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Exploring the Industrial Engineering Competences in the Changing Landscape of the New Industrial Revolution

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Abstract. The aim of this paper is to explore the possibilities of how Higher Education Institutions (HEIs), by integrating research and education, can increase the industrial competences of students. By exploring the perceptions of various stakeholders and analyzing ongoing trends, this paper seeks to shed light on the potential ways in which HEIs can contribute to future industrial competitiveness. Identifying existing skill gaps among future engineers will enable the HEIs to know the demand for skills and align graduate capabilities with industry requirements. The final reflections will explore how HEIs can collaborate with regional and national industries, through integrating activities between engineering research and education, contributing to industrial readiness as well as to the DeepINVENTHEI initiatives in Europe.

Keywords. Engineering skills and competencies, Research and Education, Industry, Innovation and Entrepreneurship, Digitalization, Life-long learning, Sustainability.

1. Introduction

The world is undergoing a rapid transformation driven by the new Industrial Revolution, where emerging technologies, including digitalization, have significantly altered our lifestyles, consumption patterns, and production processes [1] [2] [3]. This shift necessitates adaptation to new challenges, particularly amid global issues such as climate change, pandemics, and warfare. Manufacturing companies are compelled to embrace new processes and strategies to remain competitive in this dynamic industrial environment [3] [4]. The development of emerging technologies has further accelerated this process of adaptation to these new challenges. Consequently, the employees´ skills and knowledge within companies need to be updated continuously [1] [5], and life-long learning activities have emerged during the last decade [6]. However, the traditional Higher Education Institutions (HEIs) system must respond to these emerging trends as well and equip the new generation of engineers with the necessary skills and competencies to contribute effectively to the industry [2] [6]. Here, there is a need for combining basic engineering education with emerging technologies into courses and

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training activities that continuously integrate the research front. Initiatives from European Institute of Innovation and Technology (EIT) such as the Deep INnoVation and ENTrepreneurship in HEIs (DeepPINVENTHEI) [7] have identified the need for integrating the innovation and entrepreneurship perspective with engineering. From an education point of view, HEIs can support the EIT through DeepINVENTHEI initiatives by developing education through learning and mentoring activities that combines the research front with teaching activities in courses by integrating innovation perspectives in different ways. This study will focus on gathering perceptions from Academia (teachers and researchers) and the Industry (practitioners) to explore the possibilities of how HEIs, by integrating Research and Education, can increase the industrial readiness for students to contribute to the future industrial environment. By exploring the perceptions of various stakeholders and analyzing ongoing trends in Sweden and the world, we present a comparison based on the findings and trends shown in the Future of jobs report [1]. Identifying existing skill gaps among future engineers will enable the HEIs to know the demand for skills and align graduate capabilities with industry requirements. The final reflections will explore how initiatives in Europe such as the DeepINVENTHEI have driven HEIs to collaborate with regional, national, and international industries and universities, through integrating activities between engineering research and education, contributing to industrial readiness as well as to the DeepINVENTHEI initiatives in Europe. This exploratory study is limited only to Sweden, taking as a starting point an institution and companies in the same area.

2. Literature

In recent years, due the evolution of societies, there has been a notable surge collaboration between industry and HEIs. Companies' consistent pursuit of engineering students possessing the requisite skills from these institutions has underscored the importance of this partnership. HEIs, with their tripartite missions of education, research, and regional, national, and international development through external collaborations, stand at the forefront of this collaborative effort [8]. The year 2020 marked a significant milestone in this trajectory with the introduction of a pioneering Swedish research proposal. This proposal, with a central tenet of aligning research and education with industry, promises numerous advantages for both academia and the corporate world. An exemplar of this mutual benefit is witnessed in collaborative research projects, where the exchange of scientific competences from universities to industrial enterprises facilitates the absorption and practical utilization of knowledge originating in the academic realm [4]. In contemporary times, the convergence of interests and objectives between Industry and HEIs is conventionally achieved through the active engagement of researchers in educational endeavors and the promotion of research projects that incorporate and engage students. Typically, interaction with corporate entities transpires through the medium of final thesis work at the majority of HEIs. However, avenues for collaboration can also manifest within various student projects and activities, including but not limited to Industrial Placement Courses (IPC), Internships, Work Placements (LIA), or analogous initiatives. The integration between academia and industry has become increasingly pervasive, transforming the landscape of education beyond traditional classroom settings. Contemporary enterprises are now actively engaged in augmenting the specialized expertise of their workforce through continuous and lifelong learning initiatives, positioning it as a pivotal component of their comprehensive organizational strategy, as elucidated in [1]. Findings from a comprehensive survey underscore the significance of external training in collaboration with educational institutions, constituting 12% of the holistic approach employed by organizations. The collaboration between HEIs and the industrial sector is crucial, fostering the generation of scientific knowledge and valuable data, as well as empowering solution development through grounded research projects. In manufacturing, this collaboration addresses complex production challenges, optimizing operational efficiency [4]. The Swedish Knowledge Foundation employs co-production, aligning research with real-world applications and facilitating knowledge dissemination. Co-production offers benefits beyond knowledge transfer, including competency enrichment, opportunities for employee development, and the cultivation of novel knowledge domains [9]. In order to effectively address the multifaceted challenges presented by the 21st century, HEIs find themselves at a pivotal juncture, requiring transformative adjustments to equip the next generation of engineers, as underscored by [6]. The evolving dynamics of contemporary society necessitate a comprehensive overhaul of the Engineer profile, mandating the incorporation of not only technical proficiencies but also a diverse array of interpersonal and intrapersonal skills. As articulated in [2], the cultivation of soft skills within this context demands a clear and comprehensive definition. Such a definition must be developed within a holistic framework, considering the imperative of multicultural and multinational perspectives. Furthermore, this endeavor necessitates a delicate balance between the principles of sustainable development and economic viability. The contemporary engineer must assume a role of heightened global awareness, extending their purview to encompass environmental, social, and economic dimensions both within and beyond organizational boundaries, as expounded upon by [2]. This holistic perspective is essential for engineers to effectively navigate and contribute to the complex, interconnected, and rapidly evolving landscape of the 21st century.

Several initiatives play a crucial role in fostering collaboration between industries and academia to development of technologies and innovations. Initiatives such as CDIO™ advocate for the integration of sustainability principles into competency development [9]. The CDIO™ initiative is an innovative educational framework emphasizing engineering fundamentals within the context of Conceiving – Designing – Implementing – Operating (CDIO) real-world systems. Globally, CDIO has been adopted as the curricular planning and assessment framework by collaborators who acknowledge the diverse learning experiences in engineering education and value shared best practices across institutions [9]. The DeepINVENTHEI initiative on the other hand, stands as a prominent proponent, aiding HEIs in cultivating innovation and entrepreneurship competences. Its overarching objective is to stimulate sustainable economic growth and the creation of skilled employment opportunities across Europe. This mission is underpinned by the support and guidance of European Communities and distinguished partners. The initiative encompasses a spectrum of resources, including entrepreneurial education programs, services for business inception and acceleration, as well as research projects emphasizing innovation [10]. Central to this educational paradigm are design-implementation experiences, which serve as fertile ground for students to apply and contextualize their knowledge, skills, and attitudes in the realm of sustainability. These experiences extend to the development of novel technologies and the reimagining of existing ones through practices such as reuse, redesign, recycling, and rethinking. These experiential, hands-on, and transformative learning activities are instrumental in fostering students' essential competencies for sustainability, as delineated by [9]. *In anticipation of the challenges of the future, the identification of skills and competencies demanded by companies from engineering students and recent graduates is paramount.* This call extends not only to HEIs but also resonates with industry and society at large, urging the exploration of novel approaches to skill development, as articulated by [2]. However, a formidable challenge lies in the preparation of *educators* to navigate this evolving landscape and to equip them with the requisite tools and strategies to effectively guide students in adapting to the increasing complexity of modern industry.

2.1. Competencies or skills?

The delineation of competencies in the educational landscape has been somewhat fragmented, as noted by various studies [11]. These investigations have employed different nomenclature to describe the essential attributes, such as “employability skills,” “professional skills,” “soft skills” (non-cognitive skills), “professional competence,” “professional capabilities,” and specific skills like “communication skills,” “technical skills,” and social skills, to name a few [3] [2] [12] [6] [11]. However, a pertinent question emerges: what distinguishes competencies from skills? As per Merriam-Webster dictionary, “competencies” encompass an individual’s or an organization’s *aptitude* to effectively execute specific tasks, functions, or responsibilities. This broad term encompasses not only *the core skills* but also the knowledge and attributes requisite for excelling in a particular role or domain. Within the realm of Engineering sciences, foundational proficiencies encompass a blend of core knowledge in subjects like Mathematics and Physics. Complementing these technical competencies are a cluster of *soft* skills, including but not limited to teamwork, project management, collaboration, and communication skills. These *soft* skills serve as pivotal tools, forming the bedrock for establishing and sustaining robust professional relationships. Engineering students are challenged to seamlessly convey their knowledge across diverse environments, spanning the academic sphere, corporate settings, and research projects. In certain scenarios, they function as adept “translators,” bridging the gap between intricate technical concepts and practical application, as elucidated by [8]. This multifaceted skill set empowers engineering students to effectively navigate the multifarious landscape of their discipline, from theoretical underpinnings to real-world implementation. In the pursuit of pinpointing the essential competencies of engineering graduates for enhanced employability, Winberg underscores the necessity of adopting a holistic perspective [6]. This entails an amalgamation of knowledge, practical work experience, and the cultivation of technical and interpersonal proficiencies. The overarching goal is to achieve a delicate equilibrium between engineering expertise and *professional* skills [6]. The contemporary landscape of engineering demands that graduates not only adhere to exacting *technical standards* but also possess a repertoire of *soft* skills to augment their employability quotient. The development of these soft skills is an indispensable component of engineering education and training, as articulated by [3]. This duality of competencies, where technical acumen meets the finesse of soft skills, is pivotal in ensuring that engineering graduates are well-equipped to meet the multifaceted challenges of their profession and secure a competitive edge in the job market.

2.2. What skills do companies need from engineering students?

In the formulation of pedagogical projects within the engineering domain, Campos highlights a noteworthy absence of scientific instruments that encompass social-emotional skills in the training of engineers [3]. Moreover, the *decision-making* processes often lack the input and perspectives of both graduates and employers in shaping the desired professional profile. In a comprehensive study, Campos contrasts the expectations and perceptions of 40 engineering employers concerning the role of soft skills in engineering professionals. The findings reveal a misalignment between employer perceptions and their actual expectations. Notably, competencies such as *critical thinking* and *ethical perspectives* exhibit higher expectations than what is observed in practice [13] [3]. Furthermore, the transition from a strictly engineering role to a management position is marked by inherent challenges. This shift underscores the pivotal role played by skill development, especially in the context of a capitalist model that necessitates greater adaptability and flexibility [3]. The pursuit of results in this environment hinges significantly on the competencies of a manager and their ability to foster effective team dynamics [3]. Consequently, the development of these management skills emerges as a fundamental facet in the trajectory of an engineer's career evolution.

2.3. Skills classification initiatives

The imperative for a standardized and universally recognized skills language was notably addressed in 2020 when the European Commission unveiled the European Skills Agenda [14]. In 2021, the World Economic Forum, drawing inspiration from ESCO (European Skills, Competences, Qualifications, and Occupations) – a multilingual classification system (as outlined by [16]) – embarked on the creation of a *Global Taxonomy of Skills (GTS).* This innovative initiative was designed to establish a unified and universally accepted lexicon for skills, thereby offering a comprehensive framework for the adoption of a common language surrounding skills in a global context [17]. Notably, ESCO has cataloged a vast inventory of *13,890* distinct skills, organized within a hierarchical structure encompassing four distinct classifications (Knowledge, Language skills and knowledge, Skills, Transversal skills). This concerted effort underscores the growing international recognition of *the need for a standardized skills taxonomy*, which can transcend linguistic and regional boundaries, thereby fostering enhanced cooperation and understanding in the realm of skills and competencies. This pioneering initiative represents a synthesis and expansion of established taxonomies by unifying the definitions and categorizations of skills poised to play an increasingly critical role within a rapidly evolving labor market. The output encompasses an interactive taxonomy, replete with comprehensive skill definitions, along with accompanying guidelines for widespread implementation and practical application. The GTS report [17] employs a two-fold categorization, distinguishing between *Skills, Knowledge*, *and Abilities (SKA)* showed in Figure 1 and *Attitudes (A) showed in Figure 2*. This structured approach facilitating the recognition and utilization of these distinct skill elements and behavioral attributes. This unified taxonomy serves as a valuable resource for adapting to the ever-shifting landscape of the modern workforce, streamlining skill-related discussions, and enabling more effective workforce planning and development strategies. The first categorization *Skills, Knowledge*, *and Abilities* (SKA) is related to the proficiency in performing diverse cross-functional tasks and is encapsulated in skills, acquired through experiential learning or formal instruction.

While skills may become second nature with development, separating them from contextual or theoretical knowledge proves challenging. Additionally, skills are intricately tied to varying degrees of innate physical, psychomotor, cognitive, and sensory abilities [17].

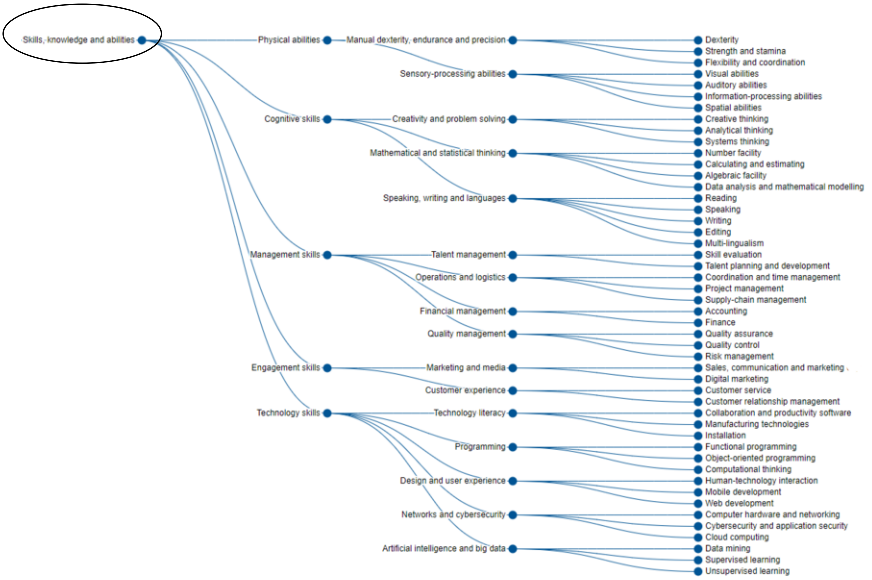

Figure 1. Global Taxonomy Skills (GTS): Skills, knowledge, and Abilities (SKA) category [17].

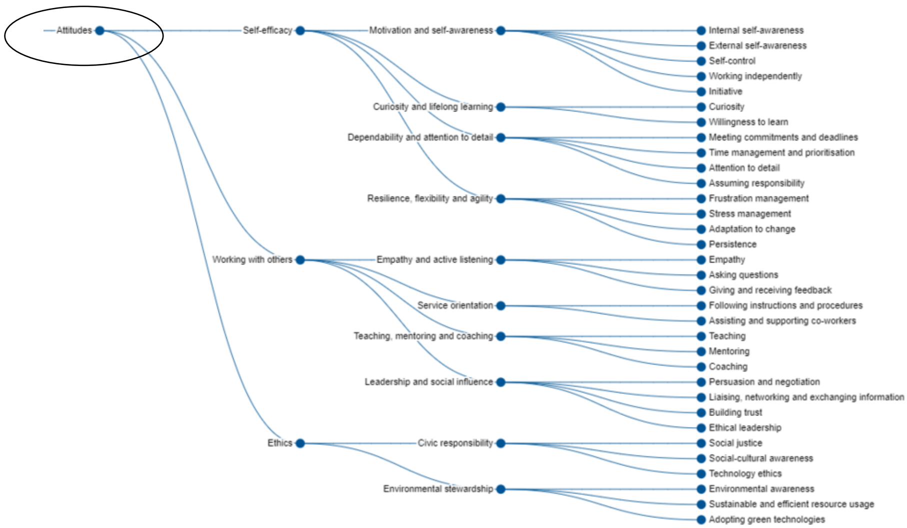

Figure 2. Global Taxonomy Skills (GTS): Attitudes (A) category [17].

The second categorization *Attitudes (A)* pertains to consistent behaviors, emotional intelligence traits, and beliefs demonstrated by individuals, influencing their interpersonal interactions and overall approach to ideas, people, and situations. Attitudes, being learned, play a significant role in motivating learning and shaping one's approach to task execution.

2.4. Trends. What skills are demanded now, and which skills will need to be developed?

According to [14], the move to a resource-efficient, circular, digitized, and low-carbon economy could create more than 1 million jobs by 2030. *Artificial intelligence and robotics* alone will create almost 60 million new jobs worldwide in the next 5 years. Other jobs may change or even disappear. The coronavirus pandemic has amplified the skills trends in the labor market, accelerating both the need and opportunities for change. In a fast-moving labor market and society, *lifelong learning* must become a reality [14]. There are no indicators on *green skills* exists, the European Commission will develop new ones. The 2030 goal of the European Commission target is increasing the level of employment 78.5%, Skills target at least 60% to 57.6% and poverty reduction at least from 15 million to 15.6 million [14]. *Reskilling* is another trend, and it refers to the process of acquiring new skills or updating existing ones to meet the changing demands of the job market. It involves *learning new competencies* that are relevant to current or future job roles, and *upskilling* means teach an employee additional skill, learning additional skills. In Sweden technological skills are more needed [5].

3. Method

The motivation behind this study stems from a genuine commitment to enhancing the educational experience and career readiness of future engineers. Recognizing the dynamic nature of industry demands, our objective is to systematically identify and address skill gaps that may exist among prospective engineers. By doing so, we aim to empower HEIs with invaluable insights into the evolving needs of the professional landscape. Through a comprehensive exploration involving teachers and researchers within our institution, as well as collaboration with regional industry professionals, we aspire to create a holistic understanding of the skill requirements integrating Research and Education. This study is not only about bridging the gap between academia and industry but also about aligning graduate capabilities with the exacting requisites of the professional world. The semi-structured interviews combined with an in-depth analysis of recent literature and secondary resources, serves as a robust methodology to capture diverse perspectives, and discern the most current trends in the field. Our multifaceted approach is rooted in the belief that a nuanced understanding of the skills landscape is imperative for educational institutions to make informed decisions. By gaining a comprehensive insight into the skills that are both extensively analyzed and currently in demand, we intend to contribute meaningfully to curriculum development and *educational strategies*. Ultimately, our motivation is to foster a learning environment that not only meets academic standards but also equips future and in process engineers with the practical skills required to excel in their professional endeavors.

3.1. Data collection

The recently initiated literature review component spans 2019 to 2023 and predominantly focuses on systematic literature review. Systematic reviews are recognized for consolidating the best available research on a specific issue, offering a synthesis of evidence drawn from studies meticulously evaluated for bias [18].

Furthermore, they play a crucial role in evaluating the strengths of newly developed methods [19]. This literature search was conducted in the SCOPUS and Google Scholar databases using the keywords "Engineering Skills" AND "Systematic Review," resulting in the identification of 409 review articles. Although this study is not a systematic review, careful selection was performed to identify the most recent and relevant articles then a review of 20 articles was carried out to discern and compile the relevant skills. Semi-structured interviews and file analysis yielded a comprehensive array of foundational data essential for the pursuit of convergence and corroboration through diverse data sources and methodologies [20]. The integration of these methodologies in investigating a common phenomenon constitutes triangulation [21], effectively mitigating potential biases and reinforcing the validity of conclusions across multiple datasets. [20] [22] From theoretical sampling procedures [23] we sampled respondents with interest in Education and the collaboration between Industry and Academia, concern for research, learning and education. In total, 40 interviews were performed, 21 respondents all worked within the industry in Sweden many with experience in the Manufacturing Sector, most of them have engineering background and were from Small and Medium-sized Enterprises (SMEs), and 19 worked within the Academia, especially in the school of engineering. Interviewers were identified [20] using a mixture of academic selection and snowball sampling. Some interviewees were contacted directly in Elmia subcontractor fair, while others were identified via recommendations [23]. Given that many respondents were actively engaged in sustainable work nationwide, the interviews were predominantly conducted through online platforms and in-person interactions. In order to ensure the confidentiality of participants, they are solely referenced by an alphanumeric code, showed in Table 1, to maintain anonymity, among other precautionary measures [19] [23].

Table 1. Respondents' roles and respondents' disciplines

No	Code	Role	Discipline
1	A	Researcher	Industrial Designer
2	B	Sustainability manager	Construction technology
3	C	Logistics specialist	Industrial Economics
4	D	Development manager	Mechanical engineering
5	E	Consultant manager	Mechanical & Computer engineering
6	F	Head of unit	Computer technology
7	G	Leader	Computer technology
8	H	Quality, environment & IT	Industrial Economics, Mechanical engineering
9	I	CEO	Industrial Economics
10	J	CEO	Mechanical & Computer engineering
11	K	HR Director	Mechanical engineering, Materials & Mechatronics
12	L	Teacher	Mechanical engineering
13	M	Teacher and researcher	Materials engineering
14	N	Teacher	Engineering management
15	O	Researcher	Materials engineering
16	P	Researcher	Computer science and engineering
17	Q	Teacher	Mechanical and Industrial engineering
18	R	Teacher	Materials engineering
19	S	Teacher	Mechanical engineering
20	T	Researcher	Mechanical engineering
21	U	Teacher	Materials engineering
22	V	Teacher	Construction Engineering
23	W	Teacher	Mechanical engineering

24	X	Teacher and Researcher	Industrial engineering
25	Y	Teacher and Researcher	-
26	Z	Manager	Computer science and engineering
27	AA	Researcher	Mechanical engineering
28	AB	Teacher and researcher	Industrial engineering
29	AC	Researcher	Mechanical engineering
30	AD	Researcher	Mechanical engineering
31	AE	Managing Director	Industrial engineering
32	AF	Managing Director	Industrial designer
33	AG	Design Engineer	Mechanical engineering
34	AH	CEO	Mechanical engineering
35	AI	Sales	Industrial engineering
36	AJ	Product Manager	Industrial engineering
37	AK	Sales Manager	Industrial engineering
38	AL	Head of Development	Industrial engineering
39	AM	Business Development M.	Environment engineering
40	AN	Sales	Industrial engineering

4. Findings and Analysis

4.1. Literature Review

Soft skills in Engineering courses should be congruent and sufficient with the current employer´s demand, expectations of proficiency levels need to provide contemporary and future services. Several studies have classified soft skills in different categories, for example, in Campos, 2019 study published by [3], highlighted *19 soft skills* for Engineers, classified into *six main categories* (Critical Thinking, Communication, Teamwork, Ethical Perspective, Creative thinking); Boon et al., 2022 [13] found *12 basic/core* and *16* evolving competencies are: cost planning, valuation of works, measurement/quantification and contract documentation, communication and negotiation, ethics and professional conduct and value management. Leandro et al., 2020, [11] created a guideline to evaluate and valid measures of student's mastery of competences in communication, lifelong learning, innovation/creativity, and teamwork in engineering education. Maturro, et al. 2019, [12] found 30 main categories of soft skills, where five skills, communication, teamwork, analytical, organizational, and interpersonal skills were the most common. Table 2 shows a comparative of the most common skills founded from the recent literature.

Table 2. Comparative with the most common skills from Literature.

Common Skills	(Campos, 2020)	(Boon, 2020)	(Leandro, 2020)	(Maturro, 2019)	(Kohlbeck, 2021)
Communication	X	X	X	X	X
Critical Thinking	X	X		X	X
Creative Thinking: Creativity and Innovation.	X		X		X
Emotional Intelligence: Lifelong learning	X		X	X	X
Ethics Professionalism	X	X			X
Teamwork	X	X	X	X	X

A comprehensive thematic [24] analysis was undertaken, involving an exploration of recent literature pertaining to the contemporary classification of skills. The investigation aimed to identify prevalent skills through a meticulous consideration of recent literature, showed in Table 2, and data from interviews, considering repetitions, typologies, descriptions, similarities, and variances. Significantly, our focus centered on similarities and variances. Following the identification of initial codes, we systematically sought relationships among themes, subsequently pinpointing key features and sub-features within two themes or categories: *Attitudes and Abilities (SKA)*. The refinement process involved a detailed examination of themes and their features, culminating in the formulation of precise definitions and nomenclature for each theme. Throughout this iterative process, attention was directed toward key questions outlined in Table 3, facilitating the articulation of essential characteristics associated with each theme. Moreover, a forward-looking approach was adopted to propose how these skills could be seamlessly integrated into each category.

Table 3. Interviews focus and questions.

Questions on Skills to increase	Questions on HEIs should improve	Questions on Skills Industry looks for/desires
What other (like "soft") or engineering skills should students have to increase their competitiveness in the industry?	How could the Higher Education Institutions (HEIs) improve preparation of the tomorrow´s engineers?	What are the skills that the industry or (research project) currently looks for in engineers?
Which skills, whether categorized as soft or hard, are considered unnecessary in the context of engineering education?	From your perspective, what are the anticipated skills or competencies, such as digital skills, sustainability, AI expertise, and circularity, that companies will require in the next 5 to 10 years?	What are the skills you want to develop or improve for your own daily work?
		Desired skills that companies will need in 5-10 years

Following the completion of the coding process, the articulation of skills within a universally understood framework is undertaken in a global context. The resultant dataset is presented in Table 4, wherein the first column comprises key questions, the second column delineates the skills identified by academia based on their perceptions, and the third column encapsulates a succinct summary of the skills deemed significant by Regional SMEs.

Table 4. Comparative results between Academia and Industry's perceptions.

Questions	Academia	Industry: Regional SMEs
Skills to increase	Problem Solving, Critical Thinking, Presentation, Resilience, Digitalization, Automation, Collaboration with Industry	Problem solving, Analytical skills, Integration of knowledge, Sustainability, Collaboration skills, Teamwork, Independence, Communication, Good cooperation, Mathematics
HEIs should improve	Creativity, Application of basic skills in well-developed learning cases, Reduce Project	**More** collaboration with Industry

	Management, **More** Collaboration with Industry	
Skills that Teachers/companies want to develop	Problem Solving, Artificial Intelligence, Leadership, Management skills,	Problem Solving, Artificial Intelligence, Leadership, Administration, Sustainability, Design Thinking,
Skills that the industry looks for in engineers	Analytical skills, Knowledge, Practical things, Communication, Teamwork, Leadership, Sustainability, Creativity, Problem solving, Environmental Impact	Creativity, Artificial Intelligence, Digital tools, Being more human
Unnecessary skills	Leadership, Multiple languages,	
Recommendations for the Education of the Future	Sustainability, Digital skills AI, Collaboration with the Industry, Lifelong learning, Dynamic Jobs	Humanism, Mathematics, Collaboration with the Industry, Focus on Industry needs by region,
Desired skills that companies will need in 5-10 years		Artificial Intelligence, Digital Skills, Security, Environmental, Being more human

4.2. Skills Classification: a common language of skills

In order to unify a common language of skills we classified our findings based on GTS approach; a result of the skills analysis conducted in alignment with recent literature, as presented in Table 2, coupled with the elucidation of focus questions outlined in Table 3 and the corresponding responses obtained from both Academia and Industry, showcased in Table 4, a comprehensive comparative evaluation is delineated in Table 5. Within this comparative analysis, nine subcategories of skills have been discerned, with four aligning with the SKA category and five with the Attitude category, as expounded upon in Section 2.3. The SKA Category, delineated as knowledge acquired through experiential learning or formal instruction, encompasses the Cognitive skills subcategory, incorporating elements such as Creativity, problem solving, and further subdividing into creative thinking, analytical thinking, and systems thinking, as illustrated in Figure 1. In contrast, the Attitude category pertains to consistent behaviors and emotional intelligence traits, encompassing subcategories such as Self-efficacy, curiosity, lifelong learning, working with others, leadership, and more, as illustrated in Figure 2.

4.3. Trends and Future skills

When the results regarding which skills will be sought after in the future are summarized in Table 5, the findings from four groups are presented. Two of the groups, Swedish industry and global industry, report values from surveys with a large respondent base. The other two groups have significantly smaller respondent bases to draw from. These two groups originate from the same region, the local university, and regional businesses. Table 5 presents response frequencies for nine subcategories of skills considered desirable in future employees. These subcategories are extensive, and cognitive skills encompass, for example, both *problem-solving and communication*, which are two distinct abilities. Remarkably similar results are reported from the two large groups. Swedish industry does not stand out against global industry at all. The greatest differences are shown for skills and traits such as *teamwork* and *curiosity*, but the disparities are not substantial. These traits were somewhat more sought after in Swedish industry than internationally. The regional groups, the university and the regional businesses, exhibit differences among themselves, but the differences compared to the other two groups, the non-regional industry, were more pronounced. The distinctive differences are evident in the prioritization of *cognitive skills* where *problem-solving* was a common response. This is a skill that has always been central in engineering education. It's not surprising if the staff from the university, who teach extensively, considered this to be an important skill to develop in students. The ability to lead was not considered as important in the regional group. Many of the regional businesses are SMEs and family-owned businesses with few employees. Perhaps these companies seek personnel with technical skills instead, as the leadership positions are already filled. The regional groups showed less interest *in curiosity* even though this trait was appreciated more by the regional industry than by the university. However, *teamwork* and *sustainability thinking* were more important for the regional groups. The academic part of the group considered sustainability thinking more important than the regional industry did. All groups had a low response frequency regarding *engagement.* Interestingly, this may be considered a given trait. It's probably uncommon to hire individuals who appear to lack engagement.

Table 5. Comparative of Skills between Surveys Results, Sweden and Global trends reported by [1]

	Category	**Sub-Category**	**Academia**	**Industry Regional SMEs**	**Industry Sweden**	**Industry Global**
1	SKA	Cognitive Skills	**41%**	**36%**	**24%**	**26%**
2	SKA	Management skills	4%	4%	12%	12%
3	SKA	Technology skills	**15%**	**21%**	15%	16%
4	Attitude	Self-efficacy/Curiosity and Lifelong learning	**7%**	**14%**	**26%**	**23%**
5	Attitude	Working with others//Leadership	**19%**	**18%**	14%	11%
6	Attitude	Ethics/Environmental/Sustainability	**11%**	**7%**	2%	3%
7	Attitude	Resilience	4%	0%	0%	0%
8	Attitude	Engagement skills	0%	0%	6%	6%
9	SKA	Physical abilities	0%	0%	2%	3%

Looking ahead, according to [1], the top priority for skills training between 2023 and 2027 is analytical thinking, which represents 10% of training initiatives. Creative thinking comes in second, with 8% of upskilling initiatives focusing on this skill. In Sweden, there are several initiatives, such as Ingenjör 4.0, an initiative based on a skills improvement program developed in cooperation with 13 Swedish universities to identify skills gaps in Sweden.

5. Discussions and Conclusion

The aim of this paper was to explore the possibilities of how HEIs, by integrating research and education, can increase the industrial competences of students.

This study explored and identified current skills for engineers. We found that there is still a gap in the development of *soft skills* sought by engineering employers [3]. Through a universal language, it is possible to categorize and evaluate the skills of both students and staff. The possibility of increasing the capabilities of engineers is to involve companies within the educational system, although it is already being done, through thesis projects, internships, and invited conferences, guest lectures, it is necessary to increase *Collaboration with the Industry*. According to Swedish companies [B,K], involving students in real problems from the beginning encourages the learning process, motivation, and engagement. Soft skills are not soft skills, they are very complex tasks and the literature related to soft skills is confusing [11]. There is some confusion with the term soft skills, in the responses of teachers and researchers, it seems that the perception is to replace technical skills with soft skills, a participant [W] commented "not to sacrifice technical skills for soft skills to meet the expectations of companies", none skill replaces another, in the engineer's profile there must be a balance, both skills are necessary, although it is true that some mathematics are not as necessary, as an industry participant [K] mentioned, if it is vital to know the mathematical foundations.

Another thought was that, although the trend is to increase digital skills, cognitive skills gain greater weight. One comment from participant [A] mentioned: "*being more human than digital*", using Natural Intelligence more than Artificial Intelligence, although technology is important, *self-awareness, curiosity, creativity, and lifelong learning skills* are essential for the human development. Regarding Entrepreneurship skill, any participant mention it, however, it is linked to *innovation and initiative* skills, so it is also important to consider it, hence the importance of highlighting the effort of initiatives such as DeepINVENTHEI [10] to strengthen the entrepreneurial spirit, not only of the students, but also of the staff and the Industry. The concept of *entrepreneurship* is not only that students create their own companies, but also to encourage the industry to generate companies within their companies, such as start-ups. It is important to highlight the role of research at this point when creating a business project. Research, on the one hand, creates new scientific knowledge and, on the other, can create new businesses, fostering *innovation* as well. There are clear examples of companies that they are doing now, SINTEF™ [25] in Norway or FIRJAN™ in Brazil, with an internal development project and the creation of specialized companies within the company with highly qualified personnel, such as doctoral students and researchers. To answer how HEIs can increase the skills of future engineers, the recommendation from teachers, researchers, and industry professionals is to focus on *cognitive skills* and *self-efficacy* skills through courses that combine technical with *analytical skills*. Companies emphasized *collaboration with industry* as a vital source of growth. In addition to courses, it is important to increase research projects and prepare staff for transition education. It is not about educating in isolation; It is clear that, scientific knowledge integration is essential for effective collaboration. To increase collaboration, at JTH some practical courses have been developed and companies have been invited to participate in courses where they pose a real problem and students can propose solutions, for example in the Projects course (Master in Product Design) and the Master Program in Product Development with specialization in Assistive Technology (MASTech).

Implications and Limitations: This study constituted an in-depth exploration into the prevailing trends in the evolution of education, focusing on the perspectives of seasoned professionals. However, it is imperative to acknowledge the study's inherent limitations, as it was confined to a singular university and regional enterprises within Sweden. As a HEI, our commitment lies in serving the local community and addressing the specific needs of regional businesses. Consequently, our goal is to discern their current and future requirements, facilitating the necessary adjustments in our educational offerings. In our pursuit of aligning education with regional business needs, we sought to understand the priorities identified by our staff and assess their congruence with the demands of the local business landscape.

Contributions and Future Research: This study has made a significant contribution by elucidating the perspectives of both the regional university and local businesses regarding the crucial future skills for engineers. Moving forward, the focus will be on continual improvement of our educational programs to ensure ongoing alignment with regional business needs. To further enhance our educational impact, we intend to embark on an expanded internationalization effort, acknowledging the global dimensions that influence our local context. Furthermore, future research endeavors will delve into the perceptions of our students and graduates. Understanding their viewpoints is paramount for refining our educational strategies and ensuring that we not only meet but exceed their expectations. This comprehensive approach will fortify our commitment to providing education that is not only globally relevant but also deeply rooted in addressing the specific needs of our regional stakeholders.

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