Abstract: The rise of digital intelligence era signifies a new paradigm of digital technology and intelligent applications, bringing fresh opportunities and challenges to engineering practice. This paper focuses on the analysis of nine key challenges. These challenges reflect the complexity and diversity of engineering education in digital intelligence era, requiring engineering education institutions to continuously adjust their curricula and teaching methods to cultivate engineers with comprehensive competencies and interdisciplinary skills. At the same time, digital intelligence era also brings new opportunities for engineering education, transformation approaches will contribute to improving the quality of engineering education and provide critical support for the sustainable development of society and the environment. The future of engineering education in the digital intelligence era is promising, but it requires us to confront challenges to actively promote progress and innovation in engineering.

Keywords: digital intelligence era, engineering education, digitalization
Introduction

Digital intelligence era has ushered in new challenges and opportunities for engineering education. The engineering field has always been a crucial engine of technological advancement and societal development, and today, a fresh paradigm of digital technology and intelligent applications is redefining the essence of engineering practice. As the complexity of engineering projects continues to grow, global challenges abound, making it imperative to nurture future engineers with a background in digital intelligence. This paper will explore the multidimensional challenges that engineering education faces in digital intelligence era and propose strategies and approaches to address these challenges. We will delve into the future direction of engineering education from various dimensions, including sustainability, digitization, interdisciplinarity, and humanism. Additionally, we will focus on refining quality assessment standards for engineering education and attracting outstanding young talent into engineering to ensure that engineering education can positively contribute to the sustainable development of society and the environment.

Characteristics of the Digital Intelligence Era

Before delving into engineering education’s challenges, it is imperative to understand the characteristics of this digital intelligence era. This will enable us to grasp better its impact on the ability to solve engineering problems.

The “digital intelligence era” is characterized by the rapid development of information technology, data science, and the widespread adoption of artificial intelligence, collectively giving rise to an era dominated by data-driven intelligent applications. In this era, data has become a vital resource. Through its collection, analysis, and utilization, people can gain deeper insights, make more accurate predictions, and make wiser decisions in various domains.

Critical characteristics of digital intelligence era include:

Data-Driven Decision-Making. Data is extensively collected, stored, and analyzed in the digital intelligence era to support decision-making. Through data analysis, people can better understand market trends, consumer behavior, societal issues, and more, enabling more informed decision-making in business, government, and society.

Artificial Intelligence. Digital intelligence era heavily relies on artificial intelligence and machine learning technologies. These technologies enable computers to learn from data and improve their performance. This intelligent capability can be applied to natural language processing, image recognition, pattern recognition, and more, leading to task automation and intelligence.

Intelligent Applications. In digital intelligence era, we have seen the rise of intelligent applications such as smart cities, smart transportation, smart healthcare, and smart manufacturing, among others. These applications leverage technology and data to improve efficiency, optimize resource allocation, provide convenient services, and address societal issues.

Privacy and Security. Data privacy and security have become critical concerns as data is widely employed and processed. People must balance the benefits of data sharing with privacy protection, taking appropriate measures to guard against data breaches and misuse.
Digital Transformation. Businesses and organizations actively undergo digital transformation, leveraging new technologies and data to optimize business processes, enhance competitiveness, and provide a platform for innovation.

As elucidated above, the digital intelligence era, characterized by data-driven approaches, prolific applications of artificial intelligence, and widespread intelligent systems, is profoundly reshaping and transforming diverse aspects of human life and societal development. Engineering education, serving as a pivotal impetus propelling technological progress and social advancement, will inevitably be subject to profound metamorphosis in this digitalized and intelligent age.

While the pervasive integration of digital intelligence brings many conveniences, it simultaneously postulates new requirements and demands regarding the working approaches and competencies required of engineers. To nurture engineering talents capable of satisfying the needs of the digital intelligence era, engineering education must respond with timely adjustments and innovations.

This paper aims to analyze and discuss the critical challenges confronting engineering education against the backdrop of the digital intelligence age. These challenges encapsulate the complexity and diversity of engineering education, necessitating that educational institutions continuously calibrate curricula and pedagogical approaches to nurture well-rounded engineers with comprehensive capabilities and interdisciplinary skills.

1) The challenge of enhancing digital competencies to solve complex engineering problems

The landscape of modern engineering is undergoing profound transformations, extending its reach into diverse realms such as natural systems, social structures, and biological entities. Examples abound, including engineering’s fusion with biological entities in deep-sea, deep-earth, and deep-space exploration projects, integration with societal components in artificial societies and social computing, and entwining with life forms through genetic engineering and neuroscience technology. The evolving nature of engineering is contributing to the escalation of complexity in problem-solving across a multitude of domains. (Qiao et al., 2023)

Typically, complex engineering problems exhibit characteristics of being ill-structured, technologically uncertain, and formidable to investigate and define. The imperative to cultivate engineers capable of addressing these intricate domestic or international challenges, particularly in the context of expansive engineering endeavors, becomes paramount. Furthermore, the dynamism in engineering knowledge spanning natural sciences, social sciences, and humanities necessitates continuous renewal and expansion of engineering disciplines, challenging conventional disciplinary boundaries daily. Notably, project management complexities have surged, requiring the simultaneous consideration of technical feasibility, economic viability, and the multitude of stakeholders’ demands. Large or small engineering projects may engender conflicts of interest among various stakeholders, necessitating engineers to navigate a spectrum of conflict resolutions.

Concurrently, the digital intelligence era presents unprecedented opportunities for tackling complex engineering problems. A key avenue is the simplification of complexity through digital technologies. Engineering quandaries often entail myriad decisions,
from technological route selection to solution choices, with an abundance of options. Digital technologies, with a focus on safety and risk control, emerge as pivotal tools in reducing this complexity. The success of the Chinese space station development exemplifies this, showcasing a 30% increase in development efficiency achieved through the complete cycle three-dimensional model digitalization process, obviating the need for paper drawings in design. Moreover, the integration of “sky-ground-digital” tri-station, encompassing in-orbit, ground, and digital twin stations, exemplifies the transformative potential of digital technology. Beyond efficiency gains, digital technologies contribute significantly to safety, reliability, and maintainability by real-time monitoring of spacecraft and astronauts through a network of sensors and monitoring systems. The work of Zhang and Pan (2022) underscores the transformative impact of digital technologies on the Chinese space station development.

In essence, digital technology emerges as a linchpin in addressing engineering challenges, streamlining complexity, boosting efficiency, and fostering new insights. These advancements, while presenting opportunities for engineering education, simultaneously pose formidable challenges in developing engineers’ capabilities and adapting to the ever-evolving landscape of engineering in the digital intelligence era.

2) The challenge of coping with the shortened half-life of knowledge in digital intelligence era

The advent of the digital intelligence era signifies a pivotal phase in the knowledge economy, marked by the gradual enhancement of knowledge production infrastructure and the unprecedented proliferation of knowledge. Within this transformative stage, a formidable challenge emerges: the accelerating decline in the half-life of knowledge. This challenge reverberates through the realms of engineering education, exerting profound effects on the entire knowledge system.

The trajectory of the knowledge economy has witnessed a sustained surge in the global workforce dedicated to research and development, substantial improvements in the material conditions supporting R&D, and a relentless augmentation of human knowledge production capacity. The sheer volume of knowledge has experienced exponential growth. For instance, global knowledge output escalated from 1,755,850 papers in 2008 to 2,555,959 papers in 2018, marking an approximate growth of 3.83%. Over the same decade, China exhibited remarkable growth, doubling its knowledge output from 249,049 papers to 528,263 papers, boasting an annual growth rate of 7.81%, and claiming a 20.67% share of the global total in 2018. While the United States maintained a relatively high total volume, with an annual growth rate of 0.71%, its share of the global total stood at 16.54% in 2018. These figures underscore the exponential growth of knowledge, particularly in emerging nations like China. Notably, Fritz Machlup’s (2007) estimate from 1958 revealed that 26.8% of the U.S. GDP was generated in the knowledge industry.

However, the expansion of knowledge does not imply its perpetual value; rather, certain knowledge becomes obsolete over time. Drawing from the concept of half-life in material decay, Machlup introduced the idea of “knowledge half-life” – the time elapsed before half of the knowledge in a specific field becomes outdated. By 1966, Thomas F. Jones estimated engineers’ knowledge half-life at around ten years, necessitating 9,600 hours of individual learning over a 40-year engineering career. As the last century drew to a close, scholars (Schüppel, 1997) suggested that the knowledge half-life at the
secondary school level was about 20 years, university-level knowledge had reduced to 10 years, professional expertise to around five years, and in the field of IT, professional knowledge dwindled to a mere 1-2 years. Though not an exact calculation, this insight partly reveals that in an individual’s lifelong learning journey, specialized fields, especially in information technology, witness rapid knowledge updates and shorter knowledge half-lives.

The accelerated decline in the half-life of knowledge, particularly in the information field, poses a profound challenge to the field of engineering education. Knowledge production efficiency is notably high today, evident in the prolific emergence of papers and patents and the expansive growth of the overall knowledge scale. Yet, the fleeting nature of specialized knowledge half-life, especially in IT, often leaves us struggling to keep pace with technological developments. Continuous learning becomes imperative due to the relentless evolution of knowledge, creating a scenario where information can be inadvertently replaced. This presents a substantial challenge for engineering education.

<table>
<thead>
<tr>
<th>Ranking</th>
<th>Region, Country, or Economy</th>
<th>2008</th>
<th>2018</th>
<th>Average Annual Growth Rate (%)</th>
<th>2008-18 Total World (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>-</td>
<td>World</td>
<td>1,755,850</td>
<td>2,555,959</td>
<td>3.83</td>
<td>-</td>
</tr>
<tr>
<td>1</td>
<td>China</td>
<td>249,049</td>
<td>528,263</td>
<td>7.81</td>
<td>20.67</td>
</tr>
<tr>
<td>2</td>
<td>United States</td>
<td>393,979</td>
<td>422,808</td>
<td>0.71</td>
<td>16.54</td>
</tr>
<tr>
<td>3</td>
<td>India</td>
<td>48,998</td>
<td>135,788</td>
<td>10.73</td>
<td>5.31</td>
</tr>
<tr>
<td>4</td>
<td>Germany</td>
<td>91,904</td>
<td>104,396</td>
<td>1.28</td>
<td>4.08</td>
</tr>
<tr>
<td>5</td>
<td>Japan</td>
<td>108,241</td>
<td>98,793</td>
<td>-0.91</td>
<td>3.87</td>
</tr>
<tr>
<td>6</td>
<td>United Kingdom</td>
<td>91,358</td>
<td>97,681</td>
<td>0.67</td>
<td>3.82</td>
</tr>
<tr>
<td>7</td>
<td>Russia</td>
<td>31,798</td>
<td>81,579</td>
<td>9.88</td>
<td>3.19</td>
</tr>
<tr>
<td>8</td>
<td>Italy</td>
<td>56,157</td>
<td>71,240</td>
<td>2.41</td>
<td>2.79</td>
</tr>
<tr>
<td>9</td>
<td>South Korea</td>
<td>44,094</td>
<td>66,376</td>
<td>4.17</td>
<td>2.6</td>
</tr>
<tr>
<td>10</td>
<td>France</td>
<td>66,460</td>
<td>66,352</td>
<td>-0.02</td>
<td>2.6</td>
</tr>
<tr>
<td>11</td>
<td>Brazil</td>
<td>35,490</td>
<td>60,148</td>
<td>5.42</td>
<td>2.35</td>
</tr>
<tr>
<td>12</td>
<td>Canada</td>
<td>53,296</td>
<td>59,968</td>
<td>1.19</td>
<td>2.35</td>
</tr>
<tr>
<td>13</td>
<td>Spain</td>
<td>44,191</td>
<td>54,537</td>
<td>2.13</td>
<td>2.13</td>
</tr>
<tr>
<td>14</td>
<td>Australia</td>
<td>37,174</td>
<td>53,610</td>
<td>3.73</td>
<td>2.1</td>
</tr>
<tr>
<td>15</td>
<td>Iran</td>
<td>17,034</td>
<td>48,306</td>
<td>10.99</td>
<td>1.89</td>
</tr>
<tr>
<td>-</td>
<td>European Union (EU)</td>
<td>528,938</td>
<td>622,125</td>
<td>1.64</td>
<td>24.34</td>
</tr>
</tbody>
</table>

Source: USA NATIONAL SCIENCE BOARD. Science and Engineering Indicators 2020
In response to the shortened half-life of knowledge, the field of engineering education must reassess the interplay between general education and professional education. Emphasis should be placed on cultivating both explicit and tacit knowledge, striking a balance between fixed curricula and flexible learning, and instilling in students the lifelong learning skills essential for adapting to the rapidly changing knowledge landscape.

3) The challenge of effectively collaborating with intelligent machines

Looking back at history, the Industrial Revolution significantly transformed human society. From the mechanization era in the latter half of the 18th century, the advent of the steam engine marked the gradual replacement of human labor by machines, with handicraft industries moving away from agricultural production towards industrialization. Subsequently, the electrification era emerged in the 1880s, replacing steam power with electricity and introducing concepts like assembly line production and fine specialization, signaling the arrival of the era of mass production. The information era, starting in the 1970s, saw automated machines gradually replace some human manual labor, with computers taking over cognitive work. Today, we are in the era of intelligence, where the rapid development of fields like Cyber-Physical Systems (CPS) and the Internet of Things (IoT) is leading intelligent machines to replace human work in both production and cognitive labor.

Currently, digital competencies have become a fundamental attribute of the modern workforce. Engineers must possess this competence to interact and collaborate with emerging machines and systems continually. The World Economic Forum indicates that at some point in the future, the number of hours worked by machines will be equivalent to the number of hours worked by humans, marking a significant milestone. There is an imbalance between the demand and supply of digital skills in Europe and the United States. Digital industrialization and industrial digitization pose new requirements for engineers’ skills.

In digital intelligence era, upskilling and reskilling have become more daunting. When dealing with the challenges posed by intelligent machines, we need to address issues related to skill enhancement and reskilling. However, the relationship with machines is not confined to individual skill development alone; more crucial is the interpersonal relationship, especially the relationship between humans and the machines they control. Therefore, discussing the interaction between humans and machines is vital for engineering education. This involves nurturing students with the ability and wisdom to collaborate with intelligent machines to address the ever-changing technological and knowledge environment. According to the World Economic Forum’s “Future of Jobs Report 2020,” the number of hours machines work will equal the number of hours human work. By 2025, the redefinition of labor divisions between humans and machines will result in the disappearance of 85 million jobs while generating 97 million new jobs related to digitalization. Although these are estimates, the emergence of new jobs undoubtedly brings significant demands for digital skills and imposes higher requirements on existing education and training systems.

4) The challenge of harnessing the role of humans in industrial digitalization
The fourth challenge revolves around elucidating the precise roles and functions of humans in the paradigm of industrial digitalization. It addresses the pivotal question of what role humans play amid the sweeping transformations of industrial digitalization. This inquiry assumes paramount significance as humans wield a critical influence on the trajectory of industrial digitalization.

Within the contemporary realm of “human-information-physical” ternary systems, the status and functions of humans have undergone profound evolution. This ternary system mandates that humans play a central and indispensable role throughout the entire industrial digitalization process. Noteworthy insights from experts in mechanical engineering, such as Zhou et al. (2018), accentuate the transformative nature of this evolution, especially in the domain of intelligent manufacturing. Their research posits a compelling perspective, asserting that the ultimate objective of engineering activities, transitioning from traditional manufacturing to the new era of intelligent manufacturing, should be to serve humanity beyond mere mechanical production. Humans, considered both an inherent factor and a constraint in this manufacturing process, play a pivotal role in ensuring that the products or systems manufactured align with human needs. Academician Zhou Ji (Zhou, 2013) underscores this by stating that “The digitization and intelligence of manufacturing” constitute the core technologies of the new industrial revolution, influencing product innovation, manufacturing technology, and industrial models.

Crucially, the role of humans in the manufacturing process transcends the mere fulfillment of human needs. Arbitrary replacement of human functions with machines poses multifaceted challenges, including the emergence of new industries and the ascent of productive service sectors. This transformative trend is actively redefining market dynamics and industrial structures.

In conclusion, the era of industrial digitalization in the digital intelligence age demands a comprehensive reassessment of the roles and responsibilities assigned to humans in manufacturing activities. Humans are not mere end-users of products and systems; they stand as an indispensable and dynamic force within the manufacturing process, contributing to functions that extend far beyond conventional boundaries. Recognizing and understanding this nuanced role will empower us to effectively address the challenges presented by industrial digitalization and pave the way for innovative industrial models.

5) The challenge of addressing the dual transformation of digitalization and sustainability

The fifth challenge revolves around the intricate interplay between sustainability and digitalization, which are often intertwined rather than existing in isolation. This dynamic relationship becomes particularly evident when technological development strives to support sustainable development and human well-being, giving rise to numerous intersections and mutual influences between these two domains.

Sustainable development encompasses a spectrum of critical areas, spanning from providing clean drinking water and sanitation facilities to improving transportation infrastructure, addressing public health crises, combating global climate change,
preventing natural disasters, developing clean energy, and ensuring sustainable electricity. Two contrasting viewpoints shape the approach to sustainable development: the neoclassical and ecological economics schools. The neoclassical economics school emphasizes efficiency improvements and the substitutability of human-made and natural capital, relying on technological innovations for sustainability. Conversely, the ecological economics school, grounded in natural limits, stresses the irreplaceability of both, even with the introduction of technological innovations.

Adhering to the Club of Rome’s perspective (Meadows et al., 1972), the focus on the limits of growth, rooted in the principles of complexity science, posits that continued trends in population growth, industrialization, pollution, food production, and resource consumption may constrain Earth’s growth within the next century.

However, previous research on sustainable development appears to have insufficiently emphasized the impact of digitalization. The intricate relationship between digitalization and sustainability encompasses positive impacts on economic, social, and environmental dimensions, while concurrently posing ethical concerns in areas like digital ethics and privacy protection, particularly in data-intensive research and service activities.

The perspective of growth limits, as proposed by the Club of Rome, may not adequately consider the rapid development of digital technologies. Thus, a crucial question emerges: Can industrial digitalization technology genuinely support sustainability? This inquiry spans various dimensions, encompassing data infrastructure, production efficiency enhancements, human resource foundations, resource and energy demands, enterprise capability gaps, and individual capability gaps. For instance, the construction of data infrastructure may contribute to environmental emissions, with semiconductor production and data storage and transmission playing roles in this environmental impact. While industrial digitalization is anticipated to enhance resource efficiency and overall economic development, the evolution of digital technologies may simultaneously drive a surge in global raw material and energy demand, potentially offsetting the anticipated benefits of digitalization efficiency. Moreover, the ascent of digitalization might engender capability gaps between businesses, favoring those who adopt digitization early. At the individual level, particularly in developing countries with limited access to education, digitalization may exacerbate existing differences within communities. (Berkhout & Hertin, 2004)

In summary, industrial digitalization bears both potential positive and negative impacts on sustainable development. Therefore, a nuanced evaluation of the intricate interrelationships between digitalization and sustainability is imperative. We must undertake judicious measures to ensure that digital development aligns seamlessly with the overarching goals of sustainable development. (Sacco, Gargano, & Cornella, 2021).

6) The challenge of conducting effective engineering practice training for real-world engineering challenges

Engineering knowledge mainly consists of two aspects: explicit knowledge and tacit knowledge. Explicit knowledge can be acquired through books, technical guideline,
and other resources, while tacit knowledge primarily comes from engineering practice. In the context of university engineering education in the digital intelligence era, three key aspects (3I) are crucial:

Integrating digitalization into practice: This combines digital technology with real-world practice. Relying solely on computer simulations is insufficient; effective teaching and learning usually occur within authentic scenarios, for instance, utilizing technologies such as simulation, virtual reality, augmented reality, and digital twins to construct new engineering practice environments. The application of these technologies will enrich the depth of practical experience.

Innovative education: This aspect highlights the innovation of teaching methods. High-level engineering practice training typically involves learning based on real-world problems, projects, and cases. This approach helps incorporate creative thinking, innovation approaches, and entrepreneurial spirit into learning.

Interdisciplinary Collaboration: This aspect requires innovative mechanisms. Many practice training activities are not limited to the campus alone; they need extensive industry-academia collaboration. However, educational institutions and companies often have different organizational goals and interests, posing various challenges. Encouraging active participation from companies in university talent cultivation is a significant challenge.

7) The challenge of attracting the younger generation to pursue engineering studies

Enhancing the appeal to outstanding young individuals in engineering education is a crucial issue. Despite incomplete data, including the absence of data from countries such as China and India, trend analysis indicates that the number of students in the engineering field has fallen to the third position globally in the subject ranking since 2013, with the top-ranking subjects primarily including Information and Communication Technology (ICT), social sciences, and journalism and information-related fields. Although these fields are not always explicitly classified as engineering, they are closely related, and many graduates tend to pursue careers in service industries and non-engineering areas. This trend is significant because the failure to attract outstanding young talents to the engineering field could lead to a loss of opportunities.

According to educational statistics (UNESCO, 2021), apart from countries like China and India, global higher education enrollment ranks Information and Communication Technology (ICT), social sciences, and journalism and information-related fields as the top two. At the same time, engineering, manufacturing, and construction programs have fallen to third place in student enrollment. More students prefer to study in ICT programs but they do services rather than engineering. Even students who choose engineering majors may later “escape from engineering” and pursue careers unrelated to engineering after graduation. This phenomenon is becoming apparent even in some industrialized nations.
More attractive engineering curricula need to be developed to address this challenge, promising career prospects should be offered, and innovation and social impact in engineering should be emphasized. Moreover, collaboration with industry and understanding their demand for engineering talent is crucial. Through these initiatives, it can be ensured that the engineering field continues to attract and nurture outstanding young talents, making significant contributions to technological and societal progress.

The path of digital transformation in engineering education still holds a degree of uncertainty. This means there may be multiple transformation paths, each with various stages and diverse strategies. Currently, the roles of government, universities, students, and teachers are usually emphasized in the digital transformation of engineering education, often neglecting the essential role of enterprises in this process. Enterprise requirements for engineering competencies and skills are critical, but our understanding of these requirements is insufficient.

Therefore, in digital transformation, there is a need for both top-down and bottom-
up initiatives. Top-down initiatives involve driving the digital transformation of the entire education system through educational administrative departments, ministries of education, and educational bureaus. Simultaneously, a deep understanding of enterprise requirements for engineering competencies should be considered a significant driver for the digital transformation of engineering education. In this regard, the article conducts a preliminary analysis of enterprises’ potential advantages and disadvantages in digital transformation.

The digital transformation of engineering education is a complicated and multi-level process that requires close cooperation and collaboration among all stakeholders. It is crucial to place human development at the core of this transformation, ensuring that engineering training and competencies can meet future demands. Only through close collaboration between governments, educational institutions, students, teachers, and enterprises can the digital transformation of engineering education be achieved to adapt to the rapidly changing technological and social environment. This will help cultivate engineers with digital skills and comprehensive competencies who can positively contribute to the sustainable development of society and industry. Table 2 shows the possible paths.

### Table 2

**Possible Paths for the Digital Transformation of Engineering Education**

<table>
<thead>
<tr>
<th>Possible Path</th>
<th>Direction</th>
<th>Main Characteristics</th>
<th>Potential Advantages</th>
<th>Potential Disadvantages</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Government → University → Faculty &amp; Students</strong></td>
<td>Top-down Approach</td>
<td>Driven by educational authorities, Universities passively adapt</td>
<td>Raises the importance of higher education institutions</td>
<td>Overemphasis on accountability</td>
</tr>
<tr>
<td><strong>Industry → University → Faculty &amp; Students</strong></td>
<td>Outside-in Approach</td>
<td>Driven by market demand, Universities passively adapt</td>
<td>Reflects industry needs</td>
<td>Overemphasis on application</td>
</tr>
<tr>
<td><strong>University → Faculty &amp; Students → Industry</strong></td>
<td>Inside-out Approach</td>
<td>Universities proactively adapt to market demands</td>
<td>Empowers universities with autonomy</td>
<td>Overemphasis on academia</td>
</tr>
<tr>
<td><strong>Faculty &amp; Students → University → Industry</strong></td>
<td>Inside-out Approach</td>
<td>Faculty and students proactively drive university changes</td>
<td>Ignites the intrinsic motivation of faculty and students</td>
<td>Overemphasis on interests</td>
</tr>
<tr>
<td><strong>Others and Combination Paths</strong></td>
<td>—</td>
<td>—</td>
<td>—</td>
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</tr>
</tbody>
</table>
Furthermore, the effectiveness of the digital transformation of engineering education still needs to be evaluated. The COVID-19 pandemic accelerated the worldwide digital transformation of education. For example, the growth in the scale of online education and its impact on educational system reforms have been historically significant. In the specific context of engineering education, the most critical challenge of digital transformation is not delivering knowledge more efficiently but effectively cultivating hands-on skills. Although there are examples of using new methods like virtual reality, augmented reality, digital twins, and other techniques in engineering education, evidence is required to assess their effectiveness. The digital transformation of engineering education is still in the early exploration stage, and its future development path remains unclear and requires long-term exploration.

Figure 2
Stakeholders in Engineering Education Digital Transformation

9) The challenge of refining the quality assessment standards for next generation engineering education

In digital intelligence era, engineering education faces unprecedented challenges, one of which is continually improving the quality assessment standards of engineering education. In November 2019, the International Engineering Alliance (IEA) and the World Federation of Engineering Organizations (WFEO) invited international organizations, including the International Center for Engineering Education (ICEE), to establish a taskforce aimed at revising the “Graduate Attributes and Professional Competencies (GAPC)” standard released by IEA in 2013. This standard is one of the most influential international benchmarks for engineering education. It serves as the basis for mutual recognition of engineering programs accreditation and engineer mobility in over 30 countries and regions.
GAPC 2021 (IEA, 2021) highlighted data is an emerging resource for engineering activities, and computing thinking and digital methods are indispensable for engineering problem-solving. In its knowledge and attitude profile, fundamental computing knowledge was emphasized. Moreover, computational thinking in analytical methods encourages the use of software and algorithms to optimize engineering methods. GAPC 2021 emphasized more digital competencies, for instance, modeling data analytics, computational thinking than before, while how to efficiently integrate these competencies into curricula remains a focus. Besides, amidst these advancements, the core challenge remains. A primary concern is achieving a balance: updating the standard to reflect emerging engineering trends while ensuring the benchmarks are practical and relevant across varied educational contexts. Additionally, as digital technologies advance, there’s a need to adapt skills and methodologies accordingly.

**Conclusion: Challenges and Opportunities Coexist**

In summary, the current international engineering education standards have significantly emphasized cultivating students’ abilities to utilize digital and intelligent means to address engineering problems in the era of digital intelligence. However, the challenges faced by engineering education are multidimensional, with digitalization being just one aspect. These challenges can be summarized into several key dimensions, referred to as CDEH:

1. **Carbon- (Sustainability Dimension):** This includes nurturing students’ capabilities to develop and apply environmentally friendly technologies. Different professional fields have distinct knowledge and skill requirements for sustainability, such as environmental protection, chemical engineering, and mechanical engineering, each with specific demands.

2. **Digital+ (Digitalization Dimension):** The digital dimension is not exclusive to traditional information technology disciplines, as all engineers need data handling abilities. This encompasses cultivating individuals’ skills in learning path planning, computational thinking, and interdisciplinary knowledge, connecting the engineering field with other domains.

3. **Engineering+ (Discipline Dimension):** Engineering education should emphasize interdisciplinary learning and lifelong learning to adapt to evolving technologies and demands.

4. **Humanity+ (Humanity Dimension):** Engineering education must not detach itself from human concerns because engineering ultimately serves human well-being. Therefore, emphasizing a sense of responsibility and ethical values is paramount.

Future engineers must work at the intersection of natural, social, and information spaces. Effectively addressing engineering education’s interdisciplinary, digital, sustainable, and humanity challenges will be critical to enhancing its quality. Engineering education must continuously adjust its curricula and teaching methods to ensure students develop comprehensively and are equipped with the skills and competencies required to adapt to the ever-changing engineering environment. Only in this way can we cultivate engineers capable of addressing future challenges and positively contributing to society and the environment.
In digital intelligence era, engineering education will continue to play a crucial role in providing essential solutions to address global complex issues. This era also brings new opportunities for engineering education while presenting new challenges. The mission of engineering education community is to ensure that engineers are well-prepared for a more sustainable planet and better society.

Declaration of Interest Statement

There is not any potential conflict of interest in the work.

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