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Procedia Computer Science 253 (2025) 1144–1153

Procedia Computer Science

www.elsevier.com/locate/procedia

6th International Conference on Industry 4.0 and Smart Manufacturing

Determining Training Needs to Promote Circular Economy and Decarbonization in Production

Johanna Kargruber[a]*, Michaela Golser[a], Angelika Hofer[a], Erwin Rauch[a]

[a]*Sustainable Manufacturing Lab, Industrial Engineering and Automation (IEA), Faculty of Engineering, Free University of Bozen-Bolzano, Piazza Università 1, 39100 Bolzano, Italy*

Abstract

To scope the actual problems regarding climatic changes and the corresponding regulations, sustainable strategies and actions become increasingly important for companies, especially in production. The industry is facing a deficit in well-trained professionals that meet these criteria. This paper attempts to determine the relevant skills and the associated training needs for: pupils, teachers, students, and professionals. For this purpose, a literature and job offer analysis on required skills and on existing regional trainings were first carried out. The results were discussed and revised at workshops with interested stakeholders. It was found that there is still a big need in trainings for basic sustainability topics, such as the SDGs. Furthermore, topics like digitalization, life cycle assessment, legislation, reporting and sustainable management systems are particularly important. To implement these topics in training courses, it became clear that practical approaches are to be preferred. Soft skills, like communication skills, should be taught alongside.

Keywords: Sustainability Education; Future Skills Profile; Sustainable Manufacturing; Lifelong Learning

1. Introduction

Circular economy and decarbonization are concepts that have been in existence for several decades but have become de facto obligatory for companies to address these topics comprehensively in recent years. The strong shift within

* Corresponding author. Tel.: +39 0471 016000; fax: +39 0471 016009.
E-mail address: johanna.kargruber@unibz.it

1877-0509
10.1016/j.procs.2025.01.176

society towards a greener and more sustainable future, mostly driven by politics, has become stronger than ever. The Paris Agreement of 2015 established a legally binding international arrangement with the objective of limiting the emissions in order to prevent a global temperature increase of more than 2° C above pre-industrial levels [1].

The ever-increasing necessity for actions that can guarantee the achievement of this goal has led to several legal requirements for companies and industry especially on a European level. Various researchers argue already that the achievement of the climate targets are very unlikely, as the current actions towards environmental sustainability needs to be accelerated much more [1-3]. Furthermore, companies are pressured more and more to change their production methods in order to facilitate the achievement of the climate goals. Until recently, companies' business models were relying mostly only on financial goals, this has changed to a business model that incorporates corporate social responsibility programs and actions to meet sustainability targets and the stakeholders' expectations, as it displays the obligation to protect, increase and enhance the benefits for stakeholders and social people [4, 5]. The transition to sustainable production can be achieved in a variety of ways: e.g. by improving the supply chain processes [6,7], favoring remanufacturing through adaptability [8] or recycling of resources from polluting vehicles that have reached the end of their life earlier than expected due to environmental policy [9]. The successful implementation of action plans, regarding Corporate Social Responsibility (CSR) or sustainability in general, is relying strongly on competent and skilled professionals [10]. The issue of universities adapting their curricula and lifelong learning offer to align with the expectation of the industry is primarily a matter. However, it may not be sufficiently addressed in the past.

Longer life expectancy and changing working conditions mean that workers are experiencing a variety of different life stages, and therefore a change in approaches to skills development is needed to ensure lifelong education and training. In addition, vocational training has become a very important component of adult education, as it is more flexible and creates more individualized educational opportunities that reflect individual learning pathways. Furthermore, this continuous learning is necessary for navigating the complexities that arise in the context of topics associated with Industry 4.0 and related fields. So-called micro-credentials (short training courses) are useful, as they make it possible to acquire the necessary skills without neglecting the previous career. It is evident, that a re-evaluation of the vocational training models and concepts is required. Due to a certain degree of uncertainty when looking at an uncertain future and not knowing what demands will be placed on people in the future labor market, it is also not known on which competence area vocational education and training should focus [11-13]. As different sources suggest, there is a deficit in employable professionals that meet the criteria for implementation of sustainability strategies as well as various concepts concerning Industry 4.0 and Industry 5.0 [14-16]. The implementation of new concepts to train pupils, students and professionals in those specific topics is challenging due to a lack of trained trainers. To overcome the obstacles to implementing Industry 4.0, projects have already been carried out in the past to promote training and further education in the necessary competencies [17-18].

The Interreg VI-A Italy-Austria 2021-2027 project "EDU-CIRC", co-funded by the European Union is an interregional initiative, with partners from Italy and Austria. It aims to raise awareness and provide training to the before bespoken focus groups to support companies in realizing their potential specifically regarding circular economy and decarbonization. The primary subjective is to enhance the knowledge in pupils of high schools and university students, as well as their teachers and other professionals. Furthermore, the project focuses on three important sectors in the Alpine region: (i) woodworking, (ii) construction, and (iii) automotive industry. The most significant outcomes will be the publication of openly accessible learning materials on the EDU-CIRC Portal, in addition to the implementation of educational training programs.

The initial stage in the creation of learning materials is a comprehensive analysis of competencies required, including both hard and soft skills. The result will be compared to the actual needs of the stakeholders. This comparison is crucial as it reflects relevance to the learning materials created. A significant number of competencies discussed in literature have neither been analyzed nor compared to the actual situation in the Alpine region. Consequently, there is still a lack of relevant information to shape the engineering education regarding sustainability. This research attempts to address the gap by conducting a comprehensive literature review that analyses the competences mentioned and determines the relevance for people in engineering. The result will then be compared to the actual situation of available education programs or courses, as well as being discussed with various stakeholders to ensure the relevance of the findings. The results generated in this way represent the need for training, for which suitable training programs are developed and offered in a second step.

2. Material and Methods

Figure 1 schematically summarizes the methodology for developing a draft of the future skills profile and the associated training needs. For this purpose, the most important requirements for hard and soft skills in the field of engineering and sustainability are first collected from the literature and job offerings. For the hard skills identified, the already existing training offer is determined. The results of both screenings form a first draft of the future skills profile and associated training gap. This is presented to various stakeholders and revised based on their experiences and wishes. Finally, a revised draft of the future skills profile is created based on which training programs are developed in a second step.

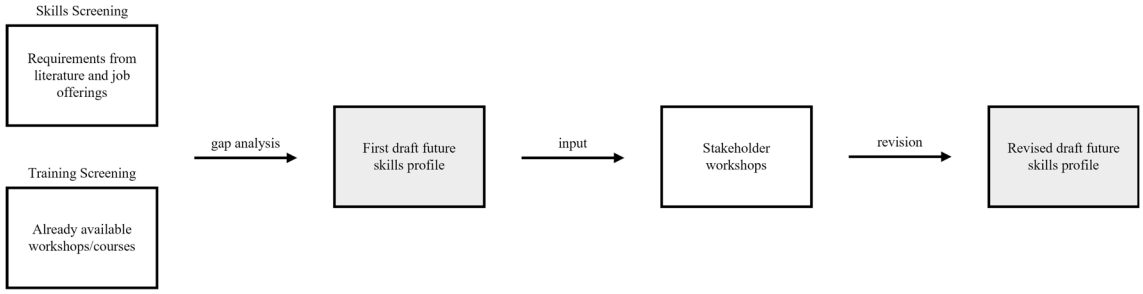

Figure 1. Methodological steps for developing a draft of the future skills profile (grey) and thus the associated training needs.

2.1. Skills Screening

To conduct a literature review about competences needed a keyword search was conducted within the platform Web of Science. The keywords searched for were:

(TITLE-ABS-KEY(engineering AND education) AND TITLE-ABS-KEY(sustainability AND skills))

For the review to be representative the limiting borders were set to only English language papers, only published articles, and published between 2019 and 2023 (5 years span), resulting in 30 papers to be reviewed. After considering relevance and accessibility, the number of papers examined was reduced to 23.

In addition, an internet screening was carried out, looking at actual job advertisements and offers. Here, the job platform stepstone [19] was used. The search term was “sustainability” with additional filters such as “region Europe only” and “engineering and technical jobs only”. The search was carried out on 03/05/2024 and is therefore only representative for that specific day. As a result, 481 results were obtained. After applying additional filters ("Building & Construction", "Distribution, Transport & Logistics", "Manufacture of machinery & equipment", "Steel" and "Other sectors & industries"), 170 job offerings remained. The first 53 were screened in full.

Due to the very long list of skills identified, only skills that were mentioned at least three times were considered. Language skills, considered a hard skill, were not included as they are very specific to the country and company seeking to recruit. Another limitation was that all general hard skills such as Excel or Microsoft skills were excluded, so the focus was more on hard skills related to sustainability or technical skills. After this limitation, 25 hard skills (Table 1) and 22 soft skills (Table 2) could be identified as relevant competencies.

2.2. Training Screening

A further screening was carried out to see what kind of workshops and courses were already being run in the Interreg Italy-Austria regions to identify gaps. Due to the thematic relevance for the overall topic of sustainable engineering, this analysis is limited to the hard skills. Furthermore, only German-speaking regions were considered for reasons of comparability. For the Italian part of Interreg Italy-Austria, this is the region of South Tyrol (north-eastern part of Italy).

The screening was mainly a keyword search combined with the words “education”, “course”, “seminar”, workshop” or “vocational training”, while secondly also main platforms for trainings were searched through. The search considered the respective national languages as well as English. As a result, the number of training programs offered today for each of the hard skills identified in the skills screening was counted.

2.3. Workshops with Focus Groups

To ensure that the requirements for bridging the educational gap are well understood, two workshops were held with different focus groups. The aim was to provide information about the project, as well as to gather insights from their own experiences, suggestions for improvement and personal wishes.

The first workshop took place on 04/22/2024 in the form of a stakeholder meeting. A total of 12 participants took part. Alongside the 2 speakers, 4 participants from industry and 6 from education took part. The participants from education comprised two teachers from a technical secondary school, two PhD students and two research assistants. The second workshop took place on 04/30/2024 with university students. A total of 23 students took part. Overall, the interests of all 4 focus groups were represented, although in the case of the pupils only indirectly through their teachers.

The workflow of the two workshops was identical. First, the project and the results of the skills and training analysis were presented. This was followed by the collection and discussion of ideas using the brainwriting method.

3. Results

3.1. First Draft Future Skills Profile

Table 1 shows the frequency in mentions of the various hard skills in the literature and in job offerings. Moreover, the quantity of courses found for each skill is shown. The hard skills “sustainability concepts”, “certification concepts”, “ESG knowledge”, “climate neutrality”, and “project management” are most frequently mentioned in literature and job offerings. However, most courses are offered for the hard skills “CAD/CAFM”, programs like “HOAI, VOB”, “technical concepts”, “ESG knowledge”, and “ICT skills”. When comparing the two data groups, no concrete pattern could be discovered. It merely shows that the hard skills, for which over 1,000 courses are offered, are mentioned less frequently in literature and job offerings.

It should be noted that the range of courses identified for individual hard skills differs greatly between the respective survey area. For example, there are over 2,500 courses on CAD/CAFM in Austria, whereas only 5 were identified in South Tyrol. One reason for this is the difference in size of the survey areas, the lack of a central database in South Tyrol, as well as country-specific requirements (HOAI/VOB as German regulations are rather irrelevant for South Tyrol in Italy).

Table 1. Frequency in mentions of the most important hard skills in the literature and in job offerings (skills screening), as well as the number of their existing trainings in the areas under consideration (training screening).

Hard Skill	Count of Mentions in Literature and Job Offerings	Count of Courses Offered in Austria | South Tyrol | Total		
Sustainability concepts	19	0	1	1
Certification concepts (management systems)	18	2	7	9
ESG knowledge	17	373	30	403
Climate neutrality	12	8	0	8
Project management	11	293	10	303
Circular economy	10	32	1	33
Laws knowledge	10	40	21	61
Auditor competence	9	158	0	158
CSRD reporting	8	10	1	11

Profitability assessment	7	10	1	11
Quality assurance (FMEA, control plan…)	7	100	2	102
Green building	6	259	1	260
Knowledge of digitalization	6	139	12	151
Life cycle assessment	6	9	1	10
Computer literacy	5	11	107	118
Programs HOAI, VOB	5	1,218	0	1,218
Simulations (Software e.g. TRNSYS)	5	2	5	7
CAD/CAFM	4	2,622	5	2,627
Decarbonization	4	1	1	2
ICT skills	4	352	0	352
Process optimization	4	10	0	10
Building automation	3	2	1	3
Creation of climate strategy	3	0	0	0
Potential analysis	3	6	0	6
Technical concepts	3	1,054	2	1,056

Table 2 shows the frequency in mentions of the various soft skills in the literature and in job offerings. The most frequently mentioned soft skills are “communication skills”, “teamwork”, “independence”, “organizational skills” and “leadership skills”. The two most common soft skills were mentioned almost twice as often as the most common hard skills.

Table 2. Frequency in mentions of the most important soft skills in the literature and in job offerings (skills screening).

Soft Skill	Count of Mentions in Literature and Job Offerings	Soft Skill	Count of Mentions in Literature and Job Offerings
Communication skills	36	Systems thinking	6
Teamwork	36	Initiative and entrepreneurial competence	5
Independence	19	Interdisciplinary thinking	5
Organizational skills	16	Resilience	5
Leadership skills	13	Decision-making technique	4
Analytical thinking	12	Learning competence	4
Solution-oriented approach	10	Motivational skills	4
Critical thinking	8	Emotional intelligence	3
Integrated problem-solving	7	Ethics	3
Consulting competences	6	Holistic thinking	3
Presentation skills	6	Innovation skills	3

In summary, Figure 2 lists the most important hard skills determined that promote circular economy and decarbonization in production in the engineering sector. To create a future skills profile, the skills were divided into three columns based on the authors’ experiences: from general, simpler skills to specialized skills and those that require a certain level of prior knowledge. Furthermore, the skills for which fewer than 100 courses are offered today in Austria and South Tyrol together are marked in bold. Accordingly, there is a training gap for these skills and thus a need for suitable training programs.

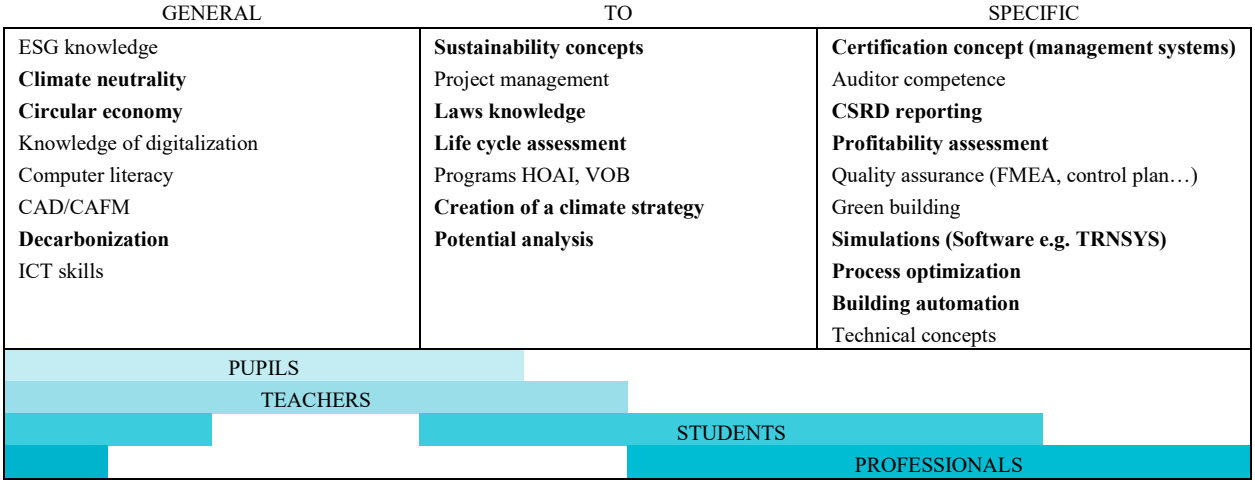

Figure 2. First draft future skills profile - classification of the relevant hard skills from general to specific and their allocation (coloured) to the 4 focus groups pupils, teachers, students, and professionals. Hard skills for which there is a need for training programs today are shown in bold.

In the lower part of Figure 2, an attempt was made to assign the hard skills identified to the 4 groups: pupils, teachers, students, and professionals. The future training program should be designed accordingly. For pupils and teachers, the focus should be on the more general skills. As pupils do not usually find themselves in a specific sector, this should create a good foundation for their future career. For teachers, the skills profile was chosen to be somewhat larger than for pupils, in order for them to understand the wider context and to be able to impart this knowledge to pupils if necessary. For students and professionals, the focus is on specialized skills, which are characterized to be more complex, industry-specific, or job-specific. Nevertheless, the basic skills are also important for these two groups. For students more than for professionals, as they are usually not yet tied to a specific job and the associated tasks. For this reason, the specific hard skills are also slightly less important.

Regarding soft skills, no direct allocation to the 4 groups could be made. In contrast to the hard skills, they cannot be divided into general and specialized/industry-specific skills. The soft skills also do not really build on each other, i.e. they are independent of each other. With a few exceptions, all soft skills are equally important for pupils, teachers, students, and professionals.

3.2. Revised Draft Future Skills Profile

Figure 3 shows the results of the two workshops with stakeholders (purple) and university students (blue). A total of 90 ideas were collected, whereby the stakeholders collected 53 ideas and the students 37. However, the stakeholders mainly concentrated on the focus groups students and professionals. Among the students, the distribution was relatively even. It can also be seen that the stakeholders collected more ideas across all focus groups than the students.

According to students, general sustainability topics and their integration into everyday life are important for pupils. For teachers, they consider the complexity and interdisciplinary nature of sustainability as well as its practical and digital integration into teaching to be important. For themselves, the students mainly mentioned sustainability strategies and the individual influence. The latter was also mentioned for professionals, alongside various regulations. Digital skills were frequently mentioned across all focus groups. Stakeholders also consider basic knowledge of sustainability and its practical application to be important for pupils. According to them, the topic of Life Cycle Assessment (LCA) should already be taught in school. Therefore, teachers must have the appropriate skills and equipment. For students, stakeholders consider digital skills and sustainability strategies to be particularly important. Regarding professionals, management in different contexts, LCA and various regulations were frequently mentioned.

Overall, only few soft skills were mentioned. “Critical and analytical thinking” was considered important for pupils and students, “teamwork” for pupils and teachers and “systems thinking” for students and professionals. In addition, “holistic thinking” and “communication skills” were mentioned for professionals.

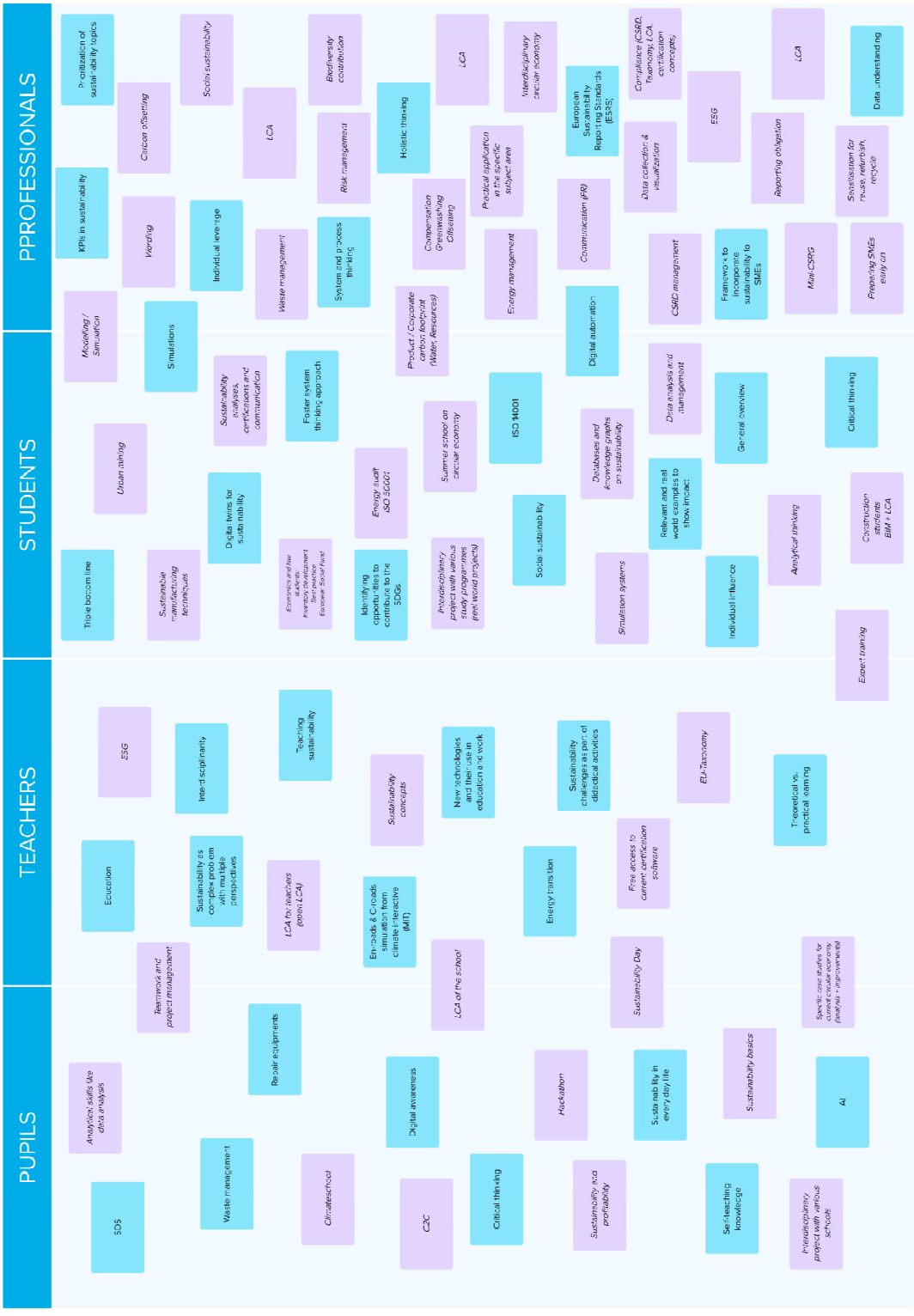

Figure 3. Results from the workshops with stakeholders (purple) and students (blue).

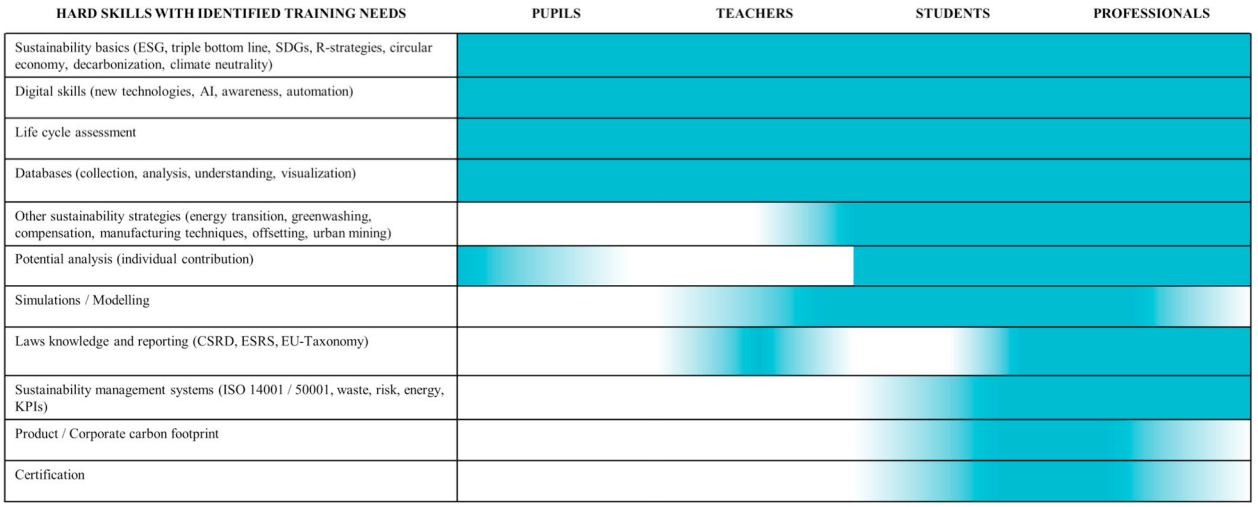

Figure 4. Revised draft future skills profile - allocation of the hard skills for which a training need was identified through the initial analysis and the workshops to the respective focus groups. The importance of the individual hard skills for the focus groups is more (opaque) or less (faded) strong, depending on the frequency with which they were mentioned for the respective focus groups in the workshops.

Taking the results of the two workshops into account, the future skills profile was further revised and specified more precisely for the focus groups (Figure 4). Almost all hard skills for which a need for training was identified in the first draft were considered, as well as those that were frequently mentioned in the workshops. Only "profitability assessment" and "process optimization" were not included, as they were never mentioned in the workshops. Others, such as "climate neutrality", were not adopted directly, but can be found within other terms such as "sustainability basics". The importance of the individual hard skills for the focus groups is more (opaque) or less (faded) strong, depending on the frequency with which they were mentioned for the respective focus groups in the workshops.

The revised future skills profile, which represents the training needs of the hard skills found, shows that a certain level of basic knowledge in sustainability is required for all 4 focus groups. This confirms the corresponding assumption in the first draft. In addition, digital skills relating to new technologies and the use and handling of databases are also demanded as well as the concept of life cycle assessment. More specific and complex hard skills are required for students and specialists, but also for teachers in some cases, e.g. in the area of reporting and simulations. The latter as well as potential analysis are particularly important topics for students. For professionals, the topics focus primarily on legal regulations, reporting and various management systems relating to sustainability.

The revised profile also refrained from assigning the soft skills mentioned to the individual focus groups. The reason for this is that the various hard skills require several soft skills without these being specifically mentioned. The hard skill “sustainability management systems” for example requires the soft skills “communication skills”, “organizational skills", “leadership skills”, “solution-oriented approach”, etc. Accordingly, most soft skills are important for all 4 focus groups and should always be taught simultaneously with the hard skills. However, the soft skills "critical thinking", "teamwork", "analytical thinking" and "communication skills" are particularly important, as they were mentioned most. For teachers, in addition, teaching methods and especially the practical applications are also significant.

4. Discussion

With the help of the skills and training screening, a first draft of the future skills profile was created for the 4 focus groups pupils, students, teachers, and professionals. The required competencies were determined through a literature and job offer analysis, assigned to the 4 focus groups and compared with the existing training programs. The training gap identified represents the training needs.

When assigning the hard skills, it was assumed that all of the respective focus groups must have a certain level of basic knowledge. Apart from that, pupils and teachers were assigned the more general and simple skills, such as climate

neutrality, circular economy and decarbonization. Students and professionals were assigned the more specific and complex skills, such as certification concepts, CSRD reporting, etc.

These results were presented and discussed with interested stakeholders and students at two workshops. Based on this, a revised draft of the future skills profile was created. With the help of the workshops, the individual hard skills could be better assigned to the respective focus groups, depending on their frequency with which they were mentioned. This confirmed the assumption that a certain level of basic knowledge is required for all focus groups and that additional specific and complex hard skills are required for students and professionals. Basic knowledge in this context refers to sustainability basics (such as SDGs, ESG...), life cycle analysis and the understanding and handling of digital skills and databases. Additionally important for students are the topics of simulation and modeling as well as knowledge of their own scope and influence. The latter is also important for professionals. For them, though, hard skills in the areas of legislation, reporting and sustainability management systems are particularly important. Since pupils and students are the future specialists, however, it is useful to teach these competencies to them as well.

No future skills profile was created for the required soft skills, as a direct assignment to the respective focus groups was not considered expedient. In the workshops, the soft skills of "communication", "teamwork" and "analytical and critical thinking" were mentioned most frequently. These were also mentioned most frequently in the literature and in job offerings. Nevertheless, the less frequently mentioned soft skills should not be neglected either, as they are implicitly required in the implementation of the hard skills. Accordingly, it makes sense to foster soft skills when teaching hard skills. For teachers, however, didactic skills are also of particular importance.

The future skills profile is a valuable tool for educational and training institutions, industry and policy makers. It helps to design the curriculum and individual training courses in such a way that professionals and future professionals in the engineering sector are well prepared for the future challenges associated with sustainability. However, it is not just about teaching certain topics, but also about choosing the right teaching methods. These can be used to teach valuable soft skills such as communication, teamwork, independence, etc. For the industry, well-trained specialists are of marginal importance in order to accelerate the transition to circular and CO2-neutral production. This is also an important goal for policy makers, who can use the tool to identify topics for funding programs.

5. Conclusion

In general, it was shown that there is still a great need for education on sustainability topics in the field of engineering. In addition to topics that are specifically related to sustainability, digital skills and the understanding of data, as well as soft skills such as communication skills and teamwork are also important. To prepare professionals for future problems, appropriate training programs are needed, which must also be addressed to pupils and students as future professionals, as well as their teachers.

However, the results of this work build heavily on the results of the workshops. The participants were university students and stakeholders from business and education, with pupils being represented only indirectly by their teachers. In order to better reflect the educational needs, additional workshops should be held with pupils. Furthermore, the research should be extended to the Italian regions of Interreg Italy-Austria in order to identify their perception of competencies needed and the education gap. The resulting findings can be used to create a final future skills profile and a holistic overview of the educational gap in the field of engineering in the Alpine region. This can be used by educational and training institutions in the design of their training programs.

Acknowledgements

This project is co-funded by the European Union’s Interreg VI-A ITA-AUT 2021-2027 program under the grant agreement No. ITAT-11-013. Views and opinions expressed are however those of the author(s) only and do not necessarily reflect those of the European Union.

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