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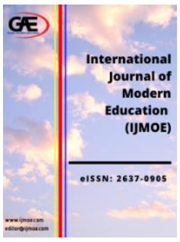

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ENGINEERING EDUCATION TRANSFORMATION: STRATEGIES FOR ADAPTATION AND PROBLEM-SOLVING

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Abstract:

This review reflects on the challenges and opportunities of engineering pedagogy. The paper shows how the digital transformation of education contributes to the preparedness of students for the job market that is rapidly changing. Similarly, the paper reveals a connection between the academic curricula and the industry's needs. This shows that the educational structures should focus on the incorporation of the practical aspects of the discipline and establishing partnerships with the industry. A methodological approach that relies on scoping review and analyzing the previous literature is essential for understanding the current practices worldwide. The main goal of this article is to review how digital technology, developing workforce requirements, and the need for equity and inclusiveness are collectively shaping the future of engineering education, to identify strategies that institutions can adopt to effectively adapt to these interconnected challenges and opportunities.

Keywords:

Digital Transformation, Engineering Pedagogy, Industry Demands, Workforce Needs, Engineering Education

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Introduction

The 21st century is a time of significant and fast changes in engineering education. The old, conventional models and ways that dominated this field in the past are undermined by various factors, for example, technological development and changes in social demands. This review assesses the current state of engineering education, identify the key factors of change, and explore how educational organizations attempt to adapt and thrive under the given conditions.

The history with regard to engineering education occupies the period of the Industrial Revolution. During this era, the primary focus was providing technical skills and knowledge for the rapidly growing industrial sectors. We are now transitioning to a phase of the digital age that is characterized by breathtaking progress in Artificial Intelligence (AI), robotics, and renewable energy, meaning engineers need a diverse and sophisticated skill set (Javaid *et al.*, 2022).

In addition, globalization and the interconnected nature concerning the modern world have shifted the form and expectations attached to engineering graduates. Organizations need professionals who have technical skills, communicate well, are flexible, and understand multiple cultural contexts (ter Hoeven & van Zoonen, 2023). This prevents the current curriculums and teaching process concepts from being reconsidered to ensure that graduates are prepared for new competition in an ever-changing world market.

Meanwhile, the population of engineering students is also changing and becoming more focused on diversity, equity, and inclusivity. The initiative to attract and retain underrepresented populations, such as women and minority groups, changes the nature of engineering classrooms and stimulates the need for more diverse and inclusive educational approaches (McCue, 2020). Diversity issues promote uniqueness and creativity and ensure that the engineering field reflects the diverse needs of the society it serves.

Additionally, the accelerated pace of technological development poses opportunities and challenges to engineering educators. New technologies, including virtual reality, simulation tools, and learning modules in the cloud, will create new digital opportunities for a better teaching and learning process (Almufarreh & Arshad, 2023). Nevertheless, the inevitable advancement of automation raises a question about the future work that human engineers will be asked to perform and the regular upskilling-to-reskill routine to remain relevant in a digitized economy (Mazurchenko & Maršíková, 2019).

In light of these complicated situations, engineering institutions worldwide are incorporating novel teaching methodologies and redesigning their programs to encourage creativity, critical thinking, and continuous learning (Waeber *et al.*, 2023). Through the various project-based learning projects and the introduction of experiential learning and interdisciplinary work, educators are genuinely revolutionizing engineering education to prepare students for these intricate circumstances. Overall, this review attempts to comprehensively analyze digital transformation, industry relevance, inclusivity, and fairness in engineering education.

Literature Review

Using digital technologies has revolutionized traditional education and training approaches and opened unique opportunities for enhancing the efficiency of teaching techniques, developing new learning environments, and helping students acquire skills required for modern

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engineering practice challenges. Thus, the engineering cohort that emerges as a result will be more comprehensive and all-covering. The objective of this literature analysis is not limited to:

The Utilization Of Digital Technology To Revolutionize The Teaching And Learning Methods In Engineering Education.

Table 1 lists the main elements of every study, so offering understanding of present issues and suggestions for utilization of digital technology to revolutionize the teaching and learning methods with regard to engineering education.

Table 1: Summary Of The Utilization Of Digital Technology To Revolutionize The Teaching And Learning Methods In Engineering Education

No	Author	Objectives	Problem Statement	Methodologies	Findings	Future Research
1	(Dart *et al.*, 2023)	To explore the theme of Engineering Education Research (EER) Capability Development globally.	EER identity varies globally, affecting development in areas like identities, knowledge, and practices.	Review and analysis of global EER papers, presentations, and workshops.	Expanded global understanding of EER, providing implications for future capacity-building in engineering education.	Further research on building global capacity for EER practices in diverse contexts.
2	(López-Fernández *et al.*, 2020)	To analyze educational experiences that integrate Challenge-Based Learning and Concurrent Engineering in Aerospace Engineering Education.	Lack of motivation and engagement in traditional teaching methods within engineering education.	Empirical research, surveys of students and professors, participation in ESA Concurrent Engineering Challenge.	Enhanced student motivation, improved professor-student relationships, and better learning outcomes.	Exploration of similar methodologies in other fields of engineering to evaluate effectiveness.
3	(Almetov *et al.*, 2021)	To identify competencies needed for future engineers and modernize engineering education content.	Engineering education content does not meet modern economic, technical, and social demands.	Survey of students and teachers, pedagogical modeling, theoretical analysis.	Competency-based approach helps improve professional and personal skills development for future engineers.	Innovative teaching methods and content adaptation to better align education with future industry needs.
4	(Patnawar, 2023)	To review the implementation of Problem-	Traditional PBL is less effective without	Systematic literature review (2012-2021) on digital PBL in	Digital PBL is more effective in preparing	More research on the application and challenges of

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		Based Learning (PBL) in digital settings and discuss challenges and future prospects.	integration of modern digital tools in engineering education.	engineering education.	students with practical engineering skills than traditional methods.	digital PBL to improve its implementation across engineering programs.
5	(Alli et al. 2023).	To identify challenges and opportunities in enhancing online engineering education in Computer Science and Engineering (CSE).	Online education may not be as effective as face-to-face classes in CSE.	Survey of 2nd, 3rd, and 4th year CSE students using spreadsheet software for data analysis.	Identified gaps in online CSE education, highlighting areas for improvement.	Focus on enhancing online learning resources to make it comparable to in-person education.
6	(Felder et al. 2021).	To summarize the challenges faced by students and instructors during the shift to online teaching due to COVID-19 at the University of Illinois.	Abrupt shift to online education resulted in lower perceived education quality and challenges in student assessment.	Surveys of students and instructors, focus groups, analysis of teaching methods.	Asynchronous and synchronous blended approach improves online learning effectiveness.	Recommendations for improving online learning assessments and fostering student community in remote environments.
7	(Binani 2022)	To develop a survey instrument to assess freshman engineering students' ethical awareness, preparedness, and challenges.	Engineering ethics instruction is insufficient in preparing students for ethical decision-making in professional contexts.	Exploratory factor analysis of survey results from engineering students.	Developed a reliable survey instrument for measuring students' ethical preparedness and challenges.	Further application of the survey to assess and improve ethics education in engineering programs.
8	(Servant-Miklos and Kolmos 2022).	To study student conceptions of problem and project-	Limited focus on student experiences and	Phenomenographic study using qualitative interviews with 16 students.	Identified varying conceptions of PBL, with gaps between	Broaden student reflection practices to include societal

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		based learning (PBL) in a systemic PBL model in Danish engineering programs.	conceptions of PBL, particularly at individual and social levels.		individual and societal relevance in student understanding.	implications of PBL.
9	(Sánchez-Ruiz et al. 2023)	To explore the impact of ChatGPT on b-learning methodologies in engineering education, particularly in mathematics.	Potential limitations of ChatGPT in fostering critical skills like problem-solving and group work among engineering students.	Survey of 110 aerospace engineering students using blended learning methods, including flipped teaching and gamification.	Positive student adoption of ChatGPT but concerns about the impact on developing essential competencies.	Adapt teaching strategies to better integrate AI tools while promoting critical skills development.
10	(Shekh-Abe and Barakat 2022).	To explore challenges to engineering education caused by the COVID-19 pandemic and propose themes for a sustainable system.	Engineering education faced challenges related to access, compatibility, and adapting to rapid changes due to the pandemic.	Questionnaire analysis using quantitative and qualitative methods with 124 engineering students.	Challenges categorized into performance, adaptation, and access, with socio-economic status affecting adaptation.	Develop infrastructure and training for advanced technology, with a focus on equity of access.
11	(Fernandes and Werner 2022).	To characterize the use of virtual worlds in Software Engineering Education (SEE) and explore the potential of the Metaverse.	Limited coverage of software engineering topics in virtual worlds and lack of interoperability between these environments.	Systematic literature review of 17 primary studies in virtual worlds for SEE.	Identified limitations in current virtual worlds for SEE, such as lack of interaction and biometric data integration.	Develop a framework for Metaverse-based SEE that integrates immersive learning experiences and interactivity.
12	(Dieck-Assad, Ávila-Ortega, and Peña 2021).	To evaluate the impact of industry collaboration in enhancing students' technological	Traditional teaching methods limit students' engagement and skill	Challenge-based learning with industry collaboration in automotive electronics.	Students with industry involvement showed higher engagement and	Explore broader applications of challenge-based learning in various

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		solution competencies.	acquisition in creating technological solutions.		improved competency outcomes compared to those in traditional courses.	engineering fields.
13	(McQuade et al. 2020)	To analyze how students self-manage team efforts in tutorless PBL groups.	Lack of tutors may lead to poor teamwork and inefficient learning in PBL environments.	Conversation analysis of video-recorded PBL sessions.	Students maintained cohesion by using informal communication and humor to foster teamwork in a tutorless setting.	Investigate the impact of tutorless PBL on long-term student outcomes.
14	(Z. H. Khan and Abid 2021).	To analyze the shift to remote learning during COVID-19 and its impact on engineering education.	COVID-19 forced a rapid transition to online learning, highlighting gaps in internet access and educational resources.	Review of web technologies and online learning tools used during the pandemic.	Remote learning presented significant challenges in developing economies due to limited access to resources, but also provided opportunities for policy improvements.	Develop policies to enhance online learning infrastructure and inclusivity.
15	(Andersen and Rösiö 2023).	To explore the impact of university-industry collaborations in CEE using PBL for reconfigurable manufacturing.	Traditional CEE models fail to address the fast-evolving knowledge fields in manufacturing industries.	PBL-based CEE course over four years involving university-industry cooperation.	PBL proved effective in developing knowledge transfer and adaptability, with enhanced collaboration between university and industry.	Extend PBL-based CEE models to other rapidly evolving sectors beyond manufacturing.

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16	(An et al. 2020).	To investigate the role of makerspaces in fostering hands-on and interdisciplinary learning in engineering education.	Despite their potential, makerspaces are underutilized in engineering curricula.	Student surveys on the learning benefits of makerspaces.	Makerspaces promote creativity and practical skills development, but face challenges in being integrated into standard curricula.	Further study on how to effectively integrate makerspaces into engineering programs.
17	(Moye et al. 2020)	To identify current and future trends and issues facing technology and engineering education in the U.S.	Technology and engineering education faces significant challenges, such as teacher shortages and curriculum development.	Delphi method to gather insights from engineering education stakeholders.	Key trends include teacher shortages, funding challenges, and the need for collaboration and curriculum improvements.	Focus on addressing teacher shortages and improving teacher development programs.
18	(Martin and Wendell 2021).	To explore the role of AI in enhancing engineering education and university operations.	Engineering education lacks sufficient AI integration to address complex real-world problems.	Analysis of AI's impact on the teaching-learning process in engineering education.	AI can improve the teaching-learning process and operational efficiency of universities, making engineering education more responsive to real-world challenges.	Research on the long-term effects of AI integration in engineering education and its scalability.
19	(Hidayat et al. 2021).	To examine the relationship between industrial work motivation and students' GPA in electronic engineering.	Industrial work readiness is crucial for improving academic performance in electronic engineering.	Survey of 75 electronic engineering students using SPSS for data analysis.	Industrial work motivation and readiness significantly impact students' GPA.	Further research on the impact of industrial revolution advancements on different engineering disciplines.

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20	(Alemdar, Moore, and Ehsan 2022).	To document how COVID-19 adaptations impacted pre-college engineering education.	The pandemic led to rapid adaptations in engineering education, but the long-term effects on learning are unclear.	Analysis of adaptations in formal and informal pre-college engineering education during COVID-19.	Despite challenges, valuable engineering learning experiences were achieved during the pandemic.	Investigate the long-term impacts of these adaptations on pre-college engineering education.
21	(Chen, Kolmos, and Du 2021)	To review challenges in implementing PBL at different levels of engineering education.	PBL faces implementation challenges at institutional and cultural levels, particularly in engineering education.	Review of 108 research articles on PBL practices across various levels (course, curriculum, project).	Challenges in PBL implementation are consistent across individual, institutional, and cultural levels, but effective strategies can optimize outcomes.	Propose strategies to overcome institutional and cultural barriers to PBL implementation in engineering.

Digital technology used in teaching and learning methods: **Figure 1** illustrates the utilization of digital technology with regard to teaching and learning methods. In engineering education, digital learning tools, like online simulations, virtual labs, and interactive tutorials, significantly enhance the learning experience of the students. Active Learning Platforms help to facilitate active learning and include features such as PBL, peer collaboration, and real-time feedback loops. How digital platforms are critical in terms of offering remote access to resources and supporting flexibility in learning during global challenges such as the COVID-19 pandemic. Online Collaborative Projects: These are projects on digital platforms where students can collaborate on a project together regardless of the distance between the two parties. Integration in the Simulations and Industry Integration may shed light on a digital simulation-integrated and industry-centric project’s teaching methodology to connect academia with industry, in-time skill set of students with current era requirements. Digital technology utilizes new trends and innovations with digital technology as it pertains to teaching engineering in the digital age, including AI, gamification, adaptive learning systems, etc.

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Figure 1: The Employment Of Digital Technology In The Teaching And Learning Methods

Confronting Workforce Requirements and Industry Demands.

Table 2 are lists the main elements of every study, so offering understanding of present issues and suggestions for development of engineering education and industry cooperation.

Table 2: Summary Of The Literature Review Of Confronting Workforce Requirements And Industry Demands.

No.	Author	Objectives	Problem Statements	Methodologies	Findings	Future Research
1	(Ogunseiju et al., 2023).	Investigate the skills required for sensing technologies deployment in construction.	Lack of workforce with sufficient knowledge and skills for sensing technologies in construction industry.	Mixed-method: surveys, case studies, and focus groups with industry practitioners.	High adoption of sensing technologies ; skill gaps exist in workforce readiness.	Expand construction education curriculum to better prepare students with sensing technology competencies for the future workforce.
2	(Zhuang & Zhou, 2023).	Examine China's policies promoting university–industry collaborative	Academia-industry disconnection hampers the effectiveness of engineering education.	Document analysis and interviews with stakeholders.	Enhanced enterprise engagement with engineering education; challenges in course	Explore stronger governance frameworks and assessment systems for sustained academia-

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		education in engineering.			updates and technological alignment.	industry collaboration.
3	(Garcés & Peña, 2022).	Propose how engineering education should adapt to Industry 4.0 and BIM through experiential learning.	Engineering curricula are not fully adapted to meet Industry 4.0 and BIM requirements.	Review of experiential learning methodologies (Kolb) and CDIO (Conceive-Design-Implement-Operate) frameworks.	Engineering education can improve competency development by integrating BIM and Industry 4.0 technologies into learning processes.	Expand research on experiential learning frameworks to include more hands-on industry applications.
4	(Kulkarni et al., 2020).	Understand the impact of personality traits on academic success in Industry 4.0 courses.	Personality traits may influence engineering students' success in Industry 4.0-related courses.	Questionnaire administered to students taking Industry 4.0 courses in an autonomous engineering college.	Personality traits significantly influence student success in Industry 4.0 courses.	Investigate how personality traits can inform career guidance and course delivery strategies in Industry 4.0 disciplines.
5	(Chikasha et al., 2020).	Propose a flexible yet rigid curriculum approach for industrial engineering education to meet industry demands.	Engineering curricula are often rigid, making it difficult to adapt to industry changes.	Proposal of a "rigid-skeleton flexible-body" approach for curriculum adaptation.	Flexibility in curriculum components can enhance the adaptability of industrial engineers to dynamic industry changes.	Develop mechanisms for continuous adaptation of micro-curriculum components to reflect real-time industry needs.
6	(Joshi et al., 2022).	Explore strategies for enhancing industry-institute interactions to improve employability of engineering students.	Lack of sufficient exposure to recent technologies among engineering students affects employability.	Case study on industry-institute alliances and collaborative training initiatives.	Industry collaboration improves employability and technological competencies among engineering students.	Strengthen collaborative training programs and partnerships between engineering institutions and industry for practical learning.

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7	(Cico et al., 2021).	Investigate the gaps between software engineering education and industry trends.	Software engineering education does not fully reflect industry trends such as Agile, usability, and global software development.	Systematic mapping study of 126 papers on software engineering trends in academia and industry.	Agile software development is the major trend addressed; gaps remain in incorporating global software engineering and startup models.	Expand academic focus on emerging trends like global software engineering and lean startup methodologies to align with industry demands.
8	(Garcés & Peña, 2022).	Assess skills gaps in low-carbon energy engineering and propose masters-level training frameworks.	Skills shortage in low-carbon energy engineering due to lack of industry-focused master's programs.	Gap analysis of existing master's programs and iterative engagement with the UK energy sector.	Flexibility in curriculum and rapid course development are needed to meet industry demands for low-carbon energy skills.	Explore flexible and modular master’s programs that can rapidly respond to emerging engineering specializations.
9	(Singh & Rawani, 2022)	Propose a method to improve engineering education quality based on industrial needs and feedback.	There is a mismatch between industrial needs and the quality of engineering education.	QFD-TOPSIS approach applied in a case study with Indian engineering education and interviews with HR managers.	Correlation between industrial needs and quality parameters highlights areas for improvement in engineering curricula.	Strengthen quality improvement processes in engineering education through continuous industry feedback.
10	(Rivera et al., 2021).	Identify innovation skills needed by future engineers to meet Industry 4.0 and SDG challenges.	Engineering students lack exposure to innovation skills needed for Industry 4.0 and sustainable development.	Literature review and development of a model integrating Industry 4.0 concepts and sustainable development goals (SDGs).	Innovation skills are critical for addressing Industry 4.0 and sustainable development challenges in engineering education.	Develop targeted programs focused on innovation and sustainability within the framework of Industry 4.0.

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11	(Razbani et al., 2023).	To evaluate the effectiveness and industry relevance of a collaborative systems engineering master's program.	The need for engineering education to better align with industry demands and prepare students for real-world challenges.	Statistical data, meeting notes, alumni survey	High success rate (87%) among alumni, who are satisfied with program flexibility and teacher quality but desire more focus on leadership and soft skills.	Focus on integrating leadership and soft skills into the curriculum; address critical industry topics like digitalization and sustainability.
	(Ghani, 2022).	To emphasize the necessity for skill-oriented, project-based learning in engineering education in response to technological advancements under Industry 5.0.	Traditional engineering education is overly focused on theoretical concepts, which may not adequately prepare students for evolving workforce demands driven by digital technologies.	Literature review and analysis	Advocates for project-based learning to better equip students for real-world engineering challenges, highlighting the need for a shift from classical education methods.	Future studies should focus on aligning educational methods with Industry 5.0 requirements and exploring innovative teaching approaches.
	(Shah & Gillen, 2023).	To systematically review university-industry partnerships in engineering education and identify best practices and areas for future exploration.	There is a lack of alignment between current engineering education practices and industry needs, particularly in the early years of undergraduate programs.	Systematic literature review	Identified various successful practices in university-industry collaborations but emphasized the need for better alignment with theoretical frameworks and robust methods.	Encourage early-stage partnerships in undergraduate programs to create curricula that better meet future workforce demands and explore innovative collaborative practices.

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(Motyl & Filippi, 2021).	To investigate the state of education related to additive manufacturing and its implications for preparing a specialized workforce under Industry 4.0.	There are significant gaps in educational practices surrounding additive manufacturing, impacting the readiness of young engineers for modern industrial applications.	Survey based on systematic literature review	Additive manufacturing education is crucial for developing relevant skills in young engineers; however, challenges persist related to equipment and trained staff availability.	Develop better training programs for educators and enhance equipment availability to support effective additive manufacturing education.
(Afkar et al., 2023)	To assess the effectiveness of using video-on-demand in enhancing student engagement and understanding of engineering concepts.	Traditional teaching methods may not sufficiently engage students or facilitate the retention of complex engineering concepts.	Case study, surveys, evaluations	Improved student engagement and retention of scientific knowledge; effective in enhancing skills such as accuracy and engineering reasoning through video-assisted learning.	Investigate further applications of video-assisted teaching across various engineering disciplines to enhance learning outcomes and engagement.
(Dieck-Assad et al., 2021).	To evaluate the competencies in creating technological solutions for electronic devices when faculty-industry collaboration is present.	The need to enhance design competencies in students through practical experiences in collaboration with industry partners in electronics.	Competency performance analysis	Students partnered with industry showed higher engagement and competency levels (55 students with industrial partners scored higher than 61 in traditional courses).	Further research should explore long-term impacts of challenge-based learning on student competencies and identify additional areas for collaboration with industries.

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	(Sitompul & Matondang, 2023).	To assess the quality of internship implementations at Medan State University's Department of Building Engineering Education.	Existing internships may not adequately prepare students for the workforce and may have quality issues in their implementation.	Questionnaires, descriptive analysis	Implementing quality internships improved students' competencies and attitudes, but specific areas need enhancement, such as internship timing and assessment processes.	Future studies should focus on improving internship frameworks, assessment criteria, and expanding the internship offerings to better prepare graduates.
	(Valentine et al., 2022)	To investigate how stakeholders initiate industry engagement in engineering education and identify barriers from stakeholders' perspectives.	Significant obstacles exist in establishing effective industry engagement in engineering education, often relying on individual relationships.	Semi-structured interviews	Industry engagement was initiated by various stakeholders, but key barriers included a lack of invitations from universities and unclear benefits for industry participants.	Future research should explore frameworks for sustaining long-term industry engagement and enhancing communication between universities and industry stakeholders.
	(Gillen et al., 2021).	To analyze how organizations build relationships in public-private partnerships aimed at integrating engineering into middle school science curricula.	Current partnerships lack strong theoretical connections to interorganizational collaboration, limiting effective stakeholder relationships and outcomes.	Qualitative, embedded multiple case study	Insights into collaborative processes revealed dimensions such as emergent collaboration, organizational tensions, and shared goals, impacting school-university-industry partnerships in engineering.	Future research should apply collaboration frameworks systematically in educational partnerships and develop strategies for intentional stakeholder engagement.

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(Elkosantini et al., 2023).	To assess the gap between industrial needs and academic offerings regarding Industry 4.0 skills in Tunisia and Morocco.	Difficulty for industries to find qualified graduates with the necessary Industry 4.0 skills and competencies.	Survey analysis	Identified gaps between existing engineering curricula and industry requirements, specifically in maintenance, production, and quality processes related to Industry 4.0.	Further research should aim to align curricula more closely with industry needs and explore strategies for integrating Industry 4.0 competencies into engineering education.
(Gürdür Broo et al., 2022).	To discuss the future of engineering education in light of digital transformation and the fifth industrial revolution, emphasizing skills over degrees.	The need for engineering education to adapt to the changes brought by Industry 4.0 and Industry 5.0, focusing on skills that address modern challenges.	Literature review, strategic framework	Four strategies for future engineering education were proposed: lifelong learning, sustainability, data fluency, and human-agent interaction experiences.	Further exploration of effective implementation strategies for the proposed competencies in engineering curricula is suggested, along with longitudinal studies to measure impact.
(Chen et al., 2023).	To evaluate US metal mining engineering education in light of industry needs and identify areas for improvement.	Insufficient preparation of graduates from the US metal mining engineering education system to meet the demands of the evolving mining industry, especially concerning critical minerals.	Online survey	Findings revealed a shortage of qualified graduates and highlighted necessary qualifications, including practical experience and theoretical knowledge in mining operations.	Future research should focus on enhancing collaborations between industry and academia, developing innovative curricula, and integrating new technologies in mining education.

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(Pacher et al., 2023).	To develop a competence profile for industrial logistics engineering education aligned with Industry 5.0 needs.	The existing gap in systematic competence development methodologies for engineering education in the context of Industry 5.0.	Competence profile development	The article identified essential competencies needed for industrial logistics education and investigated their impact on job performance and satisfaction among graduates.	Future studies should investigate causal relationships between competence orientation and job performance in various engineering fields, enhancing pedagogical frameworks.
(Gupta & Gupta, 2024).	To explore the relationship between design-based learning (DBL), plan-do-check-act (PDCA) methodology, and market-ready skills in software engineering education.	The persistent expectation gap between academia and industry regarding the preparedness of engineering graduates for the software industry.	Experimental research	Positive and significant impacts of C4 skills (creativity, critical thinking, collaborative decision making, and communication) on market readiness were found through statistical analyses.	Future research could investigate further correlations between DBL methodologies and specific industry requirements to enhance graduate employability in software engineering.
(Roy & Roy, 2021).	To analyze the influence of interdisciplinary approaches on management practices within engineering fields amidst the fourth industrial revolution.	The evolution of specialization in engineering has created silos, limiting interdisciplinary collaboration that could enhance innovation and management practices.	Historical analysis, pedagogical exploration	Identified two types of interdisciplinary approaches: hybrid fields and infusion of technological knowledge, emphasizing the importance of including emerging technologies in	Further studies should examine successful case studies of interdisciplinary programs in engineering and their impacts on management and innovation in various sectors.

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				engineering education.	
(Calica et al., 2023)	To assess the preparedness of chemical engineering graduates in the Philippines and identify gaps between academic training and industry expectations.	Discrepancies between the skills and competencies of chemical engineering graduates and the expectations of industry practitioners regarding ethical and professional responsibilities.	Exploratory research, surveys	Both graduates and practitioners acknowledged the attainment of desired skills, but significant gaps were noted in ethical responsibility and the application of subject matter knowledge.	Future research should focus on curricular improvements that enhance ethical education and application of contemporary issues in chemical engineering training programs.

Figure 2 illustrates the employer requirements and industry challenges. Importance of industry needs: It is significant that engineering education programs are able to provide a curriculum that appeals to the industry’s needs and demands to produce knowledgeable and appropriate skillful graduates. Further, there is a need for an interdisciplinary engineering education to solve some of the more complex industry challenges that usually involve more than one subject matter domain. Adaptive curriculum development processes in engineering education programs to be able to quickly respond to changes in industry trends, technologies, and job requirements. Edkent Media highlights the importance of soft skills, transferable skills related to teamwork, communication, and leadership. Therefore, we should stress the importance of integrating such competencies into the curriculum to produce well-rounded engineering professionals. Consequently, it is finished by reiterating the importance of continuous assessment and evaluation of engineering education programs to evaluate their performance against workforce and industry needs and enable continuous improvement.

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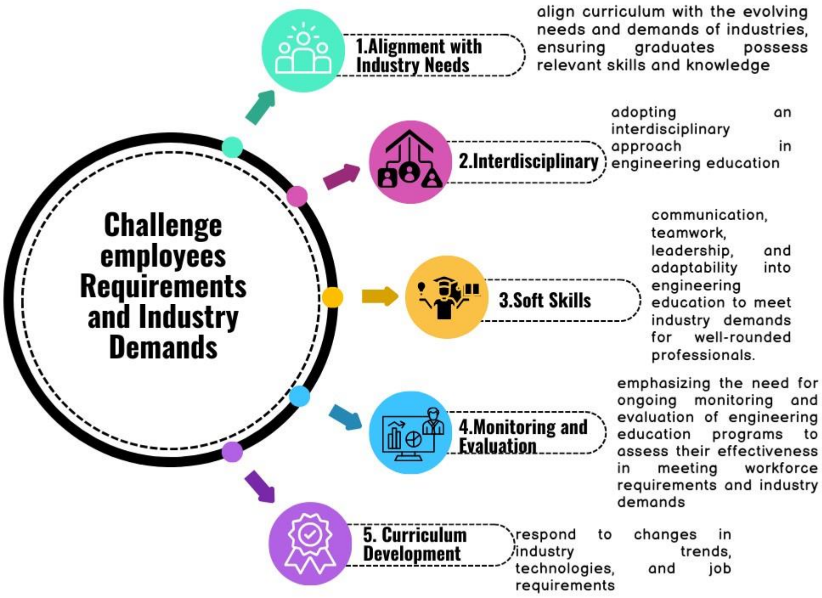

Figure 2: The Challenges Of Employees Requiring And Industry Demands.

Equity And Inclusiveness In Engineering Education

Table 3 show Key components of every study on equity and inclusiveness in engineering education—including goals, problem statements, approaches, results, and future directions of research—are compiled in this table.

Table 2: Summary Of The Literature Review Equity And Inclusiveness In Engineering Education.

No	Author	**Objectives**	**Problem Statement**	**Methodologies**	**Findings**	**Future Research**
1	(Holly and Quigley 2022).	To discuss harms in engineering education research and explore reparatory justice as a framework for better practices.	Anti-Blackness hinders Black engineers' access and experiences in engineering education and practice.	Position paper; conceptual framework analysis	Calls for reimagining research about Black people in engineering by addressing anti-Black practices and focusing on heritage knowledge to rectify research practices.	Future research should focus on practical applications of reparatory justice in engineering education.

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2	(Alarcón et al. 2021).	To examine how making spaces in engineering education enact equitable access for users.	Equity of access in makerspaces is situational and context-dependent, lacking a comprehensive definition.	Qualitative analysis; interviews and research memos	Identified four considerations for equitable access in making spaces: (a) multiple entry points for students, (b) facilitating effective making processes, (c) addressing threats to access, and (d) fostering a culture of belonging.	Future studies could assess long-term impacts of equitable access initiatives in engineering education.
3	(Wilson-Lopez and Acosta-Feliz 2021).	To identify engineering-related skills and knowledge developed by Latinx youth in workplaces.	Economic inequality forces Latinx youth into jobs that hinder their educational aspirations while developing engineering skills.	Qualitative study; multiple case studies	Youth developed engineering-related knowledge in various workplaces, mobilizing this knowledge toward humane working conditions and community well-being. Highlights the importance of recognizing youths' workplace experiences as valuable educational resources.	Future research should explore ways to integrate workplace-derived knowledge into formal education.

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4	(Gaikwad and Pandey 2022).	To identify barriers faced by women in engineering education and suggest strategies for improvement.	Women face various challenges in engineering education, including retention, discrimination, and career advancement issues.	Survey research; data collection from students	Identified barriers to women's success in engineering programs and suggested strategies to create awareness and support for gender equity in engineering. Emphasizes the need for inclusive environments that facilitate women's progression in the field.	Future studies could evaluate the effectiveness of proposed strategies for promoting gender equity.
5	(Eastman, Miles, and Yerrick 2019).	To explore equity and privilege conceptions within the culture of engineering education, particularly among White males.	Engineering education favors White men, resulting in a lack of acknowledgment of privilege and inequity among faculty.	Longitudinal qualitative study; interviews and focus groups	Through reflective practices and challenges to beliefs about privilege, the participant shifted from opposition to recognizing inequities based on class and race, highlighting the potential for change among educators.	Further research could investigate strategies to foster ongoing awareness of privilege among engineering faculty.

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6	(Martin and Wendell 2021).	To advocate for asset-based approaches that focus on youth strengths in engineering education.	Traditional engineering education often overlooks the importance of student assets, relationships, and community.	Literature review; theoretical and empirical analysis	Highlighted the significance of community and relationships in leveraging youth assets for learning, advocating for a paradigm shift in engineering education toward more humane and inclusive practices.	Future research should examine the implementation of asset-based approaches in diverse educational contexts.
7	(Pawley 2019).	To explore the connection between engineering education's lack of diversity and its response to the climate crisis.	Engineering education's demographic homogeneity parallels its inadequate response to the global climate crisis.	Conceptual analysis; interdisciplinary approach	Calls for developing a moral infrastructure to address both the demographic issues in engineering education and the global responsibility to combat climate change, emphasizing ethical considerations in engineering practices.	Future research should focus on integrating moral and ethical frameworks in engineering education curricula.

Figure 3 illustrates the equity and inclusiveness in engineering education inclusion. Women, racial and ethnic minorities, and people from economically disadvantaged backgrounds have not historically been included in STEM education. Why are support systems such as

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mentorship programs, counseling services, and academic support centers critical to engineering education and necessary to facilitate the progress of underrepresented groups? All students have good labs, technology, and extracurricular opportunities by improving outreach and recruiting efforts to facilitate access to engineering programs for historically underrepresented groups. Note that engineers educated in diversity and inclusiveness are better equipped to work in diverse teams and solve global problems.

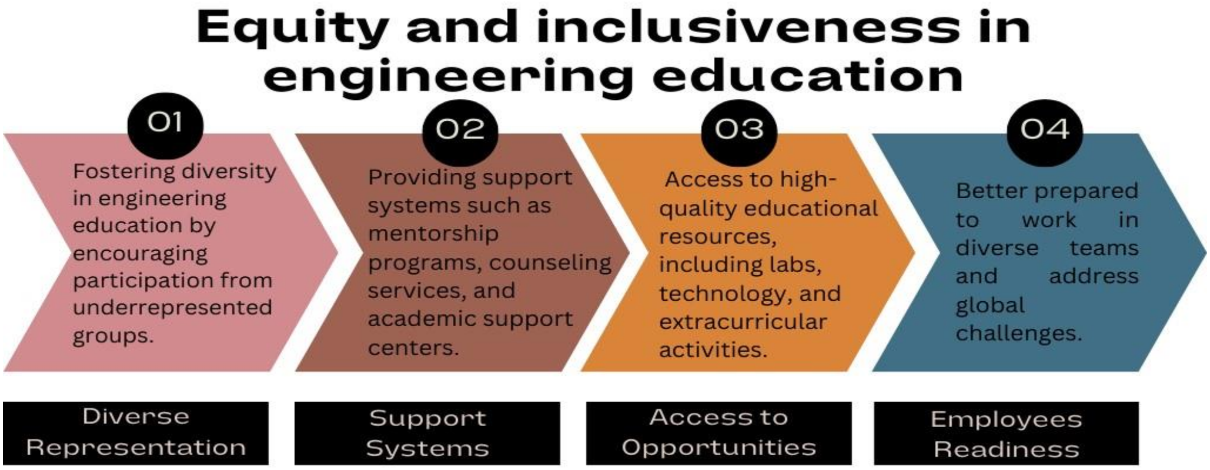

Figure 3: Equity And Inclusiveness In Engineering Education.

Methodology

This review was conducted based on scoping review method. Figure 4 show the flow of scoping review method that had been use in this review article.

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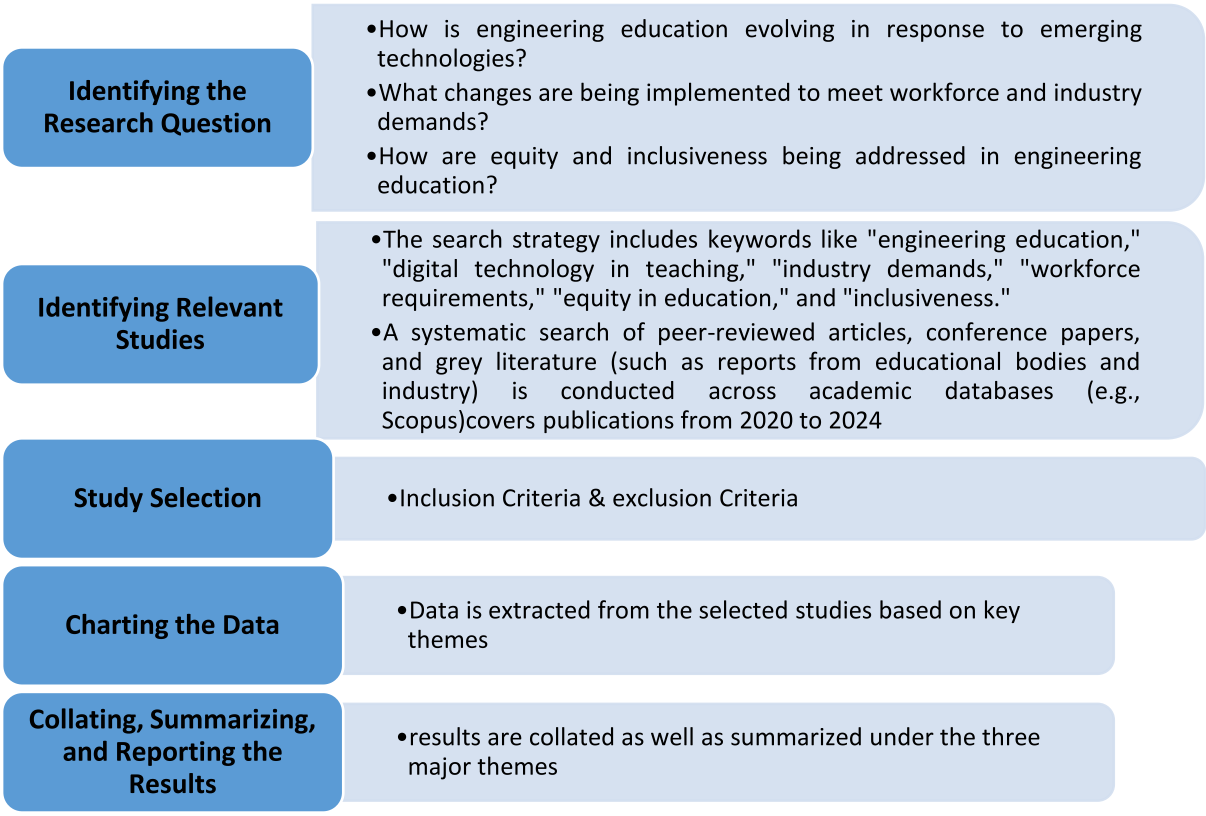

Figure 4: The Flow Of Scoping Review Method.

Discussion And Conclusion

Digital technology in engineering education has changed how teaching and learning modules are designed, bringing the need to learn in changing educational environments into the limelight. The pandemic added more pressure and made us shift to online education, forcing educators to innovate and use digital tools to enhance the learning experience from different levels, like PBL through AI. As we move forward, adopting digital technologies, like those offered in maker spaces, virtual labs, and collaborative partnerships with the industry, will be imperative to the evolution of engineering education and the delivery of skills as well as knowledge relevant to competing in a digital world. By preparing students with the capability to solve problems, optimize digital strategies, and create an adaptable, tech-integrated learning environment, engineering education can make students well-suited to face the dynamic demands with regard to the modern industry and the ever-evolving advancement of technology.

Opinions and research synthesis regarding a compliant engineering education with industry requirements and workforce needs indicate a great necessity to reshape educational programs in line with modern technology changes left by the Industrial Revolutions (IR 4.0 to IR 5.0). The stewardship of sensing technologies, a focus on industry partnerships, and novel pedagogy underpin the critical importance of producing a graduate with the blend of skills needed to succeed in a digital society. The emphasis on practical skills, flexibility, and ongoing skill development prepares engineers for the demands with regard to IR 5.0, transdisciplinary education, as well as industry-academia initiatives. Engineering education can effectively respond to the rapidly changing industrial landscape by bridging skill gaps, promoting the development of industry-relevant competencies, and engaging with emerging technologies to

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ensure that graduates are prepared to meet the demands of work today and contribute to sustainable development goals and industrial needs.

Diversifying and flooding the market with innovation while creating better opportunities for the more traditionally marginalized students in engineering education is essential. To address the widespread anti-blackness permeating engineering education and practice, particularly about the exclusionary effects of blackness on individuals' experiences and access, reimagining our approach to our teaching and scholarly endeavors is also necessary in the spirit of reparatory justice - knowledge reparation that draws upon the African epistemologies and the cultural memories that reside within us. To promote diversity, equity, and inclusion in engineering, it is vital to establish inclusive spaces and a culture of belonging in which all students, especially those from marginalized groups, have the opportunity to participate and succeed in engineering education. Hence, one of the milestones in promoting gender equity is recognizing and removing obstacles while supporting minority groups to enable all to be in a welcoming environment and enhance individuals from different backgrounds. If engineering education challenges systemic bias, promotes interdisciplinary collaboration, and reassesses educational paradigms, it might do a lot to promote broader, more responsive, and inclusive engagement for all students as well as professionals in the field.

Engineering education is undergoing a large-scale transformation because of the rapid digital technologies' evolution, the job market's needs evolution, and the necessity of a fair and inclusive approach. Our review shows that digital transformation is the most critical change factor: it allows teaching and learning to change totally. It makes it more interactive and attractive while in alignment with current technological development. However, it also needs to cover the high demands of the modern industry, align the curriculum with actual practice, and ensure that graduates have all the appropriate skills to succeed in the competitive and dynamic job market.

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