Title: Exploring perceptions towards social and generic competencies among engineering students, professors and practitioners

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Abstract

There is a growing concern in academia and industry regarding the key competencies of engineers. The present-day challenges and complexities demand that engineers possess not only specialised technological knowledge but also certain transversal competencies, along with knowledge in various social science and humanities areas. The present work aims to examine the perceptions that engineering academia and industry have towards various of these non-technological key competencies. To achieve this, a questionnaire was administered to civil engineering undergraduate and graduate students, researchers, professors, and professionals (n=583). Additionally, this investigation explores the perceived need for different sets of social knowledge areas and generic skills. The reliability and validity of the results were first checked using the Cronbach alpha and Item Response Theory measures, respectively. Then, chi-square tests of independence were used to determine the significance of the association between responses and several demographic variables like gender, stakeholder group, educational background, and personal interests. Furthermore, factor analysis was used to identify underlying latent variables of perceptions. The findings reveal a significant gap between academia and industry perceptions, which is more evident in the case of social knowledge than in generic skills. Notably, no relevant mismatches were observed from a gender perspective. The study accentuates the imperative of fortifying interconnections between academia and industry, as well as more research on the integration of social knowledge domains into engineering education.

Keywords: social sciences; survey; ethics; industry involvement; competency

Introduction

In the past decade, the engineering industry has witnessed a shift in demand towards engineers with broader skill sets, transcending mere technological specialisation (Scott, 2012; Wikle and Fagin, 2015; Amadei, 2019). This growing interest in versatile engineers stems from the recognition of their role in addressing complex global challenges that need to be tackled through an interdisciplinary lens (Walther et al., 2017) and their enhanced employability prospects (Succi and Canovi, 2019). These challenges encompass issues such as climate change, emergency management, and the provision of basic necessities.

The term "global engineer" (Mazzurco et al., 2012; Hundley et al., 2013; GDEE, 2014) has emerged to characterise this multifaceted engineering professional. Various authors have debated the question of the competencies that define this new paradigm of engineers. For instance, Canney and Bielefeldt (2015) highlighted the need for engineers to be socially aware and responsible; Allert et al. (2007) and Mazzurco et al. (2012) emphasised intercultural skills; and Amadei (2019) advocated for engineers to comprehend their societal roles and the broader implications of their decisions on socioeconomic, cultural, and political dimensions.

Though these vital competencies can be cultivated post-graduation, nurturing them at earlier stages during undergraduate and graduate studies has proven effective (Dodrige, 1999; Clark, 2011). Despite the acknowledgement of the importance of educating engineers from a broader perspective, there are still no clear directions as to what exact qualities need to be instilled in engineering students and how engineering educators can support the attainment of such skills by students (van Maele et al., 2013). Moreover, some researchers have found that the perceptions towards these different skills are different among academics and industry (Patacsil and Tablatin, 2017), a fact that may be hindering the effective development of future engineers.

Hence, the objectives of this paper are to contribute to this debate by analysing perceptions towards social knowledge, and technical and transversal competencies that different stakeholders within the engineering academia and industry have. In particular, the research questions that guided this investigation are as follows:

> **RQ1:** how do engineering students, professors, and practitioners understand the need for knowledge in the Social Sciences and Humanities (SSH) (hereafter referred to as SSH knowledge), as well as for other generic skills in the civil engineering industry?
>
> **RQ2:** are there any sociodemographic patterns influencing the perception of these competencies?

Theoretical background

The concept of competency, a fundamental aspect of this study, has been extensively explored in the literature. It was used for the first time by Selznick (1957) in the context of enterprises referring to a set of activities that companies carry out to perform better than other similar companies. Since then, several authors have contributed to understanding this construct (Bryson et al., 2007). Although various perspectives exist, a common consensus among authors is that competencies are closely linked to effective professional performance (Spencer and Spencer, 1993).

To provide clarity for the focus of this paper, a specific definition of competency that aligns with the context of engineering industry was adopted. Following the insights by Sandberg (2000), competency is understood here as a collection of attributes that workers utilise to successfully execute their tasks. These attributes can encompass a diverse range of elements, including knowledge, skills, and traits, as described by Dubois (1998).

In the following subsections, the literature on social competencies is reviewed as conceptual grounds for the analysis in the present paper.

Social competencies in the engineering industry

Social competencies hold significant importance in equipping professionals to navigate the complexities of today's society. Until the present, multiple frameworks that contribute to understanding these competencies have been developed. Some examples include the OECD Skills Studies, which provides insights into knowledge and generic skills necessary for success in the labour market (OECD, n.d.); the UNESCO competency framework, which emphasises skills for work and life that go beyond mere productivity to encompass knowledge, insights, and mindsets that help individuals lead fulfilling lives (UNESCO, 2016); the top 10 skills list by the World Economic Forum, which predicts the skillsets that will likely be most demanded in the future jobs market (World Economic Forum, 2023); or the Knowledge, Skills & Attitudes (KSA) framework, which is a model commonly used in education and training to define and organise the essential components individuals need to acquire to be competent in a particular field or profession (Seufert et al., 2021). It is essential to acknowledge that these competencies may differ globally (OECD, n.d.) and, as such, different regions and cultures may place varying levels of emphasis on specific social competencies, driven by unique societal needs and values.

Turning to engineering-specific frameworks, various declarations and conferences have stressed the importance of social competencies for engineers. In the beginning of the century, some declarations helped to shape the path of social competencies for engineers. For instance, the Barcelona Declaration, which was settled at the 2nd International Conference of Engineering Education for Sustainable Development (Engineering for Sustainability, 2004), defined seven critical skills that engineers had to possess to face current society's problems. These skills included aspects such as understanding how engineers' work interacts with the environment and society or working in multidisciplinary teams. In a similar vein, the Shanghai Declaration on Engineering and the Sustainable Future (UNESCO, 2004) defined the challenges currently faced by engineers, described their mission, and responsibility and commitment. Some of the issues to which the declaration pointed out were the protection of human health and well-being, the adoption of ethics codes, cooperation between different disciplines, and the promotion of human and institutional capacity building.

Apart from declarations and publications, accreditation bodies have traditionally played an important role in defining the abilities that students need to possess when completing their studies. A well-known accreditation body is ABET, which regularly publishes criteria for accrediting engineering programs, including expected student outcomes supporting the educational objectives of an engineering program. Other engineering accreditation boards include the Engineering Accreditation Board (EAB) of UK's Engineering Council, the European Network for Accreditation of Engineering Education (ENAEE), the Australian Engineering Accreditation Centre (AEAC), or the Network of Accreditation Bodies for Engineering Education in Asia (NABEEA).

At this point, it needs to be acknowledged that the skills required for different job roles job roles (e.g., researchers, designers, consultants, project managers) as well as different engineering disciplines might be different. The ABET criteria, which was mentioned above, not only proposes education outcomes that are generic to any engineering discipline, but also some that are specific for certain fields. Also, professional associations of specific engineering disciplines have developed frameworks that consider the particularities of their field. In the case of civil engineering, additionally, where a well-known framework is ASCE's Civil Engineering Body of Knowledge (CEBOK) (American Society of Civil Engineers [ASCE], 2019). This framework is based on the above-mentioned KSA framework.

Despite all the above, the non-technological competencies needed by engineers are not clearly specified in the previous documents and are only defined in general terms. To study these competencies, this paper classifies them into SSH knowledge and generic skills. SSH knowledge refers to competencies arising from specific knowledge, and it is generally obtained through a combination of education and professional training. It is considered to be easier to quantify than generic skills. In the literature, this sort of competency is sometimes referred to as “hard skills” (Hendriana, 2017) and has seldom been used for SSH knowledge in the past but for engineering expertise such as knowledge of structural analysis and design in civil engineering or programming languages and software development methodologies in software engineering (see, for instance, the meta-analysis by Garousi et al., 2020). In fact, most studies that discuss “hard” skills implicitly assume that the former refer to knowledge related to engineering processes or products (see, for instance, Lyu and Liu, 2021).

In contrast, the concept of generic skills is used by Chan and Fong (2018) to describe a set of basic necessary technical and transversal skills, also referred to as transferable skills, or generic competencies (Succi and Canovi, 2019). Some authors refer to them as “soft skills” (Idrus et al., 2014; Hendriana, 2017). Weber et al. (2011) defined transversal skills as ‘‘the interpersonal, human, people, or behavioural skills needed to apply technical skills and knowledge in the workplace’’. The technical side of these skills refers to basic IT and STEM knowledge.

While the literature sometimes uses the terms “soft” and “hard” skills, this paper avoids such wording, as it may indicate some kind of inferiority of the former with respect to the latter.

Having said this, it needs to be noted that some authors have emphasised that the frontier between the above-mentioned skills might be somewhat blurred, as they are interconnected (Balcar, 2016; Hendarman and Cantner, 2017). For instance, Fernandez-Sanchez (2015) does not utilise the division made here and set together both types of competencies.

Social competencies and employability

Apart from the need for social competencies to enable engineers to face the complexity of global issues, these skills have also been highlighted as essential in terms of employability. Employability, in the context of this study, refers to the ability of an individual to confidently navigate and adapt to the dynamic and uncertain demands of a continuously changing labour market (di Fabio, 2017).

Social competencies have garnered increasing attention for their significance in preparing individuals for the complexities of global challenges while also contributing significantly to their employability (Winberg et al., 2020). Several researchers have emphasised the pivotal role that these competencies play in professional success. For instance, García-Aracil et al. (2004), and García-Aracil and van der Velden (2008) concluded that certain social competencies, such as leadership, motivation, and problem-solving, hold stronger associations with success in the industry than specific technical knowledge. Often referred to as emotional intelligence, these social competencies enable individuals to work in professional environments effectively.

Even though the advocacy for transversal skills has increased over the last decades, the truth is that the consideration of both generic and domain knowledge competencies is essential when it comes to employability. In fact, Balcar (2016) conducted a study examining the influence of these two types of skills on an individual's productivity at work and found that the productivity of technical skills is enhanced when combined with transversal skills. In the context of innovation, Hendarman and Cantner (2017) established a clear connection between innovativeness and the integration of both transversal and technical skills.

Succi and Canovi (2019) furthered this understanding by analysing how specific transversal skills can enhance graduate employability. They classified these skills into three different groups: personal, social, and methodological, all of which play a vital role in shaping an individual's employability profile.

In the context of civil engineering, Bae et al. (2022) used an employability framework (i.e., the CareerEDGE framework, Pool and Sewell, 2007) to understand what the perceptions of civil engineering students are regarding professional skills, experience, career development learning, emotional intelligence, and degree-specific knowledge. While their study did not analyse in depth what type of skills are necessary, but how they are developed, it is interesting to see that the focus was greater on transversal skills rather than on engineering knowledge.

In light of the growing recognition of the importance of transversal skills, it is evident that the convergence of technical expertise with SSH knowledge and generic social competencies can enhance an individual's employability prospects. Studies by Sharma (2018) and Majid et al. (2019) underscore the criticality of soft skills or social competencies in the current business environment. Vandana (2018) highlights that employers seek graduates who not only possess technical knowledge but also demonstrate essential soft skills. Soft skills contribute significantly to long-term job success, predict employability, and even lead to higher wages. The combination of hard skills and soft skills determines an individual's productivity and overall performance, differentiating between a job well done and superior outcomes (Majid et al., 2019).

Social competency development in engineering education

It is now commonly accepted that competencies can, and should, be developed through higher education (Eraut, 2003; Miller, 1990; Lizzio and Wilson, 2004; Weissenberger-Eibl and Kugler, 2014). In fact, the declarations mentioned above (EESD, 2004; UNESCO, 2004) position education as the key to advancing towards an engineering practice that is more socially aware. This has also been supported by academic literature. For instance, Morace et al. (2017) analysed the state of humanism in engineering education and reviewed the literature status of social and intercultural competencies for engineers. They argue that until the present, companies have demanded very technically specialised engineers. However, due to the current global context, “global engineers” are needed. These are engineers that have certain competencies besides specialised technological knowledge.

From the literature, it is clear that generic skills have been more widely studied than SSH knowledge competencies. Research on generic skills presents more specific competencies than what the literature for SSH knowledge competencies does. Some examples of this can be found in Fernandez-Sanchez (2015) or Succi and Canovi (2019), who discuss specific sets of generic skills for engineers.

In spite of the above, it also needs to be mentioned that SSH knowledge competencies are implicitly included in the literature. This is common in the literature related to education for sustainable development (Terrón-López et al., 2020). In the context of Europe, the Tuning project (González and Wagenaar, 2005) identified specific competencies for different subject areas, including some science and technology disciplines. These included some social competencies, such as "Some knowledge of the historical development of mathematics and its cultural impact on the development of scientific and technological thinking" for the subject area of Mathematics. Sánchez-Carracedo et al. (2020) detected the competencies from the Tuning project that are related to sustainable development, and it can be observed that several among them require knowledge in some social areas, such as the ability to show awareness of equal opportunities and gender issues.

In the present paper, the conceptual framework by Josa and Aguado (2019) is used to define the different dimensions of SSH knowledge areas, as shown in Table 1. Until the present, there has been limited research at the intersection between the social sciences and civil engineering. The few studies in this area include Evans (2007), Evans (2011), Welch (2011), Evans and Beiler (2015), Toussaint (2019), Josa and Aguado (2021), and True-Funk et al. (2021). Therefore, the framework provided by Josa and Aguado (2019), which is the only one defining the social areas that are related to civil engineering, was deemed as the most appropriate for this study. In addition to the ten items that appear in Table 1, their framework also contained the item "Education and innovation", which has not been included here because it is already embedded in this study as a transversal item.

The generic skills included in this study are the ones shown in Table 2. The items were selected on the basis of recent literature on basic transversal and technical competencies in engineering (Berglund, 2018; Broo et al., 2022).

The tables include the abbreviations used in this paper and a general description of what they entail. Besides, references alternative to the ones given throughout this section are included as well to further support the inclusion of these competencies.

Method

To answer the study's research questions, a quantitative methodology was chosen. In particular, the research design took the form of a questionnaire. Different steps were followed for the design and implementation of this method. This is shown in Figure 1, and the three main stages of the research (design, data collection, and data analysis) are described below.

Design of the survey

First of all, the objectives of the survey and its scope were established to answer to the research questions. Then, the specific groups of participants that would be answering the questionnaires were defined. These were stakeholders directly connected to civil engineering, which included individuals from both academia (students, professors and researchers) and industry.

Afterwards, an online survey containing questions on sociodemographic profile, and on perceptions towards different sets of skills was prepared. The sociodemographic profile questions asked for information on gender, age, current occupation, and personal interests. The questions on SSH knowledge competencies and generic skills were two, both containing Likert scale-type answers (with 1=never, 2=rarely, 3=occasionally, 4=frequently, and 5=very frequently). The first one contained the question "How frequently do you think that civil engineers need knowledge on the following fields in their workplaces? Choose the most appropriate answer according to you.". The answer had to be provided for each of the items shown in Table 1. The second question was "How frequently do you think that the following skills are needed by civil engineers in their workplaces? Choose the most appropriate answer according to you.". The answer had to be provided for each of the items shown in Table 2. Regarding the items for both questions, only the labels presented in Tables 1 and 2 were presented. Note that the lack of a full description for each item could have introduced more variability in the responses, as will be discussed in the Limitations section.

The platform used to create the survey was SurveyMonkey. After the questions to be included in the survey were defined, a validation process was carried out. The validation of the survey was made in two successive stages. First of all, it was reviewed by an external committee. This external committee was chosen based on the interest groups to which the survey was addressed. The objective was to receive suggestions from the different stakeholders that would be answering the survey. In the end, eight external persons participated in the review of the survey: three professionals, four professors, two program directors and one PhD student.

Two of the professionals worked in a construction company and were recommended to the authors by the director of a regional engineering association (ASINCA). The third professional was the director of the regional construction procurement association. The four civil engineering professors that participated in the survey taught in the school in which the survey would be distributed, belonged to different disciplines (structures, transport, materials, environment) and had between 20 and 35 years of experience in similar roles; while information regarding their past working experience was not collected, they were at the moment working full time at university. The two program directors were also part of the civil engineering school, as was the doctoral candidate.

The platform used for the survey allowed creating a review version of the questionnaire, in which respondents could write comments or suggestions next to the questions. All the above stakeholders were sent this version of the survey, and the comments were collected.

Modifications according to these suggestions were made to the survey. Most comments made by these participants were related to wording of questions, to removing or adding options in certain multiple-choice questions, and to reducing the length of some parts of the survey.

After receiving the comments of these participants and correcting the survey accordingly, a pilot version of the survey was sent to 42 civil engineering graduate students. Note that, given that the objective was not to evaluate the responses but the survey itself, the specific background of the students was deemed unimportant at this stage. Apart from answering the questions, they were invited to write a comment in an open-question box at the last page of the survey with suggestions to improve the survey. After this, the results of the 42 responses were analysed and slight modifications were made, mostly in how certain questions had been worded.

The final version of the survey can be found as part of the Supplementary material. Note that the present study is part of a broader research project analysing other areas of the relationship between social sciences and civil engineering. Hence, apart from the two items reported here, there were eight additional items that respondents were asked.

Data collection

The survey was open between January 2019 and September 2019, and was distributed to different groups involved in civil engineering education at the Technical University of Catalonia (BarcelonaTECH). This included undergraduate students, graduate students, PhD students, researchers and professors. Additionally, civil engineering practitioners working in the same city as the university were also invited to participate.

The way in which each participant group was contacted is described next:

- New civil engineering students: the welcoming session for new civil engineering undergraduate students was attended by one of the authors, and specific time was allocated for students to answer the questionnaire. Of the 122 students that attended the session, 77% answered the survey.

- Undergraduate and graduate civil engineering students: professors were contacted for them to distribute the survey among their students. In most cases, the authors of this article were given some class time for students to answer the survey, and in the remaining cases the professor sent the survey directly to students so that they could answer it in their free time.
- Civil engineering professors: they were contacted individually (either in person or by email) with a request to answer the survey and to distribute it to their colleagues. Of the 102 professors that were invited to participate, 95% answered the survey.
- Practitioners: two associations of civil engineering companies were contacted so that they could distribute the survey among the member companies. Information is not available on the total number of members in these associations. Additionally, one company was also contacted so that the survey could be distributed among their 157 workers.

In the end, the total number of fully responded surveys was 583. Among the respondents, 16.2% were new students, 21.7% undergraduate students, 23.23% master students, 5.3% PhD students, 16.6% researchers and professors, and 16.8% practitioners. Note that researchers and professors are not disaggregated because all faculty members at the university analysed carry out both teaching and research tasks. Regarding practitioners, a 4.39% had been practicing for less than 5 years, 22.81% for 5 to 15 years, 53.51% for 15 to 30 years, and 19.30% for more than 30 years.

The representativeness of the data was checked by comparing the distribution of respondents with data available from the school's database. A table with the corresponding data has been included in the Appendix to this article (Table A1). Data shows that there exists an acceptable representativity of the respondents' distribution when compared to the real population. Note that no available data was found on the relative amount of civil engineering men and women working in the region and, therefore, data on the numbers of civil engineers graduated every year was used as an approximation.

Data analysis

Survey results were analysed using R, and the statistical analysis included the following steps. First of all, reliability and validity were examined through Cronbach's alpha (Cronbach, 1951), and an Item Response Theory model, the Rasch model.

Then, when the answers proved to be reliable and valid, descriptive statistics were used for an initial analysis of the data.

The analysis of the associations between responses and socio-demographic variables was performed using chi-square tests of independence using an alpha level of 0.05. For those cases in which a significant effect was found, in order to evaluate which population subgroups were different from one another, Bonferroni-Holm post hoc tests were performed (Holm, 1979).

Finally, factor analysis was used to examine any potential latent structure of the responses. Before applying factor analysis, its applicability was ensured by using the results of the Kaiser-Meyer-Olkin (KMO) measure of sampling adequacy (Kaiser, 1970) and Bartlett's Test of Sphericity (Bartlett, 1950). The approach taken for the factor analysis was exploratory, given that there are no clearly defined constructs and theories in this area are undeveloped (Daniel, 1989; Schmitt, 2011).

Results

SSH knowledge competencies

The results of the question on SSH knowledge competencies are graphically shown in Figure 2. The figure shows boxplots of the results, grouped according to current occupation. Each group is represented by a different colour. Black dots represent outliers, and the beginning and end of the vertical lines represent the minimum and maximum values, respectively. The limits of the boxes depict the first and third quartiles, the wider black line is the median, and the diamonds symbolise the means.

The following subsections present other results, including the reliability and validity of the question, the analysis of significant differences between subpopulations, and factor analysis.

Reliability and validity

First of all, the reliability analysis was carried out through the Cronbach's-alpha. The question regarding SSH knowledge competencies comprised 10 items, and the Cronbach's alpha showed the questionnaire to reach acceptable reliability, alpha=0.82. The Cronbach's alpha if Item Deleted showed that all items appeared to be worthy of retention, as deleting none of them would increase the alpha.

Secondly, the validity of the instrument was examined using Rasch analysis. First, the potential existence of atypical values was examined. Then, fit of data to the Rasch model was analysed through residual analysis, which shows differences between the values expected by the model and the data observed. In particular, the infit and the outfit statistics. The former are sensitive to unexpected response patterns to items near the person measure level, whereas the latter are sensitive to unexpected response patterns to items far from the person measure level. If these statistics vary from 0.5 to 1.5, they can be considered to be appropriate. All the infit and outfit statistics are close to 1, indicating that the instrument is measuring one single construct (in this case, the perceived frequency of SSH knowledge).

After examining the fit of data to the model, person reliability and the separation indexes between persons and items were assessed. On the one hand, Person Separation Reliability (PSR) indicates how well the test is able to separate the persons taking the test. It is considered to be a measure of internal consistency similar to KR20 (Wright and Stone, 1999). On the other hand, Item Separation Reliability (ISR) gives an indication of how well items are separated by the persons taking the test. It is a measure of the test's reliability. For this question, PSR and ISR gave values of 1.00 and 1.00, respectively.

Association between variables

Chi-square tests were used to test whether there were significant differences between groups of respondents. The sociodemographic variables that were examined were gender (female, male), position (new students, undergraduate students, master & doctoral students, professors and researchers, and industry workers), age, maximum level of studies, and activities in which they participate outside of university and work (cultural, physical, creative, personal development, service to community, training, learning, or no activities).

The results of these tests are shown in Table A2. As can be seen, the chi-square test of independence performed to examine the relationship between gender and perception towards the need for SSH knowledge showed that there was no significant association between the two variables. By contrast, significant relationships were found between position and perception towards every SSH knowledge item. Additionally, some statistically significant associations were found in the rest of the variables; the potential underlying reasons for these findings will be discussed in the following section.

Factor analysis

Factor analysis was used to find underlying factors of the responses. Before proceeding with the analysis, its applicability was ensured by checking the results of the KMO (KMO value = 0.63) and the Bartlett's test (Bartlett's K-squared = 31.53, df = 9, $p<.001$). Given that the KMO was greater than 0.5 and the Bartlett's test was found to be significant, factorability was assumed.

Both the results of the eigenvalues and parallel analyses demonstrated the need for considering three factors in the analysis. Factor analysis was performed using polychoric correlation matrices and the principal axis method for factor extraction (van der Eijk and Rose, 2015), which has been recommended in cases in which variables are highly discrete ordinal, as happens with the Likert scale. The first three factors accounted for 45.1% of the total variance and had eigenvalues greater than 1, namely 2.72 for F1, 1.43 for F2, and 1.34. The following factor, the fourth one, had an eigenvalue of 0.95. The diagram in Figure 3 shows the weights of each of the three factors found. Factors 1, 2 and 3 are represented by F1, F2, and F3 respectively. In the figure, green tones represent positive values, whereas red tones represent negative values; besides, the darker the colour, the higher the factor loading.

Besides, Figure 4 shows a biplot of the results. Biplots are a combination of score and loading plots. In them, the scores of each response on each principal factor are plotted using dots, together with vectors that show the loadings of each variable for each of the factors. Figure 4 shows, as well, different colours for different groups of stakeholders (students, professors, and practitioners). As can be seen, the 95% interval of the scores of students and professors is similar, whereas there is a greater difference with the 95% confidence interval of the scores of practitioners. In fact, it should be noted that if the factor analysis is performed separately for the different populations, the structure of the factors changes.

Generic skills

The results of the question on generic skills are shown in Figure 5.

Reliability and validity

The Cronbach’s alpha showed the questionnaire to reach acceptable reliability, with an alpha of 0.81. The Cronbach’s alpha if Item Deleted showed that all items were worthy of retention, and the deletion of none of them would increase the alpha coefficient.

As for the validity of the instrument, all the infit and outfit statistics lay in the interval from 0.85 to 1.3, indicating that the instrument measures a single construct. Regarding PSR and ISR, these indexes gave values of 1.00 and 1.00, respectively. This indicates a very high level of reliability and consistency according to IRT.

Association between variables

The same sociodemographic variables as in section 4.1.2. were used in the chi-square tests to test whether there were significant differences between groups of respondents. The corresponding results have been included in Table A3. As can be seen, compared to the previous tests, less significant associations were found within the different groups.

Factor analysis

The applicability of factor analysis was verified from the KMO measure (KMO value = 0.75) and the results of the Bartlett's test (Bartlett's K-squared = 28.77, df = 10, $p<.01$). Then, as was done before, factor analysis was carried out to find the latent variables of the perceptions towards generic skills. The eigenvalues and parallel analysis all demonstrated the need for considering three factors in the analysis. The first three factors accounted for 43.1% of the total variance and had eigenvalues greater than 1, namely 4.56 for F1, 1.41 for F2, and 1.01 for F3. The fourth factor had an eigenvalue of 0.89. The diagram in Figure 6 shows the weights of each of the three factors (F1, F2, and F3) for each competency asked for in the questionnaire.

Additionally, Figure 7 shows the biplots for the results of the factor analysis. As it happened before, the 95% confidence interval of the scores of students and professors is more aligned than the 95% confidence interval of the scores of practitioners, which does not match as well with the others.

Discussion

This article examined the differences in perceptions towards the relevance of various competencies for the civil engineering profession. The following subsections discuss the results presented in the previous section. First, the results for SSH knowledge competency and generic skills are described separately. Then, the research implications for education and industry are presented.

SSH knowledge competencies

The knowledge areas that were considered, on average, most frequently needed were LAW ($\mu = 4.33$), ECON ($\mu = 3.95$), and POLIT ($\mu = 3.87$). The ones that had the lowest average responses were ART ($\mu = 3.00$), ETHICS ($\mu = 3.07$), and CULT ($\mu = 3.24$). Nonetheless, if these averages are taken for each respondent group, important differences can be found as shown graphically in Figure 2, as well as in the chi-square tests of independence.

With regard to the chi-square tests results, significant differences between population subgroups were analysed through chi-square tests, and, if the results were significant, Bonferroni-Holm post hoc analyses were performed. Even though no significant differences were found in the responses between gender groups (which is supported by the results obtained by other authors, such as Polmear et al., 2021), there are significant differences in other population subgroups. First of all, there exist major differences between groups classified by current occupation (students, professors, and practitioners). These differences manifest themselves in the ten SSH areas that were analysed, with high significance in all the cases ($p<.001$). The post hoc comparisons revealed that perception towards each of the SSH areas was statistically different between practitioners and the remaining groups in all cases. The issue of the dichotomy of perceptions between practitioners and academia has been analysed by other authors, who have frequently advocated for closer connections between industry and academia (Oyebisi and Nassar, 1996; Enshassi and Hassouna, 2005; García-Aracil and van der Velden, 2008).

Significant differences for the subgroups "age" and "maximum level of studies" were also found. Even though there may be relationships between age, maximum level of studies attained, and current occupation of each individual, the results of the chi-square tests obtained were different for these variables. On the one hand, there were significant differences for different age groups regarding ECON, LAW, POLIT, HEALTH and PROB. The post hoc comparisons in this case revealed that the statistical differences mainly arose from pairwise comparisons between the youngest respondents (less than 25 years old) and respondents above the age of 35. On the other hand, the chi-square tests showed that the items CULT, RELA, ECON, POLIT, HEALTH, ART, PROB, and ETHICS were significantly associated with the maximum level of studies attained by the respondent.

Apart from gender, current occupation, age, and maximum level of studies, it is also interesting to discuss the significant differences found related to responses given to leisure time activities. While no significant differences were observed for responses related to participation in sports, learning and service to community activities, differences were found when examining cultural, creative, spiritual development, training and learning activities. The following points summarise these results:

- In the association between perceptions towards PSYCH and participation in cultural activities, chi-square test of independence revealed that people participating in cultural activities were more likely to perceive PSYCH as more necessary.
- When examining the association between participation in cultural activities and perceived need of LAW, the chi-square tests of independence revealed that individuals participating in such activities were more likely to perceive a medium need for LAW.
- The chi-square test examining the relationship between ART and participation in cultural, and creative activities showed significant differences.

- The association between PROB and participation in cultural, and spiritual development activities showed significant differences in the chi-square tests of independence.
- Finally, ETHICS was found to be significantly associated with the responses given by individuals participating in cultural, and spiritual development activities.

Besides chi-square tests, factor analysis was conducted to better understand the latent variables behind the responses. The results of the factor analysis showed that, regarding the frequency in which they are perceived to be needed in practice, these skills can be classified into three groups. The first factor comprised the areas PROB, HEALTH, CULT, ETHICS, and ART; the second factor included the areas LAW, ECON, and POLIT; finally, the third factor comprised RELA and PSYCH. As it can be seen, the first factor comprised some social areas that are more strongly related to the individual, while the third factor integrated elements more related to relationships between individuals. As for the second factor, it contains elements that are generally labelled as business areas.

It needs to be noted that the structure of the factors differed slightly for the different population subgroups, showing that the latent variables influencing the perceived need for each area is different. For practitioners, the structure for the first factor was very similar to the one above presented. However, RELA and PSYCH were contained in the second factor, whereas LAW, ECON, and POLIT were part of the third one. The most important difference in the structure of the factors for students and professors was with ETHICS. This item was not grouped with the elements in the first factor, but was contained in the second factor with the highest weight in it. Moreover, in both population subgroups, ART did not have a very high weight in any of the factors.

Generic skills

The competencies that had higher ratings in the responses were TEAM ($\mu = 4.69$), COMM ($\mu = 4.53$), and FLEX ($\mu = 4.38$), whereas the ones with lower ratings were MATH ($\mu =$

4.03), CREAT ($\mu = 4.14$), and INTER ($\mu = 4.24$). A first aspect to highlight from these results is that, even though civil engineering programs, explicitly or implicitly, are mostly based on mathematical and physics courses, it is a skill that is less frequently used in practice, according to the perceptions of practitioners. In fact, it is interesting to note how this perception decreases with age. The mean of the responses by new students is 4.47, whereas the responses by practitioners have a mean of 3.34. This item represents, in fact, the skill with the lowest mean value for practitioners in comparison to the other 10 items. Secondly, while CREAT yielded one of the lowest ratings, it has been emphasised by other authors to be key in civil engineering practice (Stouffer et al., 2004).

Compared to responses for technical competencies, less significant differences were found for the different subpopulations regarding transversal competencies. In fact, until the present, several authors have highlighted the need for embedding these competencies in civil engineering education (Bowman and Farr, 2000; Hadgraft and Kolmos, 2020; Liesa-Orús et al., 2020).

Regarding gender, only differences were found for INFORM. For the case in which respondents were grouped by current occupation, significant differences were found in items CONFL, CREAT, ANALY, LANG, MATH, and PROB. Post hoc comparisons for the item CONFL, CREAT, and PROB showed that practitioners were more likely than new, undergraduate, and graduate students to perceive these competencies as less necessary. As for MATH, the post hoc comparisons revealed that practitioners are more likely to consider MATH less necessary than the other groups, including students, as well as professors. Regarding ANALY, the chi-square test and corresponding post hoc comparison showed that practitioners were more likely to consider ANALY less necessary than new students, who considered it more necessary. Similarly, LANG yielded the same results, but for the difference between practitioners and both new students and undergraduate students.

As for the association between the different items and participation in certain activities, only COMM and INTER showed significant differences. In particular, the chi-square test examining the relationship between COMM and participation in spiritual development activities showed significant differences. Besides, the association between INTER and not participating in any activity showed as well showed significant differences in the chi-square tests of independence.

The analysis of the factors of the items revealed that the competencies could be structured into three different factors. In particular, the first factor comprised the areas TEAM, LANG, INTER, FLEX, CREAT, and CONFL; the second factor included the areas PROBL, and MATH; finally, the third factor comprised INFORM and PSYCH. Items COMM and ANALY had similar loadings in more than one factor. COMM factored highly in factor 1 and factor 2. ANALY had the highest factor in factor 2, followed by the third factor.

Contrary to what occurred with SSH knowledge competencies, the factor structure did not show many differences for the different population subgroups.

Practical implications

The present study has several implications for educators and researchers, as well as for practitioners. First of all, educators and university governing bodies should be aware that both students and professors have a tendency to have perceptions towards SSH knowledge competencies that are different from those working in the industry. These differences are more significant for SSH knowledge competencies than for generic skills. Hence, a way should be found at higher education institutions to better understand the industry's needs and link them to the curricula being taught.

Even though it is normal for new students to have certain misconceptions about competencies needed in practice, as students gather knowledge and advance courses, a deeper understanding of the profession should progressively dissipate these perceptions. In this sense, stronger links between university and industry could be helpful to support these processes. In relation to this, it needs to be emphasised that perceptions towards the various competencies show not only depend on current occupation, but also on other individual personality aspects proxied by participation in different leisure activities.

While the study's focus on industry alignment reflects the pragmatic aspect of engineering education, it is essential to acknowledge that the educational landscape is multidimensional. In this sense, higher education institutions play a pivotal role in cultivating well-rounded individuals (for example, by fostering critical thinking, ethical reasoning, and cultural awareness that extend beyond vocational training). Therefore, future research could explore the perceptions towards social competencies not only considering their connection with industry but also considering their value in shaping individuals' holistic development and contributing to a meaningful life.

Secondly, students should be given the opportunity to cultivate the competencies that are considered fundamental by practitioners. However, it should be noted as well that there are some SSH knowledge competency areas that are perceived by practitioners as not frequently necessary, but whose knowledge and understanding could allow graduates to better understand the social implications of their work. In fact, the need for these competencies has been advocated for in various of declarations such as Engineering for Sustainability (2004). What the results show is that there has not been a change of paradigm yet in the engineering industry as for how these competencies are learnt and perceived.

Even though a few (civil) engineering accreditations integrate social sciences and humanities as a requirement, there is a lack of more specific guidelines of what contents exactly should be introduced in civil engineering programs. In fact, the way in which these accreditations’ criteria are implemented in practice is by allowing students to take subjects from other faculties. This is one of the reasons why there do not yet exist a list of competencies related to specific SSH knowledge competency areas for civil engineering.

In this study, specific frameworks from the literature were used to classify these SSH knowledge competency areas. Nonetheless, there is still work to be done in analysing what specific social knowledge is needed by civil engineers. Contrary to what occurs with these competencies, generic skills for engineers have been more commonly examined, both in academia and industry.

Finally, other researchers interested in further studying perceptions towards SSH knowledge competency areas may consider using the instrument herein presented. Nonetheless, the authors would recommend including more categories in both questions so that there are more items to be analysed and compared, mainly in the question regarding generic skills. In the present study, no more than 10 items for SSH knowledge competencies and 11 items for generic skills were used to avoid tiredness of the respondent, as the survey was part of a bigger set of questions. Even though both reliability and validity were adequate, more items would allow to obtain even more interesting results for the factor analysis.

Additionally, if future studies were carried out, to enhance the understanding of the factors influencing perceptions towards SSH knowledge competency areas, future research can employ linear regression modelling. Linear regression modelling can provide valuable insights into the interplay between demographic factors and perceived competency requirements. It can help identify whether differences in perceptions are attributable to group membership (e.g., students, professors, or practitioners) or other individual characteristics like age or gender.

Thus, by considering multiple variables simultaneously, such as group (students, professors, and practitioners), gender, age, and others, results of the linear regression modelling could help disentangle potential confounding effects. For instance, comparing group means while controlling for age can help discern group-specific effects, rather than age-based influences on perceptions.

Limitations of the study

The present study is subject to several limitations. First of all, the survey was answered by students and professors from one single university. Regarding practitioners, they all worked in companies in Catalonia (Spain). Hence, the generalisation of the results needs to be done with caution. Besides, even though the sample of students is representative of the studied civil engineering schools, a larger sample could have been more adequate for the case of practitioners. As for the data collected, it needs to be noted that the present study contained only a cross-sectional dataset. However, it would be interesting to perform the same study to a longitudinal dataset, with data collected throughout different moments in time.

Secondly, no information was gathered regarding the work experiences among the students and professors, particularly regarding their professional backgrounds outside of academia. While the survey gathered perceptions from students and academic staff, their possible work experiences as engineers were not explicitly assessed. It is possible that undergraduate students may have exposure to real-world engineering practices through internships, whereas academic staff might have significant work experiences in engineering roles outside of academia.

The lack of information about participants' prior work experiences outside of academia could have influenced their perceptions towards competencies in the engineering industry. For instance, individuals with substantial engineering work experience might possess more nuanced insights into the specific SSH knowledge and generic skills needed for success in professional settings. On the other hand, students with limited exposure to industry practices might have more idealised or theoretical perceptions of competency requirements.

Thirdly, the questions used in this analysis were part of a broader questionnaire. In particular, the two questions about competencies belonged to the last part of the instrument. This may have slightly affected the results, as several authors emphasise the influence that the relative position in a survey has on the emotional state of the respondent, referred to as the respondent fatigue (Lavrakas, 2008).

Also related to the survey is the fact that items referring to the SSH knowledge and generic skills were not defined in the survey. Consequently, the responses could be influenced by the perception that each respondent had regarding what the items meant.

Finally, the present study is solely focused on the discipline of civil engineering due to the importance that the social dimension has in this field. Therefore, even though conclusions may be extrapolated for close disciplines such as architecture, in the case of other STEM fields that have more differences with civil engineering, the study can serve as a guide for a new research design but not as the basis for conclusions.

Conclusions

The aim of this paper was to analyse the perceived relevance of social knowledge and generic skills in the civil engineering industry among different stakeholders of civil engineering academia and industry. For this, data collected from new, undergraduate, graduate students, professors and researchers, and practitioners were used to analyse perceptions towards social knowledge and generic skills. The instrument used was found to be both reliable and valid. The results showed several mismatches between stakeholders towards these perceptions. These differences are more relevant in the case of SSH knowledge competency areas than generic skills.

Key implications were drawn from the discussion of the results. First of all, stronger links between university and industry could help align the perceived need for different social competencies. Secondly, there is still a lack of a better understanding of key generic competencies needed by engineers, which should be tackled in the future.

Appendix

Table A1 shows the distribution of survey respondents regarding gender and age in percentage. To facilitate understanding of the sample distribution, the table also shows the distribution of groups within the overall group of students, professors, and practitioners.

Tables A2 and A3 present the results of the chi-square tests of independence for the responses on SSH knowledge and generic skills, respectively. As was explained in the article, the chi-square test of independence checks whether two variables are likely to be related or not.

The columns in the tables represent the areas of competency considered for each type of skills. The rows represent items from which information was extracted in the survey. In these, bold letter represents the label for the items, whereas italics represent the possible responses that could be given to these items. As can be seen in the copy of the survey provided as Supplementary material, respondents were asked the activities in which they engage in their free time, which is represented in Tables A2 and A3 as "Activities", including Cultural activities (cult), Sports and physical activities (physical), Creative activities (creative), Personal/spiritual development (develop), Community service or volunteering (service), Learning courses (learning), or no activities (no).

The numbers in the tables represent the values of the chi-square tests statistics. For those items that were not bivariate (i.e., group, age, maximum level of studies) and whose p-value for the chi-square test was significant, the table also presents the results of the Bonferroni-Holm post hoc tests performed. As was explained in the methodology section, these post hoc tests involve pairwise comparisons. Thus, for instance, N:W*** in the table means that the differences in the responses given by new students (N) and practitioners (W) were significant with a p-value $< .001$.

Table A1 Comparison of distribution (gender and age) of survey respondents and overall group

	New students *Invited to participate: 122, responded: 77%*		**Students** *Invited to participate: N/A*		**Professors and researchers** *Invited to participate: 102, responded: 95%*		**Practitioners** *Invited to participate: N/A*	
	Survey respondents	Overall group	Survey respondents	Overall group	Survey respondents	Overall group	Survey respondents	Overall group
Women (%)	32.5	25.5	29.7	23.6	24.5	18.3	30.9	30.3
Men (%)	67.5	74.5	70.3	76.4	75.5	81.7	69.1	69.7
<21 (%)	94	90.1	50.5	63.7	0	-	0	-
22-25 (%)	4.8	3.9	31.9	25.9	0	-	0	-
26-29 (%)	1.2	1	10.9	7.3	2	-	3.9	-
>30 (%)	0	0	6.7	3.2	98	-	96.1	-

Table A2 Results of the chi-square and post-hoc tests of independence for the responses on SSH knowledge

	PROB	HEALTH	ETHICS	CULT	ART	POLIT	LAW	ECON	PSYCH	RELA
Gender (df=4) *(Male, Female)*	6.06	3.31	4.01	6.61	5.13	1.49	0.71	2.54	3.45	2.63
Group (df=16)	**97.93*** **	**86.97*** **	**53.42*** **	**83.87*** **	**50.81*** **	**99.19*** **	**46.08*** **	**88.29*** **	**40.24*** **	**53.02*** **
New (A), undergraduate (B), graduate students (C), professors (D), practitioners (E)	N:W*** U:W*** G:W*** P:W***	N:W*** U:W*** G:W*** P:W**	N:W* U:W*** G:W*** P:W***	N:W*** U:W*** G:W*** P:W***	N:W*** N:G* U:W* G:W* P:W***	N:W*** U:P*** U:W*** G:P** G:W*** P:W*	U:P* U:W* G:W*	N:W*** U:W*** G:W*** P:W***	U:W* G:W** P:W*	U:G* G:W*** P:W*
Age (df=40)	**68.90** **	**59.86***	53.15	46.34	45.18	**119.20*** **	**83.26*** **	**75.05*** **	47.59	55.66
<18 (18), 19-21 (19), 22-25 (22), 26-29 (26), 30-34 (30), 35-39 (35), 40-44 (40), 45-54 (45), 55-64 (55), >65 (65)	22:35* 22:40* 22:45*	18:40*18:45* * 18:55* 19:45* 19:55* 21:40* 21:55**22:40 ** 22:45** 22:55*				18:22**18:35* * 18:45*21:30* 21:35** 21:45* 22:30***22:35 *** 22:40** 22:45*** 22:55*** 22:65* 22:35* 35:55*	21:30* 21:40* 22:30**	18:34*18:35* 18:45*22:30* * 22:35* 22:40* 22:45*		
Max studies (df=24)	**66.75*** **	**75.8*** **	**38.08***	**75.82*** **	**44.08** **	**58.92*** **	34.76	**68.98*** **	28.64	**47.76** **
High school (H), vocational training (V), degree (D), master (M), PhD (P)	H:D*** H:M* D:P*** M:P* V:M* D:M**	H:D*** H:M** D:M*	D:P* M:D*	H:V* H:D** H:M* D:P** M:D** V:D* V:M**	H:D* D:P*	H:D** H:M** H:P** D:P* D:M*		H:D*** H:M*** M:P*		D:P**
Activities (df=4)										
cult *(Yes, No)*	**7.34***	4.46	**4.23***	1.95	**2.89***	21.29	**10.45***	3.65	**10.22***	7.28
physical *(Yes, No)*	3.75	9.44	3.14	2.79	4.3	3.3	2.22	1.63	5.05	8.83
creative *(Yes, No)*	5.17	1.89	2.39	3.01	**17.56** **	1.24	1.19	3.14	4.8	7.46
develop *(Yes, No)*	**20.41*** **	5.39	**9.79***	3	5.57	1.7	2.61	2.38	1.54	7.77
service *(Yes, No)*	6.33	4.56	5.83	3.86	0.72	3.49	3.48	6.28	3.51	2.1
learning *(Yes, No)*	6.32	3.97	6.68	5.81	3.37	2.61	2.87	6.79	1.55	5.04
no *(Yes, No)*	3.82	3.48	7.88	2.72	5.65	0.82	2.69	1.93	2.88	0.81

Notes: italics represent the possible responses to each of the items; bold is used to highlight significant results.

Abbreviations: df: degrees of freedom, *: p<0.05, **p<0.01, ***p<.001

Table A3 Results of the chi-square tests of independence for the responses on generic skills

	TEAM	LANG	INTER	FLEX	CREAT	CONFL	COMM	PROB	MATH	INFORM	ANALY
Gender (df=4) *(Male, Female)*	0.77	1.27	6.04	7.77	1.09	5.76	0.68	2.52	2.83	8.74*	7.64
Group (df=16)	10.62	44.61***	21.4	12.17	67.58***	60.44***	14.67	58.67***	118.73***	16.83	28.17*
New (N), undergraduate (U), graduate students (G), professors (P), practitioners (W)		N:W* P:W**			N:W***U:W*** G:W*** P:W**	N:W**U:P*** U:W***G:W***		N:W*** D:W** G:W**	N:W*** N:U** U:G* U:P**U:W*** G:W** P:W*		N:W**
Age (df=40)	17.48	62.03*	37.92	21.11	68.57**	68.77**	28.99	63.54*	123.73***	41.89	55.19
<18 (18), 19-21 (19), 22-25 (22), 26-29 (26), 30-34 (30), 35-39 (35), 40-44 (40), 45-54 (45), 55-64 (55), >65 (65)		21:45*22:26* 26:35*26:45*			18:45* 22:26* 22:45*	19:45**21:30** 21:45**21:55** 21:65**22:45**		18:45*	18:21*18:30*** 18:45*** 19:30* 19:45* 21:25* 21:40** 21:55** 21:65*		
Max studies (df=24)	7.32	30.04	10.65	16.42	52.39***	70.57***	17.43	41.04*	88.29***	36.76**	19.57
High school (H), vocational training (V), degree (D), master (M), PhD (P)					H:D* H:M** H:P*	H:D* H:M*** H:P***		H:D* H:M* H:P*	H:D*** H:M*** H:P***	H:D* D:M*	
Activities (df=4)											
cult *(Yes, No)*	6.42	0.89	0.8	1.18	5.78	4.52	4.38	2.84	8.05	2.52	1.17
physical *(Yes, No)*	2.77	5.3	2.61	2.4	6.8	3.39	2.8	8.84	0.6	4.06	3.87
creative *(Yes, No)*	6.31	1.47	0.42	1.34	1.62	0.35	1.4	4.94	8.45	0.7	3.76
develop *(Yes, No)*	0.97	5.91	4.12	6.49	2.46	1.48	**8.14***	1.54	1.73	5.09	2.04
service *(Yes, No)*	0.92	3.01	2.29	1.81	3.31	1.89	3.91	2.39	0.65	6.67	2.87
learning *(Yes, No)*	0.81	7.16	7.29	0.42	1.49	3.42	7.39	7.99	1.88	6.44	4.36
no *(Yes, No)*	2.06	1.91	**11.53***	2.84	6.81	5.86	4.75	8.18	5.88	0.48	3.42

Notes: italics represent the possible responses to each of the items; bold is used to highlight significant results.
Abbreviations: df: degrees of freedom, *: p<0.05, **p<0.01, ***p<.001

Data availability statement

Data generated or analysed during the study are available from the corresponding author by request.

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Supplemental material

A PDF with the survey questions is available online as supplemental material.

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Tables in the article

Table 1 SSH knowledge competency areas

Competency area	**Abbreviation**	**Description**	**Reference**
Culture and history	CULT	Cultural and historical context of projects and their communities	Li et al. (2020)
Psychology	PSYCH	Human behaviour and social perceptions	Vale (2013)
Social relations	RELA	Interaction and communication between people	Ballinas-Gonzalez et al. (2020), Carlson and Wong (2020)
Socioeconomics	ECON	Economic activity and related social processes	Vesilind (2001), Andersen (2004)
Legislation	LAW	Legal matters	Cooper and Ashurst (2011), Brambila-Macias and Sakao (2021)
Politics	POLIT	Political context, policy making, governance	Vesilind (2001)
Health and quality of life	HEALTH	Physical and mental health, and ability to enjoy normal life activities	Zitomer et al. (2003), Kudngaongarm and Sujivarakul (2011)

Arts and aesthetics	ART	Beauty, taste, visual appearance	Weinstein et al. (2020)
Social problems	PROB	Conflicts, poverty, inequality…	Vale (2013), Ballinas-Gonzalez et al. (2020)
Ethics and philosophy	ETHICS	Justice and moral values or principles	Vesilind (2001), Taajamaa et al. (2017), Tharakan (2020)

Table 2 Generic skills

Competency	**Abbreviation**	**Description**	**Reference**
Informatics	INFORM	Ability to utilize computers and technology efficiently	Perdigones et al. (2013), ABET (1996)
Communication (written and verbal)	COMM	Ability to present one's work both to professionals and lay audience	Enshassi and Hassouna 2005, Cooper and Ashurst 2011, ABET (1996)
Conflict resolution	CONFL	Withstand, endure and resolve arising conflicts	Nguyen 1998
Creativity and innovation	CREAT	Creative and innovative thinking, design and problem solving	Nguyen (1998), Rugarcia et al. (2000)
Data analysis	ANALY	Ability to analyse and interpret data	Shuman et al. (2005), ABET (1996)

Flexibility and adaptability	FLEX	Capacity to adapt to change.	Enshassi and Hassouna (2005), Perdigones et al. (2013)
Interpersonal skills	INTER	Ability to interact with other people.	Enshassi and Hassouna (2005), Martin et al. (2005)
Languages	LANG	Improved command of foreign languages.	Nguyen (1998), Rugarcia et al. (2000)
Maths and Physics	MATH	Ability to apply knowledge of STEM	Enshassi and Hassouna (2005), Shuman et al. (2005)
Problem solving	PROB	Critical thinking for problem solving	Perdigones et al. (2013), ABET (1996)
Teamwork	TEAM	Ability to engage effectively and productively in team-working.	Perdigones et al. (2013), ABET (1996)

List of figure captions