Jurnal Pendidikan Administrasi Perkantoran (JPAP)
Journal homepage: https://journal.unesa.ac.id/index.php/jpap

Jurnal Pendidikan Administrasi Perkantoran (JPAP)
Volume 13, Nomor 2, 2025
E-ISSN: 23389621

Implementation of Human Computer Interaction in Education through Sytematic Literature Review and Bibliometric Analysis: A Study On Scopus Database

Rafly Saputra[a], Jaka Nugraha[b], Attia Aman-Ullah[c]

[a1] Universitas Negeri Surabaya, Surabaya, Indonesia
[b] Universitas Negeri Surabaya, Surabaya, Indonesia
[c] Universitas Utara Malaysia, Kedah, Malaysia

ARTICLE INFO

Keywords:
Human Computer Interaction; Education; Technology; Sytematic Literature Review; Bibliometric Analysis

Article History:
Received 21 May 2025
Accepted 25 June, 2025
Available online 20 August, 2025

https://doi.org/10.26740/jpap.v13n2.p600-619

ABSTRACT

Phenomenon/Issue:
Human computer interaction in everyday is an interesting thing, so it is necessary to explore the implementation of Human Computer Interaction in education.
Purpose:
Sytematic Literature Review and Bibliometric Analysis research has not examined Human Computer Interaction in education.
Novelty:
In addition, Bibliometric mapping based on Co-Authorship is obtained which provides an overview of interconnected authors and authors who have the most citations on the topic
Research Methods:
This Sytematic Literature Review research uses Preferred Reporting Items for Systematic reviews and Meta-Analyses (PRISMA) and Bibliometric Analysis using Biblioshiny and VOSviewer.
Results:
Bibliometric mapping based on Co-Occurrence obtained an overview of the most frequently used keywords, namely Human Computer Interaction
Research Contributions:
The study provides actionable insights for educators, instructional designers, developers, and policymakers

INTRODUCTION

The rapid advancement of technology has significantly transformed the educational landscape, with digital tools becoming increasingly integral to enhancing the quality of learning. Devices such as computers, mobile gadgets, and web-based applications have opened new avenues for accessing educational materials, revolutionizing traditional teaching methods. A critical aspect of this technological integration is Human-Computer Interaction (HCI), which focuses on optimizing the interaction between users and digital systems. While extensive research has been conducted on HCI in fields like business (Koch et al., 2024; Tsou & Mejia, 2023; Zhang et al., 2024) and economics (Kim et al., 2020; Triatmanto et al., 2023), as well as healthcare (Khashe et al., 2023; Q. Li et al., 2017; Zafar et al., 2024), its application in education remains underexplored. Despite its growing relevance, studies on HCI in education are still limited, even as the use of technology in this sector continues to expand (Y. Li, 2020; Mutawa & Sruthi, 2023).

The implementation of HCI in education has shown promising potential in enhancing digital learning experiences for both students and educators. Tools such as Google Classroom, Moodle, and Edmodo have facilitated online learning, while gamification models like Minecraft Education Edition have increased student engagement (Ardura & Artola, 2016; Laguna et al., 2018; Nadolny et al., 2020).

[1] **Correspondence:**
Rafly Saputra, Universitas Negeri Surabaya, Surabaya, Indonesia. Email : rafly.21076@mhs.unesa.ac.id

E-ISSN: 23389621

These applications not only make learning more interactive but also save time and effort for users (Haleem et al., 2022). For instance, in Office Administration Education programs, students benefit from learning about office-related software like Microsoft Office through platforms such as SSO Unesa or Sidia, which are provided by Universitas Negeri Surabaya. This integration of HCI in education underscores its role in creating efficient, effective, and enjoyable learning experiences.

HCI's relevance in education is further highlighted by its ability to improve user interface (UI) and user experience (UX) designs, which enhance student engagement and accessibility while accommodating diverse learning styles (Mashudi et al., 2022). Its adoption has spread globally, with countries like the United States (Lawrence & Ashleigh, 2019), the UK, Japan, South Korea, China (Y. Li, 2020), India (Yammiyavar, 2010), and several African nations leading the way. Research by Mashudi et al. (2022) has explored various aspects of HCI in mobile learning (m-learning), examining how UI design, touch-based interactions, and responsive systems impact user experiences. Additionally, innovations such as virtual reality, personal digital assistants, and biometric authentication have further expanded the scope of HCI in education (Hasan & Yu, 2017).

This study employs Bibliometric Analysis to measure and analyze academic literature, providing insights into trends and developments in HCI research within education (Z. Li & Li, 2024). Previous studies, such as those by Tjebane (2023), have used this method to investigate the impact of technology on language learning. By analyzing large databases like Scopus, researchers can identify key themes, publication trends, and contributions from specific authors or institutions (Sundar & Gurupandi, 2025). Combining Bibliometric Analysis with Systematic Literature Review allows for a more comprehensive and objective evaluation of HCI's implementation in education, addressing gaps in existing research and offering recommendations for future studies (Elshabshiri et al., 2025).

LITERATURE REVIEW AND HYPOTHESES DEVELOPMENT

Human Computer Interaction

Human Computer Interaction (HCI) has undergone significant evolution since its emergence in the mid-20th century, driven by the need to make computers more accessible and user-friendly. According to Myers (1998), HCI originated from the necessity to simplify computer usage, particularly with the rise of personal computers in the 1980s. Carroll (1997) emphasized the role of cognitive psychology in HCI, highlighting how understanding human mental processes has led to the creation of more effective interfaces. The advent of internet and networking technologies further expanded HCI's scope, introducing challenges such as designing interfaces for global users with diverse cultural and linguistic backgrounds *(Marcus & Gould, 2000)*. This marked a new era where computers transitioned from tools for tech experts to accessible devices for the general public. From 2015 to 2025, HCI experienced transformative growth, fueled by technological advancements and evolving user needs.

Bødker (2015) identified this period as the "third wave" of HCI, shifting focus from desktop and mobile interactions to more contextual and experience-based designs. This wave emphasized participatory design, where users actively contribute to the design process rather than being passive end-users. Similarly, Frauenberger et al. (2015) stressed the importance of inclusivity in HCI, particularly in designing systems for users with special needs, such as individuals with disabilities. HCI encompasses the concepts and methods of human interaction with computers, including the design, implementation, and evaluation of computer systems (MacDonald et al., 2022).

In education, HCI has enhanced learning experiences through immersive and interactive interfaces. Research by Bacca et al. (2014) highlighted the use of Augmented Reality (AR) and Virtual Reality (VR) in creating engaging educational tools, such as visualizing abstract scientific concepts. Hwang et al. (2010) further demonstrated the role of adaptive HCI systems in tailoring learning materials to individual student needs, thereby improving learning outcomes. In healthcare, HCI has improved medical services and patient care through user-friendly electronic medical records (EMR) and wearable health monitoring devices (Kientz et al., 2007). However, challenges like data privacy and security remain critical concerns in healthcare applications of HCI.

E-ISSN: 23389621

In business and industry, HCI has optimized operational efficiency and customer experiences. Shneiderman (2020) noted that well-designed user interfaces enhance employee productivity and reduce errors in business processes. Additionally, AI-driven recommendation systems, grounded in HCI principles, have personalized customer experiences, boosting satisfaction (Zhu et al., 2018). In entertainment, HCI has revolutionized digital content interaction through interactive gaming and streaming platforms designed to deliver engaging user experiences (Bødker, 2015).

Human Computer Interaction in Education

In the current era, Human-Computer Interaction (HCI) has become increasingly vital in education, supporting educators and enhancing the teaching and learning process for students. Educators can utilize applications that facilitate learning anytime and anywhere. One example of HCI is the use of mobile devices, such as smartphones, which enable learning both indoors and outdoors. Educators can also implement game-based learning concepts using mobile devices, incorporating video games and platforms like Kahoot or Quizizz (Liu et al., 2020). These tools make learning more engaging and interactive.

According to research by Gan et al. (2015), indexed in Scopus, HCI in education focuses on designing intuitive interfaces and interactive systems that enhance students' learning experiences. Their study emphasizes the importance of understanding how learners interact with digital tools to achieve learning objectives and collaborate effectively in digital environments. Additionally, technologies like Augmented Reality (AR) and Virtual Reality (VR), supported by HCI principles, create immersive learning environments that help students grasp complex concepts more easily (Bacca et al., 2014).

The application of HCI in education has also proven effective in supporting personalized learning. Brusilovsky (2001) highlights that adaptive systems designed based on HCI principles can tailor content and teaching methods to meet individual student needs. This aligns with findings from Hwang et al. (2010), published in a Scopus-indexed journal, which demonstrate that HCI-based learning systems improve student outcomes by adapting to their unique learning styles. However, despite its benefits, the implementation of HCI in education faces challenges. Research by Ertmer (1999) points out that teachers often lack adequate training in using HCI-based tools, which can hinder their effectiveness in the classroom.

In summary, HCI plays a crucial role in modern education by enabling flexible, interactive, and personalized learning experiences. While technologies like AR, VR, and game-based platforms enhance engagement and understanding, the success of HCI in education depends on addressing challenges such as teacher training and the effective integration of these tools into the learning process.

METHOD

The research methodology employed in this study utilizes the Systematic Literature Review (SLR) approach guided by the PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analyses) framework to ensure a structured and transparent review process. The data collection process involved identifying relevant studies through comprehensive searches in reputable academic databases, followed by screening, eligibility assessment, and inclusion of studies that met the predefined criteria. Bibliometric analysis was conducted using Biblioshiny and VOSviewer to visualize and analyze publication trends, citation networks, and keyword co-occurrence patterns. These tools facilitated the identification of research gaps, emerging themes, and influential works within the field. The integration of Systematic Literature Review, PRISMA guidelines, and bibliometric analysis provided a robust foundation for synthesizing existing literature and deriving meaningful insights to address the research objectives.

RESULTS

Systematic Literature Review Results

Using the PRISMA guidelines for Systematic Literature Review based on the Scopus database a literature review was conducted. With the keyword "Human Computer Interaction In Education" that has been set in the database 4,578 articles have been obtained from the identification step. After screening by title, abstract, and type 306 articles were retrieved and 4,272 articles were not retrieved in the screening process. In addition, 306 articles that met the inclusion and exclusion requirements as eligibility requirements were found as the final search results. The results of the Systematic Literature Review were published as an appendix. However, the Systematic Literature Review only took the 15 most cited articles from 2015 to 2025. Here are the 15 most cited articles:

No	Authors	Title	Domain	Year	Publisher	Citation
1	Seaborn K.; Fels D.I.	Gamification In Theory And Action: A Survey	Teknologi	2015	Academic Press	1670
2	Zhang L.; Nouri J.	A Systematic Review Of Learning Computational Thinking Through Scratch In K-9	Pendidikan	2019	Elsevier Ltd	300
3	Lamb R.L.; Annetta L.; Firestone J.; Etopio E.	A Meta-Analysis With Examination Of Moderators Of Student Cognition, Affect, And Learning Outcomes While Using Serious Educational Games, Serious Games, And Simulations	Pendidikan	2018	Elsevier Ltd	232
4	Hew K.F.; Huang B.; Chu K.W.S.; Chiu D.K.W.	Engaging Asian Students Through Game Mechanics: Findings From Two Experiment Studies	Pendidikan dan Teknologi	2016	Elsevier Ltd	214
5	Ainin S.; Naqshbandi M.M.; Moghavvemi S.; Jaafar N.I.	Facebook Usage, Socialization And Academic Performance	Pendidikan	2015	Elsevier Ltd	203
6	Duffy M.C.; Azevedo R.	Motivation Matters: Interactions Between Achievement Goals And Agent Scaffolding For Self-Regulated Learning Within An Intelligent Tutoring System	Pendidikan	2015	Elsevier Ltd	184
7	Landers R.N.; Armstrong M.B.	Enhancing Instructional Outcomes With Gamification: An Empirical Test Of The Technology-Enhanced Training Effectiveness Model	Pendidikan dan Teknologi	2017	Elsevier Ltd	165
8	Seufert S.; Guggemos J.; Sailer M.	Technology-Related Knowledge, Skills, And Attitudes Of Pre- And In-Service Teachers: The Current Situation And Emerging Trends	Pendidikan dan Teknologi	2021	Elsevier Ltd	144
9	Arachchilage N.A.G.; Love S.; Beznosov K.	Phishing Threat Avoidance Behaviour: An Empirical Investigation	Teknologi	2016	Elsevier Ltd	143
10	Vatavu R.-D.; Cramariuc G.; Schipor D.M.	Touch Interaction For Children Aged 3 To 6 Years: Experimental Findings And Relationship To Motor Skills	Pendidikan dan Teknologi	2015	Academic Press	142
11	Lugmayr A.; Sutinen E.; Suhonen J.; Sedano C.I.; Hlavacs H.; Montero C.S.	Serious Storytelling – A First Definition And Review	Pendidikan	2017	Springer New York LLC	133

12	Schoneveld E.A.; Malmberg M.; Lichtwarck-Aschoff A.; Verheijen G.P.; Engels R.C.M.E.; Granic I.	A Neurofeedback Video Game (Mindlight) To Prevent Anxiety In Children: A Randomized Controlled Trial	Pendidikan dan Teknologi	2016	Elsevier Ltd	128
13	González C.S.; Gómez N.; Navarro V.; Cairós M.; Quirce C.; Toledo P.; Marrero-Gordillo N.	Learning Healthy Lifestyles Through Active Videogames, Motor Games And The Gamification Of Educational Activities	Pendidikan dan Teknologi	2016	Elsevier Ltd	124
14	Papavlasopoulou S.; Giannakos M.N.; Jaccheri L.	Exploring Children'S Learning Experience In Constructionism-Based Coding Activities Through Design-Based Research	Pendidikan	2019	Elsevier Ltd	122
15	Gan B.; Menkhoff T.; Smith R.	Enhancing Students' Learning Process Through Interactive Digital Media: New Opportunities For Collaborative Learning	Pendidikan	2015	Elsevier Ltd	112

Source: Data processed by author (2025)

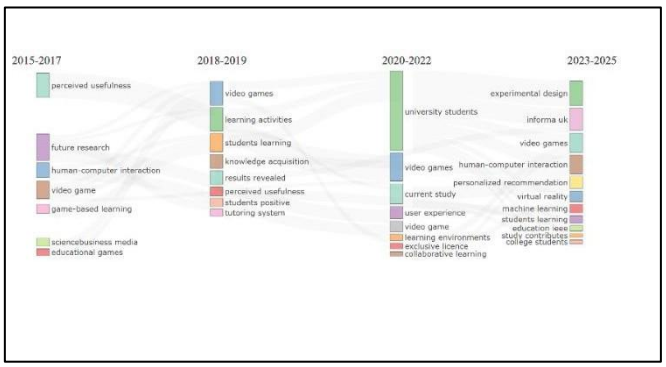
Tabel 1. Most Cited Articles

Based on the table above, 15 articles from the Systematic Literature Review have been described which have been presented in the form of a table with columns of name, domain title, year of publisher and publisher. In the 15 articles above there are 2 domains, namely education and technology in accordance with the research theme.

Bibliometric Analysis Using Biblioshiny Software

The author analyzes the data that has been described in the data analysis technique in chapter 3, namely the author uses Biblioshiny by including the features below:

Thematic Evolution



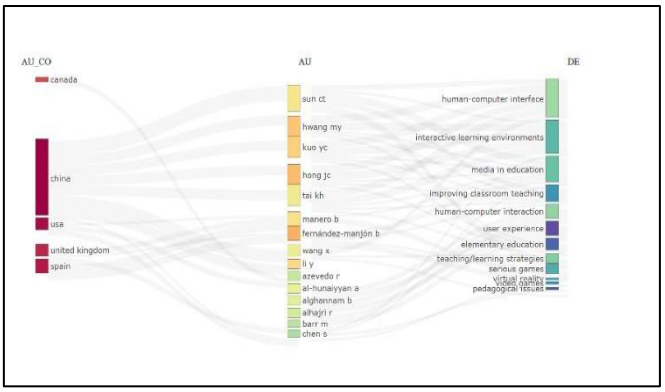
Source: Biblioshiny (2025)

Figure 1. Thematic Evalution of Abstrak Bigrams

The figure above shows that the Thematic Evolution of Biblioshiny regarding the duration of research includes four classifications using bigrams abstract filters from 2015 to 2025. In 2015 to 2017 the abstracts that appeared were perceived usefulness, future research, human-computer interaction, video games, game-based learning, sciencebusiness media, and educational games. In 2018 to 2019 the abstracts that appeared were video games, learning activities, student learning, knowledge acquisition, results revealed, perceived revealed, perceived usefulness, positive students, and tutoring systems. In 2020 to 2022 the abstracts that appeared were university students, video games, current studies, user experience, video games, learning environments, exclusive licenses, and collaborative learning. In 2023 to 2025 the abstracts that appeared were experimental design, inform auk, video games, human-computer interaction, personalized recommendations, virtual reality, machine learning, student learning, ieee education, study contributes, and college students.

E-ISSN: 23389621

1. Graph showing three fields



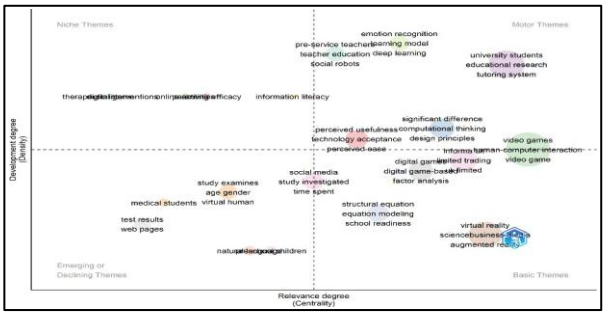
Source: Biblioshiny (2025)

Figure 2. Graph Showing Three Fields Author, Contries dan Keyword

The figure above shows that the visualization shows a visualized and precise representation of prolific scholars, their countries, and areas of interest depicted by keywords in Human Computer Interaction. The representation depicts the contribution of articles to Human Computer Interaction dividing them into country, author, and keyword categories. The left column presents a depiction of the country, the center column lists the researcher's name, and the right column shows the most used keywords. Increasing the box height and row thickness increases the relationship and connectivity between countries. The first highest number of authors is 8 authors from China and the second highest authors are in the UK and Australia with the same total of 3 authors. For the third wrinkle there is a Spanish country of 2 authors. For the last order there is only 1 writer in Canada.

The author “Manero B” has a relationship with 3 countries, namely Australia, Spain and the UK by using 2 keywords namely media in education and serious games. In addition, the author “Fernandez Manjon B” who has a relationship with Spain and the UK using 4 keywords namely media in education, inproving classroom teaching, theaching / learning strategies, and serious games. Author “Chen S” who has a relationship with China and Australia using the keyword virtual reality. Most authors such as “Sun Ct, Hwang My, Hong Jc, Kuo Yc, Tai Kh, and Wang X” have the same country relationship, namely China. The most used keyword with various authors is “Media in education” as many as 5 from the same country, namely China and 2 authors who have a relationship with Spain, Australia and the UK namely “Fernandez Manjon B and Manero B” and 1 country from the UK namely “Barr M”. The second keyword used with various authors is “human-computer interaction” as many as 6 authors from China. In addition to the keyword “human-computer interaction” there are also those who have the same number of authors, namely the keyword “interactive learning environments” where 5 authors from China and one author from the UK, namely “Barr M”.

2. Thematic Map

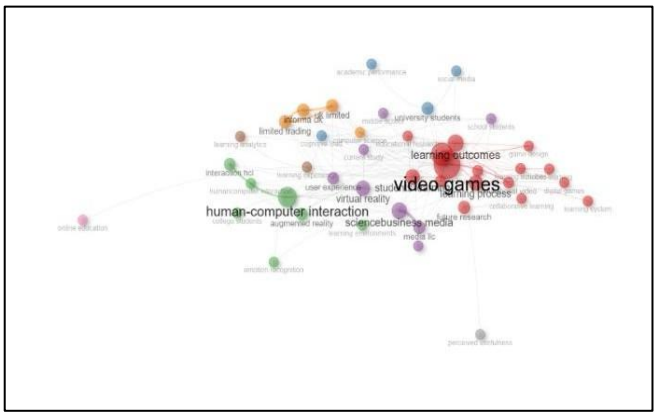


Source: Biblioshiny (2025)

Figure 3. Thematic MAP Abstrak Bigrams

Thematic MAP analysis involves grouping abstracts and exploring their interconnections to identify themes. These themes can be characterized by their properties, such as density and centrality. The vertical axis represents density, while the horizontal axis represents centrality. These properties measure the importance of the topic and determine whether the topic is necessary. The position of the anode in the network is very important and becomes more important with more relationships in the thematic network. The figure above illustrates a thematic map of food quality management, food safety and the food industry, with the x-axis representing the degree of relevance (centrality) and the y-axis representing the degree of development (density). The upper right quadrant (Q1 Motor Themes) depicts driving themes; the lower right quadrant (Q4 Basic Themes) depicts underlying themes; the upper left quadrant (Q2 Niche Themes) are highly specialized themes, and the lower left quadrant (Q3 Emerging or Declining) are emerging themes. These quadrants help to identify important and emerging topics or keywords, as well as visualize their relative position in the research network.

3. Keyword analysis
   a. Co-Occurrence Network



Source: Biblioshiny (2025)

Figure 4. Co-Occurrence Network Of Abstract Bigrams

Analysis of word pairs in high-frequency abstracts reveals research trends. Word pairs of publication abstracts are commonly used in Bibliometric Analysis to describe the hierarchical knowledge structure in a field. This study explores the co-occurrence network of abstract bigrams. The analysis establishes relationships between abstracts, which enhances the knowledge structure in the field. The findings show that Co-occurrence networks help uncover relationships between pairs of keywords that appear frequently in word clouds. Word cloud analysis can quickly identify the main topics and focus of publications by analyzing frequently used keywords.

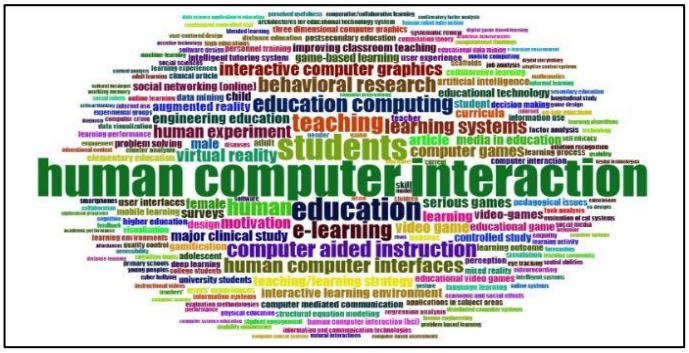
A careful examination of the color coding of these keywords shows that the more significant abstract bigrams, indicated by their width, are closely associated with smaller keywords. In the green group, human computer interaction is associated with hci interaction, argumented reality, emotion recognition, and college student. For example, the red group represents video games associated with future reserch, educational games, student learning, educational video, game design, learning process, digital games, and games-based learning. The green and red groups are the most relevant for a clear overview of current research keywords. Building the co-occurrence network in Figure 4 allows us to investigate and understand the conceptual framework of the analyzed research field.

Words	Occurrences
Video Games	45
Human-Computer Interaction	37
Video Game	35
Learning Outcomes	25
Virtual Reality	21
Sciencebusiness Media	21
Students Learning	20
Future Research	20
Learning Process	17
User Experience	16
Interaction Hci	16
University Students	16
Augmented Reality	15
Media Llc	15
Cognitive Load	14

Source: Data processed by author (2025) Tabel 2. Frequently used terms

In table 2, the most frequently cited abstract word pairs include video games 45 times at 13.51% and Human Computer Interaction 37 times at 11.11%. All of these terms have to do with how these two factors are interrelated.

b. Words Cloud



Source: Biblioshiny (2025)

Figure 5. Words Cloud of Keyword plus

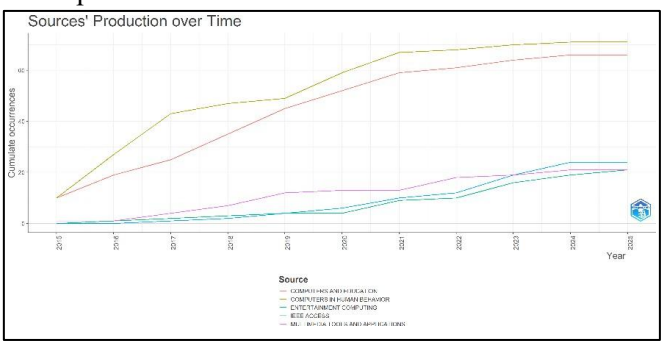
The researchers created a word cloud based on frequently used keywords, with more prominent words indicating a higher frequency of use, as shown in figure 5. Keyword Plus is a specialized algorithm that improves the search for cited references and expands search results. In Figure 5 it is shown that the keyword Human Computer Interaction has the largest font size than other keywords. That the largest font size indicates the most frequently used or most popular used among writers in 2015 to 2025.

Shown in table 3 the author takes the top 10 keywords entered in the following table:

Year	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025
Human Computer Interaction	26	51	87	110	142	168	198	221	250	285	289
Students	12	28	50	62	76	85	102	111	122	138	139
Education	14	40	69	87	91	99	103	104	105	105	105
Teaching	12	25	39	51	55	56	60	61	62	67	67
E-Learning	3	4	11	19	24	27	35	40	49	57	58
Education Computing	5	12	19	20	30	38	44	46	49	56	56
Human	2	18	30	34	37	47	53	54	55	56	56
Computer Aided Instruction	6	14	20	30	38	42	45	45	47	51	53
Behavioral Research	6	9	14	15	21	31	39	42	45	49	49
Human Computer Interfaces	7	16	18	29	37	38	44	44	46	47	47

Source: Data processed by author (2025) Tabel 3. Word dynamics last 10 years.

4. Analysis Of Source Local Impact

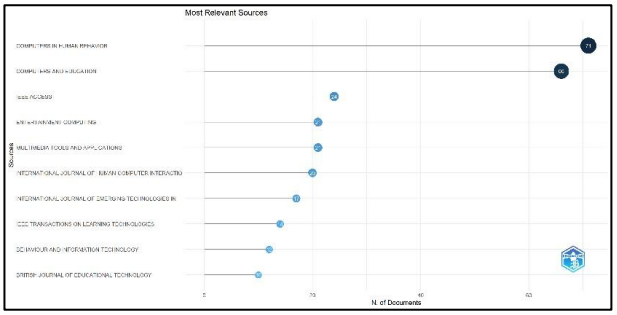


Source: Biblioshiny (2025)

Figure 6. Sources' Production Over Time

Figure 6 illustrates the growth of sources as seen from 2015 to 2025 computers and education, computers in human behavior, iee access, entertainment computing, and multimedia tools and applications have greatly increased. Shows that the journal computers and education has published 58 articles starting in 2015, besides that starting in 2015 there were also 59 articles published in the journal computer in human behavior. The iee access journal has published as many as 16 articles and 14 article publications have been published by the entertainment computing journal. The last journal in Figure 6 is the journal multimedia tools and applications as many as 21 articles that have been published starting in 2015.

a. Top Ten Most Relevant Sources



Source: Biblioshiny (2025)

Figure 7. Top Source Agencies Will Own The Most Prolific Journals

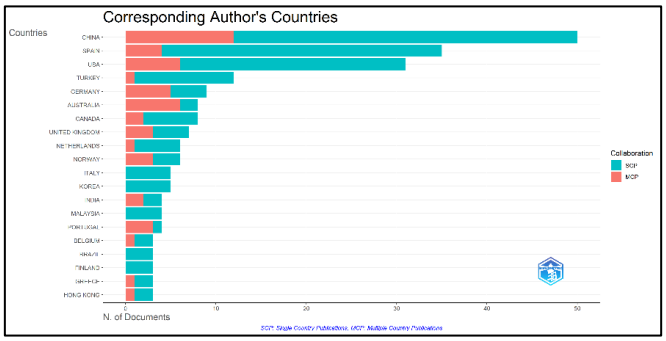
Only the top 10 source agencies will have the most prolific journals. Figure 7 displays the top 10 sources that have published research articles on Human Computer Interaction in education. The data comes from Scopus from 2015 to 2025. The most relevant source mentioned is computers in human behavior. Other sources including computers and education worldwide are IEE Access, Entertaiment Computing, Multimedia Tools and Applifations, International Journal of Human Computer Interatio, International Journal of Emerging Technologies in, IEE Transactions on Learning Technologies, Behavior and Information Technology, and Birtsh Journal of Educational Technology. Table 4 provides information on the top 10 journals that publish research articles as follows:

Source	Rank	Freq	cumFreq	Zone
Computers In Human Behavior	1	71	71	Zone 1
Computers And Education	2	66	137	Zone 1
Ieee Access	3	24	161	Zone 2
Entertainment Computing	4	21	182	Zone 2
Source	**Rank**	**Freq**	**cumFreq**	**Zone**
Multimedia Tools And Applications	5	21	203	Zone 2
International Journal Of Human-Computer Interaction	6	20	223	Zone 2
International Journal Of Emerging Technologies In Learning	7	17	240	Zone 3
Ieee Transactions On Learning Technologies	8	14	254	Zone 3
Behaviour And Information Technology	9	12	266	Zone 3
British Journal Of Educational Technology	10	10	276	Zone 3
Universal Access In The Information Society	11	9	285	Zone 3
International Journal Of Advanced Computer Science And Applications	12	8	293	Zone 3
International Journal Of Human Computer Studies	13	7	300	Zone 3
Computers In Human Behavior Computers And Education	14	1	301	Zone 3
Computers In Human Behavior Computers In Human Behavior	15	1	302	Zone 3
International Journal Of Emerging Technologies In Learning International Journal Of Human Computer Studies	16	1	303	Zone 3

Source: Data processed by author (2025)

Tabel 4. Top 10 core courses by Bradford's Law

5. Leading Institutions and Their Countries



Source: Biblioshiny (2025)

Figure 8. Top 20 Corresponding Author's Countries.

Correspondence authors are senior researchers or group leaders with some or much experience in the process of submitting and publishing scientific research. Figure 8 illustrates the top 20 correspondence author countries from 2015 to 2025. China is in first place with 50 articles and Spain is second with 35 articles. The United States is ranked third with 31 articles. The lowest country in Figure 4.10 is Hong Kong, which is as big as Belgium, Berazil, Finland, and Grecee with 3 articles. Table 5 shows the top 20 countries with the most relevant correspondence authors. Graphically, this is also presented in Figure 8. By analyzing the country of origin of correspondence authors, we gain an in-depth view of human computer interaction.

Country	Articles	Articles %	SCP	MCP	MCP %
China	50	16,5	38	12	24
Spain	35	11,6	31	4	11,4
Usa	31	10,2	25	6	19,4
Turkey	12	4	11	1	8,3
Germany	9	3	4	5	55,6
Australia	8	2,6	2	6	75
Canada	8	2,6	6	2	25
UK	7	2,3	4	3	42,9
Netherlands	6	2	5	1	16,7
Norway	6	2	3	3	50
Italy	5	1,7	5	0	0
Korea	5	1,7	5	0	0
India	4	1,3	2	2	50
Malaysia	4	1,3	4	0	0
Portugal	4	1,3	1	3	75
Belgium	3	1	2	1	33,3
Brazil	3	1	3	0	0
Finland	3	1	3	0	0
Greece	3	1	2	1	33,3
Hong Kong	3	1	2	1	33,3

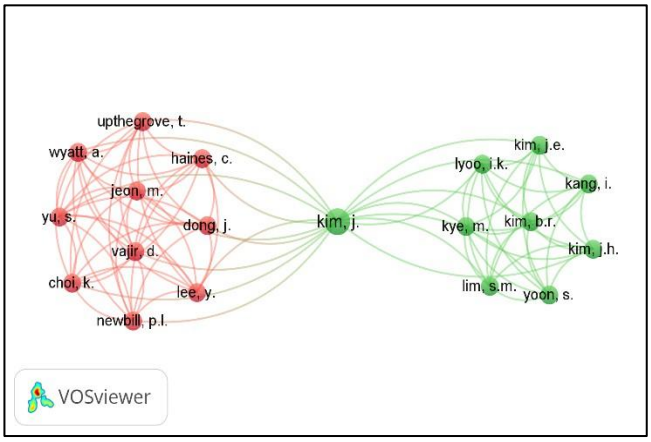
Source: Data processed by author (2025)

Tabel 5. Top 20 Corresponding Author's Countries

The country with the most Corresponding Author's is China with 50 articles. 38 Single country publications (SCP) and 12 multi-country publications (MCP) highlight the country's independent research capacity and some level of international collaboration. Spain is in second place with 35 articles. 31 Single country publications (SCP) and 4 multi-country publications (MCP). In addition, Germany has more than half of its MCPs with 55.6% being multi-country collaborations. This shows that Germany is open to collaborative research efforts with other countries and is actively involved in international research dialog. Norway shows an even split between SCP and MCP, with an MCP ratio of 50%. This suggests that while Norway has a strong domestic research presence, it is also open to collaborative research efforts with other countries.

Bibliometric Analysis Using VOSviewer Software

1. Bibliometric Analysis Based Co-Authorship
   a. Network Visualzation



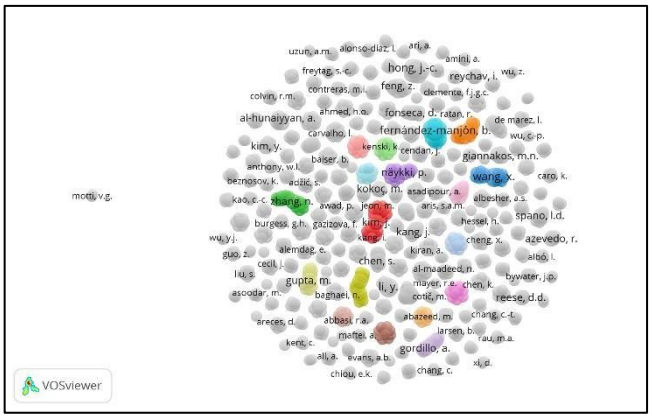
Source: VOSViewer (2025)

Figure 9. Connected Co-Authorship Network Visualzation

Based on the visualization of the connected co-authorship network, the network of authors on artificial intelligence in education is clearly visible, indicating that several researchers are connected. These relationships are characterized by circular lines and symbols, which depict a network of interconnected researchers. Among the 1000 authors involved in the Bibliometric Analysis, only 19 were found to have networks and relationships in the co-authorship visualization. In addition, the Bibliometric mapping identified two groups, marked with different colors, red and green, on the circular lines and symbols. The following are 2 clusters of connected co-authorship network visualizations based on Bibliometric Analysis:

Cluster 1 which is red in color shows there are 10 authors namely Choi, K., Dong, J., Haines, C., Jeon, M., Lee, Y., Newbill, P,L., Upthegrove, T., Vajir, D., Wyatt, a., and Yu,

S. Cluster 2 is green in color shows 9 authors namely Kang, I., kim, Br., Kim, J., Kim, Je., Kim, Jh,. Kye, M., Lim, Sm., Iyoo, Ik., and Yoon, S.

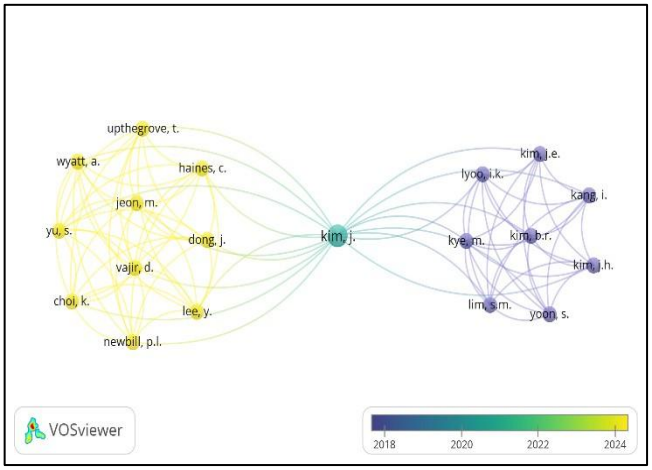


Source: VOSViewer (2025)

Figure 10. Co-Authorship Network Visualzation Unconneted

The visualization of the unconnected co-authoring network shows a network of authors who, despite choosing the same topic, have no connection with each other. Based on the selection of at least one author for each document, 1000 authors are involved. These authors are divided into 233 groups or clusters, each represented by a different color in the unconnected co-authorship network visualization.

b. Overlay Visualzation

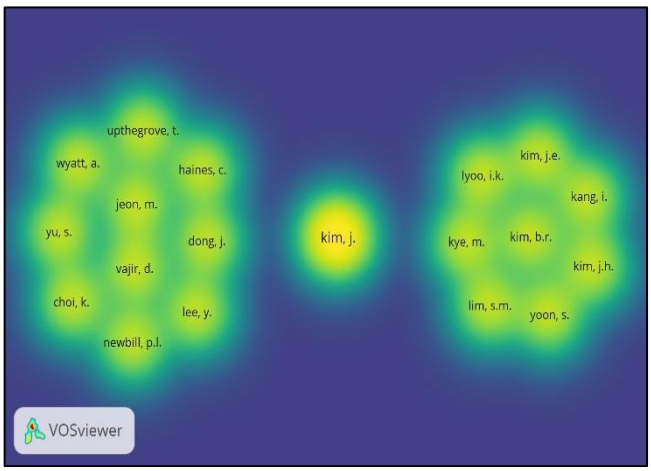


Source: VOSViewer (2025)

Figure 11. Co-Authorship Overlay Visualzation

The co-authoring visualization overlay shows the time period when the researcher conducted the study, indicated by different colors. Light colors (yellow) indicate more recent research, while darker colors (purple) indicate older research. For example, the lightest color (yellow) indicates research conducted in 2024, and the darkest color (purple) indicates research from 2018.

c. Density Visualzation

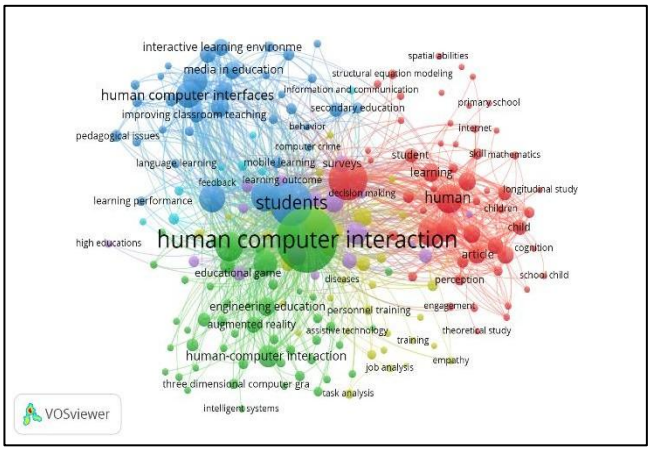


Source: VOSViewer (2025)

Figure 12. Co-Authorship Density Visualzation

In the co-authorship density visualization, there is density in the round symbols indicating collaboration between authors researching Human Computer Interaction in education. The largest font in the visualization indicates the strongest network, referring to the authors Kim, J.

2. Bibliometric Analysis Based Co-Occurrence
   a. Network Visualzation



Source: VOSViewer (2025)

Figure 13. Co-Occurrence Network Visualzation

Figure 13 shows a visualization of the connected Co-Occurrence network, which shows the relationship between each literature keyword. These relationships are characterized by interconnecting lines and round symbols. Based on the selection of at least one keyword per document, 2617 keywords were identified, with 200 interconnected keywords divided into 6 clusters in the mapping. The 6 clusters are distinguished by color in cluster 1 shown in red, cluster 2 in green, cluster 3 in dark blue, cluster 4 in yellow, cluster 5 in purple and light blue for cluster 6. The 6 clusters of Bibliometric Analysis based on the visualization of the connected Co-Occurrence network are as follows:

Cluster 1 : adolescent, adult, article, behavioral research, calculations, case report, child, children, clinical article, cognition, computational thinking, computational thinkings, controlled study, digital game-based learning, education, engagement, female, gender, gesture, head mounted displays, helmet mounted displays, high school, higher education, human, human experiment, instructional videos, interface designs, internet, internet use, learning, longitudinal study, major clinical study, male, mathematics, outcome assessment, perception, pretest posttest design, primary school, problem solving, randomized controlled trial, school child, simulation, skill, smartphones, spatial abilities, stem (science, technology, engineering and mathematics), structural equation modeling, student, tablet, theoretical study, video game, videorecording, dan young peoples.

Cluster 2 : 'current, artificial intelligence, augmented reality, cluster analysis, cognitive loads, computer interaction, curricula, data mining, data visualization, deep learning, distance education, e-learning, e-learning environment, educational data mining, educational data mining, emotion recognition, engineering education, eye tracking, eye- tracking, forecasting, human computer interaction, human computer interaction (hci), human robot interaction, human-computer interaction, human-computer interaction (hci), human–computer interaction, information systems, information use, intelligent systems, learning activity, learning algorithms, learning analytics, learning environment, learning environments, learning systems, machine learning, machine-learning, on-line education, mixed reality, online learning, online systems, regression analysis, student engagement, systematic review, three dimensional computer graphics, usability, usability engineering, user interfaces, users' experiences,

virtual reality, visualization, dan websites.

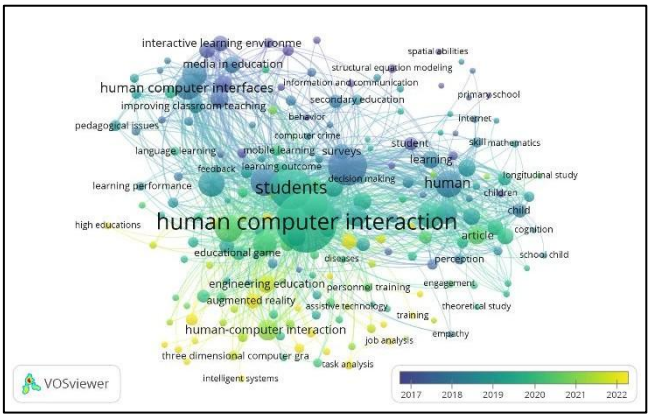
Cluster 3 : applications in subject areas, architectures for educational technology system, behavior, college students, computer aided instruction, computer crime, computer mediated communication, computer-mediated communication, economic and social effects, elementary education, evaluation methodologies, experimental groups, factor analysis, human computer interfaces, human-computer interface, improving classroom teaching, interactive learning environment, interactive learning environments, language learning, learning communities, learning community, learning performance, media in education, mobile learning, pedagogical issues, post-secondary education, postsecondary education, scaffolds, secondary education, social networking (online), social sciences, students, teaching, teaching/learning strategies, teaching/learning strategy, dan university students.

Cluster 4 : application programs, assistive technology, blended learning, computer graphics, design, diseases, education computing, educational technology, empathy, evaluation, game, games, gamification, human engineering, interview, job analysis, mobile computing, model, motivation, performance, personnel training, problem based learning, problem-based, quality control, self efficacy, software, stem, task analysis, teacher, teachers', training, user centered design, dan user experience.

Cluster 5 : computer games, decision making, educational game, educational games, educational video games, game-based learning, high educations, interactive computer graphics, learning experiences, learning outcome, learning process, physical education, serious games, social media, surveys, video games, dan video-games.

Cluster 6 : collaboration, collaborative learning, computer programming, distributed computer systems, feedback, information and communication technologies, intelligent tutoring system, intelligent tutoring systems, dan software design.

b. Overlay Visualzation



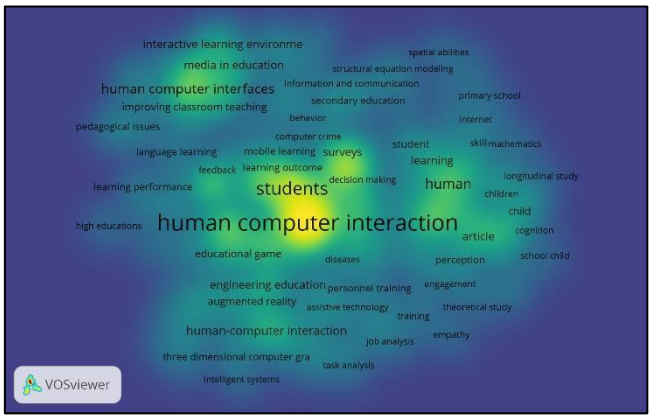
Source: VOSViewer (2025)

Figure 14. Co-Occurrence Overlay Visualzation

The co-occurrence overlay visualization shows the period of keyword usage in the literature, indicated by different colors. Light colors (yellow) indicate newer keywords, while darker colors (purple) indicate older keywords. For example, the lightest color (yellow) indicates keywords conducted in 2022, and the darkest color (purple) indicates research from 2017.

Volume 13, Nomor 2, 2025
E-ISSN: 23389621

c. Density Visualzation



Source: VOSViewer (2025)

Figure 15. Co-Occurrence Density Visualzation

In the keyword density visualization, there is density in round symbols that indicate frequently used keywords. The largest font in the visualization indicates the strongest network, referring to human computer interaction.

DISCUSSIONS

Based on PRISMA guidelines, this study conducted a Systematic Literature Review on the implementation of Human Computer Interaction in Education. During the article selection process 306 articles were identified and described which were classified into 2 domains (Education and Technology) according to the theme and purpose of the research. This Systematic Literature Review can be a useful guide for educators with examples and references on how to implement Human Computer Interaction into the classroom. The application of Human Computer Interaction in Education can be classified through 2 domains of Education and Technology.

As a result of the 15 articles reviewed by the author, the author's perspective on Human Computer Interaction in education in Indonesia can be seen as a promising approach to improving the quality of learning through the integration of interactive and user-centered technology. Based on the various studies outlined, Human Computer Interaction has great potential to create a more engaging, interactive and effective learning experience, especially if it is designed with the needs and capabilities of users, including students and teachers, in mind. In Indonesia, where challenges such as the digital divide and limited infrastructure still exist, the application of Human Computer Interaction in education can be an innovative solution to improve student engagement, learning motivation and material comprehension. For example, the use of gamification, such as points, badges and other game mechanics, can make learning more fun and encourage active student participation. In addition, interface designs that are intuitive and appropriate to students' motor and cognitive developmental levels, as suggested in research on children's interaction with touchscreens, can help optimize the use of technology in the classroom.

Research conducted by Gusteti et al. (2023) the importance of Indonesian teachers' understanding of technology and their positive attitude towards Human Computer Interaction integration are also key factors in its successful implementation in Indonesia. Training and support for teachers in using interactive technologies, such as Serious Educational Games (SEGs) or web-based collaborative platforms, can facilitate a more immersive and collaborative learning process. In addition, Human Computer Interaction can support the development of computational thinking skills through tools such as Scratch, which not only improves students' technical abilities but also trains them in creative and holistic problem solving. By considering the potential of technological developments such as artificial intelligence, Human Computer Interaction in education in Indonesia can bring more efficient and adaptive innovations, creating a learning environment that is responsive to students' needs.

However, the authors also emphasize the importance of a cautious and empirical approach to implementing Human Computer Interaction in Indonesia. Challenges such as limited access to technology, the digital divide between urban and rural areas, and a lack of understanding of motivation theory and effective system design need to be addressed. Thus, collaboration between the government, educational institutions, and the private sector is needed to develop adequate infrastructure, provide training for teachers, and design Human Computer Interaction systems that fit the local context. If implemented well, Human Computer Interaction can be a powerful tool in creating a holistic learning experience, not only improving academic outcomes but also supporting the emotional, social and motor development of students in Indonesia.

This research uses Bibliometric Analysis to analyze the literature and the results of the Systematic Literature Review related to the implementation of Human Computer Interaction in Education. This shows that research related to the implementation of Human Computer Interaction in Education is interesting to develop as an effort to understand how Human Computer Interaction can be involved in education. Human Computer Interaction plays an important role in creating an interactive and engaging learning experience for learners (González et al., 2016; Papavlasopoulou et al., 2019).

Bibliometric Analysis using Biblioshiny shows that there is significant growth in publications related to Human Computer Interaction from 2015 to 2025, with a total of 306 articles analyzed. This analysis was conducted by utilizing data from the trusted database Scopus to provide an objective perspective on the status of research in the field of Education. Most of the research related to Human Computer Interaction has been conducted in China with 8 authors and 50 articles with the best correspondence from 2015 to 2025.

Research on Human Computer Interaction in education has examined 1000 authors and 2617 keywords from the Scopus database. The Bibliometric Analysis results show 2 clusters of co-authorship network visualizations, which identify groups of authors or publications that are interconnected and frequently cited together as references in Human Computer Interaction in education research. The clusters help understand the collaboration networks and relationships between researchers in the field. In addition, there are 6 connected co-occurrence network visualization keyword clusters, which show keywords that appear simultaneously in articles. These clusters can be expanded to fill research gaps and create new ones.

In addition, the author network formed from the visualization of the connected authorship network in the scattered mapping is 2 groups with 19 authors in it which shows the selection of the same topic. The author network formed from the visualization of the connected authorship network is dominated by Kim J who has the strongest network because he has extensive relationship connections. Kim J has other author relationships from 2 research documents and has a total link strengths of 18.

This research also links keywords in 306 literatures generated from Systematic Literature Review that represent the research topic. The source of Bibliometric Analysis based on the co-occurrence of the most prominent keyword is “Human Computer Interaction” because the keyword has been used 285 times and has a total link strength of 2,043. then the keywords used in the latest or average research published in 2022 in Figure 14.

CONCLUSION

Systematic Literature Review with Preferred Reporting Items for Systematic reviews and Meta- Analyses (PRISMA) items from the Scopus database. The research results obtained related to the implementation of Human Computer Interaction in Education are 306 articles or literature that have met the eligibility criteria (inclusion criteria and exclusion criteria) that have been set. One of the eligibility criteria set is the selection of time for 2015 to 2025.

The implementation of Human Computer Interaction in Education is affiliated with various countries that produce thematic evolution, Graph showing three fields, thematic map, keyword analysis, Analysis of source local impact, and Leading institutions and their countries obtained from Biblioshiny. This Bibliometric Analysis provides a comprehensive overview of the development of research in the field under study. There are significant thematic shifts, with international collaborations and leading institutions playing an important role in advancing research. Keywords and thematic maps help identify current trends and potential future research areas. Sources with high local impact and collaboration between authors and institutions are key factors in advancing scholarship.

But there are also those obtained from VOSviewer, namely network visualization, overlay visualization, and density visualization. The mapping results obtained illustrate co-authorship analysis and co-occurrence keyword analysis. The mapping of 306 literature results from the Systematic Literature Review with a vulnerability time of 2015 to 2025 shows 2 research network clusters (co- authorship) and 6 keyword clusters (co-occuerence).

REFERENCES

Ardura, I. R., & Artola, A. M. (2016). What leads people to keep on e-learning? An empirical analysis of users' experiences and their effects on continuance intention. *Interactive Learning Environments*, *24*(6), 1030–1053. https://doi.org/10.1080/10494820.2014.926275

Bacca, J., Baldiris, S., Fabregat, R., & Graf, S. (2014). Augmented Reality Trends in Education: A Systematic Review of Research and Applications. *Educational Technology & Society*, *17*(4), 1176–3647.

Bødker, S. (2015). Third Wave HCI, 10 Years Later Participation and Sharing. *Interactions*, *22*(5), 24–31.

Brusilovsky, P. (2001). Adaptive hypermedia. *User Modeling and User-Adapted Interaction*, *11*(1–2), 87–110. https://doi.org/10.1023/A:1011143116306

Carroll, J. M. (1997). Human-computer Interaction: Psychology as a Science of Design. *Annual Review of Psychology*, *46*, 501–522. https://doi.org/10.1146/annurev.psych.48.1.61

Dourish, P. (2010). HCI and environmental sustainability: The politics of design and the design of politics. *DIS 2010 - Proceedings of the 8th ACM Conference on Designing Interactive Systems*, 1–10. https://doi.org/10.1145/1858171.1858173

Elshabshiri, A., Ghanim, A., Hussien, A., Maksoud, A., & Mushtaha, E. (2025). Integration of Building Information Modeling and Digital Twins in the Operation and Maintenance of a building lifecycle: A bibliometric analysis review. In *Journal of Building Engineering* (Vol. 99). Elsevier Ltd. https://doi.org/10.1016/j.jobe.2024.111541

Ertmer, P. A. (1999). Addressing first- and second-order barriers to change: Strategies for technology integration. *Educational Technology Research and Development*, *47*(4), 47–61. https://doi.org/10.1007/BF02299597

Fordyce, S. (2020). Value Sensitive Design: Shaping Technology with Moral Imagination. *Design and Culture*, *12*(1), 109–111. https://doi.org/10.1080/17547075.2019.1684698

Frauenberger, C., Good, J., Fitzpatrick, G., & Iversen, O. S. (2015). In pursuit of rigour and accountability in participatory design. *International Journal of Human Computer Studies*, *74*, 93–106. https://doi.org/10.1016/j.ijhcs.2014.09.004

Gan, B., Menkhoff, T., & Smith, R. (2015). Enhancing students' learning process through interactive digital media: New opportunities for collaborative learning. *Computers in Human Behavior*, *51*, 652–663. https://doi.org/10.1016/j.chb.2014.12.048

González, C. S., Gómez, N., Navarro, V., Cairós, M., Quirce, C., Toledo, P., & Marrero-Gordillo, N. (2016). Learning healthy lifestyles through active videogames, motor games and the gamification of educational activities. *Computers in Human Behavior*, *55*, 529 – 551. https://doi.org/10.1016/j.chb.2015.08.052

Gusteti, M. U., Jamna, J., & Marsidin, S. (2023). Pemikiran Digitalisme dan Implikasinya pada Guru Penggerak di Era Metaverse. *Jurnal Basicedu*, *7*(1), 317–325.

https://doi.org/10.31004/basicedu.v7i1.4417

Haleem, A., Javaid, M., Qadri, M. A., & Suman, R. (2022). Understanding the role of digital technologies in education: A review. *Sustainable Operations and Computers*, *3*, 275–285. https://doi.org/10.1016/J.SUSOC.2022.05.004

Hasan, M. S., & Yu, H. (2017). Innovative developments in HCI and future trends. *International Journal of Automation and Computing*, *14*(1), 10–20. https://doi.org/10.1007/s11633-016-1039-6

Hwang, G.-J., Chu, H.-C., Shih, J.-L., & Huang, S.-H. (2010). A Decision-Tree-Oriented Guidance Mechanism for Conducting Nature Science Observation Activities in a Context-Aware Ubiquitous Learning Environment. *Educational Technology & Society*, *13*(2), 53–64. http://www.ifets.info/

Khashe, Y., Tabibzadeh, M., & Meshkati, N. (2023). Improving quality of care for patients receiving care through telehealth in the time of COVID-19 global pandemic and beyond: HCI-based leading indicators for virtual visits. *Human Factors in Healthcare*, *4*. https://doi.org/10.1016/j.hfh.2023.100050

Kientz, J. A., Hayes, G. R., Westeyn, T. L., Starner, T., & Abowd, G. D. (2007). Pervasive computing and autism: Assisting caregivers of children with special needs. *IEEE Pervasive Computing*, *6*(1), 28–35. https://doi.org/10.1109/MPRV.2007.18

Kim, T. Y., Ko, H., & Kim, S. H. (2020). Data Analysis for Emotion Classification Based on Bio-Information in Self-Driving Vehicles. *Journal of Advanced Transportation*, *2020*. https://doi.org/10.1155/2020/8167295

Koch, M., Ott, F., & Richter, A. (2024). The future of interactive information radiators for knowledge workers How will knowledge workers consume ambient awareness information in the future? *I-Com*, *23*(2), 139–154. https://doi.org/10.1515/icom-2024-0006

Laguna, Á. S., Manero, B., Freire, M., & Manjón, B. F. (2018). A methodology for assessing the effectiveness of serious games and for inferring player learning outcomes. *Multimedia Tools and Applications*, *77*(2), 2849 – 2871. https://doi.org/10.1007/s11042-017-4467-6

Lawrence, D. O., & Ashleigh, M. J. (2019). Impact Of Human Computer Interaction (HCI) On Users In Higer Educational System : Southampton University As A Case Study. In *International Journal of Management Technology* (Vol. 6, Issue 3). www.eajournals.org

Li, Q., Huang, C., Lv, S., Li, Z., Chen, Y., & Ma, L. (2017). An Human-Computer Interactive Augmented Reality System for Coronary Artery Diagnosis Planning and Training. *Journal of Medical Systems*, *41*(10). https://doi.org/10.1007/s10916-017-0805-5

Li, Y. (2020). Visual education of music course for college students based on human-computer interaction. *International Journal of Emerging Technologies in Learning*, *15*(2), 175 – 186. https://doi.org/10.3991/ijet.v15i02.12535

Li, Z., & Li, X. (2024). Bibliometric analysis and systematic review on the electrokinetic remediation of contaminated soil and sediment. In *Environmental Geochemistry and Health* (Vol. 47, Issue 1). Springer. https://doi.org/10.1007/s10653-024-02330-7

Liu, Z.-Y., Shaikh, Z. A., & Gazizova, F. (2020). Using the concept of game-based learning in education. *International Journal of Emerging Technologies in Learning*, *15*(14), 53 – 64. https://doi.org/10.3991/ijet.v15i14.14675

MacDonald, C. M., Rose, E. J., & Putnam, C. (2022). How, Why, and with Whom Do User Experience (UX) Practitioners Communicate? Implications for HCI Education. *International Journal of Human-Computer Interaction*, *38*(15), 1422 – 1439. https://doi.org/10.1080/10447318.2021.2002050

Marcus, A., & Gould, E. W. (2000). Crosscurrents: cultural dimensions and global Web user-interface design. *Interactions*, *7*(4), 32–46. https://doi.org/10.1145/345190.345238

Mashudi, N. A., Izhar, M. A. M., & Aris, S. A. M. (2022). Human-Computer Interaction in Mobile Learning: A Review. *International Journal of Advanced Computer Science and Applications*, *13*(3), 566 – 574. https://doi.org/10.14569/IJACSA.2022.0130367

Mutawa, A., & Sruthi, S. (2023). Enhancing Human–Computer Interaction in Online Education: A Machine Learning Approach to Predicting Student Emotion and Satisfaction. *International Journal of Human-Computer Interaction*. https://doi.org/10.1080/10447318.2023.2291611

Myers, B. A. (1998). A brief history of human-computer interaction technology. *Interactions*, *5*(2), 44–54. https://doi.org/10.1145/274430.274436

Nadolny, L., Valai, A., Cherrez, N. J., Elrick, D., Lovett, A., & Nowatzke, M. (2020). Examining the

characteristics of game-based learning: A content analysis and design framework. *Computers and Education*, *156*. https://doi.org/10.1016/j.compedu.2020.103936

Nicolescu, L., & Tudorache, M. T. (2022). Human-Computer Interaction in Customer Service: The Experience with AI Chatbots—A Systematic Literature Review. In *Electronics (Switzerland)* (Vol. 11, Issue 10). MDPI. https://doi.org/10.3390/electronics11101579

Papavlasopoulou, S., Giannakos, M. N., & Jaccheri, L. (2019). Exploring children's learning experience in constructionism-based coding activities through design-based research. *Computers in Human Behavior*, *99*, 415–427. https://doi.org/10.1016/j.chb.2019.01.008

Shneiderman, B. (2020). Human-Centered Artificial Intelligence: Reliable, Safe & Trustworthy. *International Journal of Human-Computer Interaction*, *36*(6), 495–504. https://doi.org/10.1080/10447318.2020.1741118

Sundar, S., & Gurupandi, M. (2025). Exploring Strategic Entrepreneurship Research: A Comprehensive Decadal Bibliometric Analysis. *International Review of Management and Marketing* , *15*(1), 179–192. https://doi.org/10.32479/irmm.17438

Tjebane, M. M. (2023). *A Bibliometric Review of the Impact of Technology on Student Learning Facilities: Current Trends and Future Directions* (pp. 197–213). https://doi.org/10.2991/978-2-38476-134-0_14

Triatmanto, B., Bawono, S., & Wahyuni, N. (2023). The contribution and influence of total external debt, FDI, and HCI on economic growth in Indonesia, Thailand, Vietnam, and Philippines. *Research in Globalization*, *7*. https://doi.org/10.1016/j.resglo.2023.100163

Tsou, M. H., & Mejia, C. (2023). Beyond mapping: extend the role of cartographers to user interface designers in the Metaverse using virtual reality, augmented reality, and mixed reality. *Cartography and Geographic Information Science*, *51*(5), 659–673. https://doi.org/10.1080/15230406.2023.2264748

Yammiyavar, P. (2010). Status of HCI and usability research in Indian educational institutions. *IFIP Advances in Information and Communication Technology*, *316*, 21–27. https://doi.org/10.1007/978-3-642-11762-6_2

Zafar, R. O., Rybarczyk, Y., & Borg, J. (2024). A Systematic Review of Digital Twin Technology for Home Care. *ACM Transactions on Computing for Healthcare*. https://doi.org/10.1145/3681797

Zhang, C., Liao, H., & Meng, J. (2024). Evaluating the performance of gaze interaction for map target selection. *Cartography and Geographic Information Science*, *52*(1), 82–102. https://doi.org/10.1080/15230406.2024.2335331

Zhao, X., Zhang, S., Nan, D., Han, J., & Kim, J. H. (2024). Human–Computer Interaction in Healthcare: A Bibliometric Analysis with CiteSpace. *Healthcare (Switzerland)*, *12*(23). https://doi.org/10.3390/healthcare12232467

Zhu, H., Yu, B., Halfaker, A., & Terveen, L. (2018). Value-sensitive algorithm design: Method, case study, and lessons. *Proceedings of the ACM on Human-Computer Interaction*, *2*(CSCW). https://doi.org/10.1145/3274463