Paradigm Academic Press
Research and Advances in Education
ISSN 2788-7057
NOV. 2025 VOL.4, NO.9

Industrial Design Education: A Literature Review

Chunfa Sha[1]

[1] Department of Industrial Design, Jiangsu University, China

Correspondence: Chunfa Sha, Department of Industrial Design, Jiangsu University, China.

doi:10.63593/RAE.2788-7057.2025.11.004

Abstract

This review synthesizes research on industrial design education, highlighting technology integration and sustainability as key drivers. Studies explore the adoption of digital tools like VR and 3D modeling, balancing their potential for enhancing creativity with concerns over preserving traditional skills. Sustainability education research emphasizes practical, project-based learning to embed environmental principles, though implementation faces contextual challenges. Investigations into teaching methods reveal insights into student cognitive processes and the effectiveness of technological interventions. Furthermore, the field examines how policy and cultural factors shape curricula, alongside evolving career trends toward UX roles and interdisciplinary competencies. Methodologically diverse, the literature provides practical frameworks for educators. However, it remains fragmented, relying heavily on context-specific, small-scale studies, which limits generalization. Critical gaps include a lack of longitudinal data on skill retention, insufficient integration of emerging technologies like AI, and limited cross-cultural comparisons. Future research should prioritize longitudinal and comparative studies, deeper exploration of advanced technologies aligned with sustainability goals, and stronger industry collaboration to ensure curricula meet evolving professional demands.

Keywords: industrial design, education, review

1. Introduction

Industrial design education plays a pivotal role in shaping future innovators' ability of addressing complex global challenges, as it bridges technological advancement, sustainability goals, and human-centered design. The theoretical significance lies in integrating diverse disciplinary insights to redefine educational paradigms, while practical value stems from guiding curriculum development and pedagogical innovation to meet evolving industry demands. In recent decades, the field has witnessed rapid expansion, with growing attention to technological integration, sustainability imperatives, and interdisciplinary collaboration, yet existing research remains fragmented across specialized sub domains. This review first explores the impact of technology and digitization on industrial design curricula, examining how emerging tools reshape pedagogical approaches; it then delves into sustainability and eco-design education, analyzing how environment principles are integrated into learning frameworks. Next, the focus shifts to teaching methodologies and student learning processes, investigating effective strategies to enhance creative and technical competencies. The review further examines how education systems, policy and culture contexts influence program structures and institutional priorities, before exploring the evolving career landscape and skill requirements for modern industrial designers. Finally, it addresses interdisciplinary and non-design major design education, highlighting the role of inclusive design literacy in fostering cross-sector innovation. By synthesizing these interconnected areas, this review aims to construct a comprehensive analytical framework, map the evolution of industrial design education research, identify critical knowledge gaps, and provide a foundational reference for educators, policymakers, and researchers seeking to advance the field.

2. Technology and Digitization in Industrial Design Education

Technology and digitization have emerged as reformative forces in industrial design education, driving shifts in pedagogical approaches, tool integration, and interdisciplinary collaboration. This evolution reflects the need to align educational practices with industry demands for technology-driven innovation, while addressing tensions between digital tools and traditional design skills. Recent research has focused on understanding how digital technologies — including virtual reality (VR), 3D modeling software, and digital prototyping — can enhance learning outcomes, and how educators can effectively integrate these tools into curricula.

The adoption of digital tools in industrial design education has been shaped by both opportunities and challenges, particularly regarding tool functionality, user needs, and skill development. Lianget et al. (2016) identified critical functional requirements for VR systems in design education using a ZMET-QFD model, with students prioritizing real-world parameters, physical databases, and multiple viewpoints to support intuitive design exploration. Jimeno et al. (2016) further proposed a VR-based methodological framework to enhance creativity by overcoming visualization limitations of traditional prototypes, though their study noted the need for empirical assessment of creativity gains. Conversely, Hamurcu et al. (2023) highlighted barriers to VR adoption, with students and instructors expressing concerns about potential erosion of manual dexterity and material knowledge, underscoring the need to balance digital tools with hands-on skills. For 3D modeling software, Yilmaz and Gelmez (2025) found that students prioritize affordability, ease of use, and compatibility, with peer learning driving 60% of software adoption; they developed an 11-dimensional evaluation framework to align tools with design-specific creative workflows. Aldoy and Evans (2021) similarly noted resistance to fully digital processes, as stakeholders questioned the replacement of paper-based sketching and physical model making, citing tactile experiences as irreplaceable for design development.

Pedagogical innovations have centered on structuring technology-driven design processes and fostering interdisciplinary collaboration. Ahmet and Curaoğlu (2017) emphasized design labs as interdisciplinary hubs, enabling interactions between design and technology disciplines to enhance the usability of emerging technologies in products and services. Kim et al. (2022) addressed gaps in teaching technology-driven new product development (NPD) by developing a grounded theory model, derived from interviews and syllabus analysis, to guide mentoring in technical design contexts. Kucuksayrac (2023) complemented this with two frameworks for digital prototyping education: one linking product completeness to user intervention types, and another connecting user engagement scenarios to environmental and economic sustainability, highlighting the need to embed sustainability in digital design practices.

These studies collectively advance understanding of digitization in industrial design education by providing tool evaluation frameworks, VR implementation guidelines, and pedagogical models. Methodologically, they employ diverse approaches — including case studies (Kucuksayrac, 2023), surveys (Yilmaz and Gelmez, 2025), grounded theory (Kim et al., 2022), and qualitative analysis (Hamurcu et al., 2023) — strengthening the validity of findings. However, limitations include a focus on short-term tool adoption over long-term skill retention, limited exploration of institutional or cultural variations in technology integration, and under representation of emerging tools like AI-driven design assistants. Future research should address these gaps by investigating longitudinal skill development, cross-institutional comparisons, and the integration of advanced technologies with sustainability and ethical considerations in curricula.

3. Sustainability and Eco-Design Education Research

Sustainability and eco-design education research occupies a critical position in advancing industrial design practices that align with environmental goals and circular economy principles. As highlighted by Van et al. (20 20), design education for the circular economy is one of four key thematic areas through which industrial design can contribute to systems-level sustainability transitions, emphasizing the need to cultivate designers' capacity to integrate environmental considerations into product development processes. This sub field addresses not only the technical and methodological aspects of teaching eco-design but also the sociocultural and contextual factors that shape student learning and design outcomes, making it essential for bridging academic knowledge and practical application in sustainable product development.

Empirical studies across different educational contexts have explored the implementation and impacts of eco-design education, revealing both common trends and region-specific challenges. In Japan, Ueda (2018) conducted an experimental learning project with undergraduate industrial design students, finding that participants exhibited a strong inclination toward sociocultural approaches to sustainable consumption rather than technological eco-design solutions. Their study identified barriers such as complex support tools incompatible with students' academic backgrounds, alongside systemic issues like limited eco-design expertise among educators and poor integration of eco-design modules into curricula. Similarly, in Spain, Perez and Bovea (2016) organized workshops for industrial design engineering students focused on electrical and electronic toys, demonstrating that practical training on product end-of-life and environmental issues increased students' willingness to incorporate environmental requirements into their design processes. Meanwhile, at Middle East

Technical University, Dogan et al. (2016) integrated sustainability considerations — including product evolution, maintenance, and resource efficiency — into undergraduate design projects, developing a generative design research method and idea generation tool to facilitate students' understanding of sustainability in the ideation phase. Collectively, these studies highlight the importance of practical, project-based learning in eco-design education, though they differ in their focus: Ueda (2018) emphasize sociocultural orientations, Perez and Bovea (2016) focus on end-of-life considerations, and Dogan et al. (2016) prioritize tool development for idea generation.

The literature contributes valuable insights into the current state of eco-design education, yet several limitations and gaps persist. Methodologically, most studies rely on small-scale, context-specific case studies — such as Ueda (2018) noting limited participants, resources, and time — which constrain the generalizability of findings. The geographical focus is also narrow, with studies concentrated in Japan, Spain, and Turkey, leaving a lack of comparative research across diverse cultural and educational systems. Additionally, while Van et al. (2016) identify design education for the circular economy as a key thematic area, their review underscores that this body of knowledge remains under-systematized, with insufficient analysis of how educational interventions translate into long-term professional practice. Barriers to effective eco-design education, such as inadequate educator expertise (Ueda, 2018) and tool complexity, also require further investigation into scalable solutions. These gaps point to the need for more robust, longitudinal studies and cross-institutional collaborations to strengthen the evidence base for eco-design education practices.

4. Industrial Design Teaching and Student Learning Research

Industrial Design Teaching and Student Learning Research is a critical domain that bridges pedagogical strategies, student cognitive processes, and the practical application of design knowledge, directly addressing the need to cultivate competent designers capable of meeting evolving industry demands. This area explores how teaching methods, curriculum design, and learning resources influence students' acquisition of technical skills, creative thinking, and professional competencies, while also examining the interplay between student characteristics (e.g., cognitive styles, sustainability awareness) and learning outcomes. Understanding these dynamics is essential for optimizing industrial design education to foster innovation, human-centered design, and adaptability in graduates.

Contemporary research in this field encompasses diverse thematic foci, including curriculum integration of humanistic and artistic elements, student cognitive processes during design activities, the impact of technology-enhanced teaching tools, and the application of experiential knowledge. Kang and Liu (2018) emphasize the growing importance of humanized design in modern industrial design, arguing that academic programs must integrate humanistic artistic elements into teaching to align with consumer demands. They define these elements from a humanization perspective, analyze current educational gaps, and propose strategies to strengthen such integration. Complementing this, Tatlisu and Kaya (2017) explore how industrial design graduates apply experiential knowledge — rooted in engineering, ergonomics, esthetic, and culture — in non-traditional professional contexts, highlighting the compound nature of design knowledge and its transferability beyond orthodox design fields.

Studies on student cognitive processes and learning challenges reveal distinct patterns in design thinking and resource utilization. Chen (2016) identifies concept generation, design presentation, and design research as the most challenging tasks for undergraduate students in studio courses, with learning resources categorized into people, objects, methods, and environments. Further, Chen et al. (2023) distinguish between problem-driven and solution-driven students using the P-S index derived from the Function-Behavior-Structure (FBS) ontology, finding that problem-driven students focus on problem statement, while solution-driven students prioritize solution structure development; notably, these cognitive classifications remain stable across experimental conditions, with constraints disproportionately intensifying solution-driven students' design processes.

Technological advancements have also reshaped teaching and learning dynamics, as evidenced by studies on visual information processing and digital interventions. Mao and Zhang (2024) employed eye-tracking to investigate how industrial design students read technical versus design articles, and discovered that technical articles generate more text attention and top-down reading, while design articles generate more image attention and image-text interaction reading; recall scores for technical articles correlated with text reading time and fixation count, while design article inference scores correlated with image-related metrics, with upper-grade students demonstrating superior image focus and inference performance. Similarly, Mao et al. (2024) explored sustainable design education, finding that students with higher sustainability levels (assessed via the Sustainable Consumption Measurement Scale) exhibited elevated perspective scores in theoretical articles and longer image fixation duration in case articles, with female students and those with design experience performing better in sustainability related tasks. In terms of teaching interventions, Chen et al. (2025) demonstrated that integrating video tutorials into model-making workshops enhanced first-year students' self-regulated learning, cognitive

strategy use, and learning outcomes compared to traditional demonstration-based teaching.

Collectively, these studies contribute valuable insights into optimizing industrial design education by addressing curriculum design, cognitive diversity, technological integration, and domain-specific competencies like sustainability. Methodologically, the research employs diverse approaches, including surveys (Chen, 2016), eye-tracking (Mao & Zhang, 2024; Mao et al., 2024), mixed-methods (Chen et al., 2025), and cognitive process analysis (Chen et al., 2023), enhancing the robustness of findings. However, limitations persist: sample selection often focuses on specific student cohorts (e.g., first-year students in Chen et al., 2025), potentially limiting generalizability; Tatlisu and Kaya's (2017) exploratory study lacks explicit sample size details, reducing repeatability; and Kang and Liu's (2018) focus on humanistic elements predates recent technological disrupt ions in design education (e.g., AI tools). Notable research gaps include cross-cultural comparisons of teaching approaches, long-term longitudinal studies on skill retention, and the integration of emerging technologies (e.g., virtual reality) in design studios.

5. Industrial Design Education System and Policy

The intersection of industrial design education systems with policy and cultural factors is critical for understanding how educational frameworks evolve to meet societal, economic, and technological demands. Policy directives shape educational priorities, resource allocation, and curricular reforms, while cultural contexts influence pedagogical approaches, student expectations, and the perceived value of design education. This interplay is particularly evident in comparative studies across regions, where differing policy landscapes and cultural values yield distinct educational models and outcomes.

Cross-cultural and policy-driven analyzes reveal divergent approaches to industrial design education. Chen (2018) conducted a comparative study of Chinese and Western industrial design education systems, identifying key disparities in curriculum, teaching modes, and evaluation. The Chinese system was found to suffer from homogenized teaching, insufficiently distinctive curricula, and subjective evaluation standards, prompting recommendations to integrate Western educational concepts through featured courses, improved teaching modes, and diversified evaluation. In contrast, Deighton et al. (2024) examined Australian industrial design education across primary, secondary, and tertiary levels, focusing on 21st-century competence development. Their mixed-method study (surveys and stakeholder interviews) highlighted a disconnect between design educators' recognition of design's broad skill value and the wider public's perception of design as "surface decoration", emphasizing the need to align educational outcomes with societal relevance. Policy influence is a central theme in Chinese industrial design education research. Li et al. (2023) employed bibliometric analysis and policy historical analysis to map the evolution of Chinese industrial design education from 1992 to 2021, identifying "government, industry, academia and research" cooperation as a core research theme, alongside "Chinese culture" and "inter disciplinary cooperation". They noted that national policies have driven key research hot spots, including innovation and entrepreneurship education, interdisciplinary integration under "new engineering" and evaluation system reforms for high-quality development. Complementing this, Hu et al. (2021) explored integrated innovation design education in a Chinese university, demonstrating how policy-driven reforms (e.g., aligning teaching objectives, contents, and evaluation with entrepreneurial ability training) enhanced students' innovative and entrepreneurial success rates, offering a practical model for adapting to design industry transformation.

Collectively, these studies contribute valuable insights into the dynamic relationship between policy, culture, and industrial design education. Chen (2018) and Li et al. (2023) illuminate China's policy and culture influenced reform trajectory, while Deighton et al. (2024) provides an Australia perspective on competence alignment and public perception. Methodologically, however, limitations exist: Chen's (2018) comparative analysis lacks longitudinal data on curriculum evolution; Hu et al. (2021) focuses on a single university case, limiting generalizability; Li et al. (2023) relies on CNKI (A literature retrieval database of China like Web of Science) data, potentially excluding international research; Deighton et al. (2024) does not explicitly link competence frameworks to policy drivers. Notable research gaps include cross-national and policy-cultural comparisons (e.g., China vs. Australia), long-term tracking of policy impact on educational outcomes, and deeper analysis of how cultural values (e.g., collectivism vs. individualism) shape teaching and evaluation practices.

6. Career Development and Skill Requirements for Industrial Designers

The career development and skill requirements of industrial designers have evolved significantly in response to global economic shifts, technological advancements, and changing market demands. Understanding these dynamics is critical for aligning design education with industry needs and supporting designers in navigating diverse professional pathways. Recent studies highlight emerging trends in employment patterns, the integration of new skill sets, and the expanding role of industrial designers beyond traditional product development.

Care development trajectories for industrial designers reflect both continuity and transformation in employment

structures. In Turkey, longitudinal analysis spanning 1984–2018 shows that in-house employment remains the dominant form, with a notable rise in user experience (UX)-focused roles as a distinct and growing subcategory (Suner et al, 2019). This shift coincides with industrial design students increasingly considering UX careers, driven by perceptions of expanded professional opportunities and the potential to mitigate challenges in the traditional industrial design job market (Kaygan et al, 2020). Currently, the decline in self-employment has been offset by a surge in freelance work, indicating a move toward more flexible employment models (Suner et al, 2019). In Israel, the integration of entrepreneurship into design practice has emerged as a key trend, with efforts to position industrial designers as "creative leaders" through entrepreneurial thinking and lifelong learning, reflecting a broader global redefinition of the designer's role in business innovation (Schneorson et al, 2019). Additionally, the role of industrial designers in innovation-based companies, as explored in the case of Odtü Teknokent, suggests further diversification of professional functions beyond product design (Turhan, 2023).

Skill requirements for industrial designers are expanding to encompass both technical and transdisciplinary competencies. While traditional design skills remain foundational, the UX field demands additional capabilities that industrial design students perceive as aligned with their educational background, including user-centered design and problem-solving (Kaygan et al, 2020). In Israel, entrepreneurial thinking is increasingly recognized as a critical skill set, yet it is often still viewed as business-related rather than integral to innovative design practice, highlighting a disconnect in higher education curricula (Schneorson et al, 2019). This gap is compounded by structural barriers to top -down changes in design education, underscoring the need for educational interventions that explicitly integrate entrepreneurial principles into design training. The rise of UX-focused roles further emphasizes the importance of adaptive skills, as industrial design graduates must bridge their core training with UX-specific knowledge to transition effectively into these positions (Suner et al, 2019; Kaygan et al, 2020).

Collectively, these studies provide valuable insights into regional variations and emerging trends in industrial design careers, but several limitations and gaps persist. Methodologically, the Turkish employment analysis relies on data from only four institutions, potentially limiting generalizability (Suner et al, 2019), while the focus on student perceptions in UX career pathways (Kaygan et al, 2020) lacks perspectives from practicing designers or employers. The Israeli case study identifies structural barriers in higher education but offers limited empirical data on the effectiveness of proposed interventions like the "creative leaders" prototype (Schneorson et al., 2019). Additionally, the study on innovation-based companies (Turhan, 2023) lacks an available abstract, restricting detailed analysis of the specific roles and skills required in such contexts. Future research should address these gaps by incorporating multi-institutional and cross-regional data, exploring practitioner experiences in emerging fields like UX, and examining the implementation of entrepreneurial and lifelong learning frameworks in design education.

7. Interdisciplinary and Non-Design Major Design Education

Interdisciplinary and non-design major design education has become increasingly significant in equipping students from diverse academic backgrounds with design thinking and problem-solving skills, bridging traditional disciplinary silos to address complex real-world challenges. This area of study explores how design principles can be effectively integrated into non-design curricula, examining both the perception and development of design competencies among non-design students, as well as the structural evolution of design education programs across disciplines.

Wu and Mejía (2025) investigated non-design majors enrolled in a first-year industrial design foundations course, focusing on five core competencies — synthesis, speculation, modeling, facilitation, and implementation. Through qualitative interviews, they found that students recognized design's value in fostering creativity and managing uncertainty, with reflective practice emerging as a key factor in developing a design mindset, though collaborative competencies remained challenging to cultivate in non-traditional settings. Complementing this focus on student experiences, Beecher (2025) explored the historical evolution of interior design education at The Ohio State University, documenting its transition from a component of a multi-faceted industrial design program to a stand-alone accredited discipline, offering insights into how design education structures adapt to interdisciplinary and specialized needs. Meanwhile, De and Floré (2025) address interior design education through the lens of expanding design history via educational narratives, which may intersect with interdisciplinary approaches by contextualizing design within broader historical frameworks, though specific methodologies and findings are not detailed in available abstracts.

The reviewed literature contributes diverse perspectives to interdisciplinary and non-design major design education: Wu and Mejía (2025) provide empirical data on student competency development, Beecher (20 25) offers institutional and historical context for design program evolution, and De and Floré (2025) suggest potential narrative-based strategies for enriching design education. Methodologically, Wu and Mejia's (2025) qualitative approach captures nuanced student perceptions but is limited to a single institution and course, raising

questions about generalizability. Beecher's (2025) reliance on archival materials and interviews provides valuable historical depth but is constrained to a specific institutional case. The lack of abstract for de De and Floré (2025) limits critical assessment of their contribution, highlighting a gap in accessible research details. Key research gaps include longitudinal studies on the long-term impact of design education on non-design students, comparative analyzes across institutions, and empirical validation of narrative-based pedagogies in interdisciplinary contexts.

8. Summary Assessment

Collectively, the reviewed literature advances industrial design education research by addressing critical themes including technological integration, sustainability, pedagogical innovation, policy-cultural dynamics, career development, and interdisciplinary learning. Methodologically diverse approaches — ranging from surveys (Yilmaz & Gelmez, 2025) and grounded theory (Kim et al., 2022) to eye-tracking (Mao & Zhang, 2024; Mao et al., 2024) and bibliometric analysis (Li et al., 2023) — strengthen the empirical foundation, while contributions such as tool evaluation frameworks (Yilmaz & Gelmez, 2025), VR implementation guidelines (Lianget et al., 2016; Jimeno et al, 2016), and policy-driven reform models (Li et al., 2023) offer practical value for educators and policymakers. However, the field exhibits notable fragmentation: studies often focus on isolated subtopics (e.g., VR adoption (Hamurcu et al.,2023) vs. circular economy education (Van, 2020)), with limited cross-thematic integration. Additionally, geographical concentration (e.g., sustainability research in Japan (Ueda, 2018), Spain (Perez & Bovea, 2016), and Turkey (Doganet al., 2016); Chinese policy analysis (Chen, 2018; Li et al., 2023)) and small -scale case studies (Ueda, 20218; Wu & Mejía, 2025) constrain generalizability, while short-term tool adoption and intervention studies predominate over longitudinal investigations of skill retention and professional impact.

8. Research Gaps

Key gaps persist across methodological, theoretical, and empirical dimensions. Methodologically, there is an over reliance on context-specific, small-sample studies (Ueda, 2018; Wu & Mejía, 2025), with insufficient large-scale cross-institutional or cross-cultural comparisons (e.g., China vs. Western educational models (Chen, 2018)). Theoretically, the field lacks integrative frameworks that bridge technological, sustainability, and pedagogical themes, limiting holistic understanding of education -system dynamics. Empirically, critical gaps include: under representation of emerging technologies (e.g., AI-driven design tools) beyond VR and 3D modeling (Yilmaz & Gelmez, 2025); limited employer perspectives on skill requirements (Suneret et al., 2022; Kaygan et al., 2020); inadequate data on long-term professional outcomes of interdisciplinary and sustainability education (Van et al., 2020; Wu & Mejía, 2025); and insufficient analysis of how cultural values (e.g., collect individualism vs. individual ism) shape teaching practices and student learning (Deighton, 2024; Chen, 2018).

9. Future Research Directions

Future research should prioritize three strategic areas: (1) Cross-cultural and longitudinal studies to examine skill retention, curriculum evolution, and professional impact across diverse educational systems, addressing gaps in geographical generalizability. (2) Integration of emerging technologies (e.g., AI design assistants) into curricula, with empirical assessment of their interplay with traditional skills and sustainability goals. (3) Strengthened industry–education collaboration to align skill development with evolving career demands (e.g., UX roles, entrepreneurial competencies), including mixed-method studies incorporating employer and practitioner perspectives. Additionally, research on narrative-based pedagogies and the long-term effects of interdisciplinary education on non-design majors could enrich pedagogical innovation, while systemic analyzes of policy-cultural drivers would enhance understanding of global education reform trajectories.

References

Ahmet, B. F. & Curaoğlu. (2017). Design lab: for future research. *Design Journal, 20*, S4751-S4753.

Aldoy, N. & Evans, M. A. (2021). An investigation into a digital strategy for industrial design education. *International Journal of Art & Design Education, 40*(1), 282-302.

Beecher, M. A. (2025). Products that surround people: Industrial design as context for interior design education at The Ohio State University. *Interiors, 15*(1), 87-109.

Chen, C. H. (2018). Construction of industrial design education system with consideration of Chinese and western cultural integration and counter-measure analysis. *Educational Sciences-Theory & Practice, 18*(5), 1968-1975.

Chen, G., Zhao, Q., Rong, P., Li, Z., & Bei K. (2023). Comparing the design cognitive process between problem-driven and solution-driven industrial design students. *International Journal Technology and Design Education, 33*, 557-584.

Chen, M. M.,Cheng, F., Chen, J., Liang, J. & Chen, L. (2025). Enhancing industrial design students' motivation

and learning in model-making workshops: video tutorials as interventions. *International Journal Technology and Design Education.*

Chen, W. (2016). Exploring the learning problems and resource usage of undergraduate industrial design students in design studio courses. *International Journal of Technology and Design Education, 26*(3), 461-487.

De V. E., & Floré, F. (2025). Educating interior designers: expanding interior design history through educational narratives. *Interiors, 15*(1), 1-18.

Deighton, K., Kuys, B. & Tyagi, S. (2024). Industrial design education in Australia: a competence analysis across primary, secondary and tertiary education levels. *International Journal Technology and Design Education, 34*, 427-460.

Dogan, C., Turhan, S. & Bakirlioglu, Y. (2016). Evolving paths: undergraduate design education through graduate and generative research with a particular focus on sustainability. *Design Journal, 19*(4), 585-604.

Hamurcu, A.,Timur, S. & Rizvanoglu, K. (2023). A study on the adoption of virtual reality in industrial design education. *IEEE Transactions on Learning Technologies, 16*(6), 900-913.

Hu, W., Hu, Y., Lyu, Y. & Chen, Y. (2021). Research on integrated innovation design education for cultivating the innovative and entrepreneurial ability of industrial design professionals. *Frontiers in Psychology, 12*, 1-12.

Jimeno, M. A., Luis S. R. J., Mora, H. & Coll, M. R. (2016). Using virtual reality for industrial design learning: a methodological proposal. *Behaviour & Information Technology, 35*(11), 897-906.

Kang, Y. & Liu, J. (2018). The embodiment of artistic elements in modern industrial design teaching from the perspective of humanity. *Jahrbuch Der Berliner Museen, 60*(1), 10-16.

Kaygan, P., Ilhan, A. O. & Ougür, I. (2020). Change in industrial designers' jobs: the case of turkey, 1984-2018. *The Design Journal, 23*(2), 1-21.

Kim, B., Joines, S. & Feng, J. (2022). Technology-driven design process: teaching and mentoring technology-driven design process in industrial design education. *International Journal of Technology and Design Education, 33*(2), 521-555.

Kucuksayrac, E. (2023). Digital prototyping, open design, and sustainability in industrial design education: a case study. *Digital Creativity, 34*(1), 22-36.

Li, S., Zhang,Y., Wang, Z. &Li, H. (2023). The influence of national policies on the evolution of industrial design education in China. *Heliyon, 9*(7), 2405-8440.

Liang, Y. W., Lee, A. S. & Liu, S. F. (2016). A study on design-oriented demands of VR via ZMET-QFD model for industrial design education and students' learning. *Eurasia Journal of Mathematics, Science and Technology Education, 12*(5), 1205-1219.

Mao, Y. C. & Zhang, G. L. (2024). Academic performance and visual patterns in reading technical and design articles among industrial design students. *International Journal of Engineering Education, 40*(3), 614-623.

Mao, Y., Han, Y., Li, P., Si, C., & Wu, Dan. (2024). Performance and eye movement patterns of industrial design students reading sustainable design articles. *Scientific Reports, 14*(1), 16267.

Perez, B. V. & Bovea, M. D. (2016). The role of eco-design education in influencing the design of electrical and electronic equipment: a case study involving industrial design engineering students. *International Journal of Engineering Education, 32*(4), 1719-1731.

Schneorson, D., Persov, E. & Bigger, R. (2019). Designing your future-21st century skillset for industrial designers: the case study of Israel design field. *The Design Journal, 22*, 243-259.

Suner, S., Gunay, A., Yargın, T. & Ural, H. (2022). Industrial design students' perceptions towards a career in user experience field in turkey. *International Journal Technology and Design Education, 32*, 1895-1923.

Tatlisu, E. & Kaya, C. (2017). The reflection of experiential knowledge into professional practice: case of industrial design education. *Design Journal, 20,* S1415-S1429.

Turhan, S. (2023). Roles of industrial designers in innovation-based companies: the case of Odtü Teknokent. *METU Journal of the Faculty of Architecture, 40*(2), 79-97.

Ueda, E. S. (2018). Student team integrating aspects of sustainability in practical design education. *International Journal of Sustainability in Higher Education, 19*(5), 877-892.

Van D. K., Simeone, L., Keskin, D., Baldassarre, B., Niero, M. & Morelli, N. (2020). Circular economy in industrial design research: a review. *Sustainability, 12*(24), 10279.

Wu, X., & Mejía, M. (2025). Design education of Non-design students and how they perceive their design competency. *International Journal of Art & Design Education,* 1-17.

Yilmaz, O. & Gelmez, K. (2025). Rethinking 3d modeling software tools in industrial design education: a student-informed framework based on experiences and expectations. *International Journal Technology and Design Education.*