

Post-print: Research Status of Foreign Reading Services in Information Technology Environment Since 2017

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Abstract

[Purpose/Significance] This study surveys international research achievements on reading services in information technology environments from the past three years, aiming to provide a reference for the development of domestic research in this field.

[Method/Process] Using the Web of Science database, relevant international research findings since 2017 were retrieved and organized. These findings were analyzed and summarized from the perspectives of research topics and methods, extracting the advantages and characteristics of international research and discussing their implications for domestic research.

[Results/Conclusion] Research on digital and mobile reading services remains a hotspot in international studies in this domain. Regarding users, studies focusing on K-12 students constitute the largest proportion. From the perspective of research topics, studies on user behavior are relatively the most numerous. In terms of research methods, international research tends to combine one or several of the experimental method, questionnaire method, interview method, and observation method, demonstrating a relatively high degree of fit between research methods and research questions. Future domestic research should continuously monitor the development and application of new-generation information technology, continue to deepen research on user behavior, and reasonably select appropriate research methods according to research questions.

Full Text

Preamble

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Research Status of Reading Services in Information Technology Environment Abroad Since 2017

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Abstract:

[Purpose/Significance] This study investigates and analyzes foreign research on reading services in information technology environments over the past three years to provide references for domestic research and development in this field. [Method/Process] Using the Web of Science database, we retrieved and reviewed relevant foreign literature published since 2017, analyzing and summarizing the research from the perspectives of themes and methodologies. We extracted the advantages and characteristics of foreign research and discussed their implications for domestic studies. [Result/Conclusion] The analysis reveals that research on digital and mobile reading services remains a hot topic abroad. Regarding user groups, studies focusing on K-12 students are most prevalent. In terms of research themes, user behavior studies constitute the largest category. Methodologically, foreign research favors combining experimental methods with questionnaires, interviews, and/or observation, demonstrating high suitability between methods and research questions. Future domestic research should continuously monitor the development and application of new-generation information technology, deepen user behavior studies, and select appropriate research methods according to specific research questions.

Keywords: reading service; smart reading; intelligent reading; 5G reading; VR reading; digital reading

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The continuous transformation of information technology has changed human production and lifestyle, bringing infinite possibilities for the future. Reading services refer to services provided by publishing institutions, schools, libraries, and other organizations to support users' reading behaviors and processes, including reading literacy education, reading material supply, and assisted reading [1]. The impact of information technology on reading services is comprehensive, permeating every aspect and element of reading services, making it an important focus of academic research both domestically and internationally. While domestic scholars have produced some review articles on foreign research in digital reading, mobile reading, and mobile learning [2-7], there is a lack of introduction to recent research findings, especially regarding reading services in new-generation information technology environments. The development and transformation of information technology are rapid, with artificial intelligence and 5G—key new-generation technologies requiring focused attention—only being applied to reading services in recent years. Domestic research on artificial

intelligence began around 2017. To better understand recent foreign research achievements, this paper aims to organize foreign research findings on reading services in information technology environments over the past three years, analyze and summarize their research themes and methods, and provide references for domestic research development in related fields.

2 Literature Retrieval

To ensure comprehensive retrieval, we first identified relevant information technologies, including digital, mobile/5G, Internet of Things, cloud computing, big data, artificial intelligence, virtual reality (VR), and augmented reality (AR). We combined these technology terms with “reading” for searching. Since some library-related literature might also mention reading services, to reduce the probability of omission, we also combined various technologies with “library” for retrieval. The specific retrieval strategy is shown in Table 1 .

We used the SSCI and CPCI-SSH databases on the Web of Science platform as the primary sources for literature, collecting relevant foreign literature from 2017 to 2019 through subject searches on May 1, 2020. After refining by research direction, we obtained initial results. Since the literature included some library-related documents and possible false positives, we conducted further screening. Based on the initial retrieval results, we performed manual analysis of keywords, abstracts, and research purpose relevance, removing some irrelevant results and finally obtaining 153 relevant documents for subsequent analysis.

3.1 Research Themes and Content

Through reviewing the 153 documents, we found that the disciplines involved mainly include publishing, education, and library science, with education and library science literature constituting the vast majority.

When extracting research themes from the results, we used the existing reading service theoretical framework [1] as a preliminary reference for theme extraction. Based on this framework for initial classification, we conducted more detailed extraction and analysis of themes from foreign research results since 2017. The findings showed that research on reading service users concentrated on user behavior, while research on reading service content and strategies included reading literacy education, reading material supply, and assisted reading. We ultimately categorized the relevant research into seven themes, including “Research on Individual Factors Affecting Reading Behavior.” As shown in Figure 2 [Figure 2: see original paper], we conducted statistical analysis of the information technologies involved in each research theme. The results indicate that mobile/digital technology is involved in all research themes, with the largest number in the theme “Impact of Reading Medium on Reading Behavior.” VR/AR technology is distributed across four themes: “Reading Material Supply,” “Reading Teaching Strategies,” “Impact of Reading Medium on Reading Behavior,” and “Research on Individual Factors Affecting Reading Behavior,” with the largest number in

the latter. Intelligent/big data technology only involves two themes: “Reading Material Supply” and “Assisted Reading.”

As shown in Figure 1 [Figure 1: see original paper], among the information technologies involved, research related to digital and mobile technology accounts for the largest proportion, followed by research related to VR/AR technology. Research on reading services related to artificial intelligence and big data is relatively scarce, which differs somewhat from domestic research [1]. To reduce omissions, after initial screening, we read the retrieved literature and conducted additional searches using more granular themes such as “personalized recommendation” combined with “reading,” or searched citations of retrieved documents, but found no particularly relevant foreign research results. Additionally, we found no research directly applying Internet of Things/cloud-related technologies to reading services.

3.1.1 Research on Individual Factors Affecting Reading Behavior

This research mainly involves reading behavior in digital, mobile, and VR/AR technology environments, with relatively more studies on digital reading and mobile reading. The research primarily focuses on users’ reading note-taking behavior, reading payment behavior, etc., with the largest number of studies on reading comprehension effects. Reading comprehension is the result display of the reading process [10]. H. Blom et al. [11] investigated the auxiliary effect of graphics on reading comprehension and the impact of students’ cognitive language skills on understanding digital text content among students with hearing or language problems. Y. Zeng et al. [12] experimentally found that e-book format and reading devices affect reading speed and comprehension levels, with users showing relatively higher average comprehension levels when reading electronic format documents. C. Hähnel et al. [13] explored whether reading task difficulty, characteristics of digital text itself, and specific features of individual reading behavior can predict students’ comprehension effects when reading linear structured texts. S. W. Liu et al. [14] used eye-tracking technology to explore the online reading behavior of 52 non-native English learners.

Additionally, there are studies on electronic note-taking behavior on reading devices. For example, J. J. Thoms et al. [15] explored the linguistic and pedagogical advantages and areas for improvement of using digital annotation tools (eComm) to promote second language (L2) reading in second-year Chinese language courses at the university level. The research also includes purchasing behavior, with M. Zhang et al. [16] analyzing factors influencing e-book purchases.

In studying these behaviors, the main influencing factors include emotional factors, ability factors, demographic characteristics, and other individual features. F. A. Bachtar et al. [17] explored emotional factors when students read on computer platforms, using self-assessment scales to measure students’ emotions, personality, and learning styles. The results showed that students have specific

preferences and choices during reading activities, which affect their problem-solving strategies. J. Naumann et al. [18] used the Program for International Student Assessment (PISA) to study how German 15-year-old students' information technology-related abilities and attitudes toward IT affect their digital reading performance. N. Notten et al. [19] analyzed whether early home literacy environment affects adolescents' online reading behavior and whether this association differs across countries with varying levels of digitalization and educational expansion.

3.1.2 Impact of Reading Medium on Reading Behavior

Changes in reading media exert considerable influence on reading behavior. The evolution from digitalization to mobile device popularity and then to VR/AR device usage has altered user behavior, which foreign scholars have extensively studied. I. F. Liu et al. [20] examined the impact of paper-based reading ability and ICT-related skills on online reading. E. S. C. Ho et al. [21] investigated the effects of paper and different digital reading devices on reading performance, finding that users' comprehension levels were higher for paper reading than digital reading, with screen size having no impact on reading performance. They concluded that faster mobile reading speeds led to lower comprehension levels. G. Chen et al. [22] found that users' surface-level comprehension was better when reading paper materials than digital materials, but for users highly familiar with tablets, their deep-level comprehension was better than for those unfamiliar with tablets. The study concluded that reading medium is not the cause affecting reading comprehension, and that with sufficient training, digital reading can also achieve good comprehension. A. Mangen et al. [23] compared reader engagement, memory, and reasoning ability when reading longer texts on Kindle DX versus paper, finding that in most tests, subjects' performance was the same regardless of reading medium.

3.1.3 Digital Reading Literacy Assessment and Influencing Factors

This research mainly includes the definition of digital reading literacy, assessment schemes, and influencing factors of digital reading literacy. S. Ladislao et al. [24] defined online reading ability as a set of skills for using digital texts, including selecting and sequencing texts, navigating from one document to another, understanding and integrating information from different documents, and evaluating information based on its usefulness and quality. L. Salmerón et al. [25] proposed the WebLEC test based on the PISA framework to assess adolescents' Internet reading literacy skills, particularly navigation skills. I. Bråten et al. [26] showed that digital readers rarely evaluate the reliability of their information sources, and when they do, they tend to use visual information such as web design as evaluation criteria. J. Y. Wu et al. [27] explored the effects of reading medium (digital/paper), digital reading habits, cognition, metacognitive strategies, and navigation skills on digital reading literacy.

3.1.4 Assisted Reading

The emergence and gradual application of new-generation information technology, especially big data and artificial intelligence, has made it possible to use technological means to assist the reading process. This research mainly includes two aspects. First, using various information technologies to process reading content according to reading needs to assist human reading processes and achieve better reading effects. For example, B. Rüdiger et al. [28] developed a system that uses artificial intelligence technology to assist in reading scientific literature. Second, reading behavior management—some scholars help readers achieve better reading effects by consciously managing the entire reading process. For instance, S. Yoo et al. [29] found that many readers struggle to finish books they intend to read and developed a reading app called Nellodee that allows readers to estimate how many pages they need to read daily to meet their goals and track their progress to reflect on their reading performance. Other scholars directly intervene in reading behavior through intelligent means to regulate reading effects. For example, C. Mills et al. [30] experimentally tested whether Eye-MindReader (an intelligent interface for mind-wandering) could reduce the negative impact of mind-wandering on reading comprehension, finding that real-time intervention during critical periods of mind-wandering could promote long-term memory and understanding.

3.1.5 Information Technology Interference and Coping Strategies

The continuous updating of information technology also brings some negative impacts, such as the potential loss of ability or desire to read or write long texts, or current reading behaviors showing characteristics of superficiality, fragmentation, and fast-food consumption that are not conducive to better reading effects. Fragmented time allocation constantly interrupts people's attention. How to address these issues is also a key research direction for scholars.

Some scholars investigated how multitasking activities using mobile technology during live lectures, particularly browsing social networking sites and sending/receiving text messages, affect senior students' listening effectiveness. The results showed that when students had opportunities to use mobile phones to compose or send text messages, and during lectures checked Facebook profiles, read news feeds, viewed shared content, and read private messages, their learning-related performance was hindered, potentially reducing learners' cognitive abilities and leading to decreased academic performance [31]. In research on resisting negative interference, some scholars found that encouraging bilingual learning could counteract the negative effects of information technology, enabling students to switch between browsing-style shallow reading and immersive deep reading [32].

3.1.6 Reading Teaching Strategies

Due to the educational nature of reading service-related research, especially in basic education, reading education is particularly important. Some scholars specifically focus on reading education in educational contexts. Teachers can combine multimedia teaching facilities and adopt certain reading teaching strategies, with the flipped classroom being typical. G. Rodriguez et al. [33] analyzed a flipped classroom case implemented in 2017 at the San Nicolas Regional College, finding that flipped classrooms can engage students in problem-based learning and analyze their learning styles as references for teacher preparation. L. K. Shi et al. [34] explored the relationship between flipped classroom teaching models and learners' online reading strategies. Additionally, the changes brought by VR/AR devices to teaching deserve attention. H. Tobar-Muñoz et al. [35] designed a reading teaching method that combines augmented reality (AR) and game-based learning to achieve better reading teaching effects.

3.1.7 Reading Material Supply

Reading materials mainly include two aspects: teaching materials and general reading materials. Research on teaching materials primarily focuses on how to redesign textbooks using existing VR/AR technologies. For example, R. L. Lamb et al. [36] explored the effects of three textbook supply methods—paper textbooks, virtual reality (VR), and hybrid methods (paper and VR)—on two writing genres (summary writing and argumentative writing). They also investigated differences in learning effects (critical thinking, writing with complex sentences, vocabulary) among the three textbook supply methods when combined with VR experiences. Research on general reading materials mainly focuses on how to use intelligent technology for personalized supply of e-books, e-journals, and other materials. For example, K. Yi et al. [37] used association rule mining algorithms to identify readers' borrowing patterns based on their borrowing records for personalized book recommendations.

3.2 Research Methods

In foreign research results on informatization of reading services in the past three years, some focus on reading service system development, such as B. Rüdiger et al. [29] using artificial intelligence technology to assist in reading scientific literature. More results involve theoretical and empirical analysis of reading behavior and reading services in informatized environments. The main research methods include experimental methods, survey questionnaires, interviews, observation, content analysis, case analysis, user data analysis, and meta-analysis.

3.2.1 Experimental Method

Through reviewing research results, we found that foreign studies using experimental methods usually combine them with one or more of the following: survey questionnaires, interviews, and observation. For example, E. Pyörälä et al. [38]

took the first batch of iPad-adopting students at the University of Helsinki as subjects (enrolled in 2013, studied until 2018), conducting annual surveys combined with regular focus group interviews. Three focus group interviews were conducted with first-year students in spring 2014, and two with third-year students in spring 2016, with group sizes ranging from 4 to 7 students and interview durations from 49 to 89 minutes. I. F. Liu et al. [39] explored the relationships among paper-based reading ability, online reading ability, online information search ability, and grade level, using 385 students from three non-remote elementary schools as subjects and testing their paper-based Chinese reading ability, online Chinese text reading ability, and online information search ability using the Chinese Reading Comprehension Test (CRCT), Chinese Online Reading Test (CORT), and ICT-related skills: Online Information Search Strategy Inventory (OISSI) scales. S. G. Ghalebani et al. [40] studied the motivations driving children's engagement with reading apps and their performance in digital reading, using qualitative methods combining observation and interviews with 12 children. In the first interview, subjects were asked about their touch-screen device usage and favorite reading apps or e-books; in the second interview, they were asked for more details about their preferred reading topics and time spent on electronic reading. Observations were conducted using cameras to capture participants' electronic reading experiences and their behavioral and non-behavioral interactions with provided reading apps.

3.2.2 Content Analysis Method

Content analysis is often used in review articles but can also solve specific research problems. For example, M. Elena et al. [41] studied the differences between paper and digital reading in reducing reading problems caused by "digital inequality" by analyzing relevant literature content. Additionally, typical case analysis can extract general and universal patterns. For instance, K. Mullins [42] analyzed how libraries can influence students' reading literacy based on the case of Long Island University Library's "On the Go" app.

3.2.3 Meta-Analysis Method

The concept of meta-analysis was first proposed by R. J. Light and P. V. Smith in 1971 [43]. In 1976, G. V. Glass named this concept "Meta-analysis" [44] and defined it as a method for collecting, merging, and statistically analyzing results from different studies. N. Johannes [45] used meta-analysis to address the relationship between reading comprehension, reading interest, reading strategy knowledge, and time spent on reading tasks. C. C. Lin et al. [46] selected 28 empirical studies on mobile-assisted reading published between 2008 and 2018 and evaluated them using the Activity Theory (AT) model to explore the components and their relationships in research on improving reading effects through mobile-assisted language learning (MALL). V. Clinton [47] selected 29 studies between 2008 and 2018 for meta-analysis to explore reading performance, reading time, and metacognition in digital reading compared to paper reading.

P. Delgado et al. [48] analyzed data from 54 empirical studies meeting 10 criteria defined in their research to examine the effect of reading medium (paper/digital) on reading comprehension.

3.2.4 User Data Analysis Method

User data analysis primarily uses objective data generated by user activities collected through tools, such as eye-tracking experiment data and user behavior logs. T. W. Elisa et al. [49] explored reading patterns of audiobook readers. To avoid data privacy and ethical issues, they used no data crawling system logs but instead collaborated with an audiobook service platform, editing the data to be collected into queries sent to the platform, which provided regular query result data pushes to the authors through subscription services. L. H. Han et al. [50] obtained users' online reading period behavior data, constructed an Online Reading Behavior Network (ORBN) for university digital libraries, and analyzed user behavior characteristics reflected in the network.

3.3 Brief Analysis of Foreign Research

Through the review of foreign research results, we can see that foreign studies mainly involve two aspects: user behavior and service content/strategies.

User behavior research primarily focuses on digital/mobile reading behavior, with some studies on VR/AR and audiobook reading behavior. Notably, foreign research segments user groups in detail. By age characteristics, research covers children, adolescents, and the elderly, with the vast majority focusing on adolescents, followed by children, and the least on the elderly and young children. By education level, research on K-12 students is most numerous, followed by university students, with adult (post-graduation) education research being the least. By reading ability, coverage includes health status (whether having reading disabilities), reading strategies, etc., but in small numbers. There are also a few studies specifically targeting parents, librarians, teachers, and other groups.

Service content and strategy research involves five themes: digital reading literacy assessment and influencing factors, assisted reading, information technology interference and coping strategies, reading teaching strategies, and reading material supply. Among reading literacy-related studies, research on digital reading literacy assessment is relatively mature, while research on influencing factors is limited, and improvement strategies include both positive studies on using information technology to enhance teaching effects and reflective studies on negative impacts of information technology, though the latter has fewer researchers. Assisted reading and reading material supply research mainly involves AI/big data/VR/AR technologies. These two research directions use new technologies extensively but have very limited research quantities.

In terms of research methods, empirical and technology development research accounts for the vast majority. In empirical research, the combination of exper-

imental methods with questionnaires/interviews/observation is most common, with very few using only survey methods. Some scholars apply meta-analysis to research questions with abundant empirical data (such as user behavior) to address controversial issues. User data analysis mainly uses objective data generated by users, which involves larger data volumes and is more objective than experimental methods. Similar to eye-tracking experiments, it can sometimes be combined with interviews. Case analysis methods are less common, possibly related to the practical implementation degree of reading-related services. Technology development research methods are mainly applied to reading material supply and assisted reading problems.

Overall, the distribution of existing information technology in the literature shows that research on digital and mobile reading services remains a hot direction abroad. From a thematic perspective, user behavior research is most numerous but not closely integrated with new-generation information technology, lacking research on user needs. Methodologically, foreign empirical research prefers combining experimental methods with questionnaires, interviews, and observation, selecting appropriate methods for different research questions with high suitability. The combination of experimental methods with other approaches is typically used to address user behavior issues and represents the current mainstream research method.

4 Implications for Domestic Research

4.1 Continuously Monitor New-Generation Information Technology Development and Application

The distribution of information technology in foreign reading service research mainly concentrates on digital and mobile technology, with relatively little attention to new-generation information technologies such as virtual reality and artificial intelligence. However, existing information technology serves not only as an external variable bringing innovation in service methods but also gradually affects various elements in reading services through its own development and transformation, thereby changing reading services overall—including changes in service content, user behavior patterns, service strategies, and corresponding service management.

Currently, virtual reality and augmented reality technologies can simulate paper resources and environments for presentation to users, who can interact with virtual environments through corresponding devices to achieve immersive reading experiences. However, due to high equipment costs, insufficient content quantity and quality, and poor technology accessibility, application scenarios are limited, mostly appearing in small-scale applications in libraries, museums, and teaching activities with relatively limited audiences. 5G is an emerging information technology, and its specific technical application scenarios for reading services are not yet clear. However, the “2019 China Virtual Reality Industry Development Outlook” [51] shows that 5G cloud VR services drive VR user growth,

“VR/AR+” application scenarios accelerate implementation, and VR hardware, software, and content detection systems are gradually being established. The emergence of 5G technology is likely to further expand the application scenarios of virtual reality technology. Currently, foreign reading service research involving virtual reality technology mainly targets K-12 students, focusing on reading material supply, especially textbook design optimization, with no mention of 5G technology in reading service research. However, it can be expected that the combination of virtual reality and 5G technologies in the future may break through some current technical bottlenecks and expand VR application scenarios. Therefore, optimizing VR technology applications in reading material supply and considering how to better apply not-yet-implemented VR technology in services are research directions worth exploring.

Artificial intelligence technology is the core of new-generation information technology. Due to technological limitations, some AI technologies related to reading services have not matured enough for large-scale application, such as knowledge graphs, knowledge reasoning, automatic summarization, and machine reading comprehension. Foreign research on reading services and artificial intelligence is limited, but once AI technology makes breakthroughs in machine reading, it may have broad application prospects in guidance, reading recommendations, and helping users complete reading comprehension. As for cloud computing and big data technologies, they mainly provide technical means for service implementation in synergy with AI technology. The transmission, storage, and analysis of massive data require cloud computing to provide resource layer flexibility, and most AI algorithm implementations also depend on large amounts of data.

Although foreign research on reading service informatization includes relatively few studies on new-generation information technology applications, both domestic policies and current industry practices show concern for new-generation information technology. Domestic scholars should pay continuous attention to the development frontiers of new-generation information technology. Virtual reality, augmented reality, 5G, big data, and artificial intelligence are currently flourishing. To promote the further intelligent upgrading of reading services, we must keep pace with cutting-edge information technology development and monitor potential reading service application scenarios.

4.2 Deepen User Behavior Research in Reading Services

Besides the existing information technology environment, users are also the most important research variable and a key future research direction [1]. In foreign research, user behavior-related themes are most numerous, with very detailed understanding of user behavior and diversified research questions involving various user groups at different levels. The most involved information technologies are digital and mobile (4G) technologies, which are relatively mature and have rich industry applications. They mainly change reading resource provision methods and reading media, resulting in digital reading services and mobile reading

services that subsequently affect user reading behavior.

Currently, a large proportion of foreign research focuses on optimizing the application of digital and mobile technologies in reading services. Scholars attempt to optimize services from the perspective of feedback such as user behaviors and psychological activities generated when using related services, making user behavior research very rich. Regarding user groups, foreign scholars have segmented user populations according to various possible classification standards and conducted targeted research. Regarding research questions, foreign scholars have conducted extensive research on 细分 dimensions such as emotion and perception in user behavior, providing ideas and experience for domestic reading service user behavior research.

4.3 Select Research Methods According to Research Questions

Research methods are means and tools adopted to solve research problems. Selecting appropriate research methods is crucial for successfully addressing research questions and is related to research 思路 and perspectives. Currently, when conducting user behavior research, foreign studies often combine experimental methods with one or more of observation, interview, and questionnaire methods. User behavior research ultimately aims to improve and optimize service quality through capturing and understanding user behavior. The general research 思路 can be summarized as analyzing existing 落地 application service users' relevant behaviors and influencing factors to explore how existing reading service content should be optimized, with user behavior feedback being an important variable for service adjustment.

Currently, most foreign reading service user behavior research is related to digital and mobile technologies, which have been applied at considerable scale. Therefore, research can usually observe and record user behaviors in real usage scenarios or conduct surveys for analysis, making the combination of experimental methods with other methods a suitable approach for such problems. Domestic research on reading services prefers obtaining user data directly through questionnaires, but methods such as observation and user usage data analysis are less applied.

Due to differences in service environments caused by technological environments, domestic and foreign scholars may focus on different research questions and have different research 思路 and perspectives. However, all scholars need to consider selecting applicable research methods based on their research purposes and questions.

Conclusion

Information technology is one of the main driving forces for continuous innovation in reading services. Reading services in information technology environments are a major field of academic tracking research. This paper reviewed

foreign research results since 2017, which can provide certain references for domestic research, such as emphasizing user research, continuously tracking the frontiers of information technology development, paying attention to the integration of new-generation information technology development, and using appropriate methods to explore solutions according to specific research questions. In the future, we need to continue tracking foreign research frontiers, strengthen international academic exchanges, and provide new references for domestic research in the reading service field.

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