

21ST-CENTURY COMPETENCIES IN THE AGE OF ARTIFICIAL INTELLIGENCE: RECONSTRUCTING EDUCATION SYSTEMS IN THE CONTEXT OF GLOBAL TRANSFORMATIONS

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ABSTRACT

The rapid technological, economic, and social transformations of the twenty-first century have fundamentally reshaped the competencies required of individuals in education and working life. In particular, the widespread adoption of artificial intelligence technologies has made it necessary to reconsider the goals and structures of education systems. In an era where access to information is increasingly effortless, the primary function of education has shifted from knowledge transmission to fostering individuals who can adapt to change, think critically, and engage in lifelong learning.

The purpose of this study is to examine key twenty-first-century competencies in the age of artificial intelligence and to discuss the role of education systems in developing these competencies. The study draws on recent reports published by the World Economic Forum, the OECD, and the European Union, as well as contemporary international academic literature. Competency is conceptualized as a holistic construct encompassing knowledge, skills, attitudes, and values. The findings indicate that traditional knowledge-based educational models are insufficient in today's rapidly changing environment. Instead, competencies such as adaptive thinking, problem solving, creativity, ethical judgment, and the ability to formulate meaningful questions are becoming increasingly critical. While artificial intelligence enhances efficiency in information processing, human capacity for interpretation, contextual reasoning, and value-based decision-making remains essential. The study concludes that education systems must be restructured around competency-based approaches to effectively prepare individuals for an uncertain and evolving future.

Keywords: 21st-century competencies, artificial intelligence, education systems, competency-based education, adaptive thinking

1. INTRODUCTION

The twenty-first century stands out in human history as a period characterized by simultaneous and unprecedented technological, economic, and social transformations. Digitalization, artificial intelligence, globalization, climate change, and demographic shifts are profoundly reshaping individuals' lifestyles, work practices, and expectations of education. This multidimensional transformation process redefines not only the nature of occupations but also the sets of knowledge, skills, and competencies expected from individuals (Schwab, 2016; World Economic Forum, 2023).

The rapid growth in knowledge production and access has called into question traditional assumptions about the fundamental function of education. Unlike previous eras, knowledge is no longer a scarce or privileged resource; rather, it is easily accessible, constantly updated, and quickly becomes obsolete. This situation highlights that the primary aim of education should no longer be the transmission of information, but teaching how knowledge can be used, interpreted, and adapted to new situations. The OECD (2021) describes this shift as a necessary transition from knowledge-based education to competency-based education.

The rapid development of artificial intelligence technologies has further intensified debates about the role of humans in education. AI systems can perform highly in areas such as data analysis, pattern recognition, and prediction; however, they still rely on human intelligence for problem definition, contextual interpretation, and ethical reasoning (Luckin et al., 2016; OECD, 2021). In this context, the literature emphasizes that the distinguishing feature of humans vis-à-vis artificial intelligence lies in their capacity to ask the right questions, create meaning, and make value-based decisions.

These developments necessitate a re-examination of the concept of competency. In classical approaches, competency was defined as an integrated set of knowledge, skills, and personal characteristics enabling effective performance

(Spencer & Spencer, 1993). Contemporary literature broadens this definition, conceptualizing competency as a holistic and dynamic structure encompassing not only cognitive knowledge and technical skills but also attitudes, values, ethical awareness, and adaptability to changing conditions (Mulder, 2017; OECD, 2019). This perspective is particularly important for enabling education systems to prepare individuals for unpredictable future conditions.

The literature on twenty-first-century competencies highlights higher-order competencies such as adaptive thinking, critical inquiry, creativity, collaboration, problem solving, and lifelong learning. Recent reports by the World Economic Forum indicate that individuals will change professions multiple times throughout their careers and that learning agility, flexibility, and adaptability—rather than technical knowledge alone—will be decisive (World Economic Forum, 2023). Consequently, education systems must evolve from structures that merely prepare individuals for specific occupations into dynamic systems that prepare them for lifelong learning.

This study aims to discuss which competencies education systems should develop in the age of artificial intelligence and how these competencies can be fostered. Drawing on competency frameworks proposed by the World Economic Forum, the OECD, and the European Union, the study examines the transition from knowledge-based education to competency-based approaches. Based on findings obtained through literature review and document analysis, the study discusses the areas of transformation required for education systems to adapt to the future from a holistic perspective.

2. LITERATURE REVIEW

This section systematically reviews contemporary literature to understand the transformation of education systems in the age of artificial intelligence. The review aims to address the key dynamics shaping education in the twenty-first century, the theoretical foundations of competency-based approaches, and the impact of artificial intelligence technologies on human competencies within an integrated framework. Accordingly, global megatrends influencing education systems are first discussed, followed by an examination of the pedagogical and theoretical dimensions of competency-based education. The relationship between artificial intelligence and human competencies is then explored, and finally, competency frameworks developed by the World Economic Forum are critically evaluated in terms of their implications for education systems.

2.1. Global Megatrends and Education Systems

Global transformations directly affect the structure and function of education systems. In the literature, these transformations are often discussed under the concept of “megatrends,” referring to long-term, structural changes. Megatrends encompass multidimensional processes such as technological developments, demographic shifts, changes in economic power balances, environmental crises, and social transformations (Schwab, 2016; Voros, 2017). These trends reshape not only labor markets but also individuals’ learning needs and expectations from education.

Technological developments—particularly digitalization and the widespread use of artificial intelligence—are considered among the most influential megatrends affecting education systems. AI-supported systems accelerate access to information and offer the potential to personalize learning processes. However, the literature emphasizes that technological progress alone does not guarantee improvements in educational quality and may yield superficial outcomes unless supported by pedagogical transformation (Selwyn, 2019). Thus, educational technologies are viewed as means rather than ends, underscoring the importance of a human-centered learning approach.

The relationship between technological transformation and education is not merely instrumental. Castells (2010) argues that with the rise of the network society, the modes of knowledge production and circulation have fundamentally changed, inevitably transforming education systems. As knowledge shifts from linear and hierarchical structures to network-based ones, learning must become more open, interactive, and multidimensional. Accordingly, education systems should position students not as passive recipients of knowledge but as active producers of knowledge.

Demographic changes also exert significant pressure on education systems. Population aging, increased migration, and generational differences intensify the need for flexibility and inclusivity in education. New generations growing up immersed in digital technologies demand greater autonomy, meaning, and flexibility in learning processes. The learning styles of these “digital natives,” as termed by Prensky (2001), increasingly conflict with traditional instructional models, compelling education systems to rethink their pedagogical approaches.

From an economic perspective, intensified global competition and rapidly transforming labor markets are key megatrends. Brown, Lauder, and Ashton (2011) argue that the knowledge economy does not automatically provide better employment opportunities; instead, it intensifies competition over qualifications. This situation highlights that education systems should aim not only to enhance employability but also to develop individuals' long-term adaptability. Contemporary studies indicate that individuals will change professions multiple times during their careers, often requiring educational support during these transitions (World Economic Forum, 2023).

Environmental crises and climate change constitute another megatrend gaining central importance in education. Sterling (2010) conceptualizes the sustainability crisis not only as an environmental issue but also as an epistemological one, arguing that education systems must transform the ways in which the world is perceived and understood. In this context, education assumes the role of fostering systems thinking, ethical responsibility, and global citizenship, beyond merely raising environmental awareness (UNESCO, 2020).

A key point emphasized in the literature is that these megatrends are interrelated rather than independent. Technological developments reshape economic structures, economic pressures may exacerbate social inequalities, and these inequalities can generate new challenges in access to education (Piketty, 2020). Within this complex landscape, the role of education systems is defined not merely as adapting to existing conditions, but as equipping individuals with the cognitive and affective capacities to cope with uncertainty, complexity, and rapid change (OECD, 2021).

In sum, the literature demonstrates strong consensus that global megatrends compel education systems to undergo profound transformation. This transformation requires moving away from content-driven and standardized approaches toward models centered on flexibility, adaptation, critical thinking, and lifelong learning. Accordingly, the primary goal of education systems should not be to prepare individuals for specific occupations, but to equip them with competencies that enable adaptation to change itself.

2.2. Competency-Based Education Approaches

The transformative impact of global megatrends on education systems has prompted a shift away from content- and knowledge-transfer-centered approaches. In this context, competency-based education approaches are considered among the core paradigms shaping educational reforms in the twenty-first century. The literature defines competency-based education as an approach aimed not merely at acquiring knowledge, but at developing the capacity to apply, transform, and adapt knowledge across diverse contexts (Mulder, 2017).

The emergence of competency-based education is closely linked to the need to rethink the relationship between education systems and labor markets. Traditional education models largely focused on discipline-based knowledge transmission, a model increasingly perceived as inadequate in the face of rapidly changing social and economic conditions. As transferable skills and higher-order cognitive competencies gain importance, the question of "how learning occurs" has become as central as "what is taught" (Hattie, 2012).

There is broad consensus in the literature that competency is a multidimensional construct. While Spencer and Spencer (1993) conceptualized competency as a combination of characteristics enabling superior performance, contemporary approaches expand this definition to include knowledge, skills, attitudes, and values as an integrated whole (OECD, 2019; Mulder, 2017). This expanded perspective highlights that competencies are not limited to measurable outputs but are also linked to individuals' ways of thinking, value systems, and attitudes toward learning.

A key characteristic of competency-based education is its emphasis on learning processes rather than solely on outcomes. Learning is viewed not as a time-bound activity, but as a lifelong, dynamic developmental process. The OECD Learning Compass 2030 framework structures this perspective around the concept of lifelong learning, identifying the development of competencies for coping with uncertainty, complexity, and change as a central goal (OECD, 2019).

Pedagogically, competency-based approaches require a redefinition of teacher and student roles. In traditional teacher-centered models, educators function primarily as transmitters of knowledge; in competency-based models, they act as facilitators, guides, and providers of feedback. Students, in turn, shift from passive recipients of information to active learners who inquire, construct, and produce knowledge (Biesta, 2015). This transformation necessitates more interactive, collaborative, and problem-based learning environments.

Another critical dimension of competency-based education concerns assessment. While traditional assessment relies heavily on knowledge recall through examinations, competency-based models emphasize performance-, process-, and

context-oriented assessment tools. Portfolios, project-based work, self-assessment, and peer assessment enable more holistic monitoring of competency development (Boud & Falchikov, 2007).

The literature also includes critical perspectives on competency-based education. Some scholars argue that this approach risks excessive measurement and standardization, potentially marginalizing the humanistic and ethical dimensions of education (Biesta, 2010). Such critiques caution against reducing competencies to technical skill lists, emphasizing instead that competencies cannot be separated from values, ethical responsibility, and social context (UNESCO, 2020).

In conclusion, the literature indicates that competency-based education offers a strong alternative in addressing the complexity and uncertainty of the twenty-first century. However, its effectiveness depends on conceptualizing competencies not as narrow performance metrics but as dynamic structures supporting holistic human development. Accordingly, education systems must be designed with sufficient flexibility to prepare individuals not only for present challenges but also for problems yet to be defined.

2.3. Artificial Intelligence, Human Competencies, and Education

The rapid advancement of artificial intelligence technologies has reignited theoretical and practical debates about the role of humans in education. Machine learning, big data analytics, and generative AI applications increasingly demonstrate human-level or even superior performance in information access, content generation, and problem solving. These developments necessitate a redefinition of the fundamental goals of education and the competencies it seeks to cultivate.

The literature generally approaches the impact of AI on education through two main perspectives. The first views AI as a threat capable of replacing human labor, while the second considers AI as a tool that complements and augments human competencies (Autor, 2015; Brynjolfsson & McAfee, 2017). Contemporary research suggests that the latter perspective is more realistic and sustainable. The key issue is not whether AI will replace humans, but how human–AI collaboration will be structured.

AI systems offer significant advantages in data-intensive tasks due to their computational speed and capacity. However, they face limitations in defining problem goals, prioritizing values, and engaging in contextual meaning-making. In these areas, human competencies remain decisive. The education literature emphasizes that competencies such as critical thinking, creative problem solving, ethical reasoning, and contextual awareness are difficult to substitute with AI (OECD, 2021; Floridi et al., 2018).

Within this context, the ability to ask questions emerges as a central human competency in the age of AI. AI systems generate meaningful outputs only to the extent that they are prompted with well-formulated questions. Thus, the capacity to ask deep, critical, and purposeful questions becomes a prerequisite for effectively leveraging AI. The literature interprets this shift as a transition in education from an “answer-producing” orientation to a “question-generating” one (Fullan & Langworthy, 2014).

Another key concept highlighted in the AI era is adaptive thinking. Adaptive thinking refers to the ability to respond flexibly to changing conditions by reorganizing existing knowledge and experience. This competency underpins effective decision-making in environments characterized by uncertainty and complexity. Educational research indicates that adaptive thinking encompasses not only cognitive but also affective and ethical dimensions (Hatano & Inagaki, 1986; OECD, 2019).

AI also holds potential for personalizing learning processes. AI-supported learning analytics can analyze learners’ pace, preferences, and strengths to offer personalized learning experiences. However, the literature cautions that without alignment with pedagogical goals, such technologies may increase the risk of superficial learning (Selwyn, 2019). Therefore, AI use in education must be guided by pedagogical principles and ethical frameworks.

Ethical considerations are critical in discussions of AI and education. Issues such as algorithmic bias, data privacy, and accountability constitute major concerns. Floridi et al. (2018) argue that AI systems not designed in accordance with ethical principles risk deepening social inequalities. Consequently, education systems should equip individuals not only with the ability to use AI but also with the competency to critically and ethically evaluate these technologies.

In summary, the literature underscores that the primary aim of education in the age of AI should not be to adapt humans to technology, but to strengthen distinctly human competencies. While AI facilitates access to and processing of information, humans remain central in meaning-making, value-based judgment, and holistic problem solving. Education systems must therefore be restructured around a competency framework that emphasizes the complementary relationship between humans and AI.

2.4. World Economic Forum Competency Frameworks and Critical Evaluation

One of the most influential efforts to systematically define emerging competencies in the twenty-first century is the series of “Future of Jobs” reports published by the World Economic Forum. These reports analyze global labor market transformations to identify key competency domains expected of individuals in the future workforce. A review of these reports reveals that while technical skills retain importance, cognitive, social, and emotional competencies have become increasingly central (World Economic Forum, 2018; 2020; 2023).

The World Economic Forum’s competency frameworks highlight critical thinking, problem solving, creativity, learning agility, and emotional intelligence as distinguishing features of the future workforce. These frameworks indicate that education systems must move beyond merely imparting vocational knowledge and technical skills to become holistic systems that prepare individuals for uncertainty, complexity, and rapid change. This perspective aligns closely with discussions of global megatrends and competency-based education presented earlier.

However, the literature also offers critical evaluations of the World Economic Forum’s frameworks. Some scholars argue that these reports are primarily driven by business perspectives and insufficiently address the social, ethical, and cultural dimensions of education (Biesta, 2010; Young, 2013). Such critiques caution that framing competencies solely in terms of economic productivity and employability may overshadow education’s public and humanistic functions.

The risk of reducing competencies to narrow economic interpretations constitutes a major debate in education. In contrast, the OECD Learning Compass 2030 framework broadens the discussion by integrating individual well-being, social responsibility, and sustainability into competency discourse (OECD, 2019). This approach reinforces the notion that competencies should contribute not only to labor market adaptation but also to meaningful and responsible living.

A strength of the World Economic Forum’s reports lies in their treatment of competencies as dynamic rather than static constructs. The changing prominence of different skills over time illustrates the need for continuous updating in education. However, this dynamism also presents significant challenges for education systems, raising questions about how curricula can respond effectively to rapid change (Rosenberg, 2020).

Another debated issue concerns the assessment of competencies. Many competencies identified by the World Economic Forum—such as creativity, critical thinking, and adaptive learning—are inherently abstract and context-dependent, making them difficult to measure using standardized tools. This difficulty raises the risk of superficial implementation of competency-based approaches (Allais, 2014).

Overall, the literature suggests that while the World Economic Forum’s competency frameworks provide valuable reference points for education policy, they should not be treated as prescriptive solutions. Instead, they must be interpreted critically, in conjunction with pedagogical, ethical, and social considerations, and adapted to cultural contexts. The future of education depends not only on which competencies are developed, but also on the values and pedagogical principles guiding their development.

3. METHODOLOGY

This study was designed as a qualitative inquiry aimed at examining the transformation of education systems in the age of artificial intelligence and identifying prominent twenty-first-century competencies. Rather than employing quantitative measurement or experimental designs, the study utilized literature review and document analysis methods, enabling in-depth conceptual analysis. A qualitative research approach was deemed appropriate given its capacity to address complex and multidimensional educational phenomena within their contexts (Creswell, 2013).

3.1. Research Design

The study is based on a descriptive and interpretive qualitative research design. Qualitative research focuses on understanding the meaning-making processes of individuals, institutions, and systems, enabling in-depth exploration

beyond numerical measurement (Creswell & Poth, 2018). Given the abstract and multifaceted nature of concepts such as artificial intelligence, competency, and education, a qualitative design provides an appropriate framework.

In the first phase, contemporary academic studies on artificial intelligence, twenty-first-century competencies, and the transformation of education systems were systematically reviewed. Peer-reviewed journal articles, books, and academic reports—particularly those published within the last decade—were prioritized.

The literature review was conducted as an analytical process, not merely summarizing existing studies but comparing theoretical perspectives and identifying common themes and debates. This approach strengthened the study's theoretical framework and facilitated contextual positioning of the research problem (Webster & Watson, 2002).

3.2. Document Analysis and Data Analysis

In the second phase, policy documents and reports published by international organizations were analyzed using document analysis. This method involves systematic examination of written materials to extract meanings relevant to research questions (Bowen, 2009). Reports from the World Economic Forum, OECD, UNESCO, and the European Union were examined.

Data were analyzed using descriptive and thematic analysis approaches. Key concepts and themes were identified and interpreted by comparing findings from document analysis with those from the literature review. Thematic analysis was selected for its capacity to systematically reveal patterns of meaning in qualitative data (Braun & Clarke, 2006).

As the study did not involve human participants, ethical committee approval was not required. Nevertheless, all sources were properly cited, and academic ethical standards were strictly observed.

4. FINDINGS AND DISCUSSION

In this section, the findings obtained through the literature review and document analysis are presented, and these findings are discussed in the context of the transformation of education systems in the age of artificial intelligence. The findings are structured around the nature of the competencies that have come to the fore in the twenty-first century, how these competencies are addressed by education systems, and the role of artificial intelligence technologies in this process.

4.1. Transition from Knowledge-Based Education to Competency-Based Education

The research findings reveal that the traditional knowledge-based understanding of education has become increasingly inadequate under the conditions of the twenty-first century. In the literature, the accelerating pace of knowledge production and the rapid obsolescence of knowledge clearly demonstrate that education cannot be sustained through a structure based solely on the transmission of information. This finding is consistent with the paradigm-shift necessity emphasized in the reports of the OECD (2019; 2021) and the World Economic Forum (2023).

The findings indicate that education systems are increasingly moving toward competency-based approaches. Competency-based education aims to develop individuals' capacity not merely to memorize discrete pieces of information, but to use such knowledge across different contexts, adapt it to new situations, and apply it effectively in problem-solving processes. This illustrates that the performance-based competency understanding defined by Spencer and Spencer (1993) has evolved into a more holistic framework in contemporary literature (Mulder, 2017; OECD, 2019).

The findings further demonstrate that conceptualizing competency as an integrated structure of knowledge, skills, attitudes, and values has become decisive for education systems. This approach necessitates focusing not only on cognitive outcomes in education, but also on individuals' attitudes toward learning, ethical awareness, and sense of social responsibility. Studies reporting similar findings in the literature show that competency-based approaches enhance individuals' capacity to cope with uncertainty (Biesta, 2015; OECD, 2021).

In this context, the research findings indicate that the transition from a knowledge-based educational understanding to a competency-based approach is not merely a pedagogical preference, but a structural necessity. If education systems fail to realize this transformation, it is anticipated that individuals will experience serious difficulties in adapting to rapidly changing social and economic conditions.

4.2. The Central Role of Adaptive Thinking and Lifelong Learning Competencies

Another significant finding of the study is that adaptive thinking and lifelong learning competencies have risen to a critical position in the twenty-first century. In the literature, adaptive thinking is defined as an individual's ability to rapidly adapt to changing conditions and to reorganize and apply existing knowledge and experiences to new situations (Hatano & Inagaki, 1986; OECD, 2019). The findings indicate that this competency has become one of the primary goals of education systems, particularly in the context of artificial intelligence and digital transformation.

The reports analyzed within the scope of document analysis demonstrate that individuals will change occupations many times throughout their careers and that these transitions can only be managed through the capacity for continuous learning. The World Economic Forum (2023) defines learning agility as a distinguishing competency in the future workforce. This finding shows that adaptive thinking is not merely an individual skill, but also an educational outcome that must be developed systematically.

The literature emphasizes that adaptive thinking is closely associated with effective decision-making in environments characterized by uncertainty and complexity. In this context, it is noted that education systems should design learning environments that expose students not to predictable and standardized problems, but to open-ended and multidimensional challenges (Fullan & Langworthy, 2014). The research findings show that problem-based learning, project-based work, and interdisciplinary approaches are pedagogical tools that support adaptive thinking.

The competency of continuous learning stands out as a complementary element of adaptive thinking. The findings indicate that treating learning as a process limited to a specific educational period has lost its validity under current conditions. The OECD Learning Compass 2030 framework defines the development of individuals' capacity to learn how to learn as one of the fundamental goals of education systems (OECD, 2019). This approach suggests that education systems should not only provide individuals with knowledge, but also equip them with the ability to manage learning processes.

These findings directly align with the "ability to evolve" emphasized in your presentations. Adaptive thinking and continuous learning emerge as fundamental competencies that enable individuals to be prepared not only for today's conditions but also for future circumstances that have not yet been defined.

4.3. Question-Asking Skills and Human–Artificial Intelligence Collaboration in the Age of AI

The research findings reveal that one of the fundamental competencies distinguishing humans from technology in the age of artificial intelligence is the ability to ask questions. AI systems can generate rapid and effective outputs using large datasets; however, these outputs are directly related to the quality of the questions posed to them. This indicates that education must evolve from a structure focused solely on teaching correct answers to one that cultivates individuals capable of producing meaningful and deep questions.

In the literature, the skill of asking questions is emphasized as being closely related to critical thinking and creative problem solving. Chin and Osborne (2008) note that high-quality questions increase conceptual depth in learning processes and enable individuals to construct knowledge actively rather than consuming it passively. The research findings support this view and show that students demonstrate higher levels of cognitive engagement in learning environments where they confront open-ended, multidimensional, and inquiry-oriented questions.

In the context of artificial intelligence, the importance of question-asking becomes even more pronounced through the concept of human–AI collaboration. Contemporary literature emphasizes that artificial intelligence should be considered not as an element replacing human labor, but as a partner that complements human competencies (Brynjolfsson & McAfee, 2017). In this collaboration model, the human role comes to the fore in defining the problem, determining goals, and conducting contextual and ethical evaluations. Artificial intelligence functions as a support mechanism providing analytical and computational capacity within this framework.

The research findings indicate that education systems do not systematically develop the competencies needed to support this collaboration model. In particular, exam-oriented assessment approaches based on a single correct answer are observed to limit question-asking skills and critical thinking. This suggests that education systems remain distant from supporting the human–machine interaction required by the age of artificial intelligence.

In this context, the question-asking skill must be pedagogically repositioned. The research findings show that inquiry-based learning, discussion-based instruction, and problem-based learning approaches increase individuals' capacity to work effectively with artificial intelligence (Fullan & Langworthy, 2014). These approaches make it possible for students not only to access information, but also to question the boundaries and assumptions of knowledge.

As a result, education in the age of artificial intelligence should aim not to teach individuals "what to think," but "how to think" and "which questions to ask." This transformation necessitates an educational understanding that strengthens human-AI collaboration and places distinctly human competencies at its center.

4.4. Structural Transformation Requirements of Education Systems

The research findings show that education systems in the twenty-first century require transformation not only at the curriculum level but also at the structural level. In the literature, it is frequently emphasized that existing education systems have largely been shaped according to the needs of industrial society and struggle to adapt to today's world, which is oriented around knowledge, technology, and uncertainty (Robinson, 2015).

The findings indicate that the centralized, standardized, and exam-oriented structures of education systems constitute a significant barrier to competency-based education. While these structures reduce learning to measurable outputs, they constrain the development of complex competencies such as adaptive thinking, creativity, and ethical reasoning. In the literature, this phenomenon is defined as the "bias toward teaching what is measurable" (Biesta, 2010).

The research findings also show that teacher roles must be redefined within education systems. In competency-based and AI-supported learning environments, teachers evolve from the role of knowledge transmitters to positions in which they design learning processes, provide guidance, and deliver feedback. This transformation makes it necessary to restructure teacher education programs as well. Indeed, the literature emphasizes that developing teachers' digital pedagogical competencies is the key to transformation in education (Koehler & Mishra, 2009).

The findings further indicate that school and university structures must be reorganized to support interdisciplinary learning. Complex global problems cannot be solved within the boundaries of a single discipline; rather, they require integrating different domains of knowledge. This necessitates that education systems adopt interdisciplinary and problem-based learning approaches as central components (Repko & Szostak, 2020).

Finally, it becomes evident that the ethical and value dimensions should not be neglected in the transformation of education systems. In the age of artificial intelligence, education should cultivate individuals who not only use technology but also question its societal impacts and assume ethical responsibility. This approach aligns with the understanding of education as an institution that is not only economic, but also social and humanistic.

4.5. General Discussion

The findings obtained in this study largely align with the main trends identified in the literature regarding the transformation of education systems in the age of artificial intelligence. In particular, the findings concerning the limitations of knowledge-based education parallel contemporary reports published by the OECD and the World Economic Forum. The literature emphasizes that knowledge rapidly loses currency and that, for this reason, the primary aim of education should be to develop learning capacity rather than to transmit information (OECD, 2019; World Economic Forum, 2023).

The adaptive thinking and lifelong learning competencies highlighted in this study are increasingly becoming central within the educational sciences literature. The concept of adaptive expertise, whose foundations were laid by Hatano and Inagaki's (1986) early work, is considered in contemporary literature as the key to coping with uncertainty and complexity. Similarly, Fullan and Langworthy (2014) argue that deep learning approaches strengthen students' capacities to adapt to changing conditions. In this context, the study's findings support the view that adaptive thinking is not merely an individual skill but an educational outcome that must be developed systematically.

The emphasis on the central role of question-asking skills in the context of artificial intelligence also aligns with contemporary debates in the literature. While Chin and Osborne (2008) show that high-quality questions increase the depth of learning and support critical thinking, Floridi et al. (2018) argue that the distinctive human role in the age of AI lies in ethical reasoning, contextual evaluation, and the capacity to create meaning. This study brings these

approaches together in the educational context and emphasizes that question-asking skills lie at the center of human–AI collaboration.

The findings also indicate that the structural characteristics of education systems pose a significant obstacle to competency-based transformation. Biesta (2010) argues that reducing education to measurable outputs leads to the marginalization of humanistic and ethical dimensions. This critique is consistent with the constraining effects of exam-oriented and standardized education structures on adaptive thinking and creativity identified in the study. Likewise, Robinson (2015) contends that education systems are structured according to the needs of industrial society and struggle to adapt to today's creative and uncertain world.

The findings of this study show that the competency frameworks proposed by the World Economic Forum provide an important reference point, but that these frameworks should not be treated independently of pedagogical and ethical context. The fact that the OECD Learning Compass 2030 framework addresses competencies together with dimensions of individual well-being, social responsibility, and sustainability supports the holistic approach advanced by this study (OECD, 2019).

In conclusion, this general discussion confirms a growing consensus in the literature on the transformation of education systems in the age of artificial intelligence: transformation in education cannot be limited merely to technology integration or curriculum updates. Rather, it requires a deep paradigm shift that addresses together how competencies are defined, by which values they are developed, and how education systems can be restructured around a human-centered understanding.

5. CONCLUSION AND RECOMMENDATIONS

In this section, the main conclusions drawn from the study regarding the transformation of education systems in the age of artificial intelligence are presented, followed by recommendations for different stakeholders in education based on these conclusions. The conclusions and recommendations are grounded in findings obtained through the literature review and document analysis and are addressed within a holistic framework by relating them to the relevant literature.

5.1. Conclusions

One of the core conclusions of this study is that the traditional knowledge-based understanding of education is structurally inadequate under the rapid, uncertain, and complex conditions of the twenty-first century. The accelerating pace of knowledge production and the fact that knowledge quickly loses currency make it necessary to redefine the fundamental function of education. In the literature, this transformation is explained through competency-based approaches that focus on developing learning capacity rather than transmitting information (OECD, 2019; World Economic Forum, 2023).

Another important conclusion is that competency cannot be limited solely to cognitive knowledge and technical skills. When competency is evaluated as an integrated structure of knowledge, skills, attitudes, and values, it becomes clear that education should encompass not only academic achievement but also individuals' ethical awareness, their attitudes toward learning, and their sense of social responsibility. This conclusion is consistent both with classical competency definitions (Spencer & Spencer, 1993) and with contemporary holistic approaches (Mulder, 2017; OECD, 2019).

The study shows that adaptive thinking and lifelong learning competencies have assumed a central position in the age of artificial intelligence. Considering that individuals will experience multiple occupational and role changes throughout their lives, it is critically important for education systems to cultivate individuals who can adapt to change itself. This finding is consistent with the literature on adaptive expertise and lifelong learning (Hatano & Inagaki, 1986; Fullan & Langworthy, 2014).

Another key conclusion emerging from the study is that the ability to ask questions has become a distinctive human competency in the age of artificial intelligence. AI systems can produce meaningful outputs only to the extent that they are prompted with high-quality questions. This indicates that education systems should move away from approaches that promote memorizing correct answers and instead adopt pedagogical perspectives that develop inquiry, problem definition, and contextual thinking skills (Chin & Osborne, 2008; Floridi et al., 2018).

Finally, the study shows that the centralized, standardized, and exam-oriented structures of existing education systems constitute a major obstacle to competency-based transformation. This finding aligns with critiques of reducing

education to measurable outputs and suggests that the humanistic and ethical dimensions of education should be re-centered (Biesta, 2010; Robinson, 2015).

5.2. Recommendations

Based on the conclusions obtained in this study, the following recommendations have been developed for different stakeholders in education.

5.2.1. Recommendations for Researchers

It is recommended that researchers move beyond studies that address the relationship between artificial intelligence and education only at the level of technological impact or tool use, and instead focus on research that examines pedagogical, ethical, and social dimensions together. In particular, deepening concepts such as adaptive thinking, question-asking skills, and human–AI collaboration both theoretically and empirically will make significant contributions to the literature (Floridi et al., 2018; Selwyn, 2019).

In addition, it is necessary to increase comparative studies examining how competency-based education approaches operate in different cultural and socioeconomic contexts. Longitudinal research that tracks the effects of these approaches on students' learning processes, career transitions, and social adaptation will produce strong evidence for policymakers (Brown et al., 2011; OECD, 2021).

5.2.2. Recommendations for Teachers and Educators

It is recommended that teachers and educators redesign learning environments in ways that support students' inquiry, problem-solving, and critical thinking skills. Problem-based, project-based, and inquiry-based learning approaches strengthen students' adaptive thinking and deep learning capacities (Fullan & Langworthy, 2014; Hattie, 2012).

The use of artificial intelligence tools in classrooms should be handled in ways that serve pedagogical objectives and observe ethical principles. It is important to support teachers not merely as technology users, but as learning designers in this process. In this context, it is recommended to expand continuous professional development programs aimed at enhancing teachers' digital pedagogical competencies (Koehler & Mishra, 2009; UNESCO, 2020).

5.2.3. Recommendations for Educational Institutions and Administrators

School and university administrators should create institutional structures and flexible learning environments that support competency-based education. Encouraging interdisciplinary learning, project-based work, and collaboration-based instructional models at the institutional level is important for sustaining transformation in education (Repko & Szostak, 2020).

In addition, it is recommended that assessment systems be diversified by moving beyond structures based solely on standardized exams and incorporating tools oriented toward performance, process, and development. Methods such as portfolios, projects, and peer assessment make it possible to monitor competencies more holistically (Boud & Falchikov, 2007).

5.2.4. Recommendations for Decision-Makers and Policymakers

Education policies should be restructured with a competency-based understanding and a long-term perspective. It is important to address curriculum, teacher training, and assessment policies not in isolation but in an integrated and holistic manner. In particular, competencies such as adaptive thinking, lifelong learning, and ethical awareness should be clearly defined in policy documents (OECD, 2019; World Economic Forum, 2023).

Moreover, developing ethical principles and regulatory frameworks regarding the use of artificial intelligence technologies in education will help reduce risks related to data privacy and equity. Such frameworks are critical for preventing technological innovations from deepening educational inequalities (Floridi et al., 2018; UNESCO, 2020).

5.2.5. Recommendations for Families

It is recommended that families support the development of curiosity, inquiry, and positive attitudes toward learning, rather than focusing expectations solely on academic achievement. The relationship established with artificial intelligence and digital technologies should be addressed not only in terms of usage skills, but also through the lenses of critical thinking and ethical awareness (Selwyn, 2019).

Strengthening family–school collaboration will contribute to creating consistent learning environments that support children’s competency-based development. This collaboration will facilitate the implementation of a holistic educational approach that supports children’s academic as well as socio-emotional development.

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