Computational Scientometric Modeling of E-book Usability Research and Knowledge Evolution

Yuheng Tao[1], Jianping Huang[2], Wenting Fang[3], Jun Wu[4]*
[1]School of Design, NingboTech University, Ningbo 315100, Zhejiang, China
[2]School of Fine Arts, Fujian Normal University, Fuzhou, China
[3]School of Art and Design, Shanghai DianJi University, Shanghai 201306, China
[4]School of Art and Design, Division of Arts, Shenzhen University, Shenzhen, China
Corresponding author: Jun Wu (e-mail: junwu2021@szu.edu.cn).

ABSTRACT This study employs computational scientometric modeling to analyze the citation network of the seminal work *Usability Evaluation of E-books*, addressing the lack of quantitative understanding of how interdisciplinary knowledge evolves in interactive reading design and human–computer interaction. Using bibliometric data from Web of Science and Scopus, 135 citing publications were retrieved and processed through a data-driven citation-tracking algorithm. CiteSpace was utilized to generate dynamic knowledge maps integrating network topology, thematic clustering, and temporal modeling. The analysis reveals a hierarchical and concentric knowledge structure that evolved through three distinct stages: a technology-driven emergence phase (2009–2012), an application expansion phase (2013–2017), and a human-centered convergence phase (2018–present). Bridging nodes such as "visual fatigue" and "human–computer interaction" computationally link previously isolated research clusters, illustrating the mechanisms of interdisciplinary integration. The findings propose a hierarchical computational model of knowledge evolution, demonstrating the effectiveness of algorithmic citation analysis in mapping intellectual structures. This work provides a reproducible methodological framework for analyzing scholarly influence and knowledge development, offering insights into the future evolution of interactive reading design and related computational humanities fields.

INDEX TERMS computational scientometrics; citation network analysis; knowledge evolution; interactive reading design; human–computer interaction; bibliometric modeling; interdisciplinary integration

I. INTRODUCTION

THE digital revolution has profoundly transformed reading behaviors and modes of knowledge acquisition. Since the early twenty-first century, the rapid emergence of e-books, digital reading devices, and interactive texts has not only reshaped traditional reading media but has also fostered an innovative paradigm of human–computer interaction design known as interactive reading design [1]. This field aims to enhance the reading experience within digital environments through technological innovation, drawing on diverse disciplines such as human–computer interaction, cognitive engineering, and digital media design [2]. Despite its rapid development, the field's knowledge architecture, evolutionary dynamics, and disciplinary boundaries remain theoretically underexplored. Existing research largely concentrates on specific technologies or application contexts, providing empirical insights while leaving the mechanisms of knowledge formation, the regularities of intellectual evolution, and the processes of interdisciplinary integration insufficiently addressed.

Scientometric theory posits that the advancement of scientific knowledge follows socially constructed mechanisms in which highly influential publications form the intellectual foundation of a discipline. Purtill [3] further suggests that the establishment and transformation of disciplinary paradigms pivot on critical theoretical breakthroughs. Such seminal works exert sustained academic influence through citation networks, shaping the evolution and deepening of associated research themes. Building on social network theory and knowledge diffusion theory, scholars have demonstrated that citation networks effectively illuminate the structural configuration of a field, the dynamics of research frontiers, and the mechanisms of cross-disciplinary knowledge integration [4].

Within the field of interactive reading design, the *Usability Evaluation of E-books* by Kang, et al. [5] stands as a foundational milestone. By establishing a theoretical framework and methodological system for evaluating e-book usability, this study has provided enduring conceptual and analytical tools for future research. Over the past fifteen

years, it has been widely and continuously cited across human–computer interaction, educational technology, and digital media design, serving as a critical vantage point for understanding the evolution of knowledge in interactive reading design. Although recent reviews have examined the development of digital reading technologies, they predominantly rely on qualitative synthesis and lack the quantitative analysis required to uncover the structural and evolutionary mechanisms of knowledge networks.

This study addresses three interrelated research questions: how the citation network shaped by Kang, et al. [5] reveals the knowledge-evolution patterns of interactive reading design; what structural features and developmental regularities characterize this body of knowledge; and how interdisciplinary knowledge integration unfolds through citation relationships. To investigate these questions, a citation network centered on *Usability Evaluation of E-books* was constructed and analyzed using scientometric and knowledge-mapping approaches to trace the field's intellectual evolution from 2009 to 2024.

The research pursues four specific objectives. First, it develops a citation-network-based analytical framework for knowledge evolution grounded in the sociology of scientific knowledge, thereby extending theoretical understanding of emerging interdisciplinary domains. Second, it identifies core knowledge clusters, key conceptual trajectories, and mechanisms of cross-disciplinary integration through multidimensional citation analysis. Third, it detects research frontiers and emergent themes to provide evidence-based foresight and strategic guidance for the field's future development. Fourth, it validates the methodological efficacy of a core-literature-based, precise citation-tracking strategy for constructing knowledge maps of emerging disciplines.

This study contributes on three levels. Theoretically, it enriches the sociology of scientific knowledge by elucidating the evolutionary mechanisms of nascent interdisciplinary fields. Methodologically, it advances scientometric practices by refining citation-network-based approaches to knowledge mapping. Practically, it offers researchers and policy makers a systematic knowledge framework and evidence-based forecasts to guide the future trajectory of interactive reading design.

II. METHODS

This study employs a bibliometric approach that integrates citation analysis with knowledge mapping to elucidate the mechanisms of scientific knowledge dissemination and evolution [6]. Drawing on Kuhn's theory of scientific revolutions and the sociology of scientific knowledge, it assumes that highly influential publications serve as pivotal nodes whose citation networks reveal intellectual diffusion pathways, patterns of scholarly influence, and the dynamic evolution of research frontiers. Guided by this perspective, a seed-based citation network was constructed around *Usability Evaluation of E-books* [5], and all peer-reviewed journal articles citing this seminal work were systematically analyzed to uncover the knowledge structure and evolutionary patterns of interactive reading design.

A precise citation-tracking strategy underpinned the data collection. Using the study by Kang, et al. [5] as the seed document, we retrieved all citing journal articles published between 2009 and 2024 from the Web of Science Core Collection and Scopus. This approach ensured authoritative and comprehensive data coverage through two internationally recognized citation databases. By relying on citation linkages rather than keyword searches, it assembled a corpus with intrinsic intellectual coherence, thereby minimizing the risk of topic drift. Centering the network on a highly cited foundational study provided a robust basis for revealing the core knowledge architecture and long-term developmental trajectory of the field.

Data selection was conducted according to strict scientific and systematic criteria. Non-journal publications such as conference papers and book chapters were excluded to maintain disciplinary rigor. Records with inaccurate citation links or incomplete bibliographic information were removed, and each entry was manually verified for relevance to interactive reading design. This meticulous process produced a high-quality dataset that accurately reflects the knowledge construction processes of the scholarly community.

Analyses were conducted using CiteSpace (version 6.1.R6). Bibliographic records—including titles, abstracts, author keywords, and cited references—were imported with a temporal window of 2009–2024 and a one-year time slice. Keywords were selected as the primary node type. The analytical procedures comprised keyword co-occurrence analysis to calculate frequency and betweenness centrality, cluster analysis to identify thematic groupings, timeline visualization to trace the temporal development of research themes, timezone mapping to display the first-appearance years of keywords, and burst detection to identify terms with sharp increases in frequency. To complement these analyses, a country/region collaboration network was generated to map the international landscape of research cooperation. All visualizations and parameter settings are preserved in CiteSpace outputs to ensure methodological transparency, analytical reliability, and cross-study comparability. The resulting knowledge maps, interpreted through the integration of quantitative indicators and qualitative insights, reveal the structural dynamics and developmental trends of the field.

III. DATA SOURCES AND DESCRIPTION

Using the citation-tracking strategy described above, this study systematically retrieved all scholarly works citing "Usability Evaluation of E-books" by Kang, et al. [5] from the Web of Science (WoS) Core Collection and Scopus databases via the CiteSpace platform, thereby constructing a high-quality citation network dataset. The initial search yielded 205 records, comprising 132 from Scopus (64.7%) and 72 from WoS (35.3%). After rigorous data cleaning and quality control, including the removal of 70 duplicate entries and verification of all citation links, 135 valid records

were retained. The combined use of these two authoritative citation databases ensured both the accuracy of citation relationships and the comprehensiveness of data coverage, effectively mitigating potential biases associated with single-source retrieval.

The document-type distribution underscores the academic rigor and intellectual depth of the dataset. Among the 135 valid publications, peer-reviewed journal articles constitute the overwhelming majority, complemented by one early-access article and two review papers. This composition ensures the scholarly reliability of the dataset while indicating that the field has entered a stage of conceptual consolidation and theoretical synthesis. Data completeness further reinforces analytical robustness: 99.0% of the documents contain full abstracts, 92.2% include Digital Object Identifiers (DOIs), 93.1% provide author keywords, and 64.2% supply complete reference lists. These well-structured metadata offer a strong empirical foundation for subsequent multidimensional bibliometric analyses.

The temporal distribution of the citation network reveals a distinct pattern of intellectual evolution. Citations began in 2010 with four publications, rose sharply to a first peak of 15 articles in both 2013 and 2014, and reached a second peak of 13 articles in 2019, followed by sustained activity in recent years. This sequence reflects the enduring scholarly influence of Kang et al.'s seminal work: the rapid growth from 2010 to 2013 indicates its formative role in the early development of interactive reading design; the stable output from 2014 to 2018 suggests a phase of disciplinary maturation; and the resurgence in 2019 aligns with a new wave of digital reading technology innovation.

The dataset also exhibits a high degree of internationalization and disciplinary diversity. The 135 publications are distributed across 96 academic journals, authored by 388 scholars affiliated with 220 research institutions in 42 countries and regions. This wide geographic and disciplinary spread highlights the field's interdisciplinary nature, with contributions appearing in leading journals of human–computer interaction, computer science, educational technology, information science, and psychology. It also reflects the active engagement of a global scholarly community and the presence of extensive cross-border research collaboration.

Overall, the dataset is distinguished by its high quality, broad disciplinary scope, long temporal coverage, and strong international representation. These characteristics provide a reliable empirical basis for tracing the diffusion of scholarly influence and the evolutionary trajectory of knowledge surrounding this foundational work, thereby enabling a comprehensive analysis of developmental dynamics and emerging trends in interactive reading design.

IV. RESULTS

A. KEYWORD CO-OCCURRENCE ANALYSIS

Node size represents the frequency of each keyword within the corpus, while the presence of a purple ring indicates high betweenness centrality, reflecting the keyword's bridging function across thematic clusters. Edges denote co-occurrence relationships, and node colors progress from blue to green to red to indicate first appearance from early to recent years.

The network reveals several high-frequency and structurally significant keywords, including electronic publishing, e-books, students, visual fatigue, and augmented reality. Among these, electronic publishing exhibits the greatest frequency, signifying that early investigations centered on digital publishing and the usability and effectiveness of e-books [7]. The prominence of students reflects extensive scholarly interest in the adoption and impact of digital reading among learner populations, particularly the integration of electronic textbooks in educational contexts [8]. The keyword visual fatigue shows both high frequency and strong centrality, indicating sustained attention to ocular comfort and the effects of prolonged screen reading, as well as a bridging role that links human factors, device design, and reading-performance research [9]. Similarly, human-computer interaction and reading comprehension display notable centrality, underscoring the field's close intellectual connection with human–computer interaction research and its focus on how digital reading environments influence comprehension and cognitive outcomes [10].

Overall, the co-occurrence analysis reveals the field's primary thematic structure, which encompasses technological innovation in digital publishing and e-books, user adoption and experience, particularly with regard to student populations, cognitive processes, and reading outcomes, such as comprehension and memory, as well as human-factor concerns related to visual comfort and ergonomics. Together, these clusters outline the intellectual core and developmental trajectory of interactive reading design over the study period.

B. KEYWORD CLUSTER ANALYSIS

The keyword co-occurrence network is organized into eleven significant clusters (Cluster #0–#11), each represented by color-coded groups of closely related nodes. Cluster labels are derived from representative keywords or terms identified by the CiteSpace algorithm, with their strength scores indicating the robustness of the labeling (e.g., electronic publishing in Cluster #1 scores 14.92). Major clusters include electronic publishing (#1), the Technology Acceptance Model (#3), augmented reality (#6), augmented reality smart glasses (#7), and visual fatigue (#0).

The clustering results delineate the principal thematic subfields that together define the intellectual landscape of interactive reading design.

1.Early digital reading technologies and adoption.

Cluster #1 (electronic publishing) contains keywords such as electronic publishing, print media, and digital libraries, reflecting early investigations into the comparison of digital versus print media and the production and distribution of

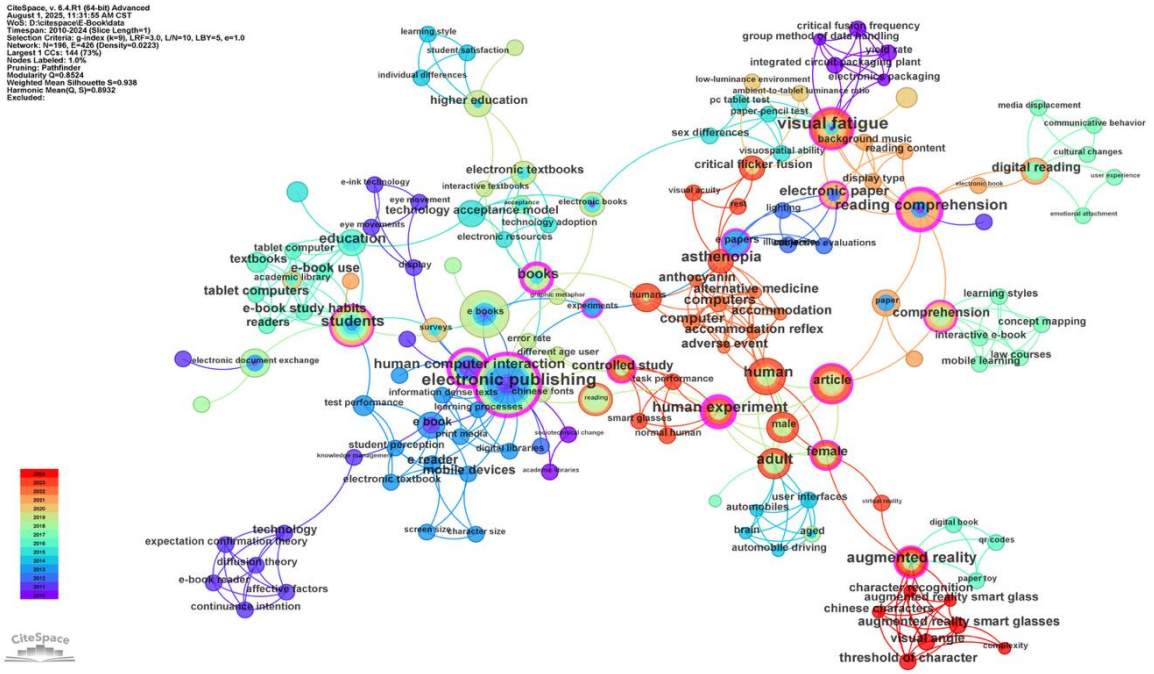

FIGURE 1. Keyword co-occurrence network in interactive reading design (2009–2024).

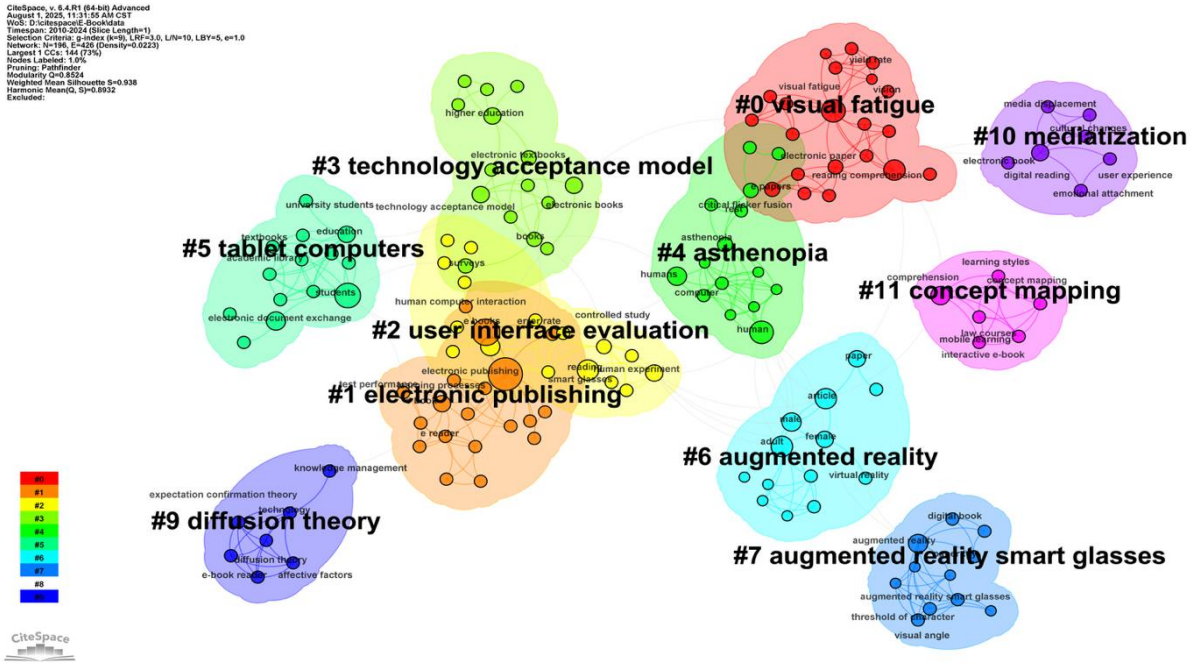

FIGURE 2. Keyword clusters in interactive reading design (2009–2024).

digital content [11], [12]. Cluster #9 (diffusion theory) includes terms such as e-book readers, continuance intention, and expectation-confirmation theory, indicating research that applied technology diffusion and user-satisfaction frameworks to study e-book adoption [13], [14]. Collectively, these clusters capture the research emphasis of the early 2010s on the emergence of digital reading technologies and patterns of user acceptance.

2.Educational contexts and user experience.

Cluster #3 (Technology Acceptance Model) and Cluster #11 (Concept Map + Interactive E-book) f focus on the use of electronic textbooks and interactive e-books in higher education and curriculum design. They emphasize constructs such as technology acceptance, learning styles, and learning

outcomes [15]. Cluster #5 (tablet computers) examines the reading preferences and device-use habits of university and elementary school students [16], [17]. Together, these clusters document the integration of digital reading into educational practice and investigate the attitudes and learning effects associated with electronic materials among students.

3.Digital reading behavior and media effects.

Cluster #10 (media displacement/mediatization) incorporates keywords such as digital reading, media displacement, and cultural change. Studies in this cluster examine how the rise of digital reading reshapes traditional reading habits and communication practices, including the degree to which digital media supplant print [18], [19]. The concentration of work around 2017 signals growing concern with the sociocultural implications of evolving reading behaviors.

4.Emerging technologies and immersive reading.

Cluster #6 (augmented reality) and Cluster #7 (augmented reality smart glasses) represent newer research directions. Cluster #6 highlights topics such as Google Glass, silent reading, reading speed, and driver distraction [20], while Cluster #7 focuses on AR smart glasses, visual angle, character thresholds, and legibility [21]. These clusters highlight the growing significance of augmented reality and wearable devices as platforms for reading, with a focus on information presentation, visual performance, and attentional demands.

5.Human factors and visual health.

Cluster #0 (visual fatigue) and Cluster #4 (computer vision syndrome/digital eye strain) address the visual and ergonomic consequences of prolonged electronic reading. Cluster #0 includes terms such as visual fatigue, reading comprehension, and display type [9], while Cluster #4 comprises digital eye strain, visual discomfort, and children's eyesight [22]. These clusters underscore the persistent centrality of visual physiological load, from early comparisons of e-paper and print to recent concerns arising from VR/AR applications.

Overall, the cluster analysis reveals a rich and multilayered knowledge structure. Technological themes, such as electronic publishing and AR devices, intersect with user-centered topics on learning outcomes and satisfaction, as well as with human–computer interaction and health-related concerns, including reading behavior change and visual fatigue. The sequential and overlapping emergence of these research fronts charts an evolutionary trajectory from technological development to user adoption and onward to experience optimization, defining the core intellectual architecture of interactive reading design..

C. TIMELINE OF KEYWORD CO-OCCURRENCE

Each horizontal line represents a thematic cluster labeled with its number and title, aligned against a dashed time axis (2009–2024). Dots indicate the publication year of individual documents within each cluster, with larger dots signifying higher centrality. Bar segments depict the duration of research activity.

The temporal patterns reveal a staged yet overlapping trajectory of knowledge development. In the early phase around 2010, electronic publishing (Cluster #1) emerged as a formative theme, remaining active from approximately 2010 to 2014. During the same period, diffusion theory and e-book acceptance (Cluster #9) exhibited concentrated activity around 2011, highlighting early efforts to examine the emergence of technology and user adoption.

Between 2013 and 2017, multiple themes evolved in parallel. Research on the Technology Acceptance Model and the integration of electronic textbooks in higher education (Cluster #3) was most active from 2012 to 2016. Investigations of tablet-based reading behaviors and preferences (Cluster #5) continued from 2013 to 2018. Studies of digital reading practices and media displacement or mediatization (Cluster #10) gained momentum between 2016 and 2019, reflecting heightened interest in the sociocultural implications of changing reading habits.

The most recent phase, beginning after 2017, is characterized by the rise of immersive and wearable technologies. Augmented reality (Cluster #6) emerged around 2015 and continued until about 2020. Augmented reality smart glasses (Cluster #7) emerged after 2018 and remained active through 2024, signifying a cutting-edge research frontier in information presentation, legibility, and attentional dynamics. Throughout the entire period, human-factor concerns remain persistent: visual fatigue (Cluster #0) and computer vision syndrome/digital eye strain (Cluster #4) have been continuously active since 2010, with a renewed intensity around 2020 in response to the widespread adoption of VR/AR applications and prolonged screen exposure.

Taken together, the timeline portrays an evolutionary sequence in which early studies on digital reading technologies laid the groundwork for research on educational adoption and societal diffusion, which in turn opened pathways to investigations of new immersive media. Earlier topics were not supplanted but instead overlapped with and informed subsequent lines of inquiry, producing a cumulative and progressively diversified knowledge base in interactive reading design.

D. KEYWORD TIME-ZONE ANALYSIS

The vertical axis lists keywords, and the horizontal axis represents publication years from 2009 to 2024. Each keyword's first appearance is shown as a node at the corresponding year, with node size proportional to occurrence frequency and color shading from cool to warm to indicate early to recent emergence.

As shown in Figure 4, The temporal distribution clarifies the sequential rise of major research themes. Around 2010, the concepts of electronic publishing and visual fatigue emerged as pioneering ideas, capturing the initial focus on the implementation of electronic publishing and the visual implications of digital reading [7]. These early keywords anchored the theoretical and methodological foundations of interactive reading design.

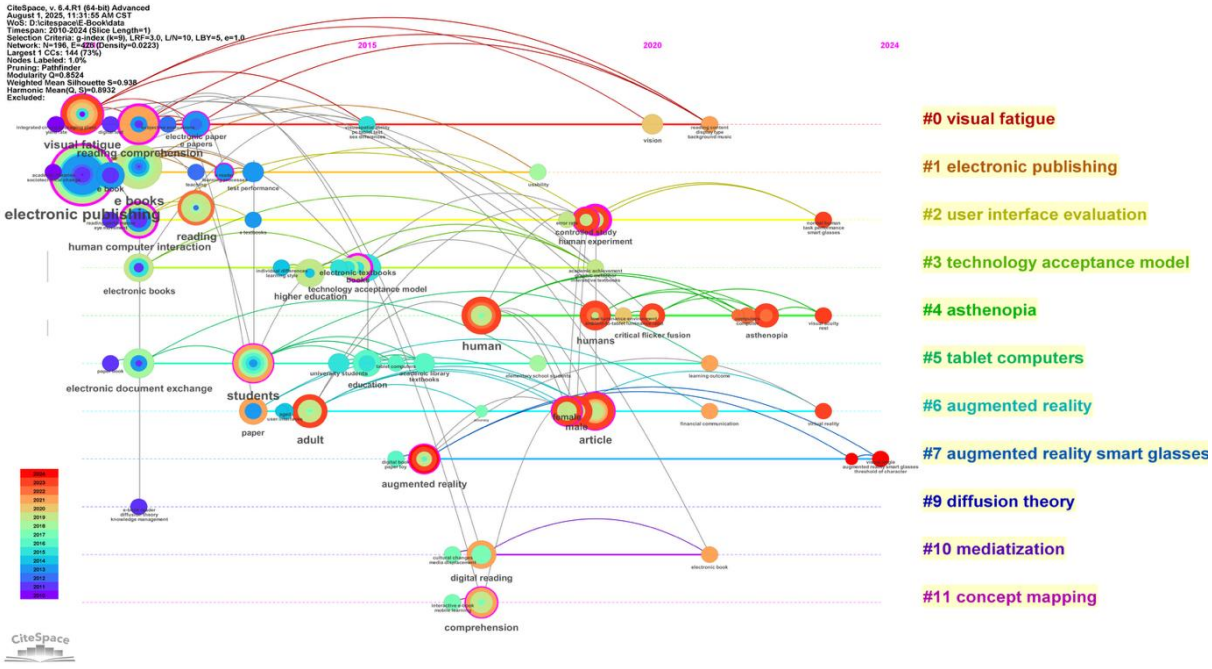

FIGURE 3. Timeline view of the keyword co-occurrence network.

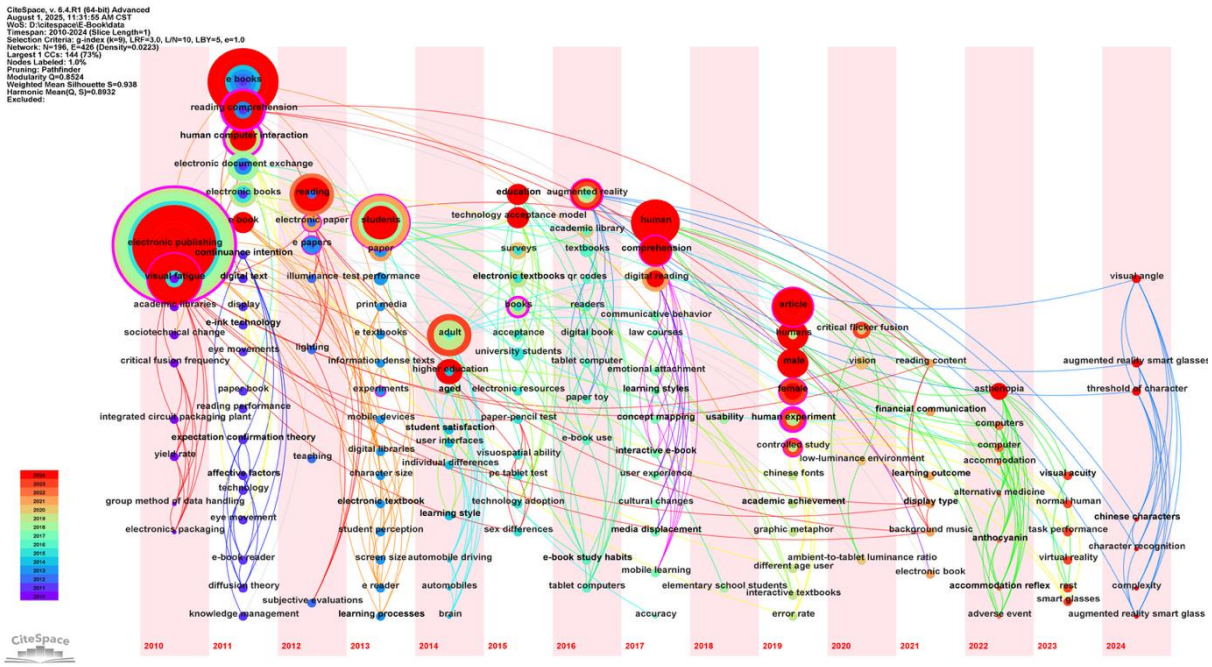

FIGURE 4. Time-zone view of keyword emergence.

From 2011 to 2013, terms such as e-book, human-computer interaction, and reading comprehension entered the discourse, reflecting an expansion toward e-reader interface design, human–computer interaction, and the cognitive impact of digital reading on comprehension [23], [24]. Between 2014 and 2016, the appearance of college students, the technology acceptance model, and electronic textbooks signaled the integration of digital reading into educational contexts and a growing emphasis on user acceptance and instructional effectiveness [25].

Around 2017, the introduction of digital reading and media displacement marked a new line of inquiry into how the growth of digital media reshapes traditional reading practices and cultural communication patterns [18]. From

2018 to 2020, concepts such as augmented reality and smart glasses marked the field's transition toward immersive and wearable technologies, foregrounding issues of information presentation and user attention [20]. By approximately 2021, augmented reality smart glasses emerged as a distinct research frontier, highlighting the latest technological advances in interactive reading [26].

In the period following 2020, keywords such as asthenopia and systematic review gained prominence.

Their emergence reflects two complementary tendencies: an increasing scholarly attention to the visual strain associated with prolonged digital reading and a growing focus on synthesizing existing findings through systematic reviews to consolidate a higher-level theoretical understanding.

Taken together, the time-zone analysis reveals a progressive and cumulative evolution of research priorities. The field has advanced from foundational concerns with electronic publishing and e-book usability to educational applications and user-centered investigations, and more recently to the integration of cutting-edge technologies and the assessment of health impacts and evidence synthesis. This layered sequence underscores the steady deepening and broadening of interactive reading design as a distinct domain of scholarly inquiry.

E. KEYWORD BURST ANALYSIS

Using CiteSpace's burst-detection algorithm, this study identifies keywords that experienced sharp, time-bound increases in frequency, thereby revealing how research interests intensified or shifted across different periods. A keyword burst signals a phase of rapid conceptual growth, indicating emerging or consolidating themes within the field.

From 2009 to 2024, the twenty strongest bursts delineate a clear temporal pattern of intellectual evolution. In the early phase (2010–2013), electronic publishing exhibited the highest burst strength (5.67), reflecting the surge of scholarly attention that accompanied the advent of digital publishing technologies [27]. During the same period, e-book and human computer interaction also displayed marked bursts, highlighting early priorities in e-reader usability and interface design [28].

Around 2015, the focus shifted toward pedagogical applications and the acceptance of technology. Keywords such as "technology acceptance model" and "education" exhibited short but pronounced bursts, indicating growing interest in electronic textbook adoption and in learning outcomes assessed through models of technology acceptance [15].

Following 2017, the field continued to diversify further. Digital reading exhibited a brief yet distinct surge around 2017, indicating heightened concern with evolving reading behaviors and the displacement of print-based practices [29]. From 2020 onward, visual fatigue has exhibited a strong and continuous increase, underscoring the sustained attention required to manage the visual strain associated with prolonged screen-based reading [30]. During the same period, systematic review emerged (2020–2022), signifying a phase of knowledge consolidation and synthesis [31]. Keywords such as "male" and "female" have repeatedly gained attention since 2019, reflecting increased interest in gender-related differences in digital reading engagement and outcomes [20], [21]. The recent surge in asthenopia in 2022 further highlights the increasing importance of eye health concerns [1].

Taken together, these patterns chart a progressive reorientation of research priorities. The early emphasis on the technological foundations of electronic publishing and e-books gave way by the mid-2010s to studies of educational adoption and user acceptance. In recent years, attention has converged on user experience and health-related issues in increasingly immersive digital environments. The persistent and strengthening bursts associated with visual fatigue and related ocular conditions suggest that eye health will remain a defining and expanding frontier in the future development of interactive reading design.

F. REGIONAL COLLABORATION NETWORK

The analysis of international collaboration reveals the global research relationships that underpin the field of interactive reading design. As shown in Figure 5, Taiwan, the United States, and the United Kingdom occupy the most central positions in the network, signifying both high research productivity and strong, sustained co-authorship links.

Taiwan's influence is particularly prominent. Foundational studies originating in Taiwanese universities established key conceptual and methodological frameworks that stimulated subsequent scholarship. In recent years, Taiwan's sustained activity in digital learning and human–computer interaction has further consolidated its role as a pivotal hub in international cooperation. The United States and the United Kingdom, long recognized as leading centers of scientific research, also demonstrate substantial contributions and maintain broad, diverse collaborative partnerships with scholars across the globe.

A second tier of active contributors includes mainland China, Australia, Malaysia, Japan, and India. Researchers in these regions produce a consistent flow of publications and engage in international joint projects, thereby broadening the field's geographic reach and enhancing its thematic diversity.

Taken together, the network depicts an increasingly mature and globally integrated research community, structured around the primary nodes of Taiwan, the United States, and the United Kingdom, with a widening circle of secondary participants. This configuration highlights the international and interdisciplinary character of interactive reading design, underscoring the central role of cross-regional collaboration in shaping the field's ongoing intellectual evolution.

TABLE I. Top 20 keywords with the strongest citation bursts.

Keywords	Year	Strength	Begin	End	2010–2024
electronic publishing	2010	5.67	2010	2013	
e book	2011	2.24	2011	2013	
human computer interaction	2011	2.19	2011	2013	
students	2013	1.96	2013	2016	
technology acceptance model	2015	3.1	2015	2015	
education	2015	2.76	2015	2016	
digital reading	2017	2.47	2017	2017	
human	2017	2.37	2017	2024	
comprehension	2017	2.34	2017	2021	
e books	2011	2.73	2018	2019	
reading	2012	2.39	2018	2019	
article	2019	3.01	2019	2024	
male	2019	2.33	2019	2024	
higher education	2014	2.08	2019	2019	
female	2019	2.08	2019	2019	
visual fatigue	2010	2.69	2020	2024	
systematic review	2020	2.15	2020	2022	
reading comprehension	2011	2.91	2021	2021	
humans	2019	2.68	2022	2024	
asthenopia	2022	2.32	2022	2024	

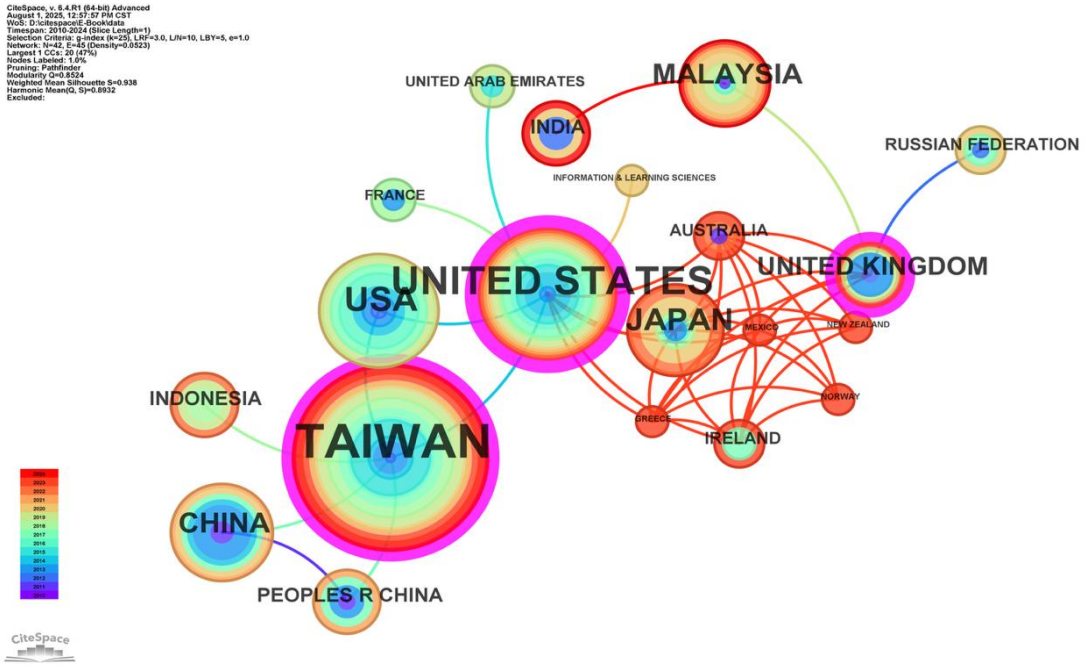

FIGURE 5. International collaboration network by country/region.

V. DISCUSSION

This study, grounded in a large-scale citation network analysis, provides both empirical evidence and theoretical refinement for the sociology of scientific knowledge. The findings reveal a clear hierarchical progression in the evolution of interactive reading design (Figure 6). Knowledge has advanced in successive layers from a technical foundation domain to user-experience, social-impact, health-concern, and finally emerging-technology domains. This pattern extends Kuhn [32] theory of scientific revolutions by showing that paradigm development in new interdisciplinary fields rarely follows a model of abrupt replacement. Instead, it reflects cumulative integration, whereby each successive layer builds on and enriches preceding structures rather than displacing them.

Network structure analysis reveals that concepts such as visual fatigue and human-computer interaction exhibit high betweenness centrality, serving as pivotal "knowledge bridges" that link diverse disciplines. This observation supports and expands Burt [33] structural holes theory by demonstrating that cross-disciplinary concepts often serve as engines of innovation. These bridging concepts not only enable the flow of ideas across disciplinary boundaries but also facilitate the formation of new theoretical frameworks. Temporal analysis (Figure 7) further reveals a cyclical feedback mechanism between technological development

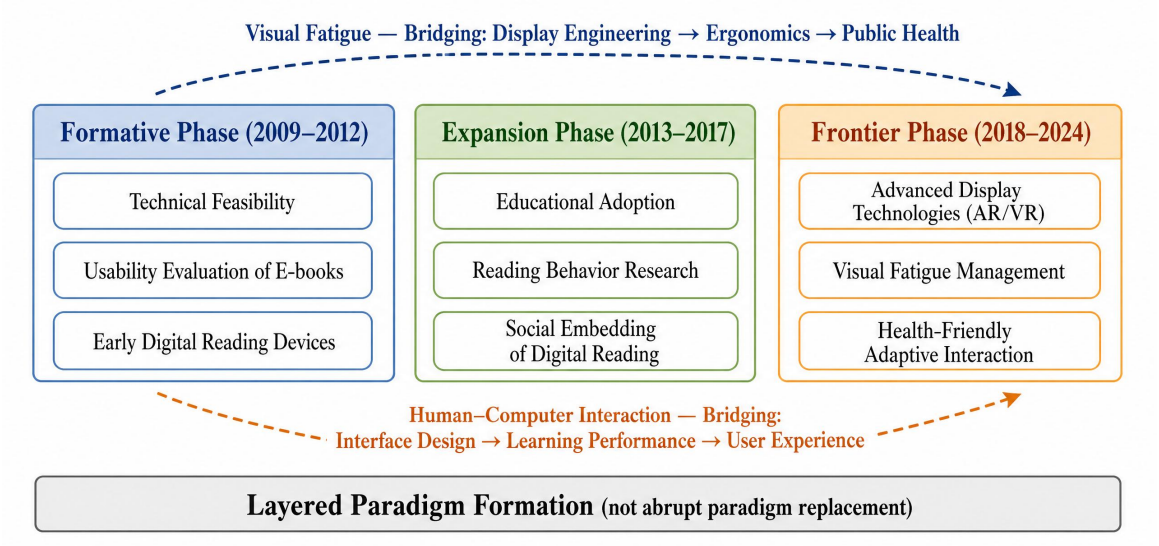

FIGURE 6. Hierarchical progression of knowledge evolution

and social demand: technological advances stimulate user adoption, which in turn highlights social implications; social concerns, in turn, elevate health considerations, driving the creation of new technological solutions. This dynamic, according to Bijker [34], is socio-technical systems theory and enriches it with the notion of a feedback cycle, emphasizing the ongoing and reciprocal construction of technology and society [35].

Methodologically, the study demonstrates the effectiveness of a core-literature-based citation-tracking strategy for mapping knowledge in emerging disciplines. Compared with conventional keyword searches, this approach more precisely delineates disciplinary boundaries, reduces topic drift, and preserves the internal coherence of the analyzed literature. By integrating five analytical dimensions—network structure, thematic clustering, temporal evolution, cross-disciplinary linkage, and geographic collaboration—this research establishes a replicable framework for comprehensive scientometric analysis. The strength of this framework lies in its ability to reveal multiple mechanisms of knowledge evolution and to provide a systematic model for future investigations.

The findings also offer concrete implications for the continued development of interactive reading design. Keyword-burst analysis indicates that future research should devote greater attention to health-related issues and emerging technologies, especially the mechanisms of digital eye strain and the optimization of AR/VR reading experiences. This trend signals a broader shift in value from technology-centered innovation to human-centered design. The pronounced cross-disciplinary character of the field, highlighted by network analysis, calls for institutionalized collaboration across human–computer interaction, cognitive science, and health psychology to foster theoretical innovation and practical breakthroughs. Geographic network analysis reveals a collaboration structure centered in Taiwan, the United States, and the United Kingdom. Strengthening partnerships between developing countries and these central hubs, while also encouraging South–South cooperation, would help establish a more balanced and inclusive global knowledge-production network.

By systematically examining the citation network surrounding *Usability Evaluation of E-books* [5], this study clarifies how a single foundational publication has shaped both the intellectual evolution and the scholarly communication of the field. The results reveal that the dialogue around this seminal work reflects a broader shift from technology-driven to user-centered paradigms. During the formative phase (approximately 2009–2012), research concentrated on the feasibility of new digital reading technologies and on user willingness to adopt them. During the expansion phase (2013–2017), scholarly attention broadened to encompass the integration of digital reading into education and learning, as well as the investigation of digital reading behaviors and their sociocultural implications. In the current frontier phase (2018–2024), the field has incorporated advanced technologies such as augmented reality, while focusing increasingly on user health and the optimization of reading experiences.

This evolutionary path illustrates a continuous rebalancing of technological innovation and user needs. Early studies emphasized technical implementation; subsequent work embedded digital reading within educational and cultural contexts; more recent research foregrounds user experience and health. At every stage, technological progress has created new opportunities; however, user requirements and responses have ultimately shaped the focus of inquiry. As each new reading technology emerged, early studies explored its functionality and performance. As adoption deepened, research shifted toward ensuring that the technology effectively supports human reading behavior and well-

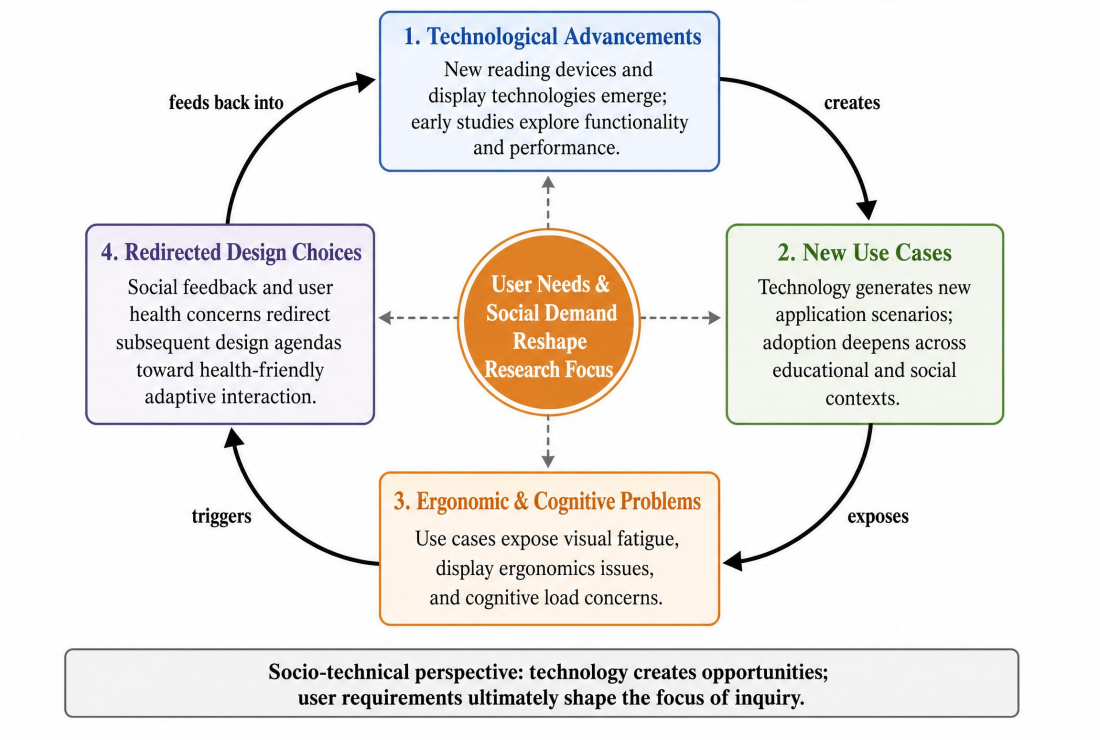

FIGURE 7. Cyclical co-evolution of technology development and social feedback

being. This pattern exemplifies a fundamental principle of human–computer interaction and is particularly evident in the trajectory of interactive reading design.

VI. CONCLUSION

This study employs scientometric methods to reconstruct the citation network surrounding *Usability Evaluation of E-books* (Kang et al., 2009), systematically elucidating the patterns of knowledge evolution and the mechanisms of scholarly influence in interactive reading design. The analysis reveals that the field exhibits a concentric knowledge structure, evolving through a hierarchical progression from technical foundations to user experience, social impact, health concerns, and frontier technologies. Interdisciplinary integration is facilitated through bridging mechanisms, while socio-technical construction unfolds as a feedback cycle linking technological innovation and societal response.

The study makes three primary academic contributions. Theoretically, it proposes a hierarchical progression model for knowledge evolution in emerging interdisciplinary fields, extending Kuhn's (1997) theory of scientific revolutions to cross-disciplinary contexts. It corroborates Burt's (2018) structural holes theory by demonstrating the role of bridging mechanisms within knowledge networks and refines Bijker's (1997) socio-technical systems perspective by introducing the concept of a feedback cycle that captures the reciprocal shaping of technology and society. Methodologically, it validates the effectiveness of a precise citation-tracking strategy for constructing knowledge maps in nascent fields and develops a multi-dimensional bibliometric framework—integrating network structure, thematic clustering, temporal evolution, cross-disciplinary linkage, and geographic collaboration-that can be replicated for the analysis of complex disciplinary networks. Practically, it provides a systematic knowledge map and evidence-based forecasts of development trajectories, offering guidance for research prioritization, the design of cross-disciplinary collaboration mechanisms, and the optimization of international cooperation networks.

Building on these findings, future research should prioritize several directions: investigations of digital health mechanisms, particularly the causes and prevention of digital eye strain; optimization of AR/VR immersive reading experiences; intelligent and adaptive interface design; cross-cultural comparative studies of reading behavior; and the establishment of standardized evaluation systems. The present study is constrained by its reliance on a single core publication, the English-language orientation of the data, and the temporal lag inherent in citation analysis. Subsequent work could address these limitations by incorporating multiple foundational texts, integrating multilingual databases, and employing near-real-time tracking to capture rapidly emerging research fronts.

Overall, interactive reading design is shifting from technology-driven innovation toward human-centered development. Sustained progress will depend on striking a balance between technological advances and user well-being, ensuring that future digital reading environments foster genuinely human-centered and sustainable reading

experiences.

FUNDING

This research was supported by the Art Program of the National Social Science Fund of China, Research on the Evolution and Index Construction of China's Design Industry from a Sino-Foreign Comparative Perspective (1980–Present) (Grant No. 23BG108).

REFERENCES

[1] K. Yan and M. Rosenfield, "Digital Eyestrain and the Critical Fusion Frequency," (in English), *Optom. Vis. Sci.*, vol. 99, no. 3, pp. 253–258, 2022. DOI: 10.1097/OPX.0000000000001872.

[2] S. Bulat Demir and A. C. Ilgaz Büyükbaykal, "Investigating book reading experiences in VR," (in English), *J. Libr. Inf. Sci.*, 2024. DOI: 10.1177/09610006241252659.

[3] R. L. Purtill, "Discussion Kuhn on Scientific Revolutions," *Philosophy of science*, vol. 34, no. 1, pp. 53–58, 1967.

[4] C. Chen, "Science Mapping: A Systematic Review of the Literature," *Journal of Data and Information Science*, vol. 2, no. 2, pp. 1–40, 2017. DOI: 10.1515/jdis-2017-0006.

[5] Y.-Y. Kang, M.-J. J. Wang, and R. Lin, "Usability evaluation of e-books," *Displays*, vol. 30, no. 2, pp. 49–52, 2009.

[6] M. Zitt and E. Bassecoulard, "Delineating complex scientific fields by an hybrid lexical-citation method: An application to nanosciences," *Information Processing & Management*, vol. 42, no. 6, pp. 1513–1531, Dec. 2006. DOI: 10.1016/j.ipm.2006.03.016.

[7] J. A. C. García, J. A. Arévalo, and H. M. Rodero, "The emergence of electronic books publishing in Spain," (in English), *Library Hi Tech*, vol. 28, no. 3, pp. 454–469, 2010. DOI: 10.1108/07378831011076693.

[8] A. K. Taylor, "Students Learn Equally Well From Digital as From Paperbound Texts," (in English), *Teaching of Psychology*, vol. 38, no. 4, pp. 278–281, 2011. DOI: 10.1177/0098628311421330.

[9] S. Benedetto, V. Drai-Zerbib, M. Pedrotti, G. Tissier, and T. Baccino, "E-Readers and Visual Fatigue," (in English), *Plos One*, vol. 8, no. 12, Dec. 2013, Art. no. e83676. DOI: 10.1371/journal.pone.0083676.

[10] K. Park, H. Seok, and K. Kim, "The effects of graphic metaphor, gesture interaction, and form factor on e-book performances and preferences," (in English), *Hum. Factors Ergonom. Manuf. Serv. Ind.*, vol. 29, no. 6, pp. 493–503, Nov. 2019. DOI: 10.1002/hfm.20812.

[11] D. H. Shin, "Understanding e-book users: Uses and gratification expectancy model," (in English), *New Media & Society*, vol. 13, no. 2, pp. 260–278, Mar. 2011. DOI: 10.1177/1461444810372163.

[12] A. M. Horcher and M. Cohen, "Ebook readers: An iPod for your books in the cloud," in *Communications in Computer and Information Science*, vol. 174, pt. 2, 2011, pp. 22–27. DOI: 10.1007/978-3-642-22095-1_5.

[13] C. Chan and C. Wu, "An ID-PKC-based scheme for digital ownerships of e-books," in *Proc. 2011 4th IEEE International Conference on Broadband Network and Multimedia Technology, IC-BNMT 2011*, 2011, pp. 70–74. DOI: 10.1109/ICBNMT.2011.6155898.

[14] T. Koizuka, S. Sano, T. Kojima, and M. Miyao, "Evaluating the effects of environmental illuminance on the readability of E-books," (in English), *Dig. Tech. Pap. SID Int. Symp.*, vol. 44, no. 1, pp. 571–573, 2013. DOI: 10.1002/j.2168-0159.2013.tb06273.x.

[15] W. Peng, R. A. Ratan, and L. Khan, "Ebook uses and class performance in a college course," in *Proc. Annual Hawaii International Conference on System Sciences*, R. H. Sprague and T. X. Bui, Eds., IEEE Computer Society, 2015, pp. 63–71. DOI: 10.1109/HICSS.2015.18.

[16] Ö. Koçak, Ö. Yildirim, E. Kursun, and G. Yildirim, "Investigating the Status of Tablet Computers and E-Books Use of Open Education Faculty Students: A Case Study," (in English), *Int. J. Distance Educ. Technol.*, vol. 14, no. 2, pp. 49–63, Apr.–Jun. 2016. DOI: 10.4018/ijdet.2016040104.

[17] A. Sugiura, T. Eto, H. Takada, and F. Kinoshita, "Cerebral blood flow in the prefrontal cortex while reading a novel on a tablet computer and its effect on sleep: Temporary and remaining changes," in *Proc. ICCSE 2016—11th International Conference on Computer Science and Education*, Institute of Electrical and Electronics Engineers Inc., 2016, pp. 35–40. DOI: 10.1109/ICCSE.2016.7581551.

[18] M. M. Nazarov and P. A. Kovalev, "Media landscape changes and current reading practices," (in Russian), *Sotsiologicheskie Issled.*, no. 2, pp. 84–95, Jan. 2017.

[19] T. R. Beelders and J. P. L. Du Plessis, "Reading usability of ereaders and ebooks for Information technology students," in *ACM International Conference Proceeding Series*, J. van Niekerk and B. Haskins, Eds., Association for Computing Machinery, 2018, pp. 205–214. DOI: 10.1145/3278681.3278706.

[20] C. H. Wang, N. H. Tsai, J. M. Lu, and M. J. J. Wang, "Usability evaluation of an instructional application based on Google Glass for mobile phone disassembly tasks," (in English), *Appl. Ergon.*, vol. 77, pp. 58–69, May 2019. DOI: 10.1016/j.apergo.2019.01.007.

[21] C. H. Wang, C. Y. Hsiao, A. T. Tai, and M. J. J. Wang, "Usability evaluation of augmented reality visualizations on an optical see-through head-mounted display for assisting machine operations," (in English), *Appl. Ergon.*, vol. 113, Nov. 2023, Art. no. 104112. DOI: 10.1016/j.apergo.2023.104112.

[22] S. Singh, M. B. McGuinness, A. J. Anderson, and L. E. Downie, "Interventions for the Management of Computer Vision Syndrome: A Systematic Review and Meta-analysis," (in English), *Ophthalmology*, vol. 129, no. 10, pp. 1192–1215, 2022. DOI: 10.1016/j.ophtha.2022.05.009.

[23] L. Ma and P. L. P. Rau, "Reading chinese in e-book readers: A review," in *Lecture Notes in Computer Science (including subseries Lecture Notes in Artificial Intelligence and Lecture Notes in Bioinformatics)*, vol. 6775, 2011, pp. 211–219. DOI: 10.1007/978-3-642-21660-2_24.

[24] A. J. Rockinson-Szapkiw, J. Courduff, K. Carter, and D. Bennett, "Electronic versus traditional print textbooks: A comparison study on the influence of university students' learning," (in English), *Computers & Education*, vol. 63, pp. 259–266, Apr. 2013. DOI: 10.1016/j.compedu.2012.11.022.

[25] C. M. Wang and C. H. Huang, "A study of usability principles and interface design for mobile e-books," (in English), *Ergonomics*, vol. 58, no. 8, pp. 1253–1265, Aug. 2015.

[26] C. Y. Hsiao, M. J. Wang, Y. T. Lu, and C. C. Chang, "Usability evaluation of monocular optical head-mounted displays on reading tasks," (in English), *Journal of Ambient Intelligence and Humanized Computing*, vol. 14, no. 11, pp. 14551–14560, 2023. DOI: 10.1007/s12652-018-1045-3.

[27] M. Letchumanan and R. A. Tarmizi, "E-book utilization among mathematics students of Universiti Putra Malaysia (UPM)," (in English), *Library Hi Tech*, vol. 29, no. 1, pp. 109–121, 2011. DOI: 10.1108/07378831111116949.

[28] Y. W. Chang and Y. C. Hsu, "User research for e-reader design in higher education," in *Ergonomics in Asia: Development, Opportunities, and Challenges—Selected Papers of the 2nd East Asian Ergonomics Federation Symposium, EAEFS 2011*, CRC Press, 2012, pp. 163–170. DOI: 10.1201/b11932-30.

[29] S. J. Lu, Y. C. Liu, M. C. Lin, and F. H. Lu, "Evaluating reading material formats on children learning in science education," (in English), *Int. J. Inf. Educ. Technol.*, vol. 9, no. 2, pp. 99–104, 2019. DOI: 10.18178/ijiet.2019.9.2.1181.

[30] H. Yu and T. Akita, "Influence of ambient-tablet PC luminance ratio on legibility and visual fatigue during long-term reading in low lighting environment," (in English), *Displays*, vol. 62, Art. no. 101943, 2020. DOI: 10.1016/j.displa.2020.101943.

[31] W. N. A. Wan Sulaiman and S. E. Mustafa, "Usability Elements in Digital Textbook Development: A Systematic Review," (in English), *Publishing Research Quarterly*, vol. 36, no. 1, pp. 74–101, 2020. DOI: 10.1007/s12109-019-09675-3.

[32] T. S. Kuhn, *The structure of scientific revolutions*. Chicago: University of Chicago Press, 1997.

[33] R. S. Burt, "Structural holes," in *Social stratification*. Routledge, 2018, pp. 659–663.

[34] W. E. Bijker, *Of bicycles, bakelites, and bulbs: Toward a theory of sociotechnical change*. MIT Press, 1997.

[35] D. G. Douglas, *The social construction of technological systems, anniversary edition: New directions in the sociology and history of technology*. MIT Press, 2012.