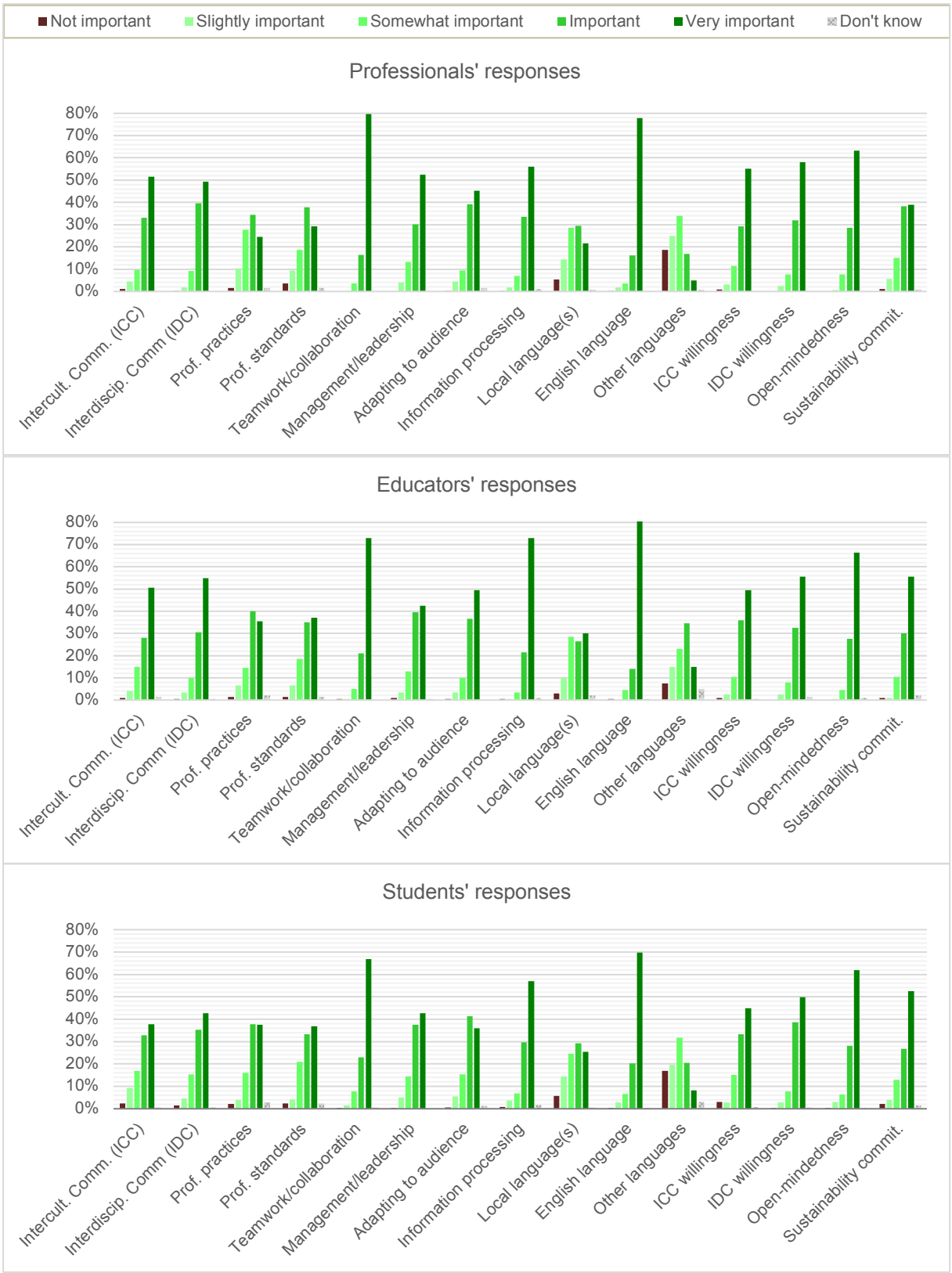

Figure 1. Stakeholder perceptions of the competences' perceived importance

We also compared the individual stakeholder groups' perceptions to see where they agree or disagree with each other. We conducted an independent sample *Kruskal-Wallis test* (CI=0.95, p=0.05), which indicated significant differences between the stakeholder rankings for 12 of the 15 competences. No significant differences were found for the competences of *local language skills*, *willingness to participate in interdisciplinary communication* and *open-mindedness towards others' opinions*. This and the differences between the individual groups' rankings are illustrated in Figure 2 below.

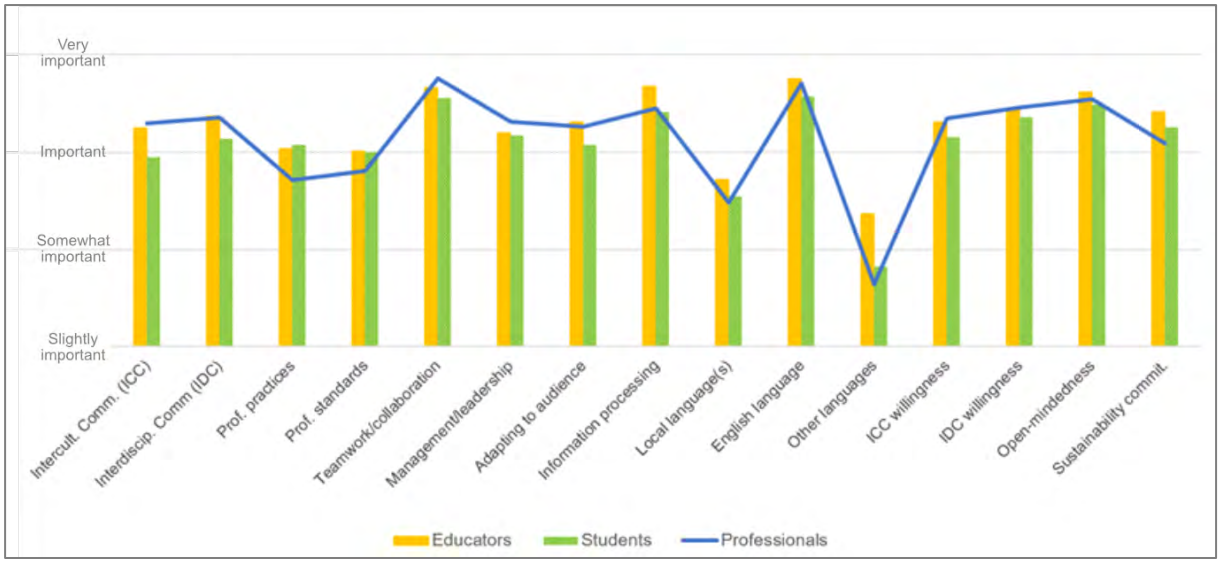

Figure 2. Comparison of the stakeholders' mean competence importance rankings

Considering the professionals' responses as a baseline, due to their first-hand experience as engineers, we decided to illustrate their rankings with a blue line against which the educators' and students' responses were measured. Figure 2 shows the overall agreement among groups and indicates some, albeit minor, differences, most noteworthy among them being:

Professionals tended to rank *knowledge about intercultural and interdisciplinary communication differences*, as well as *willingness to communicate with people from different cultural and professional backgrounds* (ICC and IDC willingness in Figure 2) slightly higher than the other groups, while the ranking for *knowledge about differences in professional practices and standards, laws, and regulations around the world* was slightly lower.

Educators tended to rank all types of *language skills*, particularly *other language skills* (i.e. neither the local language or English), *adapting to different audiences*, *information searching/analyzing/processing*, and *commitment to sustainable solutions* slightly higher than the other groups.

Students tended to generally rank the importance of individual competences lower than the other groups, the only exception being the perceived importance of *knowledge of differences in professional practices around the world*. The competences whose rankings deviated the most from the professionals' baseline included k*nowledge about intercultural and interdisciplinary communication differences* as well as *willingness to communicate with people from different cultural or professional backgrounds.* Similarly, they also ranked other social competences, such as *teamwork and collaboration skills* and *adapting to different audiences* lower than the other stakeholder groups.

DISCUSSION AND CONCLUSION

When we began our research, our intention was to identify ways in which universities could improve their curricula for the development of global competence. In order to provide insights that can be broadly applied to a variety of contexts, some decisions we made, such as removing specific analyses by field and/or location of respondents, also resulted in a loss of specificity. In no way do we deny the importance of a variety of contextual factors that will ultimately play a role in an individual's competence needs, but at the same time we recognize that no education can be tailored to address all the possibilities in a student's career. Today, the world has become so interconnected that graduates will inevitably work with people from different cultures throughout their careers. And as the world becomes more complex, so do engineering fields, programs, and professions. Not only will graduates be surrounded by people from diverse backgrounds, but as they progress through their careers, different sets of competences may be more (or less) advantageous. Thus, it would be difficult or even counterproductive for universities to limit themselves to specific cultural contexts on which to base culture-related learning outcomes. Accordingly, we undertook this study with a vision of a broad approach to competence learning that provides students with the essential foundations and the knowledge, skills, and attitudes needed to continuously develop their global competence. Our analysis follows this vision with a focus on a broadly applicable approach rather than a more discipline- or location-specific one. Based on our findings regarding both the perceived importance of specific competences and the differences in stakeholder opinions and their potential implications, we will now discuss our key findings.

For our analysis, we decided to use the professional engineers' assessment of the competences as a basis for comparison, assuming that their first-hand experiences are exemplary of the current needs of the profession. Global competences are essential assets for professional engineers, and our study showed that not only industry professionals, but also engineering educators and students seem to be aware of their value. Given the recurring criticism that engineering education does not fully meet the needs of industry (Craps et al., 2020; Pais-Montes et al., 2019), we were surprised to find such similar response patterns among our different stakeholder groups. Our findings suggest that both engineering educators and students may have a good idea of the future non-technical competence needs of graduates. While this finding is promising for engineering education, mere awareness of skill needs must be followed by action. After all, graduates merely believing that English language skills are important will not be very meaningful if they do not actually acquire these skills. Similarly, believing that teamwork and collaboration skills are important does not mean that one will behave in appropriate ways in environments that require them. To assist universities in fostering the development of global competence, we will examine some important patterns in our data and offer considerations for how our findings might affect engineering education for the development of global competence.

Looking at patterns in the rankings, it is clear that what could be considered social competences – knowledge about intercultural and interdisciplinary communication differences as well as a willingness to communicate with people from such different backgrounds, teamwork and collaboration skills, management and leadership, adapting to different audiences, and open-mindedness – were consistently ranked high by the professionals, signifying a great importance of them in professional contexts. While the majority of them had similarly high rankings, the competence *teamwork and collaboration* stood out, suggesting that graduates will have to work a lot in collaborative environments. *Management and leadership* was ranked slightly lower, presumably due to the survey questions focusing on recent graduates, who may typically only assume leadership positions in later stages of their careers. Nevertheless, these social competences were also the ones in which the students' rankings were also consistently lower than the professionals', while the educators tended to be closer to the professionals' baseline. This missing awareness of the value of social competences raises some important questions for education.

If educators are aware of the need for such competences, how can they ensure student awareness and acquisition of social competences? We have already raised the point that mere awareness does not necessarily mean that (curricular) action will be/is being taken. From our own experience we know that many educators may directly, or likely more often, indirectly address such issues through team assignments or group projects. Authors researching similar issues have emphasized the strong educational value of activities mirroring professional situations, such as group assignments (Kahn & Agnew, 2017), project work with stakeholders (Corple, Zoltowski, Kenny Feister, & Buzzanell, 2020) or international (virtual) collaborations (Kang, Kim, Jang, & Koh, 2018; Schech, Kelton, Carati, & Kingsmill, 2017), or work placements (Downey et al., 2006). Such activities also fit well within the active or experiential learning approach promoted by the CDIO initiative (Crawley, Malmqvist, Östlund, Brodeur, & Edström, 2014). However, to ensure that such activities can live up to their potential, it is essential that the thoughts and reasoning behind them are made clear to the students (Richter & Kjellgren, 2022). If educators want their students to be aware of their relevance, they should not merely assume that students recognize related assignments or activities as mirroring, or preparing them for, future work environments, but should instead take some time to highlight these considerations.

A second competence cluster showing interesting patterns revolved around languages. English language skills were perceived as highly important throughout our sample and were ranked highest among both academic stakeholder groups and as a close second (behind teamwork) by the professionals. Considering the predominance of English terminology in many technical areas and its current status as de-facto lingua franca of international work environments, its perceived high importance is of no surprise. Looking at the respondents' background, only 10 professionals (2.9%), 2 students (0.6%), and 1 educator (0.5%) were at the time of the survey residing in an English-speaking country. Engineering professions are becoming increasingly global in nature (Downey & Lucena, 2005; Jesiek, Zhu, Woo, Thompon, & Mazzurco, 2014), and English language proficiency plays a major role for communication in diverse international contexts. Nevertheless, the comparatively low importance attributed to the local language was striking, as we may assume that many organizations will have close ties or at least some professional contact with actors within local environments, where local language skills should play a role. Maybe such interactions are seldom or are perceived as simple enough so that our respondents considered local languages as only somewhat important? Maybe teams are already so internationalized or are becoming so internationalized in the competition for international talent that organizations choose English as their corporate language? This could, potentially, also be a sign of short-sightedness on the part of the respondents, not seeing beyond strict work requirements or realizing other important functions of local language proficiency, which may range from bridging the gap between "English-talking elites" of engineering professionals and the local stakeholders to the enabling of a deeper and more meaningful integration in society for internationally recruited staff. It could, however, also be a sign of language teaching simply not being properly aligned with the agenda of the technical university, which would be a shortcoming well worth addressing.

The final thematic cluster comprised competences more closely related to specific professional fields and revolved around the knowledge of differences in professional practices, professional standards/regulations/laws of the specific engineering field around the world, and finally competences related to a commitment to sustainable solutions. On average, all three of them were perceived as important, although sustainability commitment received a slightly higher ranking from all stakeholder groups. Interestingly though, this cluster is the first instance where educators and students tended to attribute a slightly higher importance than the professionals. The current educational imperative for sustainable development may certainly help account for the high value the academic stakeholders place on it, but it could be that sustainable development, in its many facets, is either not reflected on, or prioritized in our respondents' work assignments. That knowledge of differences in professional practices or standards/regulations/laws was considered not as crucial by the professionals could be

explained by a mere awareness of the existence of such differences being considered sufficient. Maybe this awareness as a basis for learning more about aspects relevant to one's individual work situation was considered to be enough.

Educating graduates who are not only technical experts but also globally competent is an ambitious goal for engineering universities. Curricula with room for high quality learning of all such competences is a daunting challenge, and universities will have to ensure their students can absorb the contents without becoming overwhelmed by efforts to fit it all in. In regard to global competence, several questions are raised: First, what are the basic competences that really could or should be addressed during engineering education and what can be done later? As we stated earlier, competences do range among fields and jobs and are highly dependent on individual situations. Second, where should competences fit within the students' education? Should they be part of individual program curricula or be offered as extra-curricular activities? Should universities address learning specific language, culture, or communication courses in-depth, or should smaller aspects be integrated into disciplinary courses so that students see the competences in action? Of course, the ideal(istic?) solution would be to weave competence learning throughout the student's education, but that may, at least at the current time, be more utopian thinking than a realistic option.

Finally, it should be noted that the complex, interrelated nature of global competence and its need to allow for flexible adaptation to a variety of contexts may make it seem elusive to those with little experience of the subject. The behavioral expression of global competence can be seen as any behavior that is both effective and appropriate to a given situation, which may vary widely between different contexts. A globally competent person recognizes this and is able to draw flexibly, perhaps even unconsciously, on a range of knowledge, skills, and attitudes that lead to these behaviors. From an educational perspective, the transfer of knowledge and skills seems much more straightforward and easier to assess than the less obvious attitudes that a learner may hold. However, some of the attitudes that we and stakeholders have identified as important for global competence, such as openness or willingness to communicate with people from different cultural or professional backgrounds, can be easily addressed by raising learners' awareness of the potential benefits that such interactions can bring. The fact that certain knowledge can lead to the formation of attitudes shows how global competences are intrinsically linked. More importantly, it also shows that multiple variations of different competences can ultimately lead to the effective and appropriate behaviors needed in specific contexts. Nevertheless, the goal of addressing multiple global competences in education may allow for a broader and ultimately more refined set of competences. After all, while there is a range of what people with whom one interacts may consider effective and appropriate, certain behaviors are likely to lead to more advantageous outcomes than others, and the better prepared individuals are, the more likely they are to be able to identify which types of behaviors these might be.

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BIOGRAPHICAL INFORMATION

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