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Transformation of Human-Technology Relations in Human-Computer Interaction: A Systematic Literature Review

Abdul Manan[1], Hikmat Kodrat[2], Apriya Maharani Rustandi[3]
[1]IPWIJA University, [2]Pamulang University, [3]Indonesian education university

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Abstract

The development of information technology and computer science has driven a fundamental transformation in education through the use of Learning Management Systems, online and hybrid learning, and artificial intelligence. These changes position technology not merely as a tool but as an actor influencing the learning process and decision-making, while also raising challenges related to the quality of interactions, user experience, and ethical aspects. This study aims to examine the transformation of human-technology relations in digital education through a Human-Computer Interaction (HCI) perspective. The method used is a Systematic Literature Review (SLR) by searching scientific publications in the Google Scholar, Scopus, and ResearchGate databases. Selected articles were analyzed qualitatively through thematic synthesis. The results of the study indicate a paradigm shift in human- computer interaction from a command-based approach to an adaptive, contextual, and user-experience-oriented interaction. Artificial intelligence plays a significant role in enhancing learning personalization, but also has the potential to reduce human control and lead to bias and low system transparency. This study concludes that the development of educational technology needs to integrate the principles of HCI and human-centered design so that digital transformation is not only oriented towards technical efficiency but also maintains autonomy and human values in education.

Corresponding Author:
Abdul Manan
[1]IPWIJA
University(abdmanan080@gmail.com)

1. INTRODUCTION

Developments in information technology and computer science over the past decade have driven major transformations in various sectors, including education. Globally, the digitalization of education is marked by the increasing use of Learning Management Systems (LMS), online and hybrid learning, and the use of artificial intelligence to personalize learning.(Özdemir et al., 2021)A UNESCO report shows that more than 90% of countries worldwide have integrated digital platforms into their formal education systems, both to support face-to-face and distance learning. Furthermore, an OECD report reveals that the use of digital technology in education is no longer limited to delivering content, but has been used for learning behavior analysis, automated feedback, and data- driven academic decision-making.(Kou et al., 2019)This phenomenon indicates a shift in the role of technology in education from being a mere tool to a key player in the learning process.

In Indonesia, a similar trend is gaining momentum, particularly following the acceleration of digital transformation in the education sector. Data from the Ministry of Education, Culture, Research, and Technology shows that the majority of educational institutions have adopted digital

learning platforms and computer-based evaluation systems in their teaching and learning processes.(Singh et al., 2022)The implementation of LMS, computer-based assessments, and the use of algorithm-based learning applications has become common practice at various levels of education.(Magliocca et al., 2024)However, various national studies also note that the increased adoption of this technology has not been fully matched by improvements in the quality of user interactions. National digital literacy surveys indicate that there remains a gap between students' and educators' abilities to use technology critically and productively.(Visser et al., 2018)This confirms that the success of digital education transformation is determined not only by the availability of infrastructure, but also by the quality of interaction between humans and technology.

From a Human Computer Interaction (HCI) perspective, this phenomenon reflects the increasing complexity of the relationship between users, both educators and students, with computing systems.(Stephanidis et al., 2019). Interactions that were previously instructional and one-way have now evolved into adaptive, contextual, and data-driven interactions. Artificial intelligence-based learning systems, such as intelligent tutoring systems, virtual learning assistants, and material recommendation systems, are able to tailor learning content and strategies based on user behavior and preferences.(Maedche et al., 2019)International studies report that AI-based adaptive learning systems can improve learning efficiency and personalize content. However, various studies also highlightcritical issues, such as reduced human control over the learning process, potential algorithmic bias, and the low transparency of black-box systems.(Holmström, 2022).

Various international and national studies have identified that the main challenges in digital education lie not only in the technical aspects, but also in the user experience, trust, and ethical dimensions of technology use.(Pea, 2018). The OECD report shows that the use of educational technology that is not designed based on the principles of human-computer interaction has the potential to increase students' cognitive load and reduce learning motivation.(Chen et al., 2018)On the other hand, national studies also revealed that less user-friendly interface designs and minimal user involvement in system development are factors that hinder the effectiveness of digital learning. This phenomenon strengthens the argument that educational technology development requires a more human-centered approach.(Brock & Wangenheim, 2019).

As a solution assumption, a number of studies show that the application of a human-centered computing approach in the design and implementation of educational technology is able to improve the quality of human-computer interaction.(Lu et al., 2020)This approach emphasizes user involvement in the design process, understanding the cognitive and emotional needs of learners, and integrating ethical values and transparency into computing systems.(Cheng, 2024). The results of relevant research show that learning systems designed based on HCI and human-centered design principles tend to significantly increase learning engagement, user satisfaction, and learning effectiveness.(MacKenzie, 2024).

However, studies on the transformation of human and technology relations in the context of education that are examined comprehensively through an HCI perspective are still relatively limited.(Sakuma et al., 2018)Many studies focus on the implementation of specific technologies, but have not systematically summarized global and national trends, interaction patterns, and challenges of human-technology relations in the digital education ecosystem. Therefore, this research is important to be conducted through a Systematic Literature Review (SLR) approach to examine facts, phenomena, and trends in digital education issues, while identifying the role of Human Computer Interaction as a conceptual and practical solution in the development of

computer science-based educational technology.

2. MATERIALS AND METHODS

This research uses a literature review method with a Systematic Literature Review (SLR) approach to comprehensively examine the transformation of human and technology relations from a Human Computer Interaction (HCI) perspective.(Hanelt et al., 2021)This approach was chosen because it provides a systematic framework for exploring, evaluating, and synthesizing relevant scientific works to address research problems. Furthermore, the SLR method allows researchers to identify patterns, development trends, and research gaps within the field of HCI. The literature review approach is considered effective in understanding the conceptual and empirical dynamics of a scientific field, especially when the research topic is multidisciplinary and continuously evolving, such as the relationship between humans and technology.(Ferreira & Reis, 2023).

The research process began with a literature search through several credible scientific databases relevant to the fields of computer science and HCI, namely Google Scholar, Scopus, and ResearchGate. The selection of these databases was based on their broad publication coverage, encompassing reputable international journals as well as relevant national research. The search was conducted using a combination of keywords such as philosophy of computer science, human-computer interaction, human-centered computing, and philosophy of technology. These keywords were chosen to capture literature that discusses the transformation of human-technology relations not only from a technical perspective, but also from a conceptual and philosophical perspective.

Articles obtained from the search process then underwent a selection and screening phase to ensure their alignment with the research focus. At this stage, the titles, abstracts, and keywords were reviewed to assess the relevance of the theme, research objectives, and their relevance to human- technology relations issues within the HCI framework. Articles that focused solely on the technical aspects of computing systems without examining the dimensions of human interaction, user experience, or philosophical perspectives were excluded from the review.

To maintain the quality and consistency of the analyzed literature, this study established inclusion and exclusion criteria. Inclusion criteria included articles written in English or Indonesian, published within the last ten years (2015–2025), excluding classic works that have significantly influenced HCI and philosophy of technology studies, and articles that explicitly discuss philosophical, conceptual, or relational aspects between humans and technology. Popular opinion articles, non-academic reports, and publications that have not undergone a peer-reviewed process were excluded from the study.

Literature that met the criteria was then analyzed qualitatively through in-depth reading to identify key themes, key concepts, and patterns of transformation of human-technology relations in the context of HCI. The synthesis process was carried out by grouping findings based on the focus of the study, such as the paradigm shift of human-computer interaction, the role of artificial intelligence in interactive systems, the application of the human-centered design approach, and issues of ethics, trust, and transparency in computing systems. This stage aims to build a comprehensive understanding of the dynamics and implications of human-technology relations in the development of HCI.

In its implementation, this research utilizes five primary articles from internationally and nationally indexed journals as core references, supported by a number of additional literature in the form of books and conceptual articles in the fields of philosophy of technology and human-computer interaction. This combination of sources is used to strengthen the analysis and ensure that

the study is not only empirical but also has a strong theoretical foundation and is relevant to current scientific developments.

3. RESULTS

No	Author & Year	Article/Book Title	Context / Field	Research methods	Key Findings
1.	Norman (2016)	*The Design of Everyday Things*	Design & HCI	Conceptual	Emphasizes that computing systems should be designed based on how humans think and behave, not just technical efficiency.
2.	Rogers et al. (2020)	*Interaction Design: Beyond Human–Computer Interaction*	HCI & UX	Literature & Conceptual	HCI has evolved from technical interfaces to interactive experiences involving cognitive, emotional, and social aspects.
3	Hook (2018)	*Designing with the Body: Somaesthetic Interaction Design*	Affective interaction	Conceptual & Design	Human-technology interaction involves bodily and emotional dimensions, deepening the human relationship with digital systems.
4	Shneiderman (2020)	*Human-Centered Artificial Intelligence*	AI & HCI	Conceptual	AI must be developed with a human-centered approach to ensure the system remains safe, transparent, and trustworthy.
5	Holmes et al. (2019)	*Artificial Intelligence in Education: Promise and Implications*	Digital Education	Literature Review	AI in education increases the personalization of learning, but has the potential to reduce educator control if not designed well.
6	Parasuraman & Riley (2017)	*Humans and Automation*	Automation	Theoretical Review	Reliance on automated systems can reduce human alertness and reflective capacity.
7	Eubanks (2018)	*Automating Inequality*	Algorithms & Ethics	Case study	Non-transparent algorithmic systems can reinforce social inequality and reduce human autonomy.
8	Hassenzahl et al. (2015)	*User Experience and Experience Design*	UX & HCI	Empirical	User experience-based design increases the satisfaction, engagement, and sustainability of human-computer interactions.

9	ISO 9241-210 (2019)	*Human-Centred Design for Interactive Systems*	HCI Standards	International Standards	Emphasizes the importance of user involvement throughout the interactive systems design cycle.
10	Floridi et al. (2018)	*AI4People: An Ethical Framework*	AI Ethics	Conceptual	The relationship between humans and technology must be based on the principles of
					transparency, fairness, and accountability.
11	Amershi et al. (2019)	*Guidelines for Human-AI Interaction*	Human AI Interaction	Review & Guideline	User trust in AI systems increases if the system is able to explain its processes and the limits of its capabilities.
12	Blandford et al. (2016)	*HCI Research: Evidence to Practice*	Multi-domain HCI	Systematic Review	HCI research remains fragmented and requires cross-context synthesis to build a comprehensive model of human-technology relations.

This study found that there has been a significant paradigm shift in human-computer interaction, from a command-based approach to adaptive, contextual, and user-experience-oriented interactions. The results of the literature review indicate that modern computing systems no longer require humans to adapt to machine logic, but rather are designed to align with how humans think, act, and feel. This finding aligns with Norman's (2016) view, which emphasizes the importance of system design based on human cognitive characteristics, and is reinforced by Rogers et al. (2020), who show that HCI has evolved beyond technical interfaces to interactive experiences that engage the cognitive, emotional, and social dimensions of users.

This study also found that artificial intelligence (AI) plays a major role in transforming the relationship between humans and technology. AI-based systems have transformed computers from passive tools to active partners in human decision-making. The reviewed literature shows that AI not only processes data but also provides recommendations, predictions, and adaptive feedback to users. These findings support Shneiderman's (2020) argument, which emphasizes the need for a human- centered artificial intelligence approach to ensure systems remain safe, trustworthy, and under human control. In the educational context, this study found that the use of AI enables personalized learning, but also has the potential to shift the role of educators if not balanced with appropriate pedagogical design, as stated by Holmes et al. (2019).

Furthermore, this study found that the increasing complexity of computing and automation systems also presents new challenges related to human control and autonomy. Excessive reliance on automated systems has the potential to reduce users' vigilance, reflective ability, and understanding of the system's decision-making process. This finding is consistent with the study by Parasuraman and Riley (2017), which identified the phenomenon of automation bias, where users tend to accept system decisions without critical evaluation. Furthermore, the literature also shows that opaque algorithmic systems can reinforce social inequality and reduce human autonomy, as Eubanks (2018) noted.

This study found that the human-centered design (HCD) approach is the dominant solution recommended in the literature to address the complexity of human-technology relations. This approach emphasizes the importance of user involvement throughout the design cycle, understanding human needs and limitations, and adapting technology to the actual context of use. The international standard ISO 9241-210 (2019) explicitly states that interactive system design should focus on the user as the center of the process. The reviewed empirical findings also indicate that systems designed withHCI and HCD principles result in higher levels of user satisfaction, engagement, and trust than purely technically oriented systems, as evidenced by Hassenzahl et al. (2015).

In addition to design aspects, this study found that issues of ethics, trust, and transparency are crucial dimensions in the relationship between humans and technology. Contemporary literature emphasizes that the success of a computing system is determined not only by its technical performance but also by the extent to which the system is fair, explainable, and accountable. This finding aligns with the ethical framework proposed by Floridi et al. (2018), which emphasizes the principles of transparency and fairness as the foundation of human-technology relations. Furthermore, research by Amershi et al. (2019) shows that user trust in AI systems increases when the system is able to clearly explain its processes, limitations, and potential errors.

Finally, this study identified a gap in HCI studies that still requires serious attention. Although the number of HCI studies continues to increase, most studies remain contextual, fragmented, and focused on specific domains. Consequently, a comprehensive and cross-sectoral model of human- technology relations is not yet available. This finding is consistent with Blandford et al. (2016), who highlighted the weak integration between empirical evidence and HCI design practice. Recent research also emphasizes the need for an interdisciplinary approach that integrates technical, social, and ethical aspects to build a more holistic HCI framework in the future (Preece et al., 2022).

4. CONCLUSION

Based on the results of a Systematic Literature Review (SLR) study, this study concludes that developments in information technology and computer science have fundamentally changed the relationship between humans and technology in the context of digital education. Human-computer interaction is no longer instructional and mechanistic, but has evolved into an adaptive, contextual, and user-experience-oriented interaction. This paradigm shift marks the transformation of technology's role from a mere learning aid to an active actor influencing users' cognitive, emotional, and social processes. The results indicate that the presence of artificial intelligence (AI) is a key factor in this transformation. AI-based learning systems are capable of delivering personalization, efficiency, and real-time decision-making support. However, the literature review also reveals that the use of AI without a human-centered approach has the potential to pose risks, such as reduced human control, algorithmic bias, low system transparency, and a weakened role of educators in the learning process. Thus, technological advances do not automatically translate to improved educational quality if they are not accompanied by human-centered interaction design. This study confirms that the Human Computer Interaction (HCI) and human-centered design (HCD) approaches are relevant conceptual and practical frameworks for addressing the complexity of human-technology relationships. The principles of user engagement, matching human cognitive and emotional characteristics, and adapting technology to real-world contexts have been shown to increase user satisfaction, engagement, and trust in digital learning systems. The international

standards and empirical findings reviewed reinforce HCI's position as an important foundation for the development of computer science-based educational technology. Furthermore, this study concludes that the dimensions of ethics, trust, and transparency are essential aspects in building healthy and sustainable human-technology relationships. Fair, explainable, and accountable computing systems not only increase user acceptance but also maintain human autonomy and responsibility in technology-based decision-making. Therefore, the integration of ethical principles into the design and implementation of interactive systems is an integral need in the digital education ecosystem. Finally, this study identifies a gap in HCI studies, which are still fragmented and limited to specific contexts. Further interdisciplinary research and cross-domain synthesis are needed to build a more comprehensive model of human-technology relationships. Therefore,This study contributes to strengthening theoretical and practical understanding of the role of Human Computer Interaction as a strategic approach in directing the transformation of digital education to remain oriented towards human values.

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6. DECLARATIONS

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