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THEMATIC ANALYSIS OF RESEARCH TRENDS IN HUMAN–COMPUTER INTERACTION USING LEXIMANCER

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ABSTRACT

The rapid advancement of computer technologies has rendered interaction with computers indispensable across nearly every facet of human life. This phenomenon has elevated the significance of Human-Computer Interaction (HCI) research, necessitating an investigation into diverse approaches and themes within the field. This study aims to reveal the evolution and trends in HCI by conducting a thematic analysis of articles published in the *International Journal of Human–Computer Interaction* between 1994 and 2025. Within the scope of this research, the digital interaction process is categorized into four fundamental periods based on chronological and thematic criteria: the Early Digital Interaction Era (1994-2002), the Web and Mobile Expansion Era (2003-2011), the Smart Systems and Experience-Oriented Interaction Era (2012-2019), and the Artificial Intelligence and Ethical/Hybrid Interaction Era (2020-2025). Utilizing a text-mining approach, the Leximancer analysis tool was employed to examine the abstracts of 3,776 articles, resulting in the generation of conceptual maps. The findings indicate a continuity of core concepts in the HCI field, such as 'design', 'study', 'user', and 'system'. While technical and application-oriented concepts including 'interface', 'task', 'performance', and 'usability' were predominant during the early period (1994-2002), user-centered and contextual themes such as 'experience', 'interaction', 'technology', 'social', and 'learning' have become prominent in the periods spanning 2012-2025.

Anahtar Kelimeler: Human–Computer Interaction, Text Mining, Leximancer.

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İNSAN-BİLGİSAYAR ETKİLEŞİMİ ALANINDAKİ ARAŞTIRMA EĞİLİMLERİNİN LEXIMANCER İLE TEMATİK ANALİZİ

Koray GÜNDÜZ¹

ÖZ

Bilgisayar teknolojilerinin hızlı gelişimi, insan yaşamının hemen her alanında bilgisayarlarla etkileşimi vazgeçilmez hale getirmiştir. Bu durum, insan-bilgisayar etkileşimi (İBE) araştırmalarının önemini artırmış ve bu alanda farklı yaklaşım ve temaların incelenmesini gerekli kılmıştır. Bu araştırma, *International Journal of Human-Computer Interaction* dergisinde 1994-2025 yılları arasında yayımlanan makaleleri tematik açıdan analiz ederek HCI alanındaki gelişim ve eğilimleri ortaya koymayı amaçlamaktadır. Bu çalışma kapsamında dijital etkileşim süreci kronolojik ve tematik açıdan dört temel döneme ayrılmıştır: 1994-2002 yılları arası Erken Dönem Dijital Etkileşim, 2003-2011 yılları arası Web ve Mobil Genişleme Dönemi, 2012-2019 yılları arası Akıllı Sistemler ve Deneyim Odaklı Etkileşim Dönemi ve 2020-2025 yıllarını kapsayan süreç ise Yapay Zekâ ile Etik/Hibrit Etkileşim Dönemi olarak sınıflandırılmıştır. Çalışmada, metin madenciliği yaklaşımı kapsamında Leximancer analiz aracı kullanılmış ve toplam 3.776 makalenin özetleri incelenerek kavramsal haritalar oluşturulmuştur. Bulgular, HCI alanında ‘tasarım’, ‘çalışma’, ‘kullanıcı’ ve ‘sistem’ gibi temel kavramların süreklilik gösterdiğini ortaya koymaktadır. 1994-2002 yıllarını kapsayan Erken dönemde ‘arayüz’, ‘görev’, ‘performans’ ve ‘kullanılabilirlik’ gibi teknik ve uygulama odaklı kavramlar ön planda iken; 2012-2025 yılları arasındaki dönemlerde ‘deneyim’, ‘etkileşim’, ‘teknoloji’, ‘sosyal’ ve ‘öğrenme’ gibi kullanıcı merkezli ve bağlamsal temalar öne çıkmıştır.

Anahtar kelimeler: İnsan-Bilgisayar Etkileşimi, Metin Madenciliği, Leximancer.

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1. INTRODUCTION

Human-Computer Interaction (HCI) began with the (Electronic Numerical Integrator and Computer) ENIAC, built in 1946. The ENIAC was the general-purpose computer (Sinha et al., 2010, p. 2). HCI was first called software psychology. HCI focuses on looking at software design and programming through a lens. HCI is expressed as a study of how people interact with computers. It is observed that HCI has become a field of research in computer science. In the 1990s, HCI earned recognition as a research area within computer science. HCI began incorporating user needs into system development processes. HCI made that approach the norm (Carroll, 1997, p. 514). Today, HCI looks at topics such as augmented reality, social computing, affective computing, and brain-computer interfaces (Jiang & Huang, 2023, p. 433). Notably, advancements in Artificial Intelligence (AI) are compelling researchers to re-evaluate traditional HCI principles, thereby necessitating more specialized studies of Human-AI Interaction (Mehdipour et al., 2024, p. 14).

HCI is a mix of fields. HCI sits at the intersection of computer science and technology, and of psychology and the social sciences (Carroll, 1997, p. 506; Wang et al., 2021, p. 1; Solis-Pino et al., 2024, p. 3). At its core, HCI examines how people use computers and other information-processing systems. Its primary focus is on the design, evaluation, and implementation of interactive computing systems, specifically aiming to make these interactions more comprehensible, efficient, and ultimately satisfying from the user's perspective (Carroll, 1997, p. 506; Sinha et al., 2010, p. 1; Solis-Pino et al., 2024, p. 3). It is widely recognized as an interdisciplinary domain that makes significant contributions to the core subjects of numerous traditional disciplines (Zhang & Li, 2004, p. 131).

Modern HCI has grown into a research area that includes disciplines. Modern HCI brings together theories and studies. Modern HCI draws especially on the fields of psychology, sociology, and ecology (Man et al., 2018, p. 797). HCI shows a structure that mixes disciplines. HCI encompasses computer science, psychology, sociology, graphic design, and industrial design (Wang et al., 2021, p. 1). The principles of HCI are widely used in different disciplines and application fields. These principles are used in the design of learning environments in the field of education (Alemdag & Çağiltay, 2018; Barutcu & Gülseçen, 2024; Solis-Pino et al., 2024), plays an important role in the development of robotic systems (Chandran, 2022) and medicine and health services (Sadeghi Milani, 2024). In addition, the principles of HCI are also applied in the design and development processes of current technologies such as voice assistants and in-car systems. In this context, it is seen that the principles of HCI not only improve the user experience, but also determine the shaping of technology (Sun & Duan, 2025, p. 1). The discipline is about learning how people use technology and what happens in the world around them (Carroll, 1997, p. 501). The discipline examines how people interact with devices. New work in areas such as Artificial Intelligence (AI) and robotics makes HCI increasingly important (Mehdipour et al., 2024, p. 14; Chandran, 2022, p. 1). This field is concerned with the analysis and design of 'user interfaces,' which are the computers as experienced and used by human users. Its primary objective is to understand the effects of human motivation, behavior, and experience on the usability of computer systems and to guide the development of new computer technologies by leveraging these constraints (Carroll & Campbell, 1989, p. 247). The goal of HCI is to build systems that are functional, safe, and usable. The goal of HCI is to ensure that systems meet end users' needs. In this context, the aim is to ensure that designed systems are user-friendly and responsive to user requirements (Khan et al., 2025, p. 864).

One research area in HCI is predicting user intentions and generating automated responses using deep learning models. The systems aim to improve user satisfaction in applications such as customer service platforms and voice assistants (Sun & Duan 2025, pp. 2-4). HCI, recognized as a 'design science,' primarily aims to understand and support people through technology. This involves not only the application of existing psychological theories but also the guidance and advancement of these theories within the context of technology development. Research in the field of HCI emphasizes that systems must be designed by taking into account the needs, abilities, and preferences of users (Carroll, 1997). In this setting, the two HCI concepts are functionality and usability. Functionality refers to the set of actions and services a system offers to the user; usability, conversely, denotes the extent to which specific users can employ the system effectively and efficiently to achieve particular goals (Sinha et al., 2010, p. 2). Usability is one of the most frequently referenced paradigms in product design, serving as a qualitative metric that allows for measuring a product's effectiveness of use (Capdevila et al., 2021; Novák et al., 2024, p. 4485).

What distinguishes this research from existing bibliometric or systematic reviews is its methodology; while it maps publication volumes and citation indices, it goes further by utilizing Leximancer-based machine learning algorithms to conduct a deep, comparative analysis of the conceptual evolution within the HCI field. In the subsequent sections of this study, conceptual maps and inter-conceptual relationships for the four identified periods will be visualized and presented. Subsequently, the findings will be discussed within the framework of HCI literature, concluding with insights and projections regarding the future trajectory of the field.

2. Literature Review

The historical evolution of HCI provides a critical foundation for understanding the current state of the discipline. The historical timeline presented in Figure 1 summarizes the technological foundations and the developmental process of the HCI field.

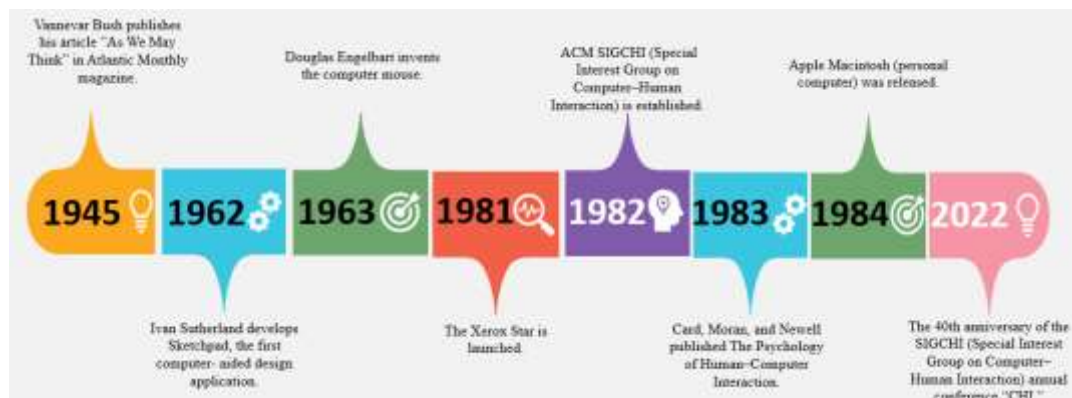


Figure 1. Major events in the history of human-computer interaction (MacKenzie, 2024, p. 3).

The field of HCI is a dynamic structure that continuously expands in parallel with technological advancements and encompasses diverse research focuses due to its inherently interdisciplinary nature. Among the pioneering studies addressing the historical development and theoretical framework of the field, Hartson (1998) examined the theories and models supporting HCI applications through the lens of usability engineering. Similarly, Ho et al. (2009) discussed the historical evolution and various research traditions of HCI by placing it within a contextual framework. Furthermore, Zhang & Li (2004), who questioned the position of HCI within Management Information Systems (MIS), reported future research requirements by analyzing publication trends between 1990 and 2002.

Comprehensive analyses aimed at determining the intellectual structure and knowledge domains of the HCI literature demonstrate how the field has transformed over time. Through a citation and cluster analysis of 1,168 articles, Shiau et al. (2016) identified twelve fundamental knowledge areas and emphasized that concepts such as personalized system design and facial expression are newly emerging terms in the literature. With the rise of technological diversity, Carvalho et al. (2017) focused on the quality metrics of ubiquitous systems, while Azofeifa (2022) systematically addressed the frequency of use for multimodal interaction Technologies such as VR/AR and haptic systems across diverse fields including medicine, industry, and cultural heritage. On the other hand, Chandran (2022) utilized bibliometric data to reveal the development of HCI in the context of robotics, with a specific focus on usability and user experience.

Recent studies prove a growing interest in the social and ethical dimensions of HCI. Man et al. (2018) theoretically examined human-technology interactions through psychological, sociological, and ecological lenses, while Himmelsbach et al. (2019) investigated the sensitivity toward diversity in HCI research using quantitative content analysis. Looking at the most recent trends in the field, the dominance of Artificial Intelligence (AI) integration is particularly noteworthy. Mehdipour et al. (2024) found that the orientation toward human-centered AI and cognitive dimensions has increased in publications over the last five years. Finally, Sanchez et al. (2025) analyzed highly cited studies using the SPIN (Situation, Problem, Implication, and Need-payoff) framework, suggesting that techno-centric approaches are giving way to alternative narratives focused on uncertainty and human experience.

The effectiveness of text mining methods in analyzing HCI literature has also established a presence in contemporary research. Gurcan & Sevik (2019) and Gurcan et al. (2021) provided a 60-year panoramic view of the field by analyzing tens of thousands of articles in the SCOPUS database using probabilistic topic modeling. Similarly, Zhao et al. (2024) evaluated the 20 year development of health-oriented HCI research through bibliometric networks.

When existing review studies in the HCI field are examined, it is observed that they are largely conducted through traditional bibliometric indicators or manual content analysis. Accordingly, this study aims to contribute to the methodological diversity of the literature by employing the Leximancer analysis method, which provides quantitative data depth and maps semantic relationships between concepts using machine learning.

3. Method

The primary purpose of this study is to undertake a comparative text-mining analysis of papers published in the International Journal of Human-Computer Interaction, indexed in the WoS database, across four temporal periods (1994–2002; 2003–2011; 2012–2019; 2020–2025). The purpose is to identify conceptual trends that stand out in

the HCI literature and to highlight the change processes of these trends over the years. This publication was selected because it is a well-recognized, high-impact journal with a high impact factor, indexed in the WoS database, that delivers both quantitative and qualitative contributions to HCI theories and applications. It thus provides a basic overview of the studies connected with the ‘Human–Computer Interaction’ term in the literature. In this context, the text mining analysis method was employed to examine the research published in the journal. Text mining aims to comprehend the semantic structures within texts, discover themes, patterns, and other meaningful information, and provide insights into the relationships between the reader and data entities through this information (Singh et al., 2024).

The text-mining analytical approach yielded results. Leximancer employs word-frequency statistics to build its visuals while simultaneously facilitating the performance of complementary analytical tasks. Researchers often use Leximancer to identify the fundamental themes within a text, disclose the relationships between these themes, and discover which source files, authors, or participants these themes are related to (Angus et al., 2013, p. 262). Leximancer is a software that performs quantitative content analysis using machine learning methods. This software identifies the key concepts in a text and reveals their relationships. It highlights the word frequency and co-occurrence levels of concepts. Once a concept is determined through the machine learning process, a thesaurus consisting of words related to that concept is automatically generated, thereby providing semantic content to the concept (Ward et al., 2014, p. 119). In line with this methodology, articles belonging to the International Journal of Human–Computer Interaction were exported from the WoS database on October 22, 2025. The data acquisition process is shown in Figure 2 below.

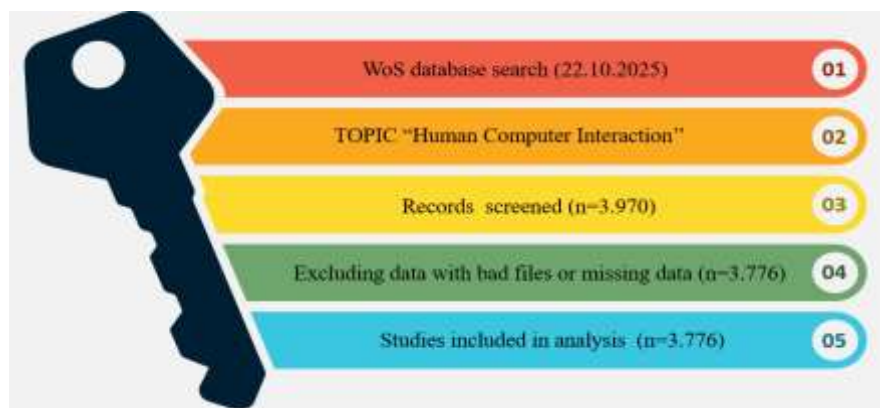


Figure 2. PRISMA flow diagram (Liberati et al., 2009)

In this study, the research published in the International Journal of Human–Computer Interaction between 1994 and 2025 was thematically evaluated and classified into four distinct periods corresponding to the developmental trajectory of the field. The periodization process was established based on technological shifts, the specific focus of the journal, and the historical evolution of the HCI field. The periods are defined as follows:

1994–2002: Early Digital Interaction Era: Defined by the dominance of basic principles such as usability, cognitive modeling, and interface design.

2003–2011: Web and Mobile Expansion Era: The Web and Mobile Expansion Era is characterized as a period when web interaction and online user experiences became increasingly prominent. The Web and Mobile Expansion Era grew as the internet spread widely and mobile devices became part of everyday life.

2012–2019: Smart Systems and Experience-Oriented Interaction Era: Smart Systems and Experience-Oriented Interaction Era focuses on user experience (UX) design and data-driven interaction paradigms.

2020–2025: AI and Ethics-Focused Hybrid Interaction Era: Characterized by the advent of remote interaction modalities after the pandemic and the escalation of conversations around AI, augmented/mixed reality technology, and ethics.

This temporal structure was created to enable a more holistic analysis of the conceptual and technological transformations within the HCI field and to reveal changes in the journal's research trends systematically.

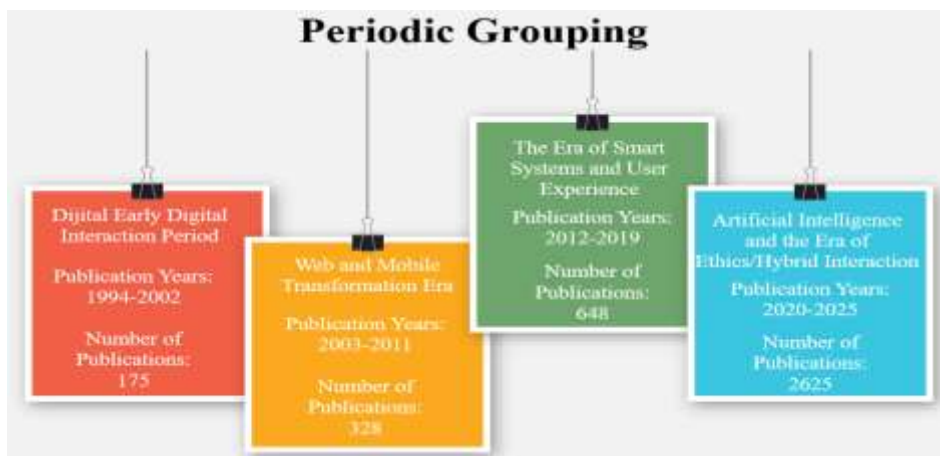


Figure 3. Periodical grouping of data between 1994 and 2025

The textual data analysis conducted within the scope of this study was carried out based on the four fundamental periods defined in Figure 3. A textual data analysis was conducted using 29,137 words from the Early Digital Interaction Period, 52,894 words from the Web and Mobile Expansion Period, 110,145 words from the Intelligent Systems and Experience-Oriented Interaction Period, and 450,617 words from the AI and Ethics-Oriented Hybrid Interaction Period. In the study, conceptual maps were created by analyzing the abstracts of a total of 3,776 articles.

4. Analysis and Findings

For the Leximancer analysis method, the data to be uploaded to the software must be in one of the following formats: PDF, DOC, DOCX, TXT, CSV, TSV, or HTML. In this study, the collected data (originally in .xlsx format) were converted into PDF format and subsequently uploaded to the system. The interface of the Leximancer analysis environment is presented in Figure 4.

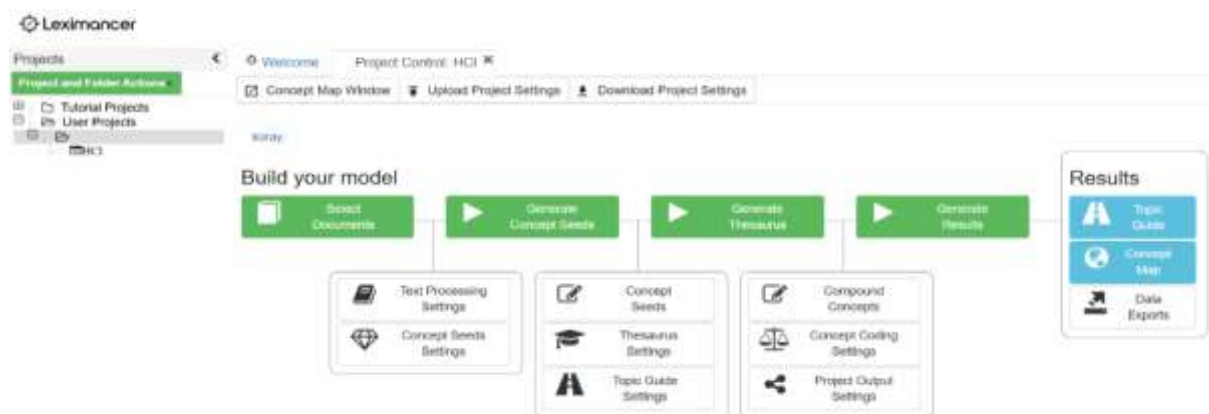


Figure 4. Interface view of the Leximancer analysis method

Within the scope of the International Journal of Human–Computer Interaction, the relationships among the concepts extracted from the article abstracts are illustrated in a conceptual map. This map reveals the network of relationships formed among the identified concepts. The period from 1994 to 2002 is referred to as the “Initial Phase of Digital Interaction.”

The Leximancer map demonstrates the relationships between the key concepts that emerged during this period. In the map, nodes represent concepts, and their sizes indicate the relative importance of each concept within the text. Similar concepts are positioned close to one another, while strong relationships between them are represented with connecting lines. Colored circles denote the thematic groups to which these concepts belong (Angus et al., 2013, p. 265). In the clustering approach, it is assumed that keywords within the same cluster have stronger relationships with each other, while the relationships between keywords in different clusters are more limited (Şimşek et al., 2023, p. 617).

- The concept 'User' was connected to the concepts of based, human, cognitive, communicative, approach, to present, and to provide.
- The theme 'Participants' was associated with the concepts of tasks, presented, experiment, control, number, and visual.
- Finally, the core theme 'System' was found to be related to the concepts of interface, analysis, and design.

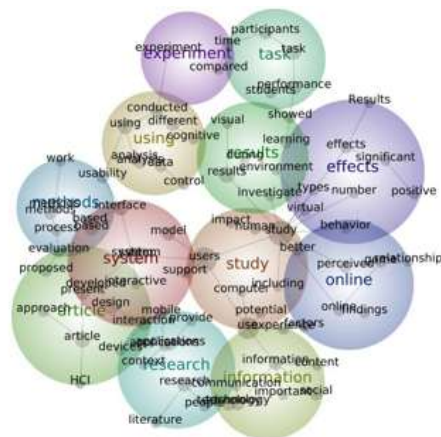


Figure 7. Concept map of the intelligent systems and experience-oriented interaction phase (2012–2019)

In the concept map presented in Figure 7, the concepts study (n=5,662), users (n=5,489), use (n=4,390), design (n=2,689), article (n=3,423), results (n=2,631), system (n=2,599), task (n=2,460), research (n=2,290), information (n=1,962), participants (n=1,861), performance (n=1,767), interaction (n=1,719), social (n=1,676), technology (n=1,673), usability (n=1,661), and interface (n=1,613) are identified, each showing relationships with other concepts within their respective thematic clusters.

The study concept is associated with results, data, online, analysis, perceived, potential, computer, behavior, explore, findings, types, impact, and included. The system concept relates to design, interaction, interface, based, model, mobile, support, and interactive. The use concept is connected to different data, conducted analysis, cognitive, and control. The information concept is linked to technology, social, experience, important, communication, and content. The article concept is associated with existing, developed devices, a proposed approach, and HCI. Finally, the research concept is connected to applications, provide, context, and literature.



Figure 8. Concept map of the artificial intelligence and ethics-oriented hybrid interaction phase (2020–2025)

In the concept map presented in Figure 8, the key concepts identified include study (n=26,589), use (n=20,784), users (n=18,832), results (n=13,250), design (n=10,955), research (n=10,888), perceived (n=10,428), effect (n=10,348), interaction (n=9,505), experience (n=8,877), technology (n=8,531), significant (n=8,309), social (n=8,201), system (n=8,034), model (n=7,791), participants (n=7,510), data (n=6,842), and learning (n=6,054). These concepts are shown to be interrelated within the thematic clusters on the map.

The study concept is associated with use, model, online, effect, students, behavior, research, context, explore, and content. The user's concept is linked to experience, information-based, cognitive, human, approach, includes, and game. The design concept is connected with interaction, system, development, virtual reality, process, existing, attention, article, and education. The research concept is associated with technology, potential, digital, understanding, framework, adult, human, communication, key, and education. The social concept is related to

frequent co-occurrence of one notion with another within the same sentence considerably raises the possibility of a direct association between them. Furthermore, the software discovers indirect associations by comparing the synonyms of concepts; this enables semantic links to be built even when concepts do not explicitly co-occur. Through this rigorous process, concepts are presented in rank order depending on the strength of their linkages and semantic similarity (Ward et al., 2014, p. 121). Using this approach, conceptual maps were generated throughout the study, and the thematic trends illustrated in Figures 5–8 were identified. Consequently, the analysis provides both a quantitative and a visual representation of the individual value of concepts and the connections between them.

The text mining analysis shows that the core concepts design, study, user, and system stay central in the research domain. The text mining analysis reveals that core concepts such as 'design,' 'study,' 'user,' and 'system' maintain a continuous and central position within the research field. When examining the distribution of concepts over the years, the early periods were characterized by the prominence of more technical, application-oriented terms, including 'interface,' 'task,' 'performance,' and 'usability.' However, subsequent periods saw an increase in user-centric and contextual themes, such as 'experience,' 'interaction,' 'technology,' 'social,' and 'learning.' This situation indicates that the research field is evolving from a strictly system- and design-oriented perspective toward a more holistic understanding that encompasses user experience, cognitive processes, and social interactions. In the bibliometric analyses conducted by Solís-Pino et al. (2024), concepts such as 'human-computer,' 'user interface,' 'virtual reality,' 'artificial intelligence,' 'design,' 'student,' 'user experience,' 'interaction,' 'human,' and 'education' were found to be prominent. This finding largely overlaps with the themes identified in the current study. Similarly, the identification of 'design,' 'user experience,' and 'quality' as core keywords in the study carried out by Li et al. (2022) aligns with the results of our research.

The concepts presented in Figures 5 and 6 illustrate that early studies formed the fundamental building blocks of HCI, particularly emphasizing the strong relationships between 'design,' 'interface,' and 'user.' It is understood that research during this period focused on efforts to optimize system functionality and user performance. Hinze-Hoare (2007) examined how and where user-centered design and requirements engineering approaches should be integrated. The early-period findings of the current study further support this approach. In contrast, the findings in Figures 7 and 8 demonstrate a significant increase in conceptual diversity, with terms such as 'social,' 'experience,' 'technology,' and 'learning' becoming prominent. This transition suggests that HCI studies, in parallel with technological advancements, have incorporated social interaction, digital learning environments, and the psychological dimensions of user experience into their research scope. This shift supports the findings of Li et al. (2022), which reveal the rise of the user experience design concept, and the study by Bala & Damla (2021), which proposes the integration of user-centered design with agile methodologies. The frequent appearance of the concepts information, data and model, in forms shows that the field is moving toward a data-driven structure and using methods better in research. This trend shows that new methods in HCI research, such as data analytics, machine learning and user behavior modeling are becoming more important. Similarly, Zhao et al. (2024) highlight the growing integration of HCI with domains such as healthcare technology, AI-supported interfaces, and data-driven user monitoring systems. The field's dynamic vitality and methodological diversity are reflected in the significant prominence of the concept "Research" in each conceptual map. Notably, the increased conceptual richness shown in Figure 8 suggests that the literature has reached a stage of maturity, with research increasingly focused on multidimensional analyses supported by robust theoretical frameworks.

Overall, the trend shown in Figures 5–8 clearly demonstrates that HCI and usability research have evolved from a technical approach to a framework focused on the user, social context, and experience. The field's multidisciplinary character is strengthened by this change, which also has the potential to create new research areas that explore the relationships among people, technology, and information systems in greater detail. By automating the creation of concept lists and the entire analytical process, Leximancer enables researchers to conduct deeper, more thorough studies, making better use of their time and resources (Angus et al., 2013, p. 262). Future research would greatly benefit from the inclusion of additional high-impact, HCI focused journals to create a more comprehensive conceptual map of the field. The scope of this study is limited to a single prominent journal indexed in the WoS database; this constitutes a limitation in terms of representing the entirety of the HCI literature. However, the interdisciplinary nature of HCI research offers a significant opportunity for future studies. Research conducted through the collaboration of various disciplines such as psychology, cognitive sciences, educational technology, and artificial intelligence will enable a more holistic and in depth understanding of the interaction between users and technology. This approach will strengthen the methodological diversity of the field and allow for the development of practical, application-oriented solutions.

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ETHICAL PERMISSION TO WORK

In this study, all rules specified within the scope of the "Scientific Research and Publication Ethics Directive of Higher Education Institutions" have been strictly followed. None of the actions specified under the heading "Actions Against Scientific Research and Publication Ethics" in the second part of the directive have been performed.

THE CONTRIBUTION RATE OF RESEARCHERS

The contribution rate of the first author to this research is 100%.

ARTIFICIAL INTELLIGENCE USAGE STATEMENT

During the preparation of this study, the author utilized artificial intelligence tools Gemini and DeepL, for purposes such as image generation, text enhancement, and linguistic/grammatical refinements. Any AI tools employed served solely as a support mechanism to refine the authors' existing ideas and facilitate more effective expression. The final content remains the intellectual product of the author, who maintain full responsibility for the integrity of the work.

CONFLICT OF INTEREST STATEMENT

There is no financial or personal connection with any person or institution regarding this research. There is no conflict of interest regarding this research.