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EDITORS

Design, Culture and Innovation

Volume Five

PERSPECTIVES, EXPERIENCES AND CONNECTIONS

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UNIVERSIDADE FEDERAL DO RIO GRANDE DO SUL
PGDESIGN UFRGS
LDCI Lab Design Cultura Inovação
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04

Competences for designers in the fourth industrial revolution: a systematic literature review

Gabriela de Oliveira Dutra
Silvia Trein Heimfarth Dapper
Júlio Carlos Souza van der Linden

Abstract

This study is a systematic review that analyzes recent literature on the competencies and role of the designer. The results indicate that designers need to develop competencies beyond those traditionally associated with the field. Among these are competencies related to: the ability to work in a transdisciplinary and collaborative manner, with both humans and other non-human agents; the ability to use technology and large amounts of data to solve complex problems; the ability to analyze problems through a systemic and interdisciplinary lens; and skills related to entrepreneurship and adaptability. Furthermore, designers must remain grounded, particularly regarding the ability to represent ideas visually.

Keywords: Competencies; Skills; Design; Technology.

1. Introduction

The era in which we live, referred to by some researchers as the "Fourth Industrial Revolution," is characterized by the reconfiguration of relationships between humans and machines, the prevalence of technologies such as artificial intelligence, and the abundance of data that places us at the threshold of a paradigm shift (CAIN; PINO, 2023). According to Zhang (2023, p. 312), the designer is the mediator of these new relationships.

Emerging technologies, particularly disruptive ones, are continuously reshaping society and generating increasingly complex challenges. In this context, design - described by Zhang (2023) as a creative practice focused on addressing human needs through problem-solving - must be reconsidered in terms of the competencies required of designers as the complexity of contemporary challenges continues to grow (CAIN; PINO, 2023).

As new technologies emerge, bringing with them new challenges and opportunities, design practices change and evolve (ZHANG, 2023). Thus, the roles of design are dynamic in the face of the growing complexities of the contemporary world, and approaches focused on multidisciplinary collaboration and the intensive use of data are increasingly necessary in the decision-making process (FLEISCHMANN, 2022). Thus, Matthews et al. (2023) assert that it is important to consider what role design will play in the Fourth Industrial Revolution.

In this context, the following research question was formulated: "What competencies are necessary for designers in the face of the paradigm shifts brought about by emerging technologies?", to analyze recent literature on changes in designers' competencies and professional roles.

This study presents a systematic literature review based on a protocol adapted from Conforto et al. (2011). By identifying emerging design competencies, it contributes to both professional practice and design education, supporting their adaptation to the challenges and opportunities associated with technological and societal change.

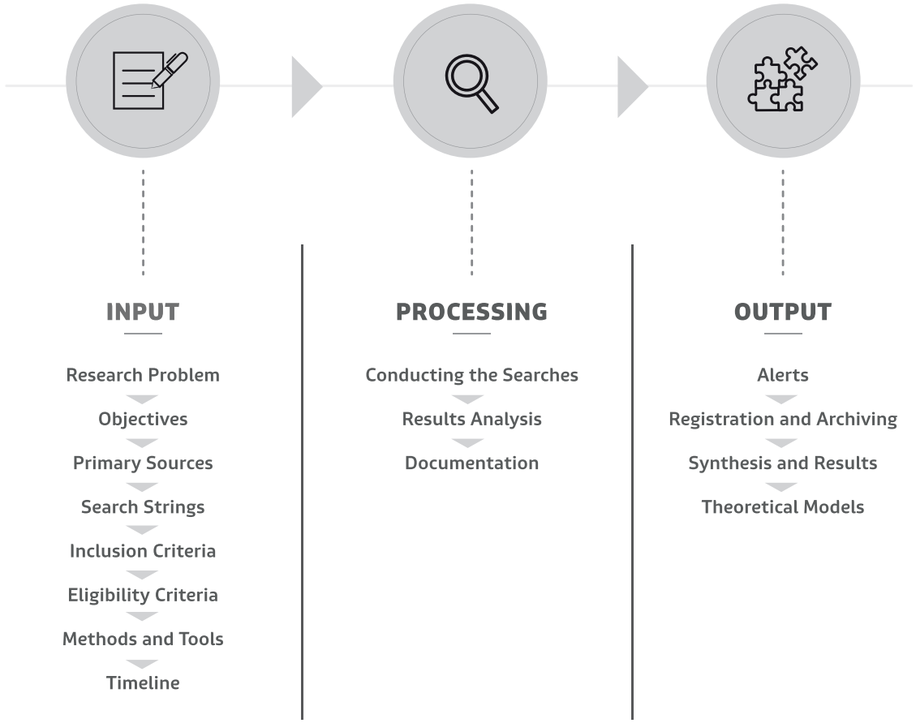
2. Methological Procedures

According to Gough et al. (2012), a systematic literature review is distinguished by rigorous, explicit, and replicable methods, which enhance the reliability of its findings. Furthermore, Moher et al. (2015, p. 335) state that a systematic review must address a "clearly formulated question," "select and critically evaluate relevant research," and "collect and analyze data from the studies included in the review."

Conducting a systematic literature review is important for identifying what has already been investigated on a given topic, thereby providing an understanding of the current state of knowledge and highlighting areas that require further research and deeper analysis. This type of review offers a comprehensive overview of existing knowledge, the methods used to generate it, variations among studies, and the gaps that remain in the field. Moreover, systematic reviews contribute to a robust understanding of a topic by synthesizing evidence from multiple studies and incorporating different perspectives (GOUGH et al., 2012).

This review adopts the structure proposed by Conforto et al. (2011), which comprises three stages: input, processing, and output. Figure 1 illustrates these stages.

Figure 1: Stages of the systematic literature review.



Source: Developed by the authors (2026), adapted from Conforto et al. (2011).

At the input stage, the guiding research questions are defined, along with the objectives to be achieved; the primary sources, that is, the key authors in the field who will provide the foundation for the subsequent stages of the research; the search strings; the inclusion and eligibility criteria; the search methods and tools; the timeline for conducting the systematic review; and the supporting tools to be employed.

During the processing stage, searches are conducted, data are analyzed, and documentation is compiled. At the conclusion of the systematic literature review, the output stage is reached, during which researchers may establish database alerts to receive notifications when new studies on the topic are published. This procedure facilitates the continuous updating of the article repository. The selected and analyzed studies are then stored in a repository, and a final report is prepared to synthesize both the identified studies and the resulting theoretical framework. The stages of the systematic literature review in this study are described below.

2.1 Input

This systematic review aimed to analyze recent literature on possible changes in designers' competencies and roles to help the design community adapt to the new technological context. To achieve this objective, the following research question was formulated: "What competencies are necessary for designers in the face of the paradigm shifts brought about by emerging technologies?"

Regarding search sources, the following databases were used: SCOPUS (www.scopus.com) and Web of Science (www.webofscience.com). The search strings were constructed using terms related to design practice, skills, and technology: *("graphic design" OR "visual design" OR "UX design" OR "design practice" OR "design studio" OR "digital design" OR "user experience design") AND ("abilit*" OR "capabilit*" OR "skill*" OR "knowledge") AND ("data" OR "data-driven" OR "machine" OR "startup" OR "start-up" OR "tech*" OR "innovation").*

The following inclusion criteria were defined: a) articles published between 2022 and 2025; b) articles available for open access; c) works related to the research's areas of interest (such as Design, engineering, multidisciplinarity, interdisciplinary application of computing, interdisciplinary applications, art, social sciences, humanities, business, management, communication, decision sciences); d) articles published in academic journals; e) works in English, Portuguese, Spanish, or French.

For the exclusion criteria, the following were considered: a) duplicate articles; b) unavailability of the full text; c) works incorrectly classified by language. For the qualification criteria of the collected studies, the following questions were considered: **(C1)** Does the study establish a connection with the theme of this work? **(C2)** In methodological terms, is the study presented clearly and in a manner that allows for replication? **(C3)** Are images, graphs, or tables clear and understandable? **(C4)** Do the conclusions or final considerations offer guidance for future work?

With respect to data management and organization, Zotero and Excel were used to document, organize, and manage the records identified during the review process. The search for articles was conducted in January 2025, and the analysis and synthesis of the selected studies were undertaken between January and March 2025.

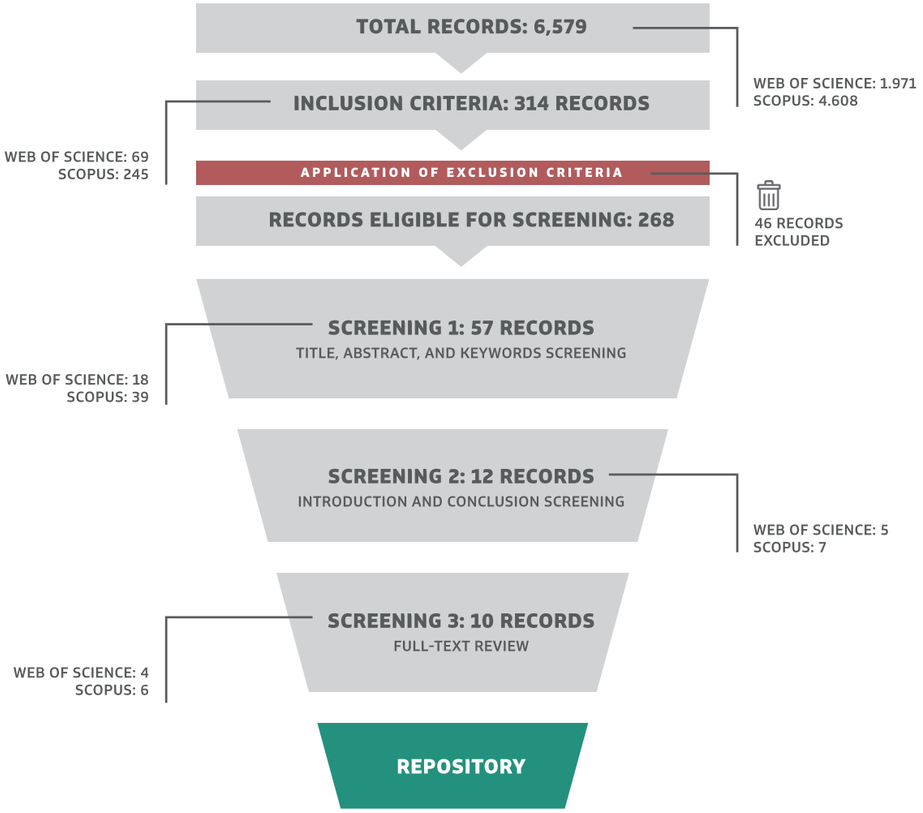
2.2 Processing

The defined search terms are entered into the selected databases. The inclusion, exclusion, and quality criteria are then applied to identify studies that are potentially relevant to addressing the research questions. To implement the inclusion criteria, the filtering tools available within each database were used to define the publication period, subject areas, document type, and language. Following this stage, the exclusion criteria were applied.

Using the search string, 1,971 records were identified in Web of Science and 4,608 in Scopus. After applying the filters available in each database, a total of three hundred fourteen (314) articles remained, comprising sixty-nine (69) from Web of Science and two hundred forty-five (245) from Scopus. Forty-five (45) records were excluded because they were duplicates, and one (1) record was excluded because it was not published in

one of the languages specified in the selection criteria. Consequently, two hundred sixty-eight (268) articles were retained for the screening of titles, keywords, and abstracts. Figure 2 presents the number of articles from each database that remained after the application of the filters.

Figure 2: Number of articles selected in each filter.



Source: Developed by the authors (2026).

Consequently, following the screening of titles, keywords, and abstracts, fifty-seven (57) articles were identified as potentially relevant and selected for the review of their introductions and conclusions. After this stage, twelve (12) studies were retained for full-text review, and ten (10) articles were ultimately included in the synthesis. Table 1 presents the studies included in the final review.

Table 1: Studies selected for the synthesis.

WEB OF SCIENCE				
Study	Title	Authors	Year	Methodology
E01	A dialogue about experiences of collaboration in design practice	Vita, Jane.	2023	Qualitative approach using focus groups and thematic analysis.
E02	Design education in transition: A multidisciplinary design classroom with non-allied disciplines	Fleischman n, Katja	2022	Qualitative approach using interviews.
E03	Navigating Design, Data, and Decision in an Age of Uncertainty	Cain, John; Pino, Zach.	2023	Narrative literature review.
E04	The value of sketching in the teaching of graphic design. Developing skills in a higher education institution	Springer, Leonardo.	2023	Narrative literature review.
SCOPUS				
E05	Destroy All Humans: The Dematerialization of the Designer in an Age of Automation and its Impact on Graphic Design—A Literature Review	Matthews, Benjamin; Shannon, Barrie; Roxburgh, Mark.	2023	Narrative literature review.
E06	Exploring an Interdisciplinary Curriculum in Product and Media Design Education: Knowledge Innovation and Competency Development	Kao, Yi-Fang; Chen, Hung-Cheng; Lo, Jung-Hua.	2023	Qualitative approach, curriculum proposal, and evaluation questionnaire.
E07	New Design Knowledge and the Fifth Order of Design	Mortati, Marzia.	2022	Narrative literature review.
E08	Teaching design students machine learning to enhance motivation for learning computational thinking skills	Wang, Hung-Hsiang; Wang, Chun-Han Ariel.	2024	Mixed-methods approach using quasi-experiment.
E09	The Ethical Turn of Emerging Design Practices	Zhang, Li.	2023	Narrative literature review.
E10	Validation of a preliminary competency assessment scale for Malaysian graphic design graduates	Wong, Shaw-Chiang; Idris, Muhammad Zaffwan.	2022	Mixed-methods approach using a questionnaire.

Source: Developed by the authors (2026).

In percentage terms, out of a total of ten (10) studies, 40% of them are from Web of Science, and 60% from Scopus.

2.2 Output

In this phase, the ten (10) articles selected in Filter 3 are analyzed and interpreted. Table 2 summarizes the studies and their main contributions.

Table 2: Studies selected for the synthesis and their main contributions.

Study	Title	Contributions
E01	A dialogue about experiences of collaboration in design practice	Vita (2022) argues that multidisciplinarity and co-creation are fundamental to innovation processes. By mastering tools that systematize creativity and broaden stakeholder participation, designers take on the role of facilitators in this process. The study highlights the challenges and benefits of multidisciplinary collaboration in innovation, while also offering a perspective on the future of this process. The author emphasizes that design fosters debate, allowing different perspectives to be considered. Organizations are increasingly recognizing the value of collaboration and the importance of viewing stakeholders—whether human or non-human—as partners in building project knowledge.
E02	Design education in transition: A multidisciplinary design classroom with non-allied disciplines	The article highlights a shift in design practice, which is evolving from creating value through artifacts and objects to generating value in "social and economic processes." This transition is driven by designers' ability to solve complex problems. The author states that contemporary technological transformations make design dynamic, requiring designers to know how to handle data and use it in decision-making. Furthermore, the complex problems of today's society demand multidisciplinary collaboration, allowing for the consideration of different perspectives on a given subject. The author emphasizes the importance of teaching design students to work collaboratively with other disciplines. The study supports the idea that designers can act as facilitators in the collaborative process of solving complex problems.
E03	Navigating Design, Data, and Decision in an Age of Uncertainty	he study addresses the question of whether the sketching technique is still important for design practice, even with the paradigm shifts brought about by new technologies. According to the author, this technique remains relevant to design practice, particularly with regard to concept development, idea generation, and communication. Designers need to know how to communicate their ideas assertively, both verbally and visually, and the sketching technique can help explore and mediate ideas.
E04	The value of sketching in the teaching of graphic design. Developing skills in a higher education institution	The study addresses the question of whether the sketching technique is still important for design practice, even with the paradigm shifts brought about by new technologies. According to the author, this technique remains relevant to design practice, particularly with regard to concept development, idea generation, and communication. Designers need to know how to communicate their ideas assertively, both verbally and visually, and the sketching technique can help explore and mediate ideas.
E05	Destroy All Humans: The Dematerialization of the Designer in an Age of Automation and its Impact on Graphic Design—A Literature Review	The study explores debates regarding the graphic design community's concerns about the possible replacement of humans by machines, and, on the other hand, authors' optimistic views on the potential for machines to serve as partners to humans in the design process. The authors suggest that design should move away from more technical and operational tasks and focus on skills associated with negotiation and facilitation, moving toward approaches such as "co-design, participatory design, service design, and speculative design."
E06	Exploring an Interdisciplinary Curriculum in Product and Media Design Education: Knowledge Innovation and Competency Development	The transformations brought about by new technologies are driving rapid changes in the design industry, making the competencies required of designers increasingly "complex and varied." Among the competencies cited by the authors are interdisciplinary skills, so that designers can bring different perspectives to their projects; social skills to communicate assertively with other stakeholders; leadership to guide the process, motivate team members, and make critical decisions; and entrepreneurship to identify opportunities and innovate. To this end, the authors propose an interdisciplinary curriculum.
EO7	Teaching machine learning to design students to enhance motivation for learning computational thinking skills	According to the authors, in the Fourth Industrial Revolution in which we live, computational thinking—described as "a set of activities that apply fundamental concepts of computer science to problem-solving, system design, and the understanding of human behavior"—is essential for addressing complex problems through algorithms and logic. The complex problems of today's world often require the management of technological, systemic, and social complexities. The authors assert that the integration of artificial intelligence tools can enhance computational thinking, creativity, and the ability to innovate. Thus, they argue that incorporating artificial intelligence and machine learning into design studies is crucial so that students can "explore new forms of automation, data-driven insights, and user interactions that were previously unattainable"—knowledge necessary for the future of the profession.

E08	Teaching machine learning to design students to enhance motivation for learning computational thinking skills	According to the authors, in the Fourth Industrial Revolution in which we live, computational thinking—described as "a set of activities that apply fundamental concepts of computer science to problem-solving, system design, and the understanding of human behavior"—is essential for addressing complex problems through algorithms and logic. The complex problems of today's world often require the management of technological, systemic, and social complexities. The authors assert that the integration of artificial intelligence tools can enhance computational thinking, creativity, and the ability to innovate. Thus, they argue that incorporating artificial intelligence and machine learning into design studies is crucial so that students can "explore new forms of automation, data-driven insights, and user interactions that were previously unattainable"—knowledge necessary for the future of the profession.
E09	The Ethical Turn of Emerging Design Practices	The study investigates, from a philosophical perspective, the design practices emerging in an era marked by constant transformation. Society faces various challenges and opportunities regarding new technologies, which drive changes in design practice and the emergence of new approaches, such as social design and ethical design. This is because traditional affirmative design practices are no longer sufficient to address the increasingly complex problems of the contemporary era. With the transformations of this era, the relationships between humans and technology are changing, and design can act as a mediator between the two, reflecting ethically on how technology impacts people's lives.
E10	Validation of a preliminary competency assessment scale for Malaysian graphic design graduates	The authors argue that digital transformation and the increasing complexity of design problems, among other contemporary changes, impact graphic design. These changes expand the scope of the practice and open up new possibilities for action in society. To explore these new possibilities, designers are expected to develop competencies relevant to these new contexts. According to the study, the competencies required for graphic design in Malaysia include leadership, management skills, marketing, self-efficacy, reflective thinking, communication, and industry knowledge, among others. According to the authors, these competencies reflect studies conducted in other countries.

Source: Developed by the authors (2026).

The studies reviewed converge on the conclusion that contemporary society is experiencing a period of continuous transformation driven by disruptive technologies. These changes affect design practice by both demanding the development of competencies, particularly those that distinguish human capabilities from those of machines, and expanding the possibilities for design action within society.

3. Theoretical Framework

The designer is a professional who deals with intractable or ill-defined problems. Intractable problems are inherently unpredictable, making it impossible to apply standardized methods with guaranteed outcomes. As designers begin to unravel these problems, new challenges emerge, increasing the complexity of the design process (GRILO & VAN DER LINDEN, 2022). Consequently, design practice is characterized by uncertainty. According to Cross (1998, p. 6), this uncertainty represents both a "frustration" and a "joy" in design practice, reflecting the "ambiguous" nature of design.

As noted by Cross (1998), design is an "emergent" process in which the problem and the solution develop simultaneously. When dealing with ill-defined problems, designers cannot limit themselves to simply synthesizing available information and proposing a solution, since many aspects of the problem only become apparent through processes of exploration and experimentation.

In this sense, designers begin the process without possessing all the information relevant to the solution. As Cross (1998, p. 5) highlights, "the directions taken during the exploration of the design territory are influenced by what is learned along the way, and by partial glimpses of what may lie ahead" (our translation).

Cross (1998) characterizes design as an "exploratory" process that extends beyond the conventional solutions typically expected for a problem. When presented with a design brief, designers look beyond the explicit requirements, seeking to examine the problem from multiple perspectives. Consequently, they are not limited to reproducing familiar examples but are instead driven by the exploration of new possibilities.

In this sense, Grilo & van der Linden (2022, p. 280) argue that, when confronted with an intractable problem, designers broaden their understanding of the problem by exploring fields of knowledge beyond Design itself. This multidimensional approach involves the interplay of "science, humanities, art, and technology," leading the authors to characterize design thinking as "a discipline of an interdisciplinary nature."

According to Grilo & van der Linden (2022, p. 281), problem-solving is made possible through "knowing how." The "how" of design, according to Verganti et al. (2022, p. 214), refers to the process itself—that is, the tools, methods, and collaborative practices involved in design activities. The "what" of design, which Verganti et al. (2022, p. 281) associate with the object, the new solutions developed, and the decisions made, is stimulated by "gaining knowledge through the intractable problem" (GRILO & VAN DER LINDEN, 2022, p. 281).

Furthermore, Grilo and Van der Linden (2022) argue that "knowing how" and "knowing what" are associated with "knowing how to interpret and knowing how to act." Through design thinking, this interrelationship enables designers to interpret and

shape the “best choices among the many possibilities” generated by intractable problems. Consequently, the knowledge that emerges from engaging with such problems contributes to the development of designers’ competencies.

Cross (1998, p. 1) defines the ability to design as “natural design intelligence.” This intelligence is innate to human beings and differs both from the intelligence of other animals and from the artificial intelligence of machines. However, while all individuals possess this ability to some degree, some stand out as “good designers,” exhibiting a more refined development of this capability. According to Cross (1998, p. 2), this difference may be explained by factors such as a possible “genetic endowment” or “social and educational development.”

Although natural design intelligence is a universal human trait, designers approach intractable problems consciously, “intentionally and intuitively integrating different forms of knowledge” (GRILO & VAN DER LINDEN, 2022). This awareness develops through practical experience as designers address a variety of intractable problems throughout their careers. Consequently, the capacity to design evolves with expertise, which is largely developed through practice and contributes to the continuous refinement of this capability.

As new technologies emerge and influence design practice, designers may need to develop new competencies to adapt effectively (COSTA & PELEGRINI, 2019). Competence is conceptualized by Brandão and Bahry (2005, p. 180) as “synergistic combinations of knowledge, skills, and attitudes, expressed through professional performance in a given context or within a specific organizational strategy”. When describing a competency, it is important to consider an “expected performance or behavior,” that is, what the “professional must be able to do”.

Designers acquire competencies as they explore emerging technologies and reinvent their practices, particularly when working in organizations that actively engage with a specific technology. This may be the case with “AI Factories”, studied by Verganti et al. (2022), where the intensive use of artificial intelligence significantly influences the design process. Therefore, when considering the competencies designers require within a particular context and in relation to a specific technology, it is necessary to “identify these organizations, as well as professional[s], faculty, and students who can serve as sources of data on new fields of practice driven by emerging technologies” (COSTA & PELEGRINI, 2019).

As emerging technologies become increasingly integrated into the design process, it is important to examine the competencies required of designers. According to Costa & Pelegrini (2019), “companies and individuals are experimenting with hybrid creative practices [and] new models of organization and work, which transcend traditional conceptual and disciplinary boundaries.” In this environment, “there are no specialists, but rather individuals who are testing their competencies in practice.”

In Costa & Pelegrini’s (2019) proposed competency model for emerging technologies, a “common competency for design practice related to all technologies” was identified, encompassing two main dimensions: the “ability to decide on the legal, ethical, and cultural limits of the personal and socially responsible use of technologies, understanding the potential risks”; and the ability to “understand, analyze, and evaluate the impact of technologies on social, economic, and cultural contexts”. According to Costa & Pelegrini (2019), in the context of experimentation with emerging technologies in the design process, such as artificial intelligence, professional roles become blurred and conventional practices are transformed.

Therefore, it is important to understand these practices to “predict, anticipate, and proactively prepare for foreseeable changes, as well as act to bring about desired changes”. Grilo & Van der Linden (2022) likewise argue that “understanding how designers operate is a way to identify the competencies these professionals employ in solving design problems.”

4. Results and Discussion

Regarding the results, the articles were analyzed to understand how they address the research questions, as shown in Table 3. The manner in which the studies address the questions posed in this systematic review is detailed below.

Study	What skills are necessary for designers in the face of the paradigm shifts brought about by new technologies?
E01	It can be stated that, for the author, the ability to work collaboratively is central to the present and future of design practice. It is through collaborative methods that design ensures all stakeholders have a voice, enabling the sharing of multidisciplinary knowledge - from both humans and machines - to solve the problem.
E02	The study demonstrates that the ability to work in a multidisciplinary manner is important for addressing the complex problems of the contemporary world through multiple points of view. In this sense, this ability must be fostered starting in university education.
E03	According to the study, in the face of emerging technologies, collaboration between design and other fields of knowledge becomes essential to promote more open, inclusive, and diverse approaches. Furthermore, the study highlights the importance of adaptability and flexibility as key competencies for designers. The adoption of a broad and systemic perspective, combined with the ability to collect and use data in an ethical and responsible manner, is one of the main highlights of the research.
E04	The author argues that, even with the advent of digital technologies, the ability to communicate visually and share ideas through sketching remains highly relevant to the design process.
E05	The article makes a satisfactory contribution to the research question by discussing the dematerialization of design in the face of emerging technologies. Skills related to entrepreneurship, adaptability, collaboration, communication, and critical thinking are cited as essential in this new era.
E06	The study proposes that, by having access to an interdisciplinary curriculum, design students can develop skills important for the future of design, such as critical thinking.
E07	The author focuses primarily on the new knowledge that designers must acquire to order to prepare for the future of the profession. For her, the ability to work with data is central.

E08	The authors describe how teaching machine learning can help design students develop computational thinking, which is important for design professionals to know how to deal with complex systems.
E09	The study asserts that traditional design practices are no longer sufficient to address increasingly complex problems. In this regard, what emerging practices are emerging, requiring skills related to the ability to question and reflect on the process from an ethical perspective?
E10	It argues that interdisciplinary knowledge is essential for addressing the complexity of current challenges. In addition to the skills that must be acquired to assume a more strategic role, designers should not abandon traditional skills related to the operational and aesthetic dimensions.

Thus, the studies selected for synthesis provide a suitable basis for addressing the research questions. Drawing on the collected data, the results are presented and discussed below. This section synthesizes the reviewed literature and examines the competencies designers need to navigate the transformations associated with the 21st century.

The 21st century presents both challenges and opportunities for design to strengthen its role in the innovation process and demonstrate its relevance to society. However, according to Mortati (2023), higher education institutions do not appear to be keeping pace with the transformations reshaping design practice. Instead, they continue to adhere to principles inherited from the Industrial Revolution, favoring solutions characterized by long life cycles and grounded in “generalization” and “standardization.”
In this context of constant change, where experiences and services can be dematerialized, a new logic for designing solutions emerges. This logic demands artifacts characterized by “infinite options,” “short life cycles,” and increasing levels of personalization. To respond to these emerging demands, design practice must evolve not only in relation to the objects being designed but also in terms of the forms of participation and control within the design process (MORTATI, 2023, p. 25).

There appears to be a broad consensus among scholars that design practice is becoming increasingly complex. This complexity requires designers to “continuously access the knowledge that allows them to better perform their functions” (VITA, 2023, p. 175). Furthermore, technological advances demand greater “flexibility” and “adaptability” in the ways designers approach their practice (VITA, 2023, p. 179). According to Cain & Pino (2023), designers must embrace the uncertainty and ambiguity inherent in the design process, recognizing that solutions are no longer expected to be complete and definitive but instead remain open to ongoing development and evolution.
In light of these developments, Zhang (2023) argues that new design practices are emerging, indicating that design is evolving in response to technological change. Some scholars characterize the current era as one of Post-humanism, in which human beings are no longer the sole focus, but instead coexist with non-human agents, objects, and the environment.

Verganti et al. (2020) predict that transformations in design practice will bring the field closer to organizational theories, particularly those related to leadership, which is intrinsically connected to processes of “sense-making”. Wong & Idris (2022) reinforce this perspective, suggesting that the role of designers is likely to become increasingly strategic and managerial. The following sections present the main themes identified in the reviewed studies.

4.1 New Technologies and Data

The disruptive technologies of the 21st century may require changes in both design processes and designers' competencies. According to Fleischmann (2022), designers must keep pace with technological innovation, as they play an important role in shaping the future of the field.

In its early stages, design focused primarily on the creation of tangible artifacts, with an emphasis on graphic and industrial products. Subsequently, its scope expanded to include the development of interaction tools and interfaces. Over time, the evolution of the field led design to incorporate approaches centered on processes, strategies, and business-related elements that are intangible in nature. Today, design is entering a new phase, characterized by Mortati (2023, p. 27) as one of "transformations." This phase is driven by data and value creation, directing designers' efforts toward the development of intangible forms of value, such as "data feedback loops" and "pathways to transformation".

According to Mortati (2023), data play an essential role in this new phase of design, as they are increasingly used to support decision-making, influence behavior, and predict future scenarios. The intensive use of data also raises important questions related to "ethics, culture, and social debates," requiring designers to develop new competencies in these areas. Mortati (2023, p. 29) identifies two relevant design practices associated with this new phase: "data conceptualization" and "data exploitation and (ab)use." The author defines "data conceptualization" as an approach to interpreting and making sense of data beyond simple visualization, whereas "data exploitation and (ab)use" represents a "new path for studying behaviors and new user experiences." Fleischmann (2022) further argues that data can provide designers with a "systematic view" when analyzing problems.

Cain & Pino (2023) highlight that data visualization, physicalization, sonification, and storytelling are valuable tools that enable designers to communicate complex ideas effectively. The authors further argue that designers must equip themselves with new techniques to capture, structure, analyze, and manipulate data. In addition, they should develop an understanding of algorithms and simulations to enhance the effectiveness and usability of their projects.

Cain and Pino (2023) further explore the increasing integration of data into design practices, arguing that this shift is essential for designers to remain relevant, effective, and responsible in contemporary contexts. The importance of data becomes even more pronounced with the advancement of artificial intelligence, which can identify patterns and associations within large datasets. In this context, human designers play a complementary role by interpreting results and exercising judgment regarding causal relationships.

According to Mortati (2023), artificial intelligence is assuming a leading role in the development of highly personalized solutions, particularly within the "AI Factories" investigated by Verganti et al. (2022). As a result, designers must redefine their relationship with machines, viewing them not merely as tools but as active partners that influence the design process and contribute to decision-making. These transformations also create new opportunities for co-creation, expanding the possibilities for collaboration between humans and intelligent technologies.

Artificial intelligence, according to Mortati (2023), plays a leading role in the development of "highly personalized" solutions, particularly within the context of the "AI Factories" studied by Verganti et al. (2022). In this scenario, designers need to reconfigure their relationship with machines, viewing them not merely as tools but as active partners that influence the design process and participate in decision-making. These transformations also point toward new opportunities for co-creation, expanding the possibilities for collaboration between humans and intelligent technologies.

Mortati (2023) refers to this period as the "Digital Revolution," in which humans are no longer the sole actors involved in solutions and decision-making processes. Artificial agents and other organisms also become part of these systems, meaning that outcomes are no longer entirely under human control. In this new era, where multiple forms of data shape both the inputs and outputs of design, the focus shifts from developing near-perfect solutions to designing adaptive systems capable of continuous evolution and learning.

The use of artificial intelligence in design can help solve complex problems, optimize processes, expand creativity, and generate data-driven insights, among other applications (Wang and Wang, 2024). Consequently, designers need to develop proficiency in AI tools and learn how to leverage their capabilities effectively. One perspective argues that achieving such proficiency requires designers not only to use AI technologies but also to understand their underlying principles and actively participate in their development - a challenge for which many professionals do not yet appear adequately prepared. According to Mortati (2023), the difficulties associated with designing AI-based solutions stem primarily from the technical complexity of these technologies, their dependence on data, and the unpredictable interactions they generate. To address these challenges, designers must develop competencies that enable them to understand what AI systems can do, evaluate their performance, and manage the complexity of the solutions they produce. Furthermore, as AI increasingly assumes the role of an active agent within the solution itself, additional layers of complexity are introduced into the design process (MORTATI, 2023).

Mortati (2023) presents another approach through which designers can engage with AI in contexts where intelligent agents play a central role in both the design process and the resulting outcomes. In this perspective, designers are responsible for managing the systems' "feedback loops". Their role involves providing and curating the data used to train AI systems, enabling them to learn from information and generate increasingly effective responses. Cain & Pino (2023) further argue that designers must recognize the inherently iterative nature of this process, as each user interaction contributes to the continuous evolution and personalization of the system. This perspective underscores the importance of close collaboration between designers and data scientists, whose combined expertise supports the development, monitoring, and refinement of AI-driven solutions (MORTATI, 2023).

Wang and Wang (2024) further argue that computational thinking is an essential competency for designers, enabling them to apply machine learning and artificial intelligence to problem-solving, enhance creativity, and develop algorithmic reasoning.

Based on the literature reviewed, the figure below organizes the competencies associated with emerging technologies and data into three dimensions: knowledge, skills, and attitudes.

Figure 1: Competencies related to new technologies and data.

KNOWLEDGE, SKILLS, AND ATTITUDES

Competencies for Emerging Technologies and Data

Knowledge	Skills	Attitudes
Structure and functioning of AI systems and their subfields, data, algorithms, and simulations. Computational thinking.	Interpret and derive meaningful insights from data beyond simple visualization. Explore and analyze data to study behaviors and design new user experiences. Communicate complex ideas effectively using data. Collect, structure, analyze, and manipulate data.	Willingness to engage in continuous learning and keep up with technological innovations. Innovative mindset and responsible use of technology.
Structure and functioning of AI systems and their subfields, data, algorithms, and simulations. Concepts of co-creation between humans and artificial agents. Limitations and capabilities of AI systems.	Integrate AI as an active partner in the design process and interpret causal relationships in data. Continuously train AI systems with data and manage continuous learning cycles. Develop solutions that evolve and learn continuously. Master AI tools and applications to optimize processes, foster creativity, and generate data-driven insights. Manage complexity and uncertainty in AI-assisted design. Apply computational thinking and AI systems to solve complex problems and generate creative solutions.	Openness to collaborating with AI and technologies as active agents. Flexibility to deal with unpredictable and collaborative processes while embracing a degree of uncertainty. Innovative mindset and responsible use of technology.

Source: Developed by the authors (2026).

The knowledge of the structure and functioning of artificial intelligence systems, data, algorithms, and simulations provides the foundation for a range of competencies. These include interpreting data beyond simple visualization, exploring and analyzing information to understand behaviors, communicating complex ideas through data, and applying AI-related techniques within the design process. Effective collaboration with intelligent systems also requires an understanding of their capabilities, limitations, and the fundamental principles of machine learning. In terms of attitudes, the literature highlights cross-cutting dispositions such as openness to continuous learning, innovation, and responsible technology use. Moreover, the integration of artificial intelligence into design practice demands a willingness to collaborate with artificial agents and the flexibility to navigate unpredictable processes, including accepting a reduced degree of direct control over outcomes.

4.2 Collaboration and Multidisciplinarity

Collaboration in design can take various forms, including co-creation, co-design, and participatory design. Despite their differences, these approaches share a common principle: incorporating the perspectives of those affected by the outcomes of the design process (VITA, 2023, p. 178). According to Fleischmann (2022), ongoing transformations in the field have increasingly positioned designers as collaboration-oriented professionals who must work across disciplinary and social boundaries to address complex challenges and generate positive societal impact. As a result, designers are expected to engage effectively in dialogue with individuals from diverse backgrounds, experiences, and perspectives.

Interaction and collaboration among stakeholders are fundamental to the innovation process, as they ensure that diverse perspectives and values are taken into consideration. In this context, Vita (2023, p. 173) argues that designers can play a key role as facilitators, employing methods and tools that foster co-creation and multidisciplinary collaboration. Similarly, Mortati (2023) highlights the importance of transdisciplinarity and participation—by both humans and other “species” - in contemporary design practice.

According to this perspective, design moves beyond the traditional boundaries of the discipline, shifting its focus from material artifacts alone to broader concerns involving perceptions, relationships, and culture.

Given the complexity and diversity of contemporary design artifacts, designers must “access and learn to use resources that promote the integration of diverse perspectives” (VITA, 2023, p. 179). According to Vita (2023), exposure to multiple viewpoints broadens designers’ knowledge and enhances learning through collaborative practices. In a similar vein, Mortati (2023, p. 23) argues that designers must engage in dialogue not only with other people but also with “machines and microorganisms,” reflecting the expanding network of actors involved in contemporary design processes.

Cain & Pino (2023, p. 202) argue that, in an era of data-driven decision-making, design processes must become increasingly “open and collaborative,” enabling a wide range of stakeholders - both human and non-human - to participate in decision-making. Similarly, Vita (2023) contends that collaborative approaches to complex problems allow

designers to develop a deeper understanding of both the challenges at hand and the ambiguous contexts in which they are situated. This emphasis on ambiguity aligns with Cross's (1998) view that uncertainty is an inherent characteristic of design, requiring designers to navigate situations in which problems and solutions are not fully defined from the outset.

According to Fleischmann (2022), technology empowers citizens and democratizes design, bringing people closer to the design process and repositioning designers as co-creators and facilitators rather than sole authors of solutions. The author argues that contemporary design practice requires multidisciplinary teams to address increasingly complex challenges. Consequently, design education should prepare students to work effectively in multidisciplinary environments and to facilitate broad participation in design processes. This requires curricula that reflect industry needs while fostering both specialized expertise and the generalist competencies necessary for collaboration across disciplines.

Matthews et al. (2023) argue that collaborative design practices contribute to the development of essential soft skills, including empathetic observation and listening, data analysis, assertive communication, and collaboration. However, the authors note that university programs tend to place greater emphasis on technical competencies than on these interpersonal and facilitative capabilities. They further suggest that the operational aspects of "designing" may increasingly be automated through the use of user data. As a result, the designer's role may shift toward mediating and facilitating interactions among stakeholders, as well as interpreting, evaluating, and refining the outputs generated by intelligent systems. Rather than directly creating solutions, designers would be responsible for ensuring that machine-generated outcomes effectively meet user and societal needs.

In this context, interpersonal skills are fundamental to contemporary design practice. Competencies in management, research, and communication are already highly valued by employers when recruiting design professionals. Matthews et al. (2023, p. 371) argue that the competencies designers should prioritize are primarily related to "collaboration, management, negotiation, and facilitation." Effective collaboration, in turn, requires designers to communicate ideas clearly, build shared understanding among stakeholders, and demonstrate empathy throughout the design process.

Wong & Idris (2022) emphasize that empathy is a critical competency for designers, contributing to their versatility and adaptability in dynamic professional contexts. According to the authors, empathy enables designers to navigate conflicts, collaborate effectively in teams, listen actively to diverse perspectives, make informed decisions, solve problems, and facilitate organizational and social change.

Kao et al. (2023) argue that team alignment is essential in design projects and that designers play a key role in coordinating stakeholders to ensure that shared objectives are achieved. In this context, leadership competencies are fundamental for effectively guiding project teams. Wong & Idris (2022) further contend that successful collaboration requires designers to develop strong communication, management, and leadership skills, enabling them to engage constructively with team members and communicate ideas with clarity and confidence. Based on the literature reviewed, the figure below organizes these competencies into three dimensions: knowledge, skills, and attitudes related to collaboration and multidisciplinarity.

Figure 2: Competencies related to collaboration and multidisciplinarity.

KNOWLEDGE, SKILLS, AND ATTITUDES
Competencies for Collaboration and Multidisciplinarity

Knowledge	Skills	Attitudes
Methods and tools to facilitate collaboration and multidisciplinary work. Transdisciplinarity and the integration of diverse perspectives. Management, research, and communication.	Facilitate collaborative processes, particularly in multidisciplinary environments. Act as a mediator among stakeholders (human and non-human). Listen and observe empathetically, analyze data, communicate effectively, and collaborate. Communicate ideas effectively and demonstrate empathy. Coordinate teams to achieve shared goals.	Willingness to act as a facilitator of co-creation. Openness to collaboration and diversity of perspectives. Willingness to deal with ambiguity and uncertainty. Leadership mindset. Assertiveness and empathy.

Source: Developed by the authors (2026).

The knowledge of collaborative approaches, such as co-creation, co-design, and participatory design, as well as of methods and tools that foster multidisciplinarity, is increasingly important for designers operating in complex and diverse contexts. This knowledge supports competencies such as facilitating collective processes, mediating stakeholder interactions, communicating ideas effectively, and coordinating multidisciplinary teams. In terms of attitudes, openness to collaboration, along with a willingness to navigate ambiguity and uncertainty, emerges as particularly important. Moreover, the ability to assume facilitative and leadership roles is essential for guiding collaborative efforts and aligning diverse perspectives.

4.3 Entrepreneurship and Adaptability

Industry transformations require designers not only to respond to market demands but also to shape and anticipate them. This involves understanding broader societal and technological developments, maintaining continuous dialogue with users, and identifying emerging needs and opportunities before they become explicit demands (VITA, 2023, p. 181).

This ability to identify opportunities and develop innovative solutions is closely associated with entrepreneurial competencies (KAO et al., 2023). Matthews et al. (2023) further argue that contemporary job opportunities for designers increasingly require competencies related to management, business-oriented strategic thinking, service design, and innovation. The authors also emphasize the importance of adaptability and cognitive flexibility, enabling designers to respond effectively to change and avoid rigid modes of thinking. Based on the literature reviewed, the figure below organizes these competencies into three dimensions: knowledge, skills, and attitudes related to entrepreneurship and adaptability.

Figure 3: Competencies related to entrepreneurship and adaptability.

KNOWLEDGE, SKILLS, AND ATTITUDES

Competencies for Entrepreneurship and Adaptability

Knowledge	Skills	Attitudes
Strategic thinking focused on business. Service design. Entrepreneurship.	Proactively generate demand rather than merely responding to market needs. Engage in continuous dialogue with users. Adapt quickly to changing conditions. Demonstrate cognitive flexibility. Identify opportunities and develop innovative solutions.	Entrepreneurial mindset to create demand and identify opportunities. Willingness to adapt strategies in response to change.

Source: Developed by the authors (2026).

As the designer's role becomes increasingly diffuse and shifts toward strategic and business-oriented concerns, competencies related to entrepreneurship and adaptability become increasingly important. Knowledge of business strategy, service design, and entrepreneurship enables designers to proactively generate demand, engage with users, respond to changing circumstances, and identify emerging opportunities. In addition, attitudes such as an entrepreneurial mindset, openness to change, and a willingness to adapt strategies are critical for navigating dynamic and uncertain environments.

4.4 System thinking, ethics, and Interdisciplinary Knowledge

Cain & Pino (2023) argue that designers increasingly need to adopt a systemic perspective, understanding how both problems and solutions generate consequences across different contexts, particularly in social and ecological domains. This broader view is closely related to what Zhang (2023, p. 313) describes as the "ethical turn" in design. According to the author, this shift manifests across three dimensions: ontological, epistemological, and methodological. Ontologically, design is concerned with assessing the moral risks associated with technological development. Epistemologically, it focuses on anticipating and intervening in possible futures characterized by uncertainty.

Methodologically, it explores alternative futures and unrealized possibilities as a means of inquiry and action. Together, these dimensions expand the scope of design beyond immediate problem-solving, emphasizing responsibility, foresight, and the ethical implications of intervention.

Within this perspective, Zhang (2023) argues that new forms of design practice are emerging and groups them into three categories: affirmative design, social design, and ethical design. Affirmative design encompasses traditional fields such as graphic, industrial, fashion, interaction, management, and digital design, as well as emerging areas associated with technological innovation, including AI design and biodesign. These practices generally seek to explore and integrate new technologies into design processes, identifying opportunities for their application while remaining attentive to the ethical implications of their use.

The two emerging categories identified by Zhang (2023) - social design and ethical design - are, in contrast, less directly focused on technological development itself. Ethical design seeks to examine the moral implications, challenges, and societal consequences associated with disruptive technologies, often drawing attention to their potential negative impacts on individuals and communities. Social design, by contrast, adopts a more practical and political perspective, using participatory and inclusive approaches to address social issues, incorporate diverse viewpoints, and empower marginalized groups.

Zhang (2023) refers to this classification as a tripartite framework of design practices, emphasizing that these emerging approaches are not intended to replace traditional forms of design but rather to complement and expand them.

Matthews et al. (2023) argue that critical thinking is essential for designers to act responsibly and ethically, reflecting on how their decisions, as well as the actions of technologies and other stakeholders, affect society. Cain & Pino (2023) further emphasize that, as designers increasingly work with personal data used to support the continuous evolution of intelligent systems, ethical conduct becomes imperative. This includes understanding how data are collected, managed, and stored, with the aim of ensuring both user experience and data security.

Integrating these multiple perspectives into the design process requires an interdisciplinary knowledge base. According to Kao et al. (2023), designers must be able to draw upon insights from the natural sciences, humanities, and other fields in order to develop innovative and sustainable solutions that meet "the needs of the present without compromising the future". Wong & Idris (2022) similarly argue that social, cultural, and environmental responsibility, grounded in ethical awareness, is fundamental to contemporary design practice. Based on the literature reviewed, the figure below organizes the competencies associated with systemic thinking, ethics, and interdisciplinary knowledge into three dimensions: knowledge, skills, and attitudes.

Figure 4: Competencies related to systemic vision, ethics, and interdisciplinary knowledge

KNOWLEDGE, SKILLS AND ATTITUDES

Competences for systemic thinking, ethics, and interdisciplinary knowledge

Knowledge	Skills	Attitudes
Understand how problems and solutions impact different contexts through a systemic perspective. Interdisciplinary knowledge to create sustainable solutions. Ethical considerations regarding the use of technologies. Critical thinking. Understand how and which data will be collected and stored.	Analyze the social, environmental, and technological impacts of solutions. Integrate ethical and social perspectives into design decisions. Ensure the best user experience and safety.	Ethical and social responsibility, considering social, cultural, and environmental impacts. Openness to interdisciplinarity. Ethics in the use of data and technologies.

Source: Developed by the authors (2026).

As the use of data and technologies such as artificial intelligence becomes increasingly prevalent, competencies related to ethics, interdisciplinary knowledge, and systemic thinking become essential for addressing complex design challenges. Designers must understand the impacts that both problems and solutions generate across different contexts, while critically examining the ethical implications of data and technology use. Such competencies enable them to assess potential consequences, integrate diverse perspectives, and develop solutions that promote positive user experiences and safety. In terms of attitudes, ethical and social responsibility, together with openness to interdisciplinary perspectives, emerge as fundamental dispositions for contemporary design practice.

4.5 Traditional Competencies

Mortati (2023) argues that, despite the growing importance of emerging competencies, designers must continue to cultivate traditional skills that help bridge the relationship between people and new systems. Similarly, Wong & Idris (2022) found that operational competencies related to the creation of visually compelling artifacts remain highly valued and expected in professional practice. Furthermore, although the field is increasingly oriented toward the conceptualization, development, and implementation of innovative ideas, it should not lose sight of its operational foundations. As a result, designers are required not only to develop new competencies but also to preserve and strengthen the artistic sensibility that has long been central to the discipline.

Among the traditional competencies identified by the authors as essential for preserving the core foundations of design, visual intelligence stands out. Grounded in the construction of models through sketches and other visual representations, this competency enables designers to translate ideas into artifacts and to “share knowledge” (MORTATI, 2023, p. 33). In an era in which machines are expected to assume a greater role in problem-solving activities, human contributions are likely to become increasingly concentrated in the early stages of the design process. As Verganti et al. (2020) argue, humans will remain primarily responsible for defining problems and constructing meaning. Consequently, visual thinking becomes even more valuable as a means of interpreting complex challenges and translating abstract concepts into forms that can be explored, communicated, and developed (MORTATI, 2023).

Springer (2023) argues that, despite the paradigm shift and the growing emphasis on digital technologies in contemporary society, the ability to visually externalize thoughts and concepts through tools such as sketching remains essential for communication and cognitive development. These ideation practices can foster creativity, support the visual exploration of problems, and facilitate the communication of ideas and meanings, thereby making complex concepts more accessible and understandable. This capacity to represent intricate issues visually becomes even more relevant in a context of increasing cultural mobility and diversity. Furthermore, the materialization of abstract concepts contributes to the construction and refinement of designers’ knowledge.

4.6 Implications for Education

Matthews et al. (2023) emphasize the importance of higher education institutions keeping pace with industry developments so that design curricula evolve alongside professional practice. In a similar vein, Kao et al. (2023) contend that design education should place greater emphasis on interdisciplinarity in order to develop the competencies required by future professionals. Wang & Wang (2024) further highlight the need for curricular reform, particularly with regard to the integration of computational thinking into design education.

Wong & Idris (2022) evaluated the competency levels of final-year graphic design students in Malaysia. Their findings indicate that students perceived themselves as most competent in teamwork and leadership, which received the highest ratings, while business-related knowledge and skills were identified as areas of lower preparedness. Based on these results, the authors emphasize the importance of interdisciplinarity, arguing that emerging design professionals must develop knowledge and competencies that extend beyond the traditional boundaries of the discipline.

Springer (2023) similarly argues that higher education institutions must prepare future professionals for a world characterized by continuous sociocultural change, increasing access to information, and the rapid dissemination of ideas, all of which contribute to greater complexity and uncertainty. The author emphasizes the importance of teaching design students to use ideation tools, such as sketching, to represent and materialize abstract concepts. Through these practices, the ability to visually communicate and explore complex ideas can support the understanding and resolution of future challenges, which increasingly require the integration of knowledge from multiple disciplines.

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5. Conclusion

This systematic literature review aimed to examine recent literature on the evolving competencies and roles of designers in the context of emerging technologies, thereby contributing to the adaptation of both professional practice and design education.

The literature reviewed highlights the societal transformations brought about by emerging technologies. According to the authors analyzed, this period - often described as the Fourth Industrial Revolution or Digital Revolution - is characterized by continuous and rapid change, resulting in increasingly complex challenges for designers.

The findings indicate that designers need to broaden their range of competencies beyond those traditionally associated with the field. Among the competencies identified as essential in this new phase of design are the ability to work in a transdisciplinary and collaborative manner with humans, machines, and other organisms; the ability to understand and leverage the potential of machines and large volumes of data; the ability to integrate interdisciplinary knowledge to develop a systemic and ethical perspective on the impact of design on society; and the ability to demonstrate entrepreneurship and adaptability. Furthermore, the authors emphasize that traditional competencies, such as the ability to visually communicate and represent ideas, remain important.

It is important to note that, although we live in an increasingly globalized world, the competencies required of designers may vary across countries and industries. Therefore, future research should investigate these competencies in different contexts. Moreover, given the dynamic nature of contemporary society and technological change, designers' competencies should be understood as continuously evolving, requiring ongoing review and refinement.

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