Chapter

Education and Training in the Digital Era: A Compass for "Building Forward Better"

Bianca Christina Weber-Lewerenz

Abstract

Knowledge is the greatest raw material. To build a secure future, you need knowledge, skills, to network and get involved in the new. Digitization with the technological and social challenges requires a rethinking and adjustment of professional qualifications at the same time. More than half of 70% of the open AI positions in companies are currently unfilled. This high number describes the dilemma and the challenges for the teaching and training of tomorrow. Are we ready for the technological challenges of tomorrow? This research found that there is significantly high potential for diverse teams, staffing the STEM fields with more female specialists and fully using specialist knowledge and personal qualifications of men and women. Last but not least, this research contributes setting up compass for building forward better by ensuring gender-independent decision-making structures in human-technology interaction and use diversity as key for reaching sustainable goals and set milestones in the digital era. The main research results consist that the foundation for diversity, inclusion and sustainable digital innovations can only be ensured by adjusted education and academic training. To achieve sustainable digital transformation with a strategy foundation, education and academic training are most essential. This research fills the gap by highlighting the importance of these two essential areas that call for immediate action: Diversity, education, and training represent the drivers for the sustainable success in the Digital Age.

Keywords: education, academic training, curricula, STEM, digital innovation, digital transformation diversity, inclusion

1. Introduction

The Italian Presidency decided at the Digital Economy Ministers' Meeting in Trieste on the 5th of August 2021 to place digitization at the core of G20 discussions. Participation in education and training for all to eliminate digital gender gaps and challenge stereotypes are, thus, not just buzzwords anymore but lived engagement. The diversity of existing regulatory approaches and technologies within the G20 means that many questions are yet to be answered: how to make digitization an opportunity for all? Fostering diversity and inclusion in the digital era is essential to protect and enlarge global value chains, create a trustworthy Artificial Intelligence (AI) ecosystem, enhance the digital to achieve sustainable growth. In other words,

when using the term "sustainability of digital innovations" in this article, it refers to securing the necessary basis for the solid ground for innovations: education and training. It lays the foundation in digital era and guides as compass for "Building Forward Better."

As a Senior Civil Engineer with a background of international experience in Europe and China, the author deals with all aspects of new technologies in Construction Engineering in multidisciplinary, intercultural environments, arising with Industry 4.0. The author's field of expertise in the Construction Industry covers her own engineering company in multinational environments since 2007—after filling various management and leadership positions—and mentoring female apprentices and academics in STEM disciplines. In 2019, she took a pioneering role by starting as the Representative for *"Sustainable, Human-led AI in Construction Industry"* by investigating human-technic interaction. Therefore, in 2020, she founded the Excellence Initiative under the same name [1]. Her research examines ethical, social, and economic impacts of digitization and AI on human, societal, and technological development [2].

By assessing how and why education and learning lay the essential foundation of the digital age, the research also found out that knowledge and AI not only automatize learning processes but strengthen Corporate Digital Responsibility (CDR), diversity, and inclusion in Construction 4.0.

Pioneers are role models equally to develop and implement technical innovations. They shape the digital age as they share their experiences as Best Practices.

The research includes political strategies, but also makes new demands and work out specifically, where the advantages and disadvantages of the current curricula lie in order to provide the future educational foundation as broad as possible. With that, the acquisition of both the appropriate professional and personal social skills could succeed in the best possible way.

2. Knowledge and AI automatize learning processes

The tension between the new qualification requirements through digitization and AI and existing resources for teaching and curricula with an adequate academic infrastructure could not be greater. New job profile descriptions clearly speak of holistically thinking experts and system-integrating specialists. The learning curve for everyone involved is steep, and the demands in construction are equally high: Climate and environmental protection, sustainability with resource efficiency, thinking through the entire construction life cycle—from the project idea to dismantling and recycling, budget compliance, and efficient timeline as well as a building project of highest quality. New technologies not only may ensure, but perform such processes in a much more structured, efficient, safer, successful, and profitable way. Teaching and training carry responsible roles in order to explain these powerful technological tools, to practice first approaches and to allow making mistakes. The safe and efficient use of emerging technologies and knowing its positive and negative effects require targeted instruction within this innovative interaction between human and technology.

Why is it important to specifically integrate digital methods and AI into teaching in Civil Engineering? Because only construction experts are able to localize obstacles and weak points in construction projects, name improvements, and define potential fields of application for digital methods and AI. They know the processes, interfaces, and hurdles exactly and know "where things get stuck."

The digital transformation and the latest technologies require a rethinking of previous teaching methods, teaching aids, teaching environment (laboratories, equipment, IT), knowledge in theory and practice, practical samples of application, the relationship between theory and practice, the qualifications of the teaching staff and their openness, and networks across disciplines [3–6].

3. The path forward: education and training in digital era

The basis for diversity, inclusion, and sustainable digital innovations can only be ensured through appropriate training and further education [7, 8]. The Action Plan for digital education is an essential prerequisite for creating a European education area by 2025. It contributes to the realization of the goals of the *European Skills Agenda* [9], the *Action Plan* on the European Pillar of Social Rights and the *"Digital Compass 2030: The European Path to the Digital Decade."*

The dependencies and weaknesses of European digital capacities, competencies, and technologies are becoming increasingly clear. They see a need for action particularly in the area of AI [10].

Numerous studies and forecasts on digital transformation provide information about the extensive effects on jobs. New professional fields and task profiles are emerging; they require new knowledge and skills. Some professional fields will no longer exist in the course of digital change, but new ones emerge. They accelerate the development, use and further improvement of new digital technologies and AI, and facilitate imparting the necessary knowledge to others.

AI will not only change people over the next few decades, but society as a whole. Companies that want to forego 50% of their talent face a massive problem in the medium term. Digital twins, self-learning construction sites, automation and robotics on construction sites, VR, Smart Design, Smart Construction, Smart Operation, Smart Cities, Blockchain, AI, Next Generation Computing, 5G and 6G, IoT, AIoT, AR, VR, and XR strongly influence corporate business models and daily construction site organization, construction operations, building informatics, and technical building automatization.

Analyzing the content of curricula of selected universities and colleges, crystallize out, that terms such as BIM (Building Information Modeling) and AI are mostly not or rarely listed in the overview of lectures—both for Bachelor and Master. At the same time, it can be seen that more and more new curricula modules are being set up in construction, such as Computational Engineering or Data Engineering. The aspects of human responsibility that engineers, designers, and developers bear by the nature of profession cannot be adequately taught, e.g., with the modules for Ethics: it is taught on the sidelines, and—as interviewed experts share—is usually still an optional subject on a voluntary basis. Some teachers fear that they will have to forego their own learning content and therefore see no point. These aspects are part of an even larger package of influencing factors in education and teaching, why—at this stage—education and teaching cannot do justice to the expectations and requirements of the economy and society.

In addition, there are innovative research initiatives at universities and emerging AI hubs, digital campus locations, AI labs, increasing digital transformation competence networks, endowed professorships and chairs sponsored by corporates, high-tech offensives launched by individual federal states, and AI centers as well as completely newly created modules: "Applied AI" and "Digital Ethics," "Digital Transformation,"

"Human-Computer Interaction," "Digital and Data Science Engineering," "AI-based Technical Building Automatization," "Digital Process Management of Construction Projects."

4. Shared experience from user practice

It now depends on the answers we humans give, how we can fill these gaps, and the new professional fields. For the analysis and evaluation in this research work, experts were interviewed based on the qualitative method: representatives from universities, colleges, newly created chairs and professorships, professional associations, new corporate departments, and institutes. They share their opinion and tendencies they assess. Statistics and job profile descriptions in national and international newspapers and professional journals were evaluated for obtaining a picture as accurate as possible of where we "stand" in the Construction Industry. What are the concrete measures to be taken to set up adequate curricula? And what distinguishes the skilled workers and "engineers of tomorrow"?

Teizer [11], partner and head of the management of technology and innovations at VOLLACK, is active in academic teaching himself. "*AI is rarely or rarely promoted and taught in teaching. For example, architecture students at many colleges and universities still have to create and present analog designs and models. BIM is often not used. The day-to-day work that follows looks different. Perhaps one of the reasons is that decades of standards are reluctant to go crazy. And with civil engineers, the purely technical discipline way of thinking is a hindrance. In order to master the digital transformation successfully and together, however, interdisciplinary cooperation, openness with an innovative flair and the integration of new technologies are required.*"

Kiefer [12] refers to the results of the study carried out by the VDI in 2017/18 on "Engineering training for digital transformation." "*Professors, students, representatives from business environment and executives were interviewed. The feedback was sobering, as in parts of the professorships, among other things, results brought to light about insufficient knowledge, less open attitude to innovations, lack of willingness to participate, underestimated importance of the influence on engineering training and the necessary measures. The discussions have high priority, especially at universities.*" Kiefer offers further important insights: "*Engineering training has already changed fundamentally: it has been opened up, via modularized design and internationalization. Highly recommended for considering the university's commitment: the umbrella organization '4ING', the Faculty Days for Engineering and Computer Science at Universities. The German Federation of European National Engineering Associations FEANI (in German "Föderation Europäischer Nationaler Ingenieurverbände") tries to influence engineering training on the european level, to agree on the necessary qualification profiles across national borders, to level the differences between the countries, to facilitate the professional entrance for the engineers, to be armed with knowledge and skills successfully. In fact, to be fully committed designing the digital transformation process in Construction. Indeed, there are major discussions about the engineering profile at FEANI. The process of opening up to realignment and adjustments is ongoing. In addition, it is the current generation, which defines the different attitudes and attitudes toward the topic.*"

Digital transformation bears high potential to aid both economical and efficient building project life cycle and greatest possible social benefit, economic prosperity, and protection of our natural resources of life.

But at the same time, the economy is lagging behind digitization and AI, diversity, and inclusion. 60% believe that the lack of diversity in the tech workplace is a serious

issue [13]. Strong support for change comes from national and international networks and associations promoting the fields of STEM, construction, and digitization. In the 2020, *Digital Education Action Plan* and the *European Skills Agenda*, the Commission announced a range of actions to ensure and develop digital skills. In the next few years, the need for skilled workers will continue to increase and corporate personnel planning will have to adopt. Digital transformation changes job profiles and creates new ones. Universities, colleges, and training centers feel this change and start expanding their curricula to accommodate the subjects of digitization and AI so that the next generation of engineers and specialists provide ethical and interdisciplinary skills in digitization and AI. This is a key competence in Germany for "AI—Made in Germany", which is recognized worldwide as a seal of quality.

The decisive factor is leadership behavior, the example of top management and clear communication of the culture of values [14]. It is the responsibility of every corporate management to promote diversity at all levels, inclusion, best qualifications, and personal competence, to maintain, to ensure sustainable and—in the interests of the common good—to increase its contribution to the value chain. Corporate environments with agile, dynamic management style, and female leadership should be a matter of course to generate high performance.

Profound insights, openness, and recommendations of the interviewed experts enabled this research to reveal these new findings and set constructive approaches as a Call for Action into the ongoing debate. The wide variety of specialist knowledge and areas of responsibility illuminated the challenges and innumerable chances of diversity from different angles.

Furthermore, the holistic, inclusive, interdisciplinary approach of the author not only empowers to educate, raise awareness, and provide orientation in dealing with digital transformation but adds value to this new field of scientific research.

Algorithms, which make AI possible, are daily routine for computer scientists, but only a negligibly small proportion of society is familiar with AI and speaks this expert language. Trust in this new technology therefore is imperative but can only be established and built where it is explained and awareness is formed. In total, 125 million girls of primary and secondary age in the developing world are out of school. Girls' exclusion from education begins early and increases over their lifetime (**Figure 1**). While the vast majority of adolescent girls of upper secondary age begin primary education, fewer than half make it to the upper secondary level where STEM skills can be further solidified.

It is essential to give access to girls and women around the globe to learn and utilize these technologies; they possess high communicative, social skills as well as significant high human-driven decision-making process dynamics and are catalysts for highly dynamic and efficient learning processes, which is the real core of this innovation.

The young generation has high expectations of teaching and training in handling and transferring knowledge about both future key technologies and offer constructive solutions and gain required professional and personal skills. The best indicator for job seekers is companies that are already actively shaping the digital transformation, using methods such as BIM, helping to develop the first AI technologies, defining potential fields of application, and developing new business models as a result. The opportunities are significant and diverse for young skilled workers and engineers to prove their qualifications and enlarge the value chain by their contribution to success.

It takes people, fully participating to reach these goals, platforms, visionaries, and men of action from fields of teaching, education, business, politics, and society. *We see a strong need for the discourse, this is the only way to constructively investigate the question of*

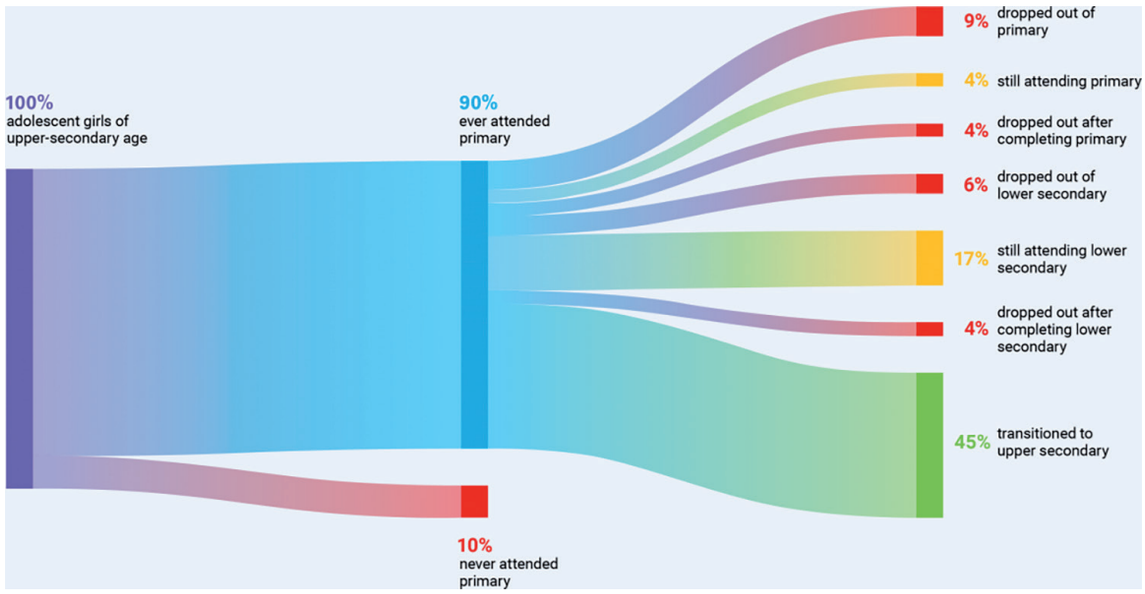

Figure 1.
Education pathways of girls in: the story of disparities in STEM, mapping gender equality in STEM from school to work source: UNICEF 2020 [15].

the qualification profile … of the "engineers of tomorrow", which digitization and AI require. Decision-makers have a responsibility. Certain things taken for granted from the past will no longer apply in the future … Innovative technologies—hand in hand with ethical questions—must generally be included in teaching. That has not happened yet. Mistake and problematic: it is a process in which everyone, and not just individual, has to deal with the effects of digitization and AI. Reservations, an attitude of rejection, waiting, or the attitude "we don't need" have no chance in this process that affects all of them," state Lautwein and Fox [16].

5. Algorithm complexity and gender bias

Digital transformation sets flag for disruptive reforms in the educational landscape. Best Practices are evidence for best results in increasing both personal social and expert skills. Axel Wallrabenstein sets impulses: "*Diversity in management bodies is not only important, but essential for the success of companies and for our society.*" His counterpart Rainer Esser follows, "*Companies that want to fore-go 50 percent of their talent will face a massive problem in the medium term*" [17].

New approaches offer the historical chance to break boundaries, move forward global digital competition, add value to the system of computer algorithms, and increase its share in the value chain. Women are underrepresented, so there is less data, data of lower quality, not free of bias. Thus, the results are unpredictable and unexpected. There are serious concerns regarding the scalability of taking automatically biased decisions that can affect large sectors of the population, particularly minorities and more vulnerable communities. A growing body of evidence is indicating that algorithms are increasingly affecting decisions by replicating unequal or unfair treatments [18].

In line with the European Commission' priority to strive for a "Union of Equality" by its *Gender Equality Strategy 2020–2025*, the author's Memorandum (**Table 1**), shared with the *T20* Task Force Digital Transformation in preparation of the *G20 Summit* in October 2021, focus on:

• Develop technologies and algorithms to evaluate and address bias in AI-based systems. These methods will help addressing gender in AI-based systems and support the deployment of such bias-free AI-based solutions.
• Develop standardized processes to assess and quantify the trustworthiness of the developed AI systems, in particular assessment of bias, diversity, non-discrimination, and intersectionality—based on different types of bias measures. Consider diversity and representativeness of data, ensure the reliability, traceability, and explain ability of the AI systems. Include mechanisms to flag and remove risks of biases and discrimination.
• Develop recommender and algorithmic decision-making systems, which reduce bias in the selected use case.
• Conduct trainings and awareness rising on preventing gender and intersectional bias for AI researchers, students, and practitioners in line with the Digital Education Action Plan 2021–2027.
• Cooperate with relevant partnerships across industrial and digital sectors, including digital professional associations (e.g., IEEE), computing industry, hi-tech start-ups/SMEs etc., to further promote the use and uptake of the developed tools.

Table 1.
The memorandum, shared with the T20 task force digital transformation in preparation of decision papers at G20-summit in oct 2021. July 2021 source: Bianca Weber-Lewerenz and Ingrid Vasiliu-Feltes.

6. Disruptive changes in curricula

Digitization abolishes traditional structures and boundaries. Thus, it is necessary to highlight the digital era's opportunities for society and new fields of activity that have so far been largely ignored.

Digital teaching itself becomes an aspect of teaching: having access to digital equipment is not a matter of course, because there is no fundamental right and universities and educational institutions need to apply for funding. It is about the acquisition of devices such as laptops, tablets, or whiteboards and the integration of these devices into lessons. Not every university is financially that well positioned to have extensive digital teaching equipment and facilities. Here, new challenges require new strategies.

Pure knowledge transfer can succeed very well, if not better than with previous teaching, by fully using digital possibilities. Digitization offers a way to open up the access to education to a larger extent.

The engineering training sets most important basis. It requires an open-minded, interdisciplinary, collaborative mentality of all those involved. The engineer of tomorrow will no longer just plan, construct, maintain a building, but bring people together that are involved in the construction project. The engineer networks knowledge, uses interfaces and interdisciplinary perspectives, shares technical engineering knowledge, leads a project, is part of a large team with a common goal: to use skills and knowledge in a goal-oriented and efficient manner toward a successful, sustainable project. It is about a building that is realized by help of a lot of emerging technologies. The engineer of tomorrow is a visionary, a dedicated one. He tackles work with foresight, works on solutions that are compatible with the common good; the engineer takes a stand on social issues, prevents violations, helps to shape the dynamic field of work preventively, to curb possible negative developments. The engineer promotes an open dialog between the construction and society in order to protect the culture of values in construction industry. His interdisciplinary approach is the most essential requirement. Thus, the curricula need to be thoroughly adapted; the reality of life must be made the subject of engineering training.

Furthermore, from the beginning of studying and training, the engineer needs to work interdisciplinary: with other faculties such as Architecture, Design, Computer Science, Law, Philosophy, Media, and Cultural studies. As the sustainable, value-based design of the living and urban worlds of tomorrow, future-proof urban infrastructures, space, and society are enabled by the necessary ethical principles in dealing with digital technologies and AI, the more technically oriented engineer can supplement his knowledge.

In higher education across the world, the progress of digitization is deeply influenced by government policies and institutional development strategies, both of which play a key role in shaping the digitization landscape of higher education [19].

The following dilemmas require deeper research: Nowadays, university research and teaching have to look for funds and, therefore, choose topics according to demand. Students are confronted with the omnipresent situation of the labor market; lecturers are already part of the academic precariat. The structure and organization of teaching are determined less by a belief in the educational ideal than by the learning of competencies that are intended to increase the individual's chances of competition. Not every excellence strategy and funded chair—often financially supported by companies—means excellent teaching and training. Digitization of teaching hand in hand with a more humane education allows contemporary teaching. Content and structure of academic training require concrete revisions, balancing theory, and practical application with case studies. Transferred to practice this means, e.g., the integration and application of BIM, digital twins, applying simulation methods, getting first contact with AI-based forecasting methods, self-experiencing virtual reality tools. Training personal skills include social, communication skills, network-oriented thinking, critical reflection based on holistic approaches, and interdisciplinary environments.

Digital teaching and training increase the flexibility of study and working hours as much as possible. It demands from each individual a high level of responsible behavior and planning. Such freedom offers high potential: gender-independent access for each and every one.

From November 2019 and February 2021, the author carried out primary studies with expert and interview surveys for winning more information on the recent status of corporate and training policy discussions and implementation of digital technologies and AI, as well as receiving more insights on how companies respond to and handle new needs in terms of specialist knowledge and new job profiles in the digital era. In addition, multipliers were interviewed for interdisciplinary holistic approach—including industry associations and chambers of crafts, foundations, representatives of various specialist disciplines at universities and colleges, educational and teaching institutions.

Fraunhofer Institute IAO and Cyber Valley Stuttgart-Tübingen published the common study with the author [20]. New findings were shared at presentations and conferences with a multidisciplinary, international audience [21]. The reason for choosing the qualitative research method was that the research field is a fringe area, the topic is new, and only the intensive expert interviews offer deep insights into the status and use of technologies, needs, tendencies, critical reflections, social problems, and recommendations for constructive solutions. The evaluation shows a practical implementation of education, knowledge, and awareness building, still bearing a lot of ignorance, business planning performance "on sight," attitude of rejection, and reservations about scientific interdisciplinary work. These conditions that prevent success have to be named. They not only hinder the exchange between specialist disciplines and the search for holistic solutions in the design of the digital transformation process, but also the innovative progress and digital change in construction in

Germany. "*In the technical sciences, it is still a long way off those values and principles are used and that ethics training has to be anchored in training,*" Loh knows [22].

7. Strengthen social and professional skills

Technical experts confirm that progress and reforms in digital change can only be achieved through critical questioning and new food for thought. Responding to corporate responsibility in the digital society requires a new quality of discussion.

The study considers both UN sustainability goals and requirements of the EU Commission in its "*White Paper on AI*" as guide for designing value-based, sustainable digitization and AI. These guidelines offer orientation to strengthen the responsible role of the construction industry. Ethical values and codes of conduct have to be further developed in order to strengthen trust in new technologies. New job profiles tailored to digital competence, automation, robotics, AI and related sustainability issues, are steadily reflected in increasing numbers of start-ups, tailor-made specialist and managerial positions, and new job advertisements. The professional and personal requirements are diverse and extensive (**Tables 2** and **3**).

In addition, new university research initiatives, endowed professorships and chairs are founded, sponsored by industry and companies, and new areas of lesson created. They have in common the formation of technical, interdisciplinary project cooperation—as early as the training phase. For a holistic view, faculties increasingly work cross-disciplines in intercultural teams. Train such forms of cooperation, team structures, processes, and methods from the earliest stage enable to keep pace with technological, economic, and societal changes. The most precious foundation is: reflecting, thinking ahead, and thinking outside the box. Values and ethics, digitization, and AI can no longer only be assigned to other specialist disciplines such as philosophy, law, IT. They must be embedded in the teaching and education of tomorrow's engineers, the engineering sciences.

• Self-learning competence.
• Decision-making ability: In the future, it will be crucial to be able to differentiate between the essential and the insignificant and to be able to assess alternatives.
• Cooperation competence: Engineers should be able to work together, find consensus, and be able to accept each other. In addition to being able to work in a team, this also requires the ability to enter into non-organizational collaborations.
• Cognitive skills.
• Empathy.
• Thinking and acting with foresight, far-sighted leadership.
• Working in partnership with employees, suppliers, and customers (Covid-19 crisis clearly shows: the human factor and good management is the highest selection factor and criterion for quality).
• Think first, then act.
• Creativity.
• Interdisciplinary, network-oriented thinking
• Foreign language opens up for thinking along, empathizing with other people and situations, and empathizing with others.
• Value—and common good—oriented.

Table 2.
Social skills. Source: Bianca Weber-Lewerenz.

• Hybrid competencies: In addition to knowledge and skills of the respective subject area, the engineers of tomorrow also have knowledge of the digital disciplines.
• Interdisciplinary competencies: digital transformation will succeed through interdisciplinary and transdisciplinary cooperation.
• Simulation technologies: Understanding simulation technologies is the basis for developing systems and scenarios in the digital world.
• Big Data: Engineers know how to obtain information using sensors and how to implement it using actuators. In addition, they should be able to filter large amounts of data and have knowledge of agile process methods in software development.
• Technology assessment: Questions such as data protection and misuse as well as data security and falsification, but also decision parameters of autonomous systems are part of engineering developments. In addition, engineers help shape normative processes.
• Understanding of quality: Engineers must balance well security measures on the software side and the limits of the underlying model approaches.
• Acquisition of skills in the context of digital work and business processes designed as an interdisciplinary cross-sectional task.
• Strategic knowledge and working style
• Intelligent weighing for the use of AI.
• Predictive analytics.
• Safe handling of data, data protection (basic knowledge on legal regulations).
• Being able to explain technologies and thus gain confidence.

Table 3.
Professional skills source: Bianca Weber-Lewerenz.

That is, the Faculty of Applied Computer Science offers a wide range of courses: classic computer science topics and teaching the latest advances in technology. The course is intended to offer future skilled workers a wide range of opportunities on the job market, i.e., to contain potential dangers that arise through the use of digital processes ("Cyber Security") or to develop learning systems ("Artificial Intelligence"). Whether courses such as Applied Computer Science, Business Informatics, or the Internet of Things (IoT), one can choose between countless job offers and be part of shaping digital change. Applied AI, Digital Ethics, Digital Transformation, Digital and Data Science Engineering, Technical Building Automatization, Chief Digital Officer, Digital Ethic Boards, Digital Process Management of Construction Projects, Learning Transport Infrastructure are some of the new job portfolios. In the area of Technical Building Automatization—as part of the climate protection programs—the latest digital methods and AI are applied. In corporate trainings, teaching of hybrid competencies is in full swing.

Daily digital work assumes not only teaching and training digitally but, thus, re-orientation and adaption of qualifications of the teachers. New chances for women arise as to fill in these positions, promote digital innovations, and represent role model for other women. The inclusion of underrepresented and marginalized groups in the design development, and training of the AI systems, and a transdisciplinary approach, involving multidisciplinary and intersectoral partners in the consortium will be essential.

The path of understanding and dealing with AI, understanding opportunities and risks only is paved by an adequate education and rigorous academic training. Education is the core element required to build a legacy of gender equality.

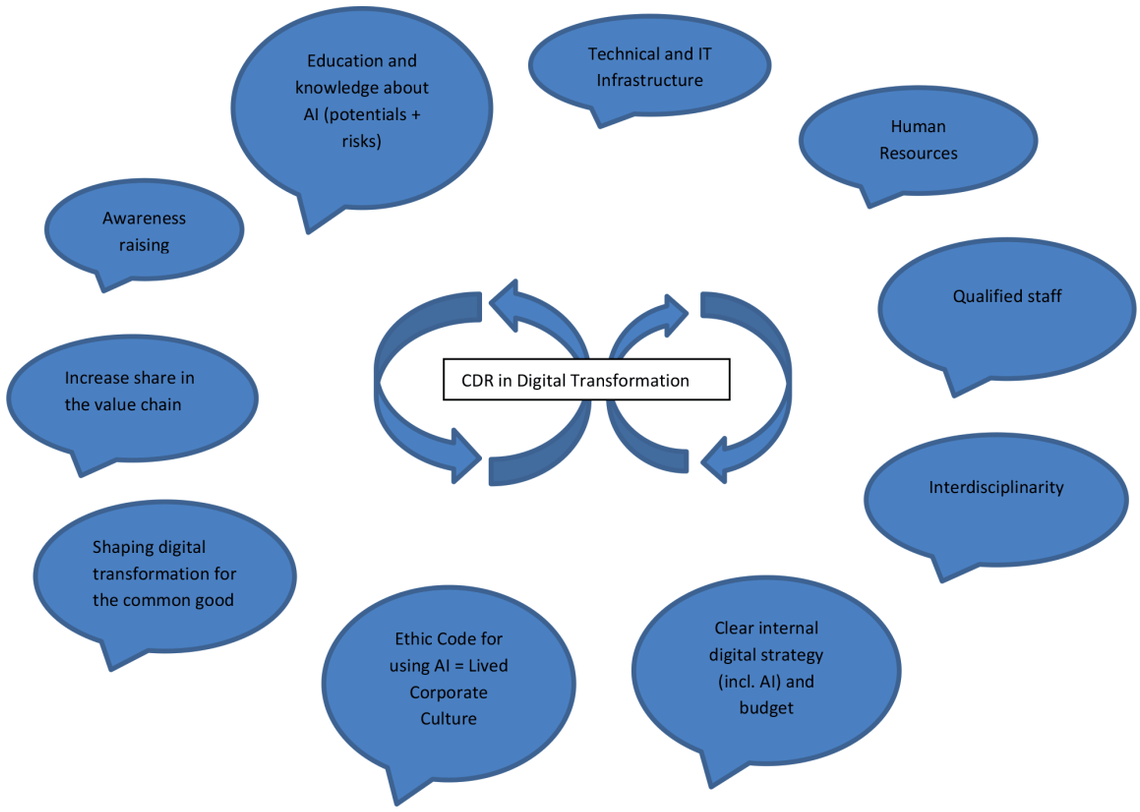

Figure 2.
Mind map "The interrelationship among the key elements of CDR" source: Bianca Weber-Lewerenz.

However, there are several complex issues we need to address. How do we define an optimal "future-proof" curriculum? Who is qualified to teach young children skills that will be beneficial for their future life and careers? How should we deliver this new curriculum? How and should we even score their performance of this revised future-oriented curriculum? The *UNESCO* presented its key findings in the *Global Dialog on AI* and *Gender Equality Report 2020*. The digital era takes diversity, inclusion, and integration into account. What is long overdue must now be pushed faster: adjusted teaching and training regulations, adjusted training and qualification of teachers, creation of new digital learning methods. Innovative, agile university, college, and training locations are in the focus when it comes to the choice of teachers and students determining new work places and study locations.

In times of crisis—such as the corona pandemic—it also became clear who was ahead of the pack when it came to dealing with these tasks. In the digital transformation, they are the key factors for successful implementation in construction (**Figure 2**), which must be sustainably anchored in research, teaching, and training.

8. "German engineering": construction in the focus

New job profiles clearly speak of holistically thinking experts and system-integrating specialists. The learning curve is steep for everyone involved, and the demands in daily construction industry business are equally high: Climate and environmental protection, sustainability with resource efficiency, thinking through the overall construction cycle—from the project idea to dismantling and recycling, keeping within budget and time, as well as realizing the highest quality. New technologies not only ensure but make

such processes significantly more efficient, safe, and successful. Teaching and training represent responsible roles for explaining these powerful technological tools and practicing initial approaches. The safe, efficient use of this technology and its effects require targeted instruction in this innovative interaction between human and technology. Why is it important to specifically integrate digital methods and AI into teaching in civil engineering? Because only construction experts are able to localize obstacles and weak points in construction projects, name improvements, and define potential fields of application for digital methods and AI. The sensible use of this technology with the help of an AI strategy tailored to the company and highly qualified staff require a joint rethinking, process and communication improvement, awareness raising with the help of comprehensive education, and orientation through a lot of knowledge. It offers orientation and security for users and employees at all times. Digital growth strategies require digital skills. This is the only way to completely redesign new business models in the construction industry in the digital world of work 4.0. According to experts, the planning and construction industry must redefine itself with reference to its own business models in its own task and job profiles. Close corporate contacts with universities and colleges support the development of professional skills. By communication and technology exchange—via guest lectures and the supervision of bachelor and master theses of students—skilled engineers can be trained. Another perspective is that universities and colleges should be attractive for students and stand out innovatively in the educational landscape. Working in the Construction Industry has lost its attractiveness, maybe it will be possible to revive it with new, exciting technologies?

To women this digital era offers enormous potential in construction in fields of work, research, networking, building trust in new technologies, widen application areas, and set up innovative business models.

In the future, the technical competence increases mutual benefit between young and experienced employees. Because lacking experts in digital technologies and AI, teaching and training make a significant contribution to building on existing skills with the help of additional digital knowledge and to promoting the use of innovation technologies. This increased awareness of the need to create appropriate teaching and lecturing digitization and AI. Following the opinion of university experts, according to interview evaluation, these fields should not just lead to one new field of academic lesson in addition to existing subjects, but be holistically integrated, taught cross-disciplines, and be embedded in all modules and lessons.

In the opinion of economic experts, a general entrepreneurial rethinking and new approaches in corporate recruiting and personnel marketing are required. In terms of strategic personnel planning, companies should define task and job profiles and address them to universities, colleges, and training centers. New job profiles require the integration of new specialist skills.

Universities and colleges should stand out innovatively in the educational landscape when training architects and engineers. Digitization with BIM and AI are opening up new opportunities that could revive the lack of attractiveness of the entire construction industry for years. The use of new technologies and production methods such as the three-dimensional printing of entire components or even houses will be able to counteract the now noticeable shortage of skilled workers.

The Construction Industry has an extraordinarily high reputation: “German engineering” and “German craft ship” stand for the highest quality and sustainability worldwide.

Teaching and training are no longer just training, but to think holistically and in networks, shaping and paving the way for successful digital change.

9. Conclusion and outlook

There are *four main pillars* of disruptive and transformative change our society needs to undergo as to fully ensure diversity and gender equality: education, profession, culture, and governance. It is important to address all levels of education from preschool to executive level [23, 24]. Furthermore, skills that are expected to be in highest demand in the digital era need to be embedded into the classical curriculum [25].

WEF highlights that some of the top skills in demand by 2025 will be creativity, analytical and innovative thinking, active learning, complex problem-solving, as well as technology design, use, monitoring and control to only, name a few [26].

By offering full access to quality education and equal employment opportunities, societies around the globe ensure to not leave any girl's and women's rights neglected [27].

To be clear: education and training represent the strategic basis for both sustainable digital and human transformation. However, to bring it to the next level, the adaptation of higher education and training will almost certainly need to be accelerated to keep up with the already high dynamics of the digital ecosystem and the emerging technologies. Some of the latest emerging technologies (such as Blockchain, Quantum Computing, Metaverse, AI, IoAI, Next-Generation Computing, 5G and 6G, 3D, IoT, AR, VR and XR etc.) can serve as catalysts or gateways to enhance inclusion and diversity when deployed mindfully [28].

Curricula is far from satisfying the needs of companies and fulfilling the requirements of economy and society. Strategies and white papers are seen too much of theory, there is a gap between the media hype of talking about digital ideas, dreams, and visions, what we can, what we should do, could do, what would be good, what would be great. The gap goes deep right into the daily practice, the practical ways of highly interested companies in implementing such tools and methods, and modern digital working environments, daily routine utilizing digital methods and AI.

Only a minority of universities, universities of applied sciences and schools offer adequate digital infrastructure and learning environment [29]. But innovation requires qualified experts and skilled workforce with diverse and inclusive backgrounds—on both sides: teaching and students. Best practice, user experiences help interested and new users at the start.

How can it be that only a handful of the 100 advertised AI professorships are filled [30], the course content is still not adapted to the requirements of the digital transformation, and companies are desperately facing the shortage of skilled workers, which is still growing?

This research is a direct approach to calls made by the various national and international strategies with focus on the Construction sector—a branch that is being studied scientifically for the first time with this research.

It represents a significant path forward that some Best Practices already walk. For the holistic understanding, algorithm complexity and gender bias are shortly introduced and social and professional skills stressed. Thus, clear definitions of the concrete disruptive changes in curricula can be provided, eventually leading to the German Engineering seal of quality.

This chapter is intended to be a plea for more disruptive thinking and acting in teaching and training. The digital and human transformation begins in the head—where education lays the foundation.

Acknowledgments/other declarations

Education is the foundation for progress. Knowledge is the door to the world.

I thank my mentors and all supporters who share this vision.

I thank all the experts interviewed in this research. I thank all who strengthen education and training in digital transformation process.

In particular I would like to thank my supervisor, Prof. Dr.-Ing. Marzia Traverso, Head of Chair of the Institute of Sustainability in Civil Engineering, Faculty of Civil Engineering at RWTH Aachen University, Germany.

Statistics and reports were of great support with data and facts to underlay the statements and recommendations made in this paper.

This research received no specific grant from any funding agency in the public, commercial, or not-for-profit sectors.

Conflict of interest

The author has no relevant financial or non-financial interests to disclose. There is no Conflict of interest/Competing interest.

Publication permission was given by all respondents. Some public statements, which come from internet, literature, and archive research, also underline the quality and statistical values of the expertise and survey values obtained, as well as limitations and urgently necessary measures.

The author of this study conducts external research, is company-independent, and is not financially supported by third-party funds, companies, or other institutions. She is free in her research and shares her findings at the interface of "application practice—applied technical research—economic and social transfer." In this way, the author is researching the responsible use of digitization and AI—neutrally, critically, and inclusive—and promoting the ethical debate about the AI technologies.

Key Terms

AI	Artificial Intelligence is a branch of computer science that deals with the automation of intelligent behavior and machine learning. It is an attempt to reproduce certain decision-making structures in humans, e.g., B. a computer is built and programmed in such a way that it can deal with problems relatively independently. Often, however, it is also used to designate an imitation intelligence, whereby an "intelligent behavior" is to be simulated using mostly simple algorithms.
BIM	Building Information Modeling describes a working method for networked planning, construction, and management of buildings and other structures using software. All relevant building data are digitally modeled, combined, and recorded.
Diversity	Diversity is the range of human differences, including but not limited to race, ethnicity, gender, gender identity, sexual orientation, age, social class, physical ability or attributes, religious or ethical values system, national origin, and political beliefs. Diversity of people does not mean just the obvious in terms of demographics such as race, ethnicity, gender, and age. Diversity means people

	with different skill sets, experiences, educational backgrounds, cultural and geographic perspectives, ways of thinking and working. Diversity is part of social, corporate, and political responsibility.
STEMs	These fields include Science, Technology, Engineering, and Mathematics.

Author details

Bianca Christina Weber-Lewerenz
Excellence Initiative for Sustainable Human-Led AI in Construction,
Bianca Weber-Lewerenz Engineering, Aichtal, Germany

*Address all correspondence to: bianca.christina@gmx.de

References

[1] Weber-Lewerenz B. Excellence Initiative for Sustainable, Human-Led AI in Construction. 2020. Available from: https://www.bwl-engineering.com/iethics

[2] Weber-Lewerenz B. Corporate digital responsibility in construction engineering: Ethical principles in dealing with digitization and AI. International Journal of Responsible Leadership and Ethical Decision-Making (IJRLEDM). 2020;**2**(1):32-49. DOI: 10.4018/IJRLEDM.2020010103

[3] Burnett M. Doing inclusive design: From gender mag to inclusive mag. In: Human-computer Interaction Institute Seminar Series Paper [Paper Presentation]. Pittsburgh, PA: Carnegie Mellon University; 2020. Available from: https://scs.hosted.panopto.com/Panopto/Pages/Viewer.aspx?id=1fa67161-215d-45e8-b228-ab3e00f844ce [Accessed: December 14, 2021]

[4] AI Ethics Lab. A Guide to the Dynamics of AI Principles: Our Toolbox for Understanding & Using AI Principles. 2020. Available from: https://aiethicslab.com/big-picture [Accessed: December 14, 2021]

[5] World Economic Forum. These are the Top 10 Job Skills of Tomorrow—and How Long it takes to Learn Them. 2020. Available from: https://www.weforum.org/agenda/2020/10/top-10-work-skills-of-tomorrow-how-long-it-takes-to-learn-them [Accessed: December 14, 2021]

[6] UNESCO. New UNESCO Report on Artificial Intelligence and Gender Equality. Report 2020. 2020. Available from: https://en.unesco.org/AI-and-GE-2020 [Accessed: December 14, 2021]

[7] German Federal Ministery for Education and Research. Digital Future: Learning. Researching. Knowing—The Digital Strategy. 2019. Available from: https://www.bildung-forschung.digital/digitalezukunft/de/unsere-ueberzeugungen/digitalstrategie-des-bmbf/die-digitalstrategie-des-bmbf/die-digitalstrategie-des-bmbf.html [Accessed: December 14, 2021]

[8] European Commission. Action Plan for Digital Education (2021-2027). 2021. Available from https://ec.europa.eu/education/education-in-the-eu/digital-education-action-plan_de [Accessed: December 14, 2021]

[9] European Commission. European Competency Agenda. 2021. Available from https://ec.europa.eu/social/main.jsp?catId=1223&langId=en [Accessed: December 14, 2021]

[10] Merkel A, et al. 2021. Europe must see its Digital Sovereignty. Letter to the Head of the EU Commission. Available from: https://www.handelsblatt.com/meinung/gastbeitraege/digitalisierung-appell-von-vier-regierungschefinnen-an-die-eu-europa-muss-seine-digitale-souveraenitaet-staerken/26962398.html?share=mail&ticket=ST-12911066-YRfg5bjTdBqhfCVlySXD-ap6 [Accessed: December 14, 2021]

[11] Teizer K. Dealing with Digitization, AI and ethics in construction at Vollack Company. Telephone Interview with the author as of 21 December 2020. 2020

[12] Kiefer T. Dealing with Digitization, AI and ethics in construction at the German Association of Engineers: International Job Policy and Technical Education (German "VDI Verein Deutscher Ingenieure"). Telephone

Interview with the author as of 03 December 2020. 2020

[13] Agarwal P. Gender Bias in STEM: Women in Tech Still Facing Discrimination. 2020. Available from: https://financesonline.com/women-in-technology-statistics [Accessed: December 14, 2021]

[14] Wieland J. Founder of Governance Ethics, 1996 Founder of the Ethic Management in Construction Industry Association (Since 2007 renamed "EMB - Value Management Association of Construction Companies"). 1996. Available from: https://www.emb-werte.com

[15] UNICEF. Education Pathways of Girls. In: The Story of Disparities in STEM, Mapping Gender Equality in STEM from School to Work. 2020. Available from: https://www.unicef.org/globalinsight/stories/mapping-gender-equality-stem-school-work [Accessed: December 14, 2021]

[16] Lautwein M, Fox J. Dealing with Digitization, AI and ethics in construction at the Federal Institute for Building, urban and spatial research (BBSR), at the Federal Office for Building and Regional Planning (BBR). [Dealing with Digitization, AI and Ethics in Construction at the Federal Institute for Research of Building, City and Environment Planning]. Interview by the author as of 04 December 2020. 2020

[17] All Bright Foundation. Introduction of Board Members. 2021. Available from: https://www.allbright-stiftung.de/English [Accessed: December 14, 2021]

[18] Leavy S. et al. Mitigating gender bias in machine learning data sets. In: Boratto L, Faralli S, Marras M, Stilo G. Bias and Social Aspects in Search and Recommendation. BIAS 2020. Journal of Communications in Computer and Information Science. 2020;**1245**. DOI: 10.1007/978-3-030-52485-2_2

[19] Walker R, Jenkins M, Voce J. The rhetoric and reality of technology-enhanced learning developments in UK higher education: Reflections on recent UCISA research findings (2012-2016). Journal of Interactive Learning Environments. 2016;**26**(7):858-868. DOI: 10.1080/10494820.2017.1419497

[20] Weber-Lewerenz B. Ethik in der KI im Bauwesen in Deutschland" und KI Methoden und Erfahrungswerte im Rahmen der Studie von Giannakidis, Alexandros; Weber-Lewerenz, Bianca; Stolze Denis KI im Bauwesen in Deutschland" des Fraunhofer Instituts Stuttgart IAO im Auftrag des Cyber Valley Stuttgart - Tübingen 2021. 2021. Available from http://publica.fraunhofer.de/eprints/urn_nbn_de_0011-n-6306697.pdf [Accessed: April 28, 2021]

[21] Weber-Lewerenz B. Gender innovation in construction in digital era, Conference Proceedings and Oral Presentation; 14 October 2021; Reser Conference 14-15 October 2021 Heilbronn, The Disruptive Role of Data, AI and Ecosystems in Services. In: Bienzeisler B, Peters K, Schletz A, editors. Conference Proceedings of the 31st RESER Conference. 2021. p. 29 Available from http://publica.fraunhofer.de/dokumente/N-642928.html [Accessed: December 10, 2021]

[22] Loh J. Künstliche Intelligenz und Ethik: Alles gut, oder was? [AI and Ethics: Is All Good?]. Podium Discussion as of 05 December 2018. Bonn, Germany: Telekom Headquarter; 2018

[23] Lazareva M et al. Digital technologies in preschool education: Risks and prospect. In: Proceedings of the 2021 1st International Conference on Technology Enhanced Learning in Higher Education

(TELE). Piscataway, New Jersey, United States: IEEE; 2021. pp. 93-95. DOI: 10.1109/TELE52840.2021.9482538

[24] Zevenbergen R. Digital natives come to preschool: implications for early childhood practice. Contemporary Issues in Early Childhood. 2007;**8**(1):19-29. DOI: 10.2304/ciec.2007.8.1.19

[25] Grimus M. Emerging technologies: Impacting learning, pedagogy and curriculum development. In: Yu S, Ally M, Tsinakos A, editors. Emerging Technologies and Pedagogies in the Curriculum. Bridging Human and Machine: Future Education with Intelligence. Singapore: Springer; 2020. DOI: 10.1007/978-981-15-0618-5_8

[26] World Economic Forum. These are the Top 10 Job Skills of Tomorrow – and How Long it takes to Learn Them. 2020. Available from: https://www.weforum.org/agenda/2020/10/top-10-work-skills-of-tomorrow-how-long-it-takes-to-learn-them [Accessed: December 12, 2021]

[27] Krieger-Boden C et al. Labour market opportunities for women in the digital age. Journal of Economics. 2018;**12**(1):10567. DOI: 10.5018/economics-ejournal.ja.2018-28

[28] Tortoriello M et al. Being a catalyst of innovation: The role of knowledge diversity and network closure. Journal of Organization Science. 2015;**26**(2): 423-438. DOI: 10.1287/orsc.2014.0942

[29] Edler J et al. Technology sovereignty as an emerging frame for innovation policy: Defining rationales, ends and means (No. 70). In: Fraunhofer ISI Discussion Papers-Innovation Systems and Policy Analysis. 2021 Available from: https://www.econstor.eu/handle/10419/236194 [Accessed: January 01, 2022]

[30] Mah D et al. Künstliche Intelligenz in Studium und Lehre. Überblickstudie zu Professuren und Studiengängen der Künstlichen Intelligenz in Deutschland. Berlin: VDI/VDE Innovation+ Technik GmbH; 2019. Available from: https://www.plattform-lernende-systeme.de/files/Downloads/Diverses/Studie_KI_in_Studium_und_Lehre.pdf [Accessed: January 01, 2022]