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Quantitative and Qualitative Analysis of Interaction Design and Usability a Bibliometric Approach

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Abstract

With the continuous development of computer technology and the widespread popularity of the Internet and mobile devices, there has been a keen interest in how to better interact with users through computers. This paper reviews the evolution of computer interfaces, from early command-line interactions to the emergence of graphical user interfaces, emphasizing the importance of interaction design and user experience design in the field of design. To gain insight into the research trends in the field of multimedia interaction design, we conducted a decade-long survey, comparing academic output and research impact across different regions globally using Springer and SCOPUS Elsevier databases. Through bibliometric analysis, we highlighted key themes of research and publications related to interaction design and identified the regions and countries most actively researching in this area. The research findings indicate that since 2013, there has been a growing trend in multimedia interaction design research globally, with publications after 2013 focusing more on aspects such as interaction design, user experience, and interface design. These bibliometric analysis results provide valuable insights for countries or regions conducting research in multimedia interaction design.

Keyword: *Bibliometric Analysis, Interaction Design,Usability ,UI*

Introduction

With the continuous advancement of science and technology, there have been significant improvements in multimedia computer technology. For systematic studies of publications, bibliometric methods have been used to quantify the development of systems in multiple disciplines (Kalantari et al., 2017). However, additional indicators are needed to assess research. In many cases, citation analysis and peer review ensure better judgment. Currently, various technologies have greatly simplified the generation of bibliometric reports (Ellegard & Wallin, 2015). However, with the increasing processing of citations, Google Scholar cannot collect all types of academic literature. This poses a problem in its coverage (Mongeon & Paul, 2016). The most comprehensive databases for retrieving literature from various scientific fields are Springer and SCOPUS (Chadegani et al., 2013). Therefore, this study compared the keyword "interaction design" in the Springer and SCOPUS databases, respectively, to finally determine the selected database.

Bibliometric analysis is a quantitative method for analyzing publication rates, citations, impact factors, and other bibliographic quantities, with the aim of revealing publication trends and relationships. Bibliometric analysis is useful for reducing specific disciplinary research and publications or measuring the level of academic attention to specific subjects. This bibliometric analysis reviewed the publication

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trends of articles on "interface design" and "usability" from 2013 to 2024. The databases for bibliometric analysis mainly include Web of Science Core Collection, Springer, SCOPUS, ScienceDirect, and Google Scholar, to display annual publications, most relevant authors, sources, countries, topics, and keywords. Google Scholar enables users to find and access academic information more easily, providing free access to all types of academic literature. Springer and Scopus are the most extensive databases in different scientific fields and can be used to retrieve literature.

Methodology

This study employs bibliometric research methods to evaluate and analyze publication trends, and to determine insights into publications on interaction design. Initially, a search was conducted for "interaction design" in literature, titles, abstracts, and keywords based on two prominent databases, SCOPUS and Springer, with SCOPUS chosen for data collection. A search on SCOPUS yielded 1236 literature items, while a search on Springer using the same keywords yielded 2807 literature items. Springer is a renowned academic publishing institution offering a wide range of academic publications and online resources covering multiple disciplines such as science, technology, medicine, humanities, and social sciences. It includes academic journals, professional books, textbooks, and reference books. Although Springer is one of the primary and most renowned databases for literature retrieval and research, SCOPUS claims to have broader coverage than Springer (Ghanbari et al., 2019). Therefore, SCOPUS was selected for the search for titles, abstracts, and keywords related to "interaction design." As of January 28, 2024, a search on SCOPUS for "interaction design" and "usability" yielded 585 literature items. Since 2013, the total number of citations for all papers is 3995, with an average of 7 citations per paper.

The theme search for "interaction design" and "usability" in the SCOPUS database yielded 585 literature items. The average citation count for these 585 relevant documents is 7 times. The last 585 groups of documents were analyzed using the scientific mapping tool BiBliometrix-collection (http://www.bibliometrix.org/) (Aria & Cuccurullo, 2017).

Table 1 summarizes key information from the collected bibliometric data. A total of 132 articles, 9 reviews, and 444 conference papers were included. In order to delineate current subtopics within the field of interaction design, particularly interaction design and user experience, we conducted a qualitative analysis of the 20 most frequently cited articles selected from the total of 585 papers. The following sections provide both quantitative and qualitative content.

Table 1: Synopsis of the Essential Information of Accumulated Bibliometric Data.

Description	Results
Timespan	2013-2024
Sources (Journals, Books, etc)	271
Documents	580
Annual Growth Rate %	-29.8
Document Average Age	5.62
Average citations per doc	6.636
Keywords Plus (ID)	3285
Author's Keywords (DE)	1754
Authors	1741
Authors of single-authored docs	45
Single-authored docs	49
Co-Authors per Doc	3.44
International co-authorships %	19.83
article	132
conference paper	435
conference paper review	1

3. Quantitative Analysis

3.1 Analysis of Publication Years

Figure 1 illustrates the annual systematic output of publications on "interaction design," "usability," "user experience," and "interface design" from 2013 to January 28, 2024. During this period, a total of 585 papers were published, comprising 444 conference papers, 9 literature reviews, and 132 articles. In 2017, 65 papers were published, while the same number, 59 papers, were published in 2019 and 2021. The number of publications decreased from 2013 to 2015 but peaked in 2017 with 65 papers, marking the climax of the field. Subsequently, several turning points occurred. There was a rapid increase in the number of publications from 2016 to 2017. From 2017 to 2019, there was a fluctuation in the number of publications, initially decreasing and then increasing again. From 2019 onwards, the number of publications stabilized. However, there was a slight increase in the number of publications from 2022 to 2023, with 58 papers published in 2022 and 60 papers published in 2023. As of December 2023, the number of papers continued to show a rising trend, indicating sustained interest from many researchers in the field of interaction design.

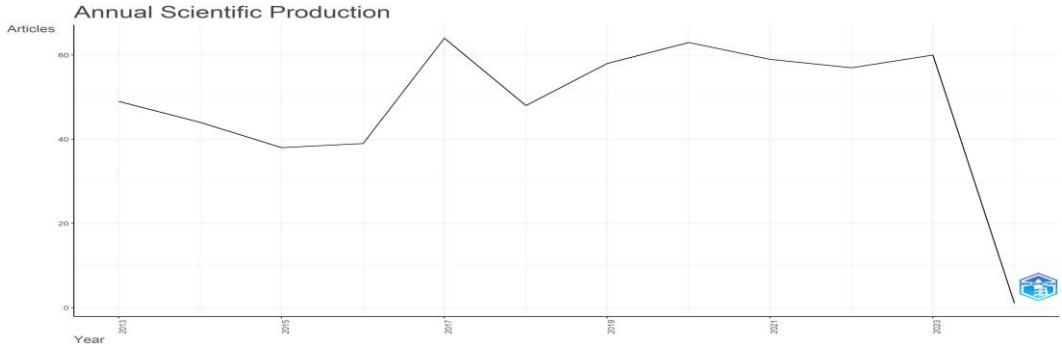


Figure 1: Annual Scientific Output for Interaction Design Research, 2013- – 2024.

From 2013 to January 28, 2024, the median number of citations per year for articles is depicted in Figure 2. According to this trend, articles published in 2015 had the highest average number of citations per year. Papers published in 2013 also had relatively high average citation rates. However, starting from 2021, the number of papers published gradually decreased. In this bibliographic collection, a total of 585 cited documents, including articles, conference papers, and literature reviews, were included. Figure 3 displays the most cited documents from 2013 to 2024. Local citation measures the number of citations received by papers within the analyzed set. As shown in the figure, the top two local citations belong to articles published in 2015, with the bulk of average article citations occurring in 2015.

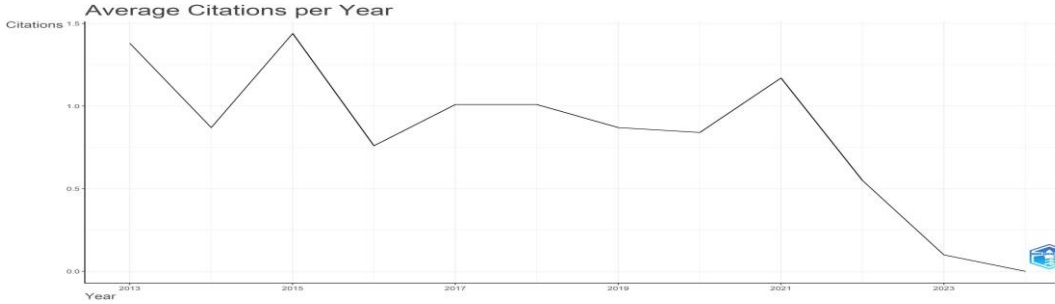


Figure 2: Average Citations according to a Year of Articles Used in Interaction Design Research,2013-2024.

Analysis of Authors

Figure 3 presents the results for the most relevant authors from 2013 to 2024. The red color indicates the active time periods of the authors, among which LEE H has published 9 papers on interaction design from 2013 to 2024, making them the most active author over this period. The size of the bubbles correlates with the number of publications in recent years, while the intensity of the bubble colors is proportional to the total citation count each year. During this period, authors like LEE-J and ZHAO have been among the most prolific in this field, publishing more than 8 relevant articles each. Several authors also published highly cited papers from 2013 to 2014. This chart indicates an increasing number of researchers delving into interaction design and demonstrating a strong interest in this field.

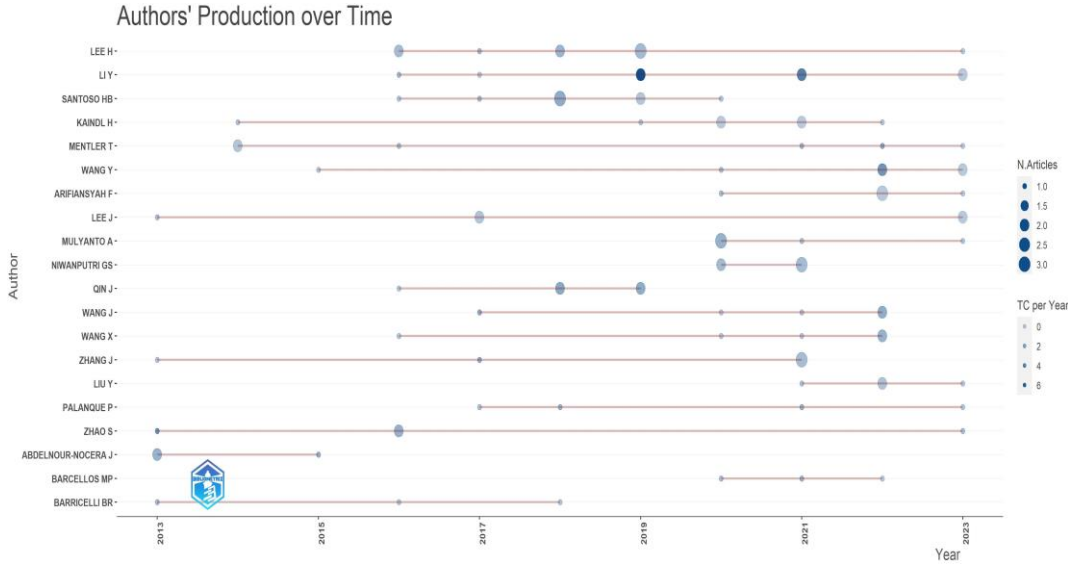


Figure 3: Top 20 Locally Cited Publications on Interaction Design Research Field.

Analysis of Sources

A total of 585 data sources including journals, literature, and conference series were utilized in this bibliometric study. Figure 5 illustrates the relevant literature sources in interface interaction design and usability. Each source contributed one or more documents to this analysis. Among them, LECTURE NOTES IN COMPUTER SCIENCE (including subseries LECTURE NOTES IN ARTIFICIAL INTELLIGENCE and LECTURE NOTES IN BIOINFORMATICS) stands out as one of the most significant journals in the field of interface interaction design, publishing approximately 98 documents from 2013 to 2024. COMMUNICATIONS IN COMPUTER AND INFORMATION SCIENCE follows as the second top journal, publishing 15 articles currently. ADVANCES IN INTELLIGENT SYSTEMS AND COMPUTING published approximately 14 articles during the period from 2013 to 2024. The number of documents published by other journals in this analysis is less than 5. The top-ranked journals hold significance for scholars in the field of interaction design research, as this determines whether they consider submitting their papers to these journals.

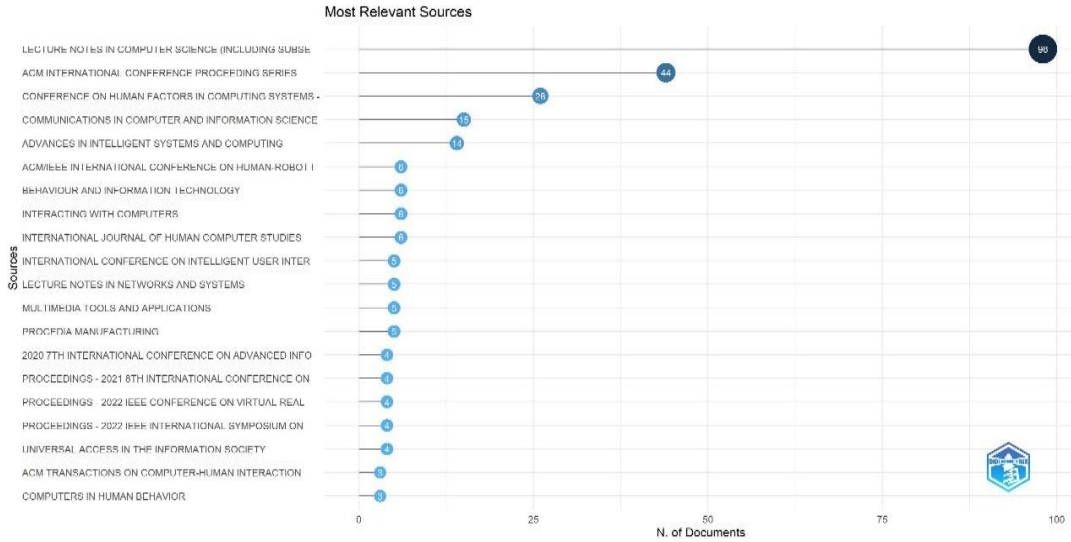


Figure 4: Top 20 Most Pertinent Author's Publications on Interaction Design Research Area From 2013 to 2024 (Red Stroke: The Author's Timeline, Bubble Size: The Number of Publications, Bobble Color Robustness: Total Citations Per Annum.

3. Analysis of Countries

In the field of multimedia interaction design, a total of 585 articles are distributed across 64 countries. The scientific productivity of the top 20 countries is depicted in the graph, where red represents articles with at least one foreign co-authorship, and green represents articles authored by individuals from the same country. These publications are referred to as Multi-Country Publications (MPC) and Single-Country Publications (SCP). China has 63 publications, the United States has 29 publications, and Germany has 27 publications, making them the most influential and relevant countries. Thus far, China is one of the most internationally collaborative countries. In terms of stakeholder interests, the United States leads in the number of articles authored by single authors.

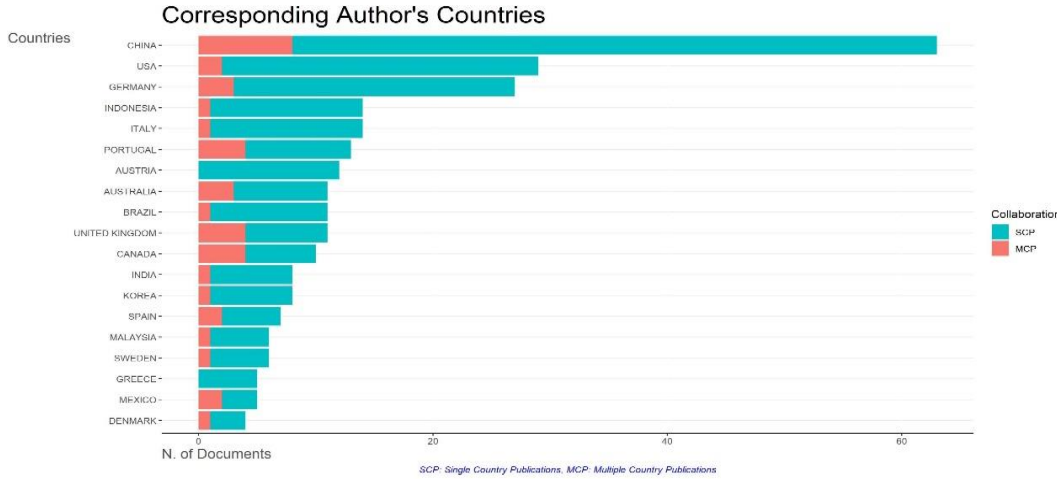


Figure 5: Top 20 Corresponding Author's Country (Red Stroke: Multiple Countries Publication (MCP), Single Country Publication (SCP).

Figures 6 and 7: Number and Collaborative Relationships of Authors on Global Interaction Design Usability Themes. Figure 6 provides a comprehensive depiction of the number of authors categorized by publishing country. The quantity of articles jointly published on interaction design usability themes by major nations is illustrated in Figure 7. The intensity of blue in both figures is proportional to the number of collaborating authors from each country. Each shade of blue represents a range of associated authors, ranging from the deepest shade (Chinese authors) to the lightest (Greece, Moscow, and Denmark). The United States and China stand as the two leading research powerhouses in interaction design studies. The United Kingdom and Germany represent the second largest producers. In Figure 9, the thickness of the red strokes correlates with the quantity of multi-party publications from each country. The sections of closest red interconnection between nations represent the quantity of collaborative documents, with the most prominent being between the United States and China. As depicted in Figure 9, China and the United States collaborate extensively in systematic production. Overall, China emerges as a central nation for all published documents, given the numerous frequent interconnections between China and other nations.

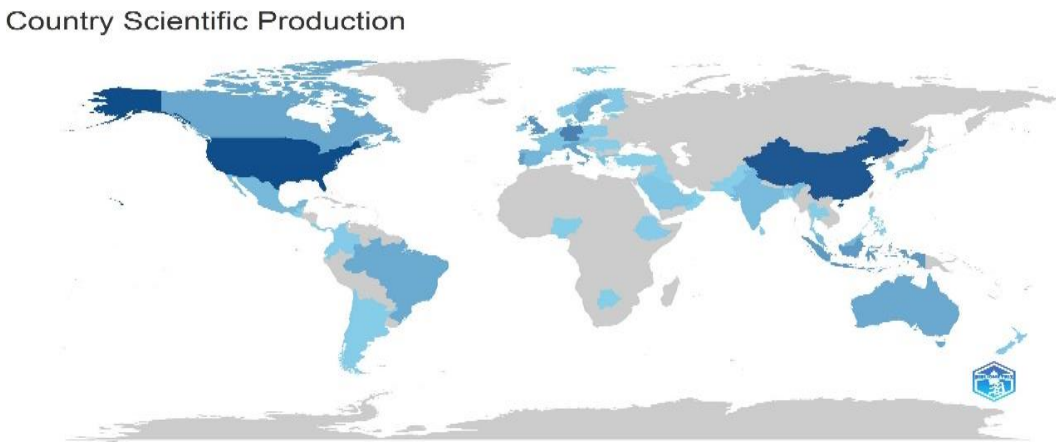


Figure 6: Country's Systematic Production World Map of Interaction Design (Blue Color Robustness: the Number of Authors Related with Each Country, Grey Color: Non-affiliated Country).

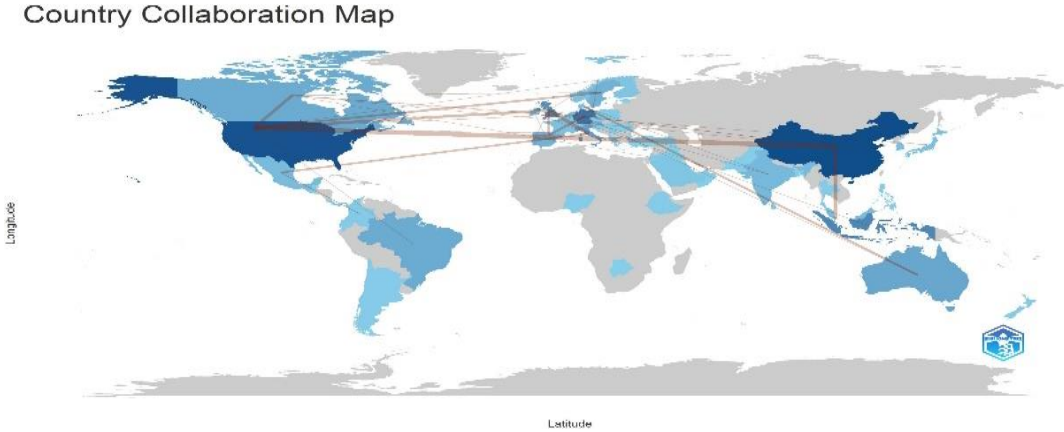


Figure 7: Country Alliance World Map of Interaction Design (Blue Color Concentration: the Number of Authors Allied with Each Country, Grey Color: Non-allied Country, Red Stroke Thickness: The Number of Shared Publications).

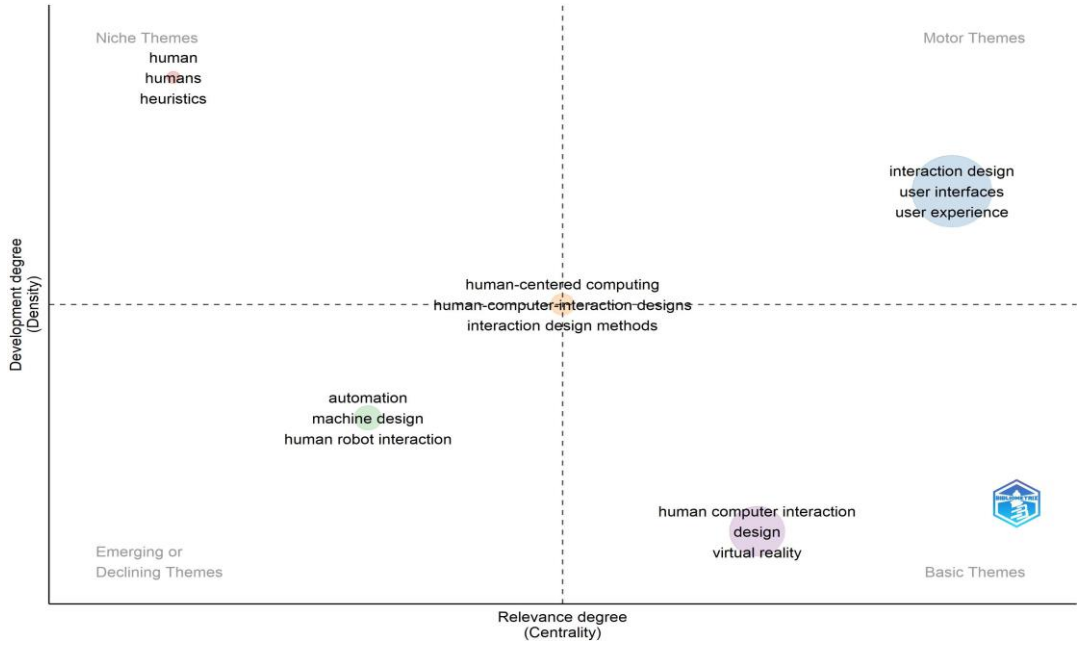


Figure 8: Thematic Map of Keywords Network Clusters in Interaction Design (Bubble Magnitude: The Collections Word Occurrence Rate).

Analysis of Keywords

Figures 9 and 10: Association of Keywords in Interaction Design and Usability Research with Authors' Affiliated Schools. This study establishes three domain graphs to present the keywords of articles related to interaction design and usability. Figures 9 and 10 display the graphs of the three domains, primarily focusing on the top keywords. Figure 9 demonstrates the selection of three primary metadata regions: countries in the midfield, keywords in the rightward region, and journals in the leftward region. It illustrates the connections between keywords, journals, and countries. The most commonly used relevant keywords include interaction design, usability, user-centered design, computer interaction, human-computer interaction, among others. The authors frequently utilize keywords such as interaction design, usability, user experience, interface design, human-computer interaction, and production design. Figure 10 is generated by selecting three different information regions: authors' affiliated schools in the middle, journals on the left, and keywords on the right. It elucidates the connections between keywords, journals, and schools. Keywords are computer-generated words or phrases that frequently appear in title citations. Compared to Figure 9, Figure 10 indicates a denser association between keywords and journals. The analysis of keywords in the field of interaction design research and prominent research topics assists readers in discovering new literature. As depicted in Figure 10, many papers are published in the "Lecture Notes in Computer Science" including subseries "Lecture Notes in Artificial Intelligence" and "Lecture Notes in Bioinformatics" journals, which also feature numerous articles on interaction design, user experience, interface design, user interfaces, and usability testing. Furthermore, 44 articles are published in the ACM International Conference Proceeding Series.

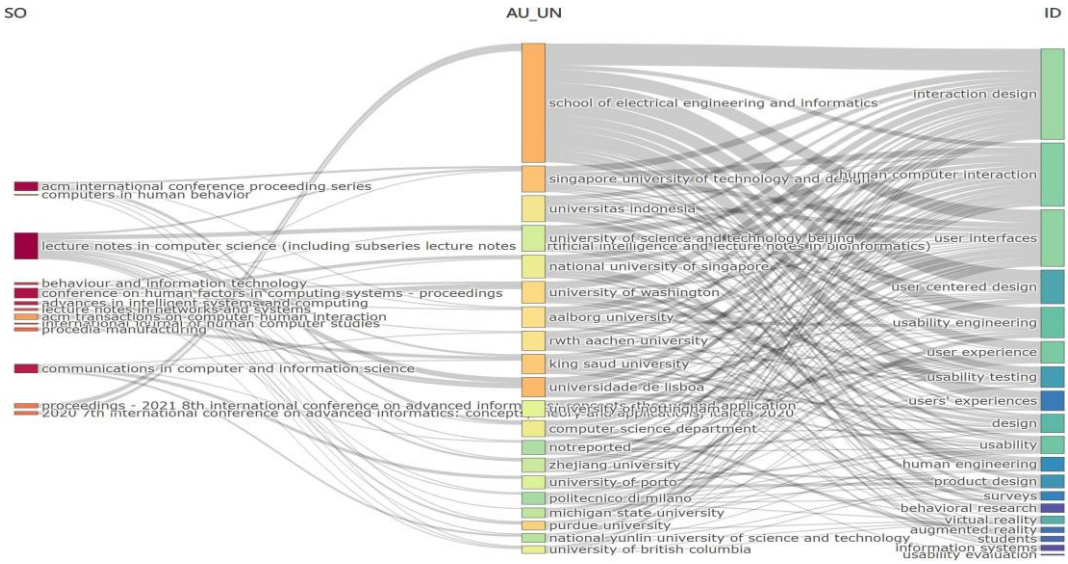


Figure 9: Three-Area Plot for the Affiliation among Topmost Keywords (the Left Area), Top Authors (the Mid Area), and Top Countries (the Mid Area) in Interaction Design.

Additionally, 27 articles are published in the "Conference on Human Factors in Computing System Proceedings," a journal covering topics such as user-centered design, usability testing, users' experiences, design, human engineering, interaction design, and human-computer interaction. Moreover, there are 15 articles each published in "Advances in Intelligent Systems and Computing" and "Communications in Computer and Information Science." Since each author engages with a plethora of available publishers in their articles, Figure 9 proves particularly useful for identifying the themes of articles published in top-tier journals, thereby providing guidance for submitting papers to specific journals.

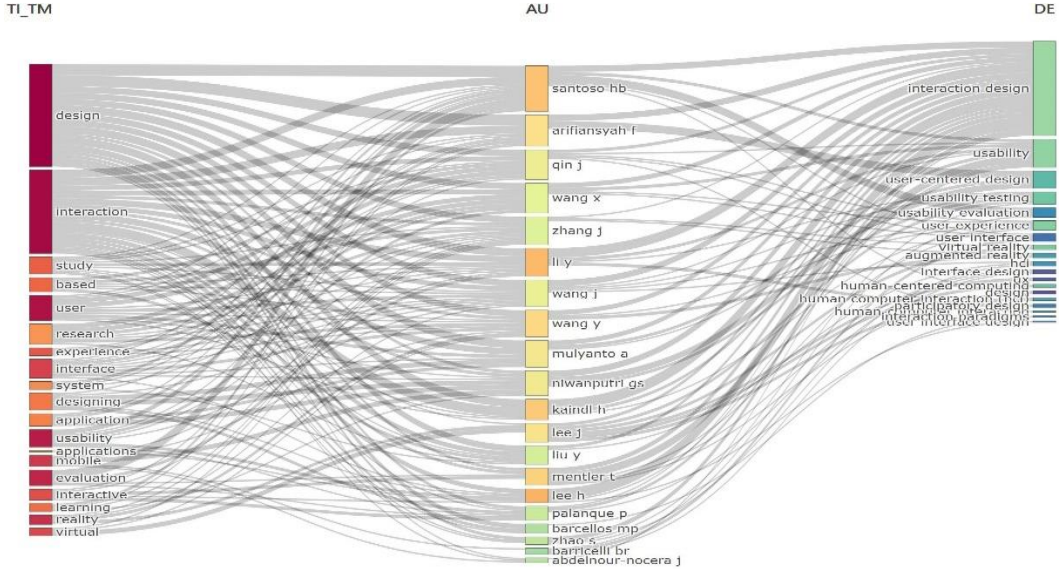


Figure 10: Three-area Plot for the Affiliation among Topmost Keywords (the Left Area), Top Authors (the Right Area), and Top Countries (The Mid Area) in Modularity for Sustainability Publications.

Analysis of Keywords

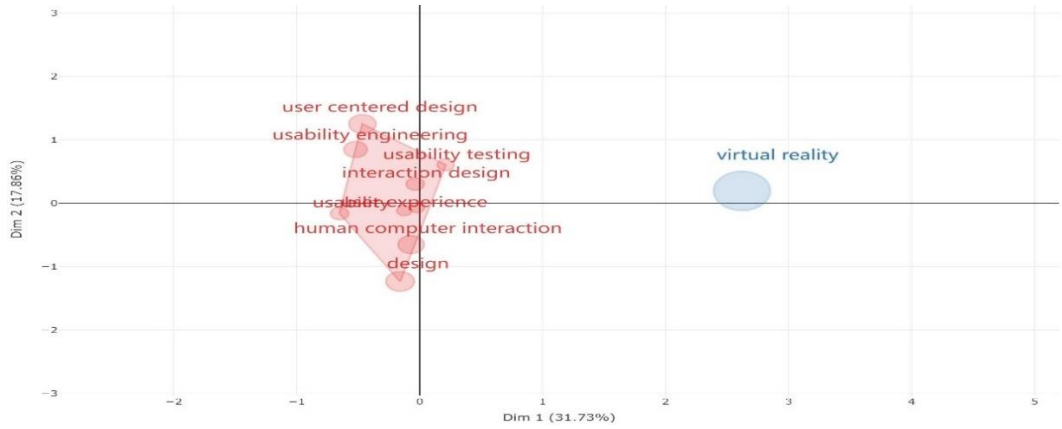


Figure 11: Conceptual Structure Map of Keywords in Interaction Design (Dim.1 and Dim.2: the Typical Situation of the Articles Involved in Each Keyword).

Figure 11: Results of Keyword Clustering Analysis
As shown in Figure 11, each color represents a cluster of words known through categorized clustering. Hence, keywords are divided into two clusters. On the other hand, the blue cluster contains only one keyword, while the red cluster is more prominent compared to the blue cluster. The red cluster consists of 9 keywords, indicating that this cluster contains a single keyword. The cluster of keywords includes interaction design, user interfaces, human-computer interaction, user experience, usability, usability engineering, design, virtual reality, user-centered design, and usability testing.

Figure 12 displays another conceptual structure of keywords called a tree map. The term "tree map clusters" may refer to a tree map, a data visualization technique used to represent the distribution of hierarchical data. Tree map clusters organize data hierarchically and use rectangular areas to represent the data of each level, with the size of the rectangle often associated with the size of the data or some measure. This graph contains the same information as Figure 11 but with a different view. Similarly, the conceptual structure tree map displays two clusters of keywords, measuring the distance between words or clusters of words. Each tree map cluster describes a partition while dividing at the right place.

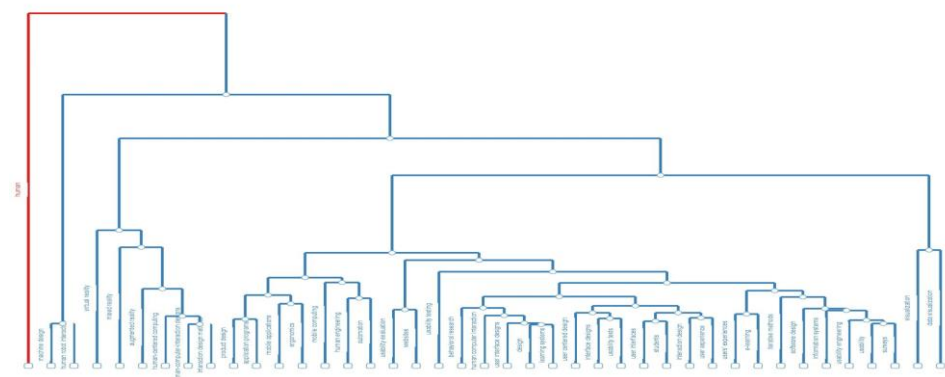


Figure 12: Conceptual Structure Dendrogram of Keywords in Interaction Design (Height: The Distance Among Clusters of Words).

Sometimes, authors need to quickly identify the most prominent terms in their research field. "Word cloud" is a graphical way of visualizing textual data. A word cloud arranges words from the text based on their frequency and importance and presents them in a visually appealing manner, commonly used to display keywords in textual data. Figures 13-16 represent top keywords, top author keywords, top title words, and top abstract words, respectively. Keywords are extracted from the titles of the articles, providing insight into the depth of the articles' content. Author keywords constitute a list of words matching the articles from the authors' perspective. While both keywords and author keywords have similar effects in knowledge exploration through bibliometric analysis, author keywords are more inclusive in providing topics. Top title and abstract words are driven by abstracts or titles devoid of any punctuation or trivial terms like paper, study, work, data, etc



Figure 13: Top Keywords Plus Interaction Design Publications (Font Size: Word Existences).

Figure 14 displays author keywords, ranging from 340 occurrences to a minimum of 2, including terms like interaction design, user interfaces, human-computer interaction, user experience, usability, etc. Figure 15 illustrates commonly occurring words in titles such as design, interaction, user, usability, evaluation, reality, mobile, interface, virtual, interactive, which are most relevant. Figure 16 indicates that the most common words in abstracts are design, interaction, usability, user, experience, study, system. These words frequently appear in the context of interaction design. In summary, author keywords, keywords, and abstract keywords follow a similar pattern. Therefore, authors should use more relevant vocabulary in their titles, abstracts, or as keywords for their publications.



Figure 14: Word of Top Author's Keywords in Interaction Design Publications (Font Magnitude: Word Existences).



Figure 15: Top Title Words in Interaction Design Publications (Font Size: Word Occurrences).



Figure 16: Topmost Abstract Words in Interaction Design Publications (Font Magnitude: Word Occurrences).

Figure 16: Displays keywords appearing in abstracts, with the most common ones being design, interaction, usability, users, experience, study, and system. These abstract keywords frequently appear in publications related to interaction design. What's most interesting is that the top few terms originate from data collection terminology. Surprisingly, the words in author, title, or abstract keywords do not follow the pattern observed in the keyword cloud. Therefore, authors should use more relevant terms to theme.

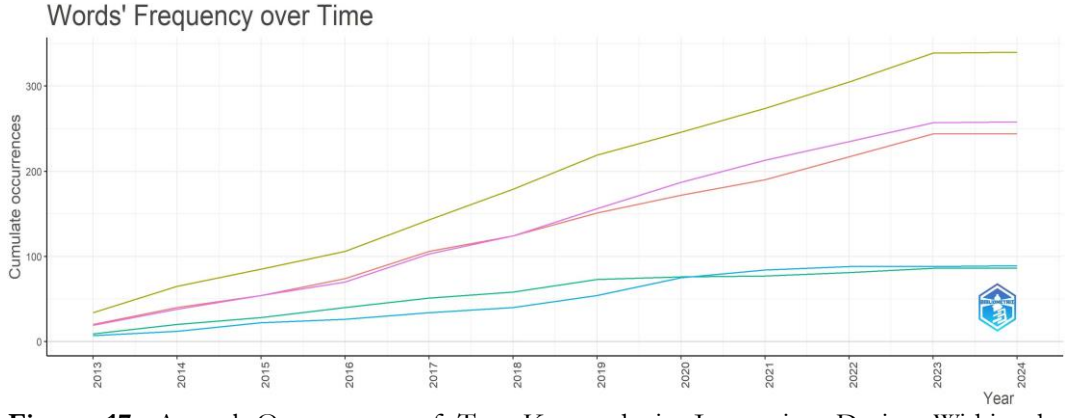


Figure 17: Annual Occurrences of Top Keywords in Interaction Design Within the 2013to2024 Period (Method: Loess Smoothing).

Figure 17 illustrates a steady increase in the prominence of interaction design as a research topic from 2013 to January 2024. By 2023, it had reached 280 occurrences. Keywords such as Human-Computer Interaction, user interfaces, user experience, and usability have become increasingly frequent in recent publications. Since 2019, the keyword "user experience" has received relatively little attention in the academic community. The most commonly used keywords have been increasing each year, indicating an expanding research interest in these topics. With the rapid growth in frequency from 2013 to 2024, it is anticipated that there will be a substantial amount of research in the field of interaction design in the future.

Qualitative Analysis

From 2013 to January 2024, 585 papers related to interactive design were published in the multimedia field. It is noted that 2% of scientific papers have been cited over 50 times, indicating high-quality papers within our bibliographic dataset. Therefore, at least 12 papers published from 2013 to 2024 have been cited at least 50 times. This section will conduct a qualitative analysis based on the data.

Subjects

Common themes among the cited articles on interactive design include user experience, interactive design, usability, interface design, and more. The supplementary table also highlights the most relevant article themes along with their sub-themes. Each top-level article has discussed or utilized the usability of interactive design in its case studies or in some form as the primary theme of the authors.

The majority of statistical analyses were conducted using variance analysis and t-tests. SPSS, a robust quantitative data analysis software, was employed for document analysis or directly importing documents. In this paper, a literature analysis was conducted based on ten articles concerning interactive design. These ten highly cited articles collectively emphasize the comprehensive consideration of technology, user experience, and practicality in design. Studies on user satisfaction, usability, biofeedback, among others, provide a comprehensive perspective for design, yet challenges within their respective domains still need to be addressed.

In the realm of technological intervention and social media design, Helen et al. (2011) focused on the role of technology in social media interactive design, emphasizing the potential of real-time feedback and passive monitoring. They underscored the pivotal role of technology in social media design, positively impacting usability and sociability. Regarding electronic health record navigation, navigation is considered a crucial aspect of evaluation, significantly influencing system usability and user experience (Lisette et al., 2017). In terms of cognitive-affective models and user satisfaction, Oren and Ayelet (2013) compared the performance and user preferences between tangible interfaces and graphical interfaces, with users showing a preference for tangible interfaces despite comparable performance, highlighting the importance of users' subjective experiences.

Research by Coursaris and Osch (2016) focused on the impact of cognitive and affective dimensions on user satisfaction, emphasizing that website design should consider visual aesthetics and cognitive factors based on the influence of cognitive and affective dimensions on user satisfaction. In the field of mobile augmented reality application design, scholars

emphasized exploring the interaction design principles of mobile augmented reality applications (Boletsis et al., 2015). Design principles are crucial for ensuring high usability and performance of Mobile Augmented Reality (MAR) applications, enhancing user satisfaction and overall user experience.

Other studies have focused on the application of low-cost camera-based free gestures in 3D user interfaces (Oren & Ayelet, 2013) because free gestures offer a natural and immersive user experience of 3D environments but face different challenges from 2D interaction and device-dependent interaction. Research on mobile UI design patterns is currently limited, necessitating more comprehensive research to formulate design guidelines (Punchoojit & Hongwarittorrn, 2017). Therefore, based on augmented reality learning system mobile UI design patterns, current research focuses on the application of augmented reality technology in geometry learning, enhancing students' spatial perception and academic performance. However, it requires larger sample sizes and in-depth research (Koong et al., 2015), and the shortcomings of this research are also one of the key points for future research.

Overall, these literature reviews demonstrate the diversity of design and evaluation in different fields, emphasizing the value of integrated approaches in addressing practical issues and enhancing user experience. Further research can better understand user needs, improve design methods, and drive innovation in technology and user experience. Ultimately, enhancing students' interest in mobile UI design through augmented reality-based UI has profound educational significance and simultaneously enhances augmented reality UI design.

Conclusion

Bibliometric analysis employs mathematical and statistical methods to evaluate scholarly output. Despite extensive bibliometric studies on "interaction design" and "usability," there is currently no bibliometric analysis of literature on "interaction design." This study primarily utilized SCOPUS data to conduct bibliometric analysis of research literature on interactive design from 2013 to January 2024. The results indicate progress in recent years based on interactive design and usability, with the number of papers on interactive design research steadily increasing each year, peaking in 2015. Researchers from countries such as China, the United States, Germany, and Japan contributed the majority of publications, with China and the United States ranking first and second, respectively, in publication output. "Lecture Notes in Computer Science (including subseries Lecture Notes)" was identified as the most suitable journal for research in the field of interface interaction design.

The top terms in our bibliographic set, both in terms of occurrence and co-occurrence, include representative keywords such as interaction design, usability, and user experience. Interaction design and usability have made significant progress in recent years, with 2015 and 2017 serving as turning points. The results of this work are expected to provide a better vision for future research directions and offer valuable insights for practice in the field of interaction design.

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