








Innovation-Driven Education Reforming Engineering Education in the AI Era

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Abstract. Currently, the global business and innovation environment is rapidly evolving due to the rise of the platform economy, digital transformation, and the shift towards remote and hybrid work. This shift emphasizes personal innovation and entrepreneurship, leading to an increase in self-employment and consulting roles over traditional employment. Simultaneously, key technological drivers such as artificial intelligence and advancements in system integration technologies, like semiconductors and advanced packaging, are significantly impacting on the expertise required for business. In this paper, we first identify key factors and analyze their impact on the future business and innovation environment in the era of artificial intelligence on education. We then introduce the concept of innovation-driven education and its impact on the ICT education framework. Our baseline is the European Institute of Innovation & Technology's (EIT) educational framework and quality measures. An new key themes include innovation entrepreneurship, multifaceted innovation processes, multicultural business ecosystems, and the platform economy. The future engineering profession will be characterized by 1) innovation entrepreneurship, 2) communication, collaboration, and workflow management with AI, and 3) a holistic and diverse understanding of entireties.

Keywords: Innovation-driven education · Digital transformation · Education 4.0 · Engineering profession · Education transformation · Innovation entrepreneurship · Artificial intelligence

1 Introduction

The global business landscape and innovation environment are undergoing a fundamental transformation, driven by the rise of the platform economy, e-commerce, rapid digital transformation, and the shift toward remote and hybrid work models [1]. The COVID-19 pandemic has accelerated these trends, leading to the adoption of advanced ICT infrastructure to support remote work and collaboration.

These shifts are changing traditional business models, enhancing digital ecosystem, and introducing new opportunities and challenges for organizations worldwide. The growing emphasis on individual innovation and innovation entrepreneurship has led to an expansion of self-employment and consulting work. This signals a departure from traditional employment structures. At the same time, technological advancements in artificial intelligence (AI) and system integration technologies are redefining engineering skills sets in the ICT sector. To address these new demands, leading universities are redefining curriculum aligned with Education 4.0 [2, 3]. This paradigm focuses on technical skills and with transferable critical soft skills such as creativity, design thinking, communication, and emotional intelligence. These skills are essential for adapting to a technology-driven, interconnected world.

As highlighted by the IEEE Future Directions group, three key technological megatrends are shaping the future of business and innovation [4]. Firstly, the growing focus on sustainability drives businesses to adopt renewable energy, circular economy principles, and eco-friendly products. Secondly, digital transformation continues to reshape societal operations and job markets, creating demand for new engineering professions and fostering remote work models. Thirdly, advancements in Artificial General Intelligence (AGI) promise breakthroughs in productivity and innovation, enhancing multiple engineering fields and human-machine communication.

This study examines the transformation of ICT engineering education toward innovation-driven models in the era of AI. It provides insights into rethinking educational frameworks to meet emerging challenges. The primary contributions of this work are:

- Analyzing the key factors reshaping the future engineering education
- Introducing the concept of innovation-driven education
- Identifying key aspects reformulating next generation engineering profession

2 Global Business and Innovation Environment

The worldwide business scene and innovation setting are experiencing immense transformation. This shift is mainly fueled by the emergence of the platform economy, digital transition, and the transition towards remote and hybrid work arrangements [5]. As per the World Economic Forum's Future of Jobs Report 2025, the top 10 skills needed by 2030 include: (1) AI and big data; (2) analytical thinking; (3) creative thinking; (4) resilience, flexibility, and agility; (5) technological literacy; (6) leadership and social influence; (7) curiosity and lifelong learning; (8) systems thinking; (9) talent management; and (10) motivation and self-awareness [18]. These changing demands not only transform job roles and skill sets but also significantly impact education and training.

For instance, the platform economy depends on essential technologies like cloud computing, blockchain, cybersecurity, data analytics, IoT, AI, mobile technology, and GPS, which necessitates a heightened focus on digital competencies. These relations are shown in Fig. 1. As these platforms redefine industry borders, educational institutions must modify their curricula to prepare students with the skills needed for success in a digitally powered innovative environment. In addition to technical expertise, a comprehensive understanding of network economics and platform-based business models is essential for navigating this new environment.

Interdisciplinary learning becomes crucial as platforms integrate technology, business, and social networks. Education systems need to encourage cross-disciplinary collaboration and creative problem solving. The students can link theoretical knowledge with practical applications by emphasizing project-based learning, and real-world case studies. This will prepare them to tackle complex challenges in platform-centric industries. Aligning education with industry demands requires frequent updates to curricular content and teaching methodologies [6]. The quadruple-helix model fosters collaboration among academia, industry, government, and society. This will play a pivotal role in ensuring that graduates have not only knowledge, but also practical skills needed.

Digital transformation [7] shift allows companies to allocate resources more effectively and focus efforts towards innovation and creativity. Advanced data analytics will provide businesses with deeper insight and enable more informed and strategic decision-making processes. This transformation will enhance collaboration and communications for efficient and cohesive organizational workflows. The cultural shift provided by digital transformation encourages innovation and agility. The curricula need to include digital and data analysis skills, and prepares students to excel in dynamic innovation and co-creation environments.

The shift towards remote and hybrid work models [8], primarily stems from advancements in communication technologies, virtual presence technologies, and evolving engineers' preferences. Increased flexibility reduced commuting time, and access to a wider talent pool are the key benefits of remote work. The challenges are related to collaboration, communication, and company working culture. The shift towards remote and hybrid work catalyzes the need to adjust teaching methodologies for preparing students to working life. This creates a need to develop skills on virtual collaboration tools and co-creation.

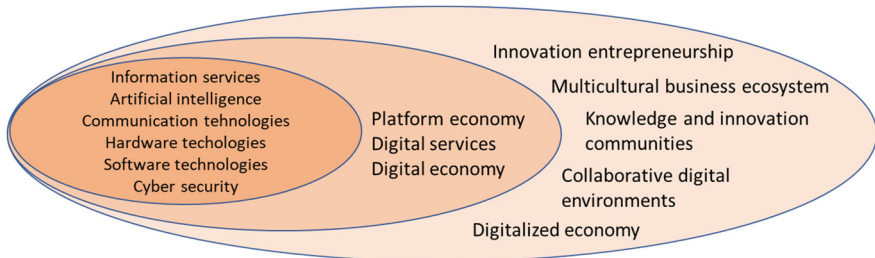


Fig. 1 Platforms connect technologies to business and innovation.

3 Impact of Technological Drivers

Key technological drivers, such as AI and system integration technologies are fundamentally changing the expertise required in business. Artificial intelligence [9] will dramatically reshape how we work, innovate, and interact socially by automating complex tasks and enhancing human capabilities [10]. This allows engineers to concentrate on strategic

thinking and creative and innovative tasks. Universities must incorporate AI skills into their curricula to prepare students for an evolving job market, which increasingly relies on technology to achieve unprecedented productivity levels [11]. Equipping students with hands-on experience empowers them to harness these tools for personal and professional growth. AI's ability to analyze vast datasets and recognize patterns can lead to significant breakthroughs in complex problems across various industrial sectors. By exposing students to real-world scenarios and data-intensive analyses, educational systems can cultivate a new generation of problem-solvers. They are capable of leveraging AI to create meaningful and innovative solutions.

Advances in system integration technologies [12] have significantly enhanced computational power and empowered the development of energy-efficient processing capacity, which is essential for AI, big data, and other data-intensive applications. The progress in AI and system integration technologies goes hand in hand, like two sides of a coin. Cost reductions driven by technological advancements and mass production have made semiconductors and advanced technologies more accessible, broadening their availability across the whole of society. This democratization facilitates widespread digital transformation within education and operations of educational institutions. This provides the necessary computational backbone for innovative applications and enriched learning experiences. Educational goals should focus on digital literacy, technology integration, and ethical technology usage, aligned with system integration technologies and AI advancements. This prepares students to thoughtfully engage with emerging technologies as responsible, innovative contributors to a technology-driven future.

4 Re-Envision Educational Models

The rapid evolution of the business and innovation environment has forced the leading universities to re-envision their educational models and to align them with Education 4.0 goals [13]. Education 4.0 emphasizes the integration of technology, interdisciplinary learning, and practical skills to prepare students for the demands of the modern workforce in the new emerging world of business.

Curriculum design in Education 4.0 emphasizes the importance of interdisciplinary approaches, which promote collaboration among students from various fields to tackle complex problems in order to address real-world challenges. By incorporating technologies such as AI, blockchain, and IoT/edge computing, educational programs will provide students with hands-on experience through labs, coding workshops, and hackathons. This pragmatical engagement allows students to apply theoretical knowledge and develop skills that are essential for today's technology-driven industries. Industry partnerships [14] play a crucial role in bridging the gap between academic knowledge and practical application. Co-locating industry and university education and R&D activities will enforce the mutual benefits, as described above. Co-locating education programs are particularly effective to allow students to work within an industry while completing their studies, thus acquiring firsthand insights into real-world business.

5 Innovation-Driven Education

Innovation-driven education is a new paradigm, which emphasizes creativity, problem-solving, and innovation entrepreneurship. It is built on the European Institute of Innovation & Technology (EIT) educational framework and quality measures [15]. The EIT framework has been successful in integrating academic learning with innovation and entrepreneurship. This is achieved by embedding technology and entrepreneurship in educational settings, promoting a culture of exploration and creativity in co-location center environments.

The rise of the platform economy and digital transformation has increasingly shifted focus towards personal innovation and entrepreneurship. This provides individuals opportunities to start businesses, offer consulting services, and work as freelancers.

Three fundamental changes are currently shaping the future of education, particularly in addressing technological content challenges:

Firstly, the shifting student demographics are notable. The student population is transitioning from the digital/internet-savvy Generation Z to the AI-savvy Generation Alpha. Both generations have grown up with advanced technology, resulting in distinct expectations and learning preferences. To effectively engage and inspire these tech-savvy students, universities must adapt their teaching methods to integrate more interactive, technology-driven learning strategies, embracing tools and platforms. As student populations become increasingly varied, based on a mix of cultural, socioeconomic, and educational backgrounds, educational institutions need to prioritize inclusive and equitable education practices. These can significantly differ from the ones of the past.

Secondly, the evolving nature of work is progressing from the industrial age to a knowledge and intelligence age. This transition, reminiscent of the shift from steam to electrical power, is now transferring us to an intelligence age. Here AI and robotics are beginning to supplant both blue- and white-collar jobs, and providing more time to creativity and to innovations of the whole work force. As these technologies become integral to various sectors, they are not only reshaping business practices but also fundamentally transforming societal structures, future of jobs, and employment landscapes.

Thirdly, the global landscape is undergoing a fast shift towards the geopolitically multi-polar world. Global South will play a crucial role in re-shaping innovations, technologies, and business practices. This will result to significantly growing economic impact to world's economy and trade. Understanding the dynamics of this new multi-polar environment is essential for all stakeholders to navigate successfully in a rapidly changing global world. Education plays a pivotal role in these global shifts by preparing students to engage with, and to contribute to this multipolar world. By creating and fostering an education environment that promotes international collaboration and free flow of ideas, education can provide students the new needed skills.

6 The Innovation-Driven Education Framework

The restructuring of the educational framework focuses on transitioning traditional approaches like the Conceiving-Designing-Implementing-Operating (CDIO) model to more dynamic, challenge-driven methodologies. The CDIO framework, known for its

emphasis on hands-on, project-based learning, is being evolved to address real- world problems specifically [16]. Its strategic element is the capstone projects based on complex teamwork in order to solve a specific engineering complex problem. Challenge-driven education (CDE) [17] further builds on this by immersing students in projects that target pressing global challenges such as sustainability, healthcare, and urbanization. These projects foster interdisciplinary collaboration, requiring students to work with industry partners and community organizations, and with students from other disciplines.

Innovation-driven education (IDE) advances CDE by embedding innovation and entrepreneurship directly into the curriculum. This approach teaches students to not only identify and solve existing problems but also to conceive innovative solutions and effectively bring them to market. By integrating entrepreneurial elements, IDE prepares students to become proactive contributors to the economy, ready to navigate the challenges of contemporary business landscapes and platform-based economies. Innovation entrepreneurship is a core component in this transformation, because future engineers are expected to not only have technical expertise, but also to have fore- sight to identify and pursue new business opportunities. Furthermore, engineers are required to have a holistic and diverse understanding of entire systems, considering the social, economic, and environmental impacts of their work. A systems thinking approach is essential, with an awareness of ethical and sustainability considerations. The innovation-driven ICT engineering Education 4.0 framework is illustrated in Fig. 2.

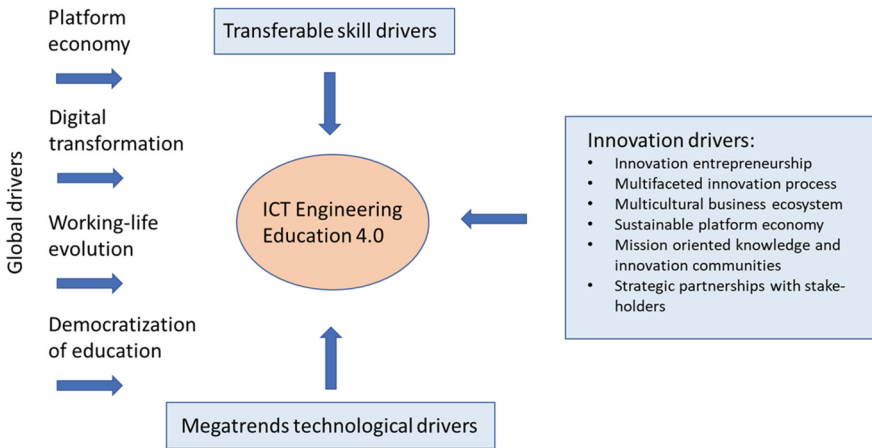


Fig. 2 Innovation-driven ICT Engineering Education 4.0

7 Future Engineering Profession

The future engineering profession will be characterized by 1) innovation entrepreneurship, 2) communication, collaboration, and workflow management with AI, and 3) a holistic and diverse understanding of the whole. Innovation entrepreneurship requires engineers to recognize and capitalize on new business opportunities. The purpose is to

increase their chances of launching successful startups, bringing innovative products to market, and selling their own innovative ability as freelancers. AI enables engineers to concentrate on strategic and visionary thinking. The key focus is in holistic and multi-faceted understanding of the whole, instead of concentrating detailed engineering. This new skill is becoming one of the core competences for engineering professionals.

Ethical considerations and sustainability are increasingly vital elements in modern engineering profession. According to industrial leaders, important individual transferable skills for our Education 4.0 approach include:

- **Collaboration Skills:** Building partnerships within and outside the team, creating trust.
- **Integrity and Trust:** Forming open and honest relationships across the team and stakeholders.
- **Innovation Skills:** Being open-minded and creative to seize innovation opportunities.
- **Personal Growth:** Pursuing continuous learning and development.
- **Passion for Excellence:** Striving for the best and continuously improving.

8 Conclusion and Future Vision

In this paper we analyzed key factors reshaping the future engineering education. Further we introduced the concept of innovation-driven education and the key aspects reformulating next generation strategic engineering profession. Our vision is to equip students with the skills required to thrive in a rapidly evolving world through an innovation-driven education. Our commitment extends to preparing students to navigate and address challenges caused by emerging global megatrends. By integrating education, research, and innovation, we aim to empower students to drive societal progress and environmental impact positively. By collaborating effectively, we believe in creating a dynamic educational environment that cultivates future leaders and innovators.

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