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Recommender Systems in Libraries: A Systematic Review of Service Quality and Engagement

Ludia Rosema Dewi*[1], Rajesri Govindaraju[2], Destina Ratna Asih Khodijah Kadarsah[3]

*Industrial Engineering Study Program, Faculty of Industrial Technology, Institut Teknologi Bandung, Bandung, Indonesia
*Correspondence E-mail: 23424044@mahasiswa.itb.ac.id

Abstract

This study presents a systematic literature review (SLR) on recommender systems (RS) in library contexts, covering both service-provider perspectives and user engagement. Using the PRISMA framework, 14 studies from ScienceDirect and IEEE Xplore were synthesized to map dominant use cases, data sources, and algorithmic strategies. Hybrid approaches combining collaborative filtering and content-based filtering are most frequently reported, supporting libraries in mitigating cold-start and sparsity in circulation data. Fuzzy linguistic modeling and association rule mining are also used to handle imprecise preferences and identify co-borrowing patterns. Emerging work highlights knowledge graphs and graph neural networks for capturing semantic relationships between readers and collection attributes. Evaluation commonly relies on offline metrics (e.g., precision, recall, NDCG) and is complemented by user studies in fewer cases. The review provides practical recommendations for phased, privacy-aware RS deployment in regional and public library services. Key implementation enablers and barriers include metadata quality, integration with OPAC/digital portals, and privacy-ethics governance for using user interaction and borrowing logs.

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INTRODUCTION

Academic libraries face growing pressure to sustain service quality and user engagement as information-seeking practices change and collections expand across physical and digital environments (Dhage & Verma, 2025; Simović, 2018). Although abundant resources broaden opportunities for learning and research, they can make relevant materials difficult to identify. Recommender systems (RS) offer a means of prioritizing potentially useful resources by matching collection characteristics and user preferences. Within catalogs, online public access catalogs (OPACs), and digital library portals, these systems can support the discovery of books, e-books, and scholarly materials. They may also inform collection development by revealing patterns relevant to acquisition, retention, and weeding decisions (Pal, 2025; Rhanoui et al., 2022).

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RS address information overload by estimating the relevance or expected utility of items and presenting ranked suggestions (Anwar et al., 2020; Nykänen, 2021; Uta et al., 2024; Zardindast & Wood, 2021). In smart library settings, recommendations can extend beyond reactive search to personalized discovery and sustained interaction with resources. Studies linking recommendation technologies with digital learning environments and data-intensive services suggest potential benefits for satisfaction and continuing engagement, although these outcomes depend on implementation context and evaluation design (Amin et al., 2023; Bourkoukou & El Bachari, 2022; Pal, 2022). For libraries serving diverse communities, personalization must also accommodate unequal access to technology, changing interests, and differing information needs rather than assuming uniform user behavior.

Library RS commonly draw on three complementary methodological families. Collaborative filtering (CF) infers preferences from similarities in users' interaction histories, making borrowing records or ratings valuable signals but potentially limiting performance when interactions are sparse (Hikmatyar & Ruuhwan, 2020; Koren et al., 2022; Najafabadi et al., 2019). Content-based filtering (CBF) instead compares item attributes with observed or declared preferences. Bibliographic descriptions, subject headings, keywords, and other metadata can consequently support recommendations even where explicit ratings are limited, although their utility depends on metadata coverage and quality (Sakib et al., 2021; Xia et al., 2025; Zhu et al., 2019). Hybrid approaches combine these sources of evidence to address limitations associated with sparsity, new users, and new items. Switching hybrids, for example, select recommendation components according to available information rather than applying one method uniformly (Çano & Morisio, 2017; Subudhi et al., 2025).

Additional approaches address preferences and relationships that conventional user–item representations may overlook. Fuzzy linguistic models provide ways to represent uncertain or qualitative judgments; the 2-tuple approach is particularly relevant when preference statements must be aggregated without unnecessarily discarding linguistic distinctions (Morawski et al., 2017; Serrano-Guerrero et al., 2011). Multigranular and incomplete preference information also motivates methods designed to integrate evidence of varying specificity (Porcel & Herrera-Viedma, 2010; Ye et al., 2023). Association rule mining can reveal co-borrowing relationships and other recurring patterns, potentially combining circulation records with reader or collection attributes (Jomsri et al., 2024; Zhang & Zhang, 2023). More recent research explores deep learning, knowledge graphs, and graph neural networks to model complex relationships among users, resources, and semantic attributes (Wang et al., 2019; Wu et al., 2023; Xiao et al., 2026). These techniques broaden the design space but also raise requirements concerning data volume, interpretability, maintenance, and technical expertise.

Despite this methodological breadth, evidence on library RS remains difficult to translate into comparable guidance for implementation. Studies address different service objectives, ranging from book discovery and research-resource recommendation to profiling and search reranking. They also rely on heterogeneous inputs, including bibliographic metadata, loan records, ratings, and digital interaction logs. Evaluation strategies differ substantially: some report offline ranking or prediction measures, such as precision, recall, F1, RMSE, MAE, and normalized discounted cumulative gain (NDCG), whereas others use user feedback, behavioral logs, or service-level outcomes. Because

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these measures capture different dimensions of performance, strong predictive accuracy cannot automatically be interpreted as improved discovery, satisfaction, or sustained engagement. Comparisons are further complicated when datasets, baselines, evaluation protocols, and deployment conditions are insufficiently described. An SLR can distinguish designs demonstrated in operational settings from those evaluated only on historical datasets, thereby clarifying which reported benefits reflect observed real-world service outcomes and which remain hypotheses for future institutional deployment.

These limitations are especially consequential for public and regional libraries, where collections serve heterogeneous populations and circulation histories may provide only intermittent preference signals. Data protection, consent, fairness, and metadata interoperability may further constrain the feasibility of highly personalized or computationally demanding systems. A technically sophisticated model is therefore not necessarily the most suitable operational solution. Implementation choices require evidence about the relationship between local data readiness, integration with existing catalog infrastructure, staff capacity, and outcomes that matter to users and library managers.

Accordingly, this study conducts a systematic literature review (SLR) of recommender systems in library services. The review aims to synthesize reported application contexts and service objectives; classify algorithms, data sources, and integration arrangements; compare evaluation measures and empirical evidence; and identify implementation enablers, constraints, and gaps, with particular attention to public and regional libraries. Rather than presupposing the superiority of any approach, it examines the conditions under which methods can be implemented and evaluated meaningfully. The synthesis will inform phased, privacy-aware deployment recommendations, including whether hybrid baselines using circulation records and bibliographic metadata represent a feasible starting point. By linking technical choices with service quality, user engagement, and governance considerations, the review seeks to provide an evidence-grounded basis for future library RS research and practice.

METHODS

Review Design and Research Questions

This study employed a systematic literature review (SLR) to examine the application of recommender systems (RS) in library services, focusing on implementation approaches, service quality, user engagement, evaluation practices, and institutional readiness. The review was reported in accordance with the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA 2020) guidelines to support transparency in study identification, screening, eligibility assessment, and inclusion (Page et al., 2021).

The review process comprised five main stages: (1) literature identification through database searching, (2) metadata consolidation and duplicate removal, (3) title and abstract screening based on predefined eligibility criteria, (4) full-text retrieval and eligibility assessment, and (5) data extraction and synthesis. These stages were designed to identify relevant evidence while maintaining consistency between the review objectives and the selection procedures. Six research questions guided the review:

- **RQ1.** What types of recommender system implementations are used to improve library services, and at which service touchpoints are they most frequently integrated?

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- **RQ2.** What outcomes are reported regarding the impact of recommender systems on library service quality, and how are these outcomes measured?
- **RQ3.** To what extent do recommender systems contribute to user or visitor engagement, and which indicators are most commonly used?
- **RQ4.** What algorithmic approaches and data sources are employed, and what strategies are used to address cold-start and data sparsity challenges?
- **RQ5.** What enabling and inhibiting factors affect recommender system implementation in libraries, particularly in public or government library services?
- **RQ6.** What research gaps and practical recommendations can be identified for developing recommender systems in public and regional libraries, particularly in Indonesian contexts such as West Java?

Data Sources and Search Strategy

Literature searches were conducted using ScienceDirect and IEEE Xplore to identify publications addressing recommender systems in library-related environments. The searches focused on studies examining recommendation technologies, algorithmic approaches, information discovery, user engagement, and their application within library services.Retrieved bibliographic records were exported in Research Information Systems (RIS) format and consolidated for processing using R. The metadata were examined to identify duplicate records based on Digital Object Identifiers (DOIs) and publication titles. Duplicate records were removed before the screening stage to avoid repeated assessment of the same publication.

The consolidated records subsequently underwent rule-based screening using titles, abstracts, and publication-type information. This preliminary screening was intended to retain studies explicitly addressing recommender systems in library contexts while excluding records that did not meet the predefined eligibility criteria.

Full-text PDF documents were subsequently collected for records retained after preliminary screening. These documents formed the basis for detailed eligibility assessment and data extraction.

Inclusion and Exclusion Criteria

Eligibility criteria were established to ensure that the included publications were relevant to the research questions and provided sufficient information for evidence extraction. The review included journal articles and conference papers explicitly addressing recommender systems, book recommendation, or resource recommendation within library environments or closely related information services.

Studies involving public, academic, research, and digital libraries were considered eligible. Full-text availability was required to permit detailed examination of the research objectives, recommendation methods, data sources, evaluation procedures, and reported findings. Records were excluded when they represented duplicate publications, ineligible publication types, or studies using the term recommendation as general advice rather than as a computational recommendation mechanism. Publications without accessible full-text documents were also excluded from the final evidence synthesis.

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Table 1

Inclusion and Exclusion Criteria

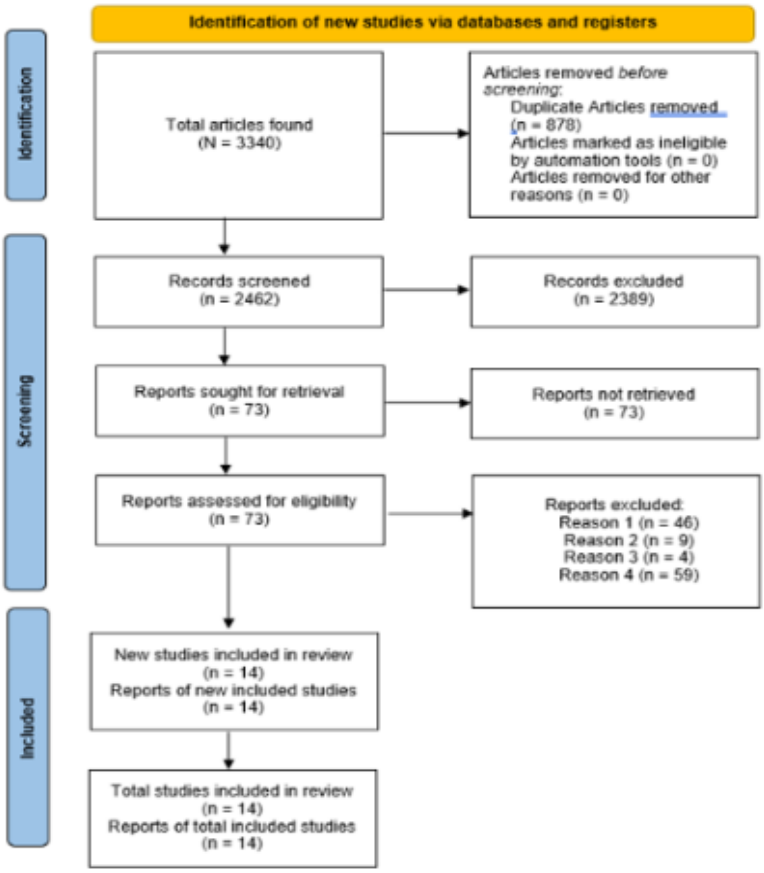
Inclusion Criteria	Exclusion Criteria
Studies explicitly discuss a recommender system or book/library recommendation. The application context is within library environments (public, academic, research, or digital libraries) or closely related information services. Publication type is a journal article (JOUR) or conference proceeding (CONF). Full-text (PDF) is available for data extraction.	Duplicate metadata records (same DOI/title) across sources. Non-article publication types: CHAP/BOOK/STD, editorials, short articles/briefs/notes, theses/reports. Studies using the term "recommendation" only as general advice rather than a recommender system. Full text is unavailable or inaccessible.

Study Selection and PRISMA Flow

The study selection process followed the identification, screening, and inclusion stages described in PRISMA 2020. The selection process is summarized in Figure 1, which presents the number of records identified, duplicates removed, records screened, reports sought for retrieval, full-text reports assessed for eligibility, and studies included in the final review.

Figure 1

PRISMA 2020 Flow Diagram of the Study Selection Process



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Following database searching, records from ScienceDirect and IEEE Xplore were consolidated and deduplicated. The remaining records were screened using titles, abstracts, and publication-type information to identify studies potentially relevant to recommender systems in library services. Records that did not satisfy the initial screening criteria were excluded. Full-text documents were then sought for the remaining records, and accessible publications were assessed against the inclusion and exclusion criteria.

Data Extraction and Evidence Synthesis

Data extraction was organized according to the six research questions to support systematic comparison of the included studies. The extracted information focused on the application context, recommendation approach, data requirements, reported outcomes, and implementation considerations. For RQ1, the review examined library types, recommender system applications, and service touchpoints. RQ2 and RQ3 focused on reported service quality and user engagement outcomes, including the indicators used to evaluate these outcomes. RQ4 examined algorithmic approaches, data sources, and strategies for addressing cold-start and sparsity problems.

For RQ5, the review considered reported implementation enablers and barriers, including data readiness, system integration, institutional resources, and privacy considerations. RQ6 focused on research gaps and practical implications for developing recommender systems in public and regional library environments. The extracted evidence was organized by research question to facilitate comparisons across application contexts, technological approaches, and evaluation practices. Particular attention was given to distinguishing algorithmic performance metrics from evidence concerning service quality, user experience, and engagement.

The synthesis was intended to identify recurring implementation patterns, methodological differences, and areas where the available evidence remains limited. These findings provide the basis for developing evidence-informed recommendations relevant to public and regional library services.

Study Selection Process and Data Extraction

In total, 3,340 records were identified, 2,462 records remained after deduplication, 73 full text articles were assessed for eligibility, and 14 studies met all criteria and were included in the synthesis Figure 1. Data extraction was performed using a structured template aligned with RQ1 to RQ6, enabling consistent mapping of each study to use cases, service outcomes, engagement outcomes, technical approaches, data characteristics, evaluation strategies, implementation factors, and identified research gaps.

RESULT AND DISCUSSION

Result

Study Characteristics and Overall Mapping of Findings

A total of 14 studies as in Table 2 were included in the synthesis, spanning publication years from 2009 to 2026. Most studies were conducted in university, digital, or research library settings, accounting for 11 studies, while 3 studies addressed public, regional, or national library contexts. Implementation platforms included web portals, catalogs and OPAC interfaces, digital library systems, as well as applications or service components connected to broader library information systems.

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Table 2

Mapping of Included Studies

Year	Country/ Region	Library type	Platform	Context	Use case (bucket)	Approach (bucket)	Evaluation (bucket)
2022	Morocco	Regional (National)	Web (Catalog & Amazon API)	Staff/ Decision Support	Collection management (acquisition/ weeding)	Hybrid	Case study / deployment
2020	Indonesia	Other (University)	Desktop application	Book search system	Book/collection discovery	Collaborative filtering	Case study / deployment
2020	India	Public/Academic context	Multi-platform (Web/ OPAC)	Digital catalog	Book/collection discovery	Association rules/ ARM	Other
2023	Algeria	Public context	Web (Python/ Surprise)	Personalized suggestion engine	Book/collection discovery	Hybrid	Offline
2018	Belgrade, Serbia	University	Web/LMS (Moodle)	Logon point, Moodle API	Book/collection discovery	Hybrid	Mixed (offline + user/online)
2014	Udine, Italy	Scientific	Web (RES System)	Profile management	Research resources recommendation	Content-based	Mixed (offline + user/online)
2011	Castilla-La Mancha, Spain	University digital library	Google Wave platform	Collaborative space	Program & service recommendation	Hybrid	Online
2009	Jaén, Spain	University digital library	Web portal	Information dissemination	Research resources recommendation	Hybrid	Online
2014	Granada, Spain	University digital library	Web application	Re-ranking module	Research resources recommendation	Hybrid	Online
2010	Jaén, Spain	University digital library	Web portal	User profiling step	Program & service recommendation	Hybrid	Online
2018	Bangkok, Thailand	University	Library website	Search system	Book/collection discovery	Association rules / ARM	Mixed (offline + user/online)
2014	Granada, Spain	University digital library	Web-based	Re-ranking module	Research resources recommendation	Hybrid	Online
2026	Guangdong, China	University	Web (Backbone FM-KGAT)	Recommendation engine	Book/collection discovery	KG / GNN / DL	Offline
2020	Hamadan, Iran	Medical university	Integrated software (Pars Azarakhsh)	Loan transaction management	Service optimization / behavior prediction	Association rules / ARM	Offline

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Use Cases, Algorithmic Approaches, and Data Sources (RQ1 and RQ4)

For RQ1, recommender system (RS) applications primarily focused on book and collection discovery (6 studies), followed by research resource recommendations (4 studies), program and service recommendations (2 studies), collection management (1 study), and service optimization or user behavior prediction (1 study). Integration points included library catalogs, online public access catalogs (OPACs), web portals, digital library platforms, and transaction-based service modules, highlighting the predominance of resource discovery across library services.

For RQ4, hybrid approaches were most prevalent (8 studies), followed by association rule mining (3 studies), collaborative filtering, content-based filtering, and knowledge graph or graph neural network models. Data sources included circulation records, bibliographic metadata, user profiles, and ratings or reviews, with several approaches addressing sparsity and cold-start challenges. Evaluation designs comprised online (5 studies), offline (3 studies), mixed (3 studies), deployment or case study (2 studies), and other approaches (1 study). Table 3 summarizes the study-level mapping of applications, algorithms, data sources, and evaluation designs for RQ1 and RQ4.

Table 3

Mapping of RQ1 and RQ4 for each Included Study

Year	Country/ Region	Library type	RQ1: Use case	RQ4: Approach	RQ4: Data used	RQ4: Evaluation design
2022	Morocco	Regional (National)	Collection management (Acquisition & Weeding)	Hybrid (CF + Content-based + Sentiment Analysis)	Books metadata, text review, Amazon rating	Evaluation on real case study national library
2020	Indonesia	Other (University)	Collection Discovery (Personalized Search)	User-Based Collaborative Filtering	Loan logs (transaction data)	Black-box testing (trial-and-error)
2020	India	Public/Academic context	Collection & Service optimization	Multi-approach (Classification, NN, ARM, Clustering)	User profile, load history, metadata	Literature benchmark analysis
2023	Algeria	Public context	New Collection Discovery	Hybrid (Memory-CF, Content, Model-SGD)	Goodreads data (ratings, genres, authors)	Offline comparison with KNN & NMF
2018	Belgrade, Serbia	University	Collection Discovery (Books & E-books)	Hybrid (CF + Big Data Hadoop)	Loan logs, Profile, Online Bookstore logs	Mixed (log analysis & user impressions)
2014	Udine, Italy	Scientific	Research Resource Recommendation	Content-Based (Concept Graph)	Full text (Key phrases), Metadata	Mixed (offline benchmarking and user study)
2011	Castilla-La Mancha, Spain	University digital library	Program & Collaboration Recommendation	Fuzzy Linguistic (Hybrid)	User profiles, Resource vectors	Online (user interaction analysis)
2009	Jaén, Spain	University digital library	Multidisciplinary Research Resource	Hybrid (CF + Content-based)	Resource metadata, user interest topics	Online Experiment

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Year	Country/ Region	Library type	RQ1: Use case	RQ4: Approach	RQ4: Data used	RQ4: Evaluation design
2014	Granada, Spain	University digital library	Recommendation Research Resource Recommendation	Switching Hybrid (Content-based + CF)	Preference relations, Rating matrix	Online Study
2010	Jaén, Spain	University digital library	Collection and Collaboration Recommendation	Hybrid (KB-like Fuzzy)	Incomplete preference relations	Online Trial
2018	Bangkok, Thailand	University	Collection Discovery (Books)	Association Rule Mining (FUCL)	Loan records, Categories, Faculty data	Mixed (offline and expert rating)
2014	Granada, Spain	University digital library	Research Resource Recommendation	Switching Hybrid (Content-based + CF)	Incomplete preference, Quality score	Online test
2026	Guangdong, China	University	Collection Discovery (Diversified Books)	ML/DL (GNN + KG + Contrastive)	Loan records, Entity-attribute Graph	Offline Experiment
2020	Hamadan, Iran	Medical university	Service Optimization (Behavior Prediction)	Data Mining (ANN, DT, Clustering, ARM)	Loan transactions, user demographics	Offline Analysis

Service Quality and Engagement Outcomes (RQ2 and RQ3)

For RQ2, service quality outcomes were assessed using offline evaluation metrics, including precision, recall, F1, RMSE, MAE, and NDCG, alongside user-centered methods such as user studies. Studies conducted in operational settings also examined recommendation quality through user interactions in online trials and the effectiveness of recommendations within service delivery platforms. For RQ3, user engagement was primarily assessed through interactions with recommended items, including clicks, resource accesses, repeated usage patterns, borrowing or circulation activity, and resource exploration. Although not all studies measured physical visits, digital interaction indicators provided preliminary measures of user engagement in library contexts. Table 4 presents the study-level mapping of service quality and engagement outcomes and their evaluation indicators for RQ2 and RQ3.

Table 4

Mapping of RQ2 and RQ3 for each Included Study

Year	Country/ Region	Library type	RQ2: Service outcomes	RQ2: Measurement	RQ3: Engagement outcomes	RQ3: Engagement metrics
2022	Morocco	Regional (National)	Supports accurate acquisition and weeding decisions	Real-world case study; Trusted Rating & Weighted Score	Builds bilateral relationships & user engagement in collection policy	Number of reviews & user trust score

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Year	Country/ Region	Library type	RQ2: Service outcomes	RQ2: Measurement	RQ3: Engagement outcomes	RQ3: Engagement metrics
2020	Indonesia	Other (University)	Improves search time efficiency & reduces reference errors	Blackbox testing (Trial and Error); Most Similar Member Ranking	Easier selection of books matching the user profile	Member similarity rank (KNN)
2020	India	Public/Academic context	Improves prediction & recommendation accuracy	Systematic review; Precision, Recall, F-measure, RMSE, MAE	Enhances user experience in decision-making quality	Rank correlation coefficient (Spearman)
2023	Algeria	Public context	High accuracy in discovering relevant books	Offline (Train-Test Splits); RMSE, MAE	Increases reader satisfaction & loyalty	Novelty; Coverage
2018	Belgrade, Serbia	University	Long-term satisfaction & search efficiency	Survey & Log analysis; Likert Scale, Mean Grade	Increase in the number of loans by 269.5%	Loan count increase; Clickstream
2014	Udine, Italy	Scientific	Improves explainability of recommendations by explanations	User Study & Experiment; RMSE, nDCG	Content fit with researchers' interests	Novelty; Accuracy
2011	Castilla-La Mancha, Spain	University digital library	Improves collaboration effectiveness among researchers	Experiment/ Prototype test; Precision, Recall, F1	User satisfaction with collaborator/partner recommendations	Acceptance rate (invitation)
2009	Jaén, Spain	University digital library	Accuracy of cross-disciplinary recommendations	Experiment (Trial version); Precision, Recall, F1	Researchers' satisfaction with complementary suggestions	Satisfaction Score
2014	Granada, Spain	University digital library	Increase in rating prediction accuracy (4.80%)	Online Experiment; MAE, Precision, Recall, F1	User satisfaction via improved item quality	F1 Measure
2010	Jaén, Spain	University digital library	Facilitates user profile acquisition	Experiment; Precision, Recall, F1	Satisfaction with received recommendations	User feedback judgements
2018	Bangkok, Thailand	University	High accuracy of specific book category recommendations	Experiment/ Evaluation Matrix; Precision (Top-1, Top-5)	Satisfaction in faculty-specific book search	Relevancy score
2014	Granada, Spain	University digital library	MAE reduction (4.8%) through quality integration	Online Experiment; MAE	Improved service accuracy and usefulness	User satisfaction score
2026	Guangdong, China	University	Improved recall & topical diversity	Experiment on real dataset;	Exploration of new genres by readers	Channel Weight;

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Year	Country/ Region	Library type	RQ2: Service outcomes	RQ2: Measurement	RQ3: Engagement outcomes	RQ3: Engagement metrics
2020	Hamadan, Iran	Medical university	Delay prediction accuracy (90.1%)	Recall, HR, NDCG, ILD, Coverage Analytical Survey (CRISP-DM); Accuracy, Sensitivity, Specificity, R2, MSE	Identifies user loyalty (loyalty vs churn)	Prediction Score Loyalty classification score

Implementation Factors, Research Gaps, and Practical Recommendations (RQ5 and RQ6)

For RQ5, key implementation enablers included data availability, metadata quality, system integration, and staff capacity. Major barriers involved sparse interactions, cold-start challenges, heterogeneous preferences, integration complexity, and privacy concerns. For RQ6, the main research gaps concerned limited evidence from public and regional libraries, inconsistent evaluation indicators, and insufficient attention to privacy governance and transparency. Recommendations included integrating loan logs with OPAC data, adopting hybrid approaches, and establishing routine service quality and engagement indicators. Table 5 summarizes these findings and their practical implications.

Table 5

Mapping of RQ5 and RQ6 for each Included Study

Year	Country	Library type	RQ5: Enablers	RQ5: Barriers	RQ5: Privacy/ Ethics	RQ6: Reported gaps	RQ6: Implications for public/regional libraries
2022	Morocco	Regional (National)	Availability of External APIs (Amazon) & Machine Learning	Lack of internal library preferences data & reviews	Third-party data integration	Limited RS studies specifically for weeding	Highly relevant for budget optimization & shelf space management in regional libraries
2020	Indonesia	Other (University)	Python programming & MySQL database	Information overload in legacy search methods	Confidentiality of member IDs	Lack of automated systems in local libraries	Improves reference quality at the local level
2020	India	Public/Academic context	Advances in machine learning algorithms	Profile privacy threats & language ambiguity	Security of personal data in user profiles	Lack of contextual information integration (time/ mood)	Need to adopt context-aware models
2023	Algeria	Public context	Surprise library & public datasets	Sensitivity to initial parameters (SGD)	Ethics of providing reading suggestions	Suboptimal novelty optimization tuning	Hybrid models are well-suited for heterogeneous profiles of regional readers

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Year	Country	Library type	RQ5: Enablers	RQ5: Barriers	RQ5: Privacy/ Ethics	RQ6: Reported gaps	RQ6: Implications for public/regional libraries
2018	Belgrade, Serbia	University	Hadoop & Open source big data tools	Need for data science expertise; input data quality	Personal data security & user trust	Lack of surveys on big-data RS in libraries	Highly relevant for integrating community interest data
2014	Udine, Italy	Scientific	Algoritma Dikpe & reliable metadata	Cold-start problem for new user profiles	Algorithm transparency (white box)	Lack of public datasets for scholarly literature	Relevant for concept-based non-fiction book discovery
2011	Castilla-La Mancha, Spain	University digital library	Google Wave Protocol & Robots	Technology still in preview stage	Google account security	Changing user-profile dynamics	Useful for reader communities or book clubs
2009	Jaén, Spain	University digital library	Proactive information tailoring	Staff workload for metadata input	Ethics of delivering relevant information	Need tools to assist information gathering	Suitable for cross-genre book recommendations for the community
2014	Granada, Spain	University digital library	Integration of popularity & quality metrics	Staff interaction for representation	Protection of preference data	Limitations of automated representation techniques	Important for promoting high-quality books in regional contexts
2010	Jaén, Spain	University digital library	Efficiency in user-profile acquisition	Complexity in defining initial relations	Security of vague/implicit preference data	Need tools to simplify user input	Helps new users quickly identify reading interests
2018	Bangkok, Thailand	University	Reduced storage costs	Infrequent visitors	Data anonymity	Lack of rating data in loan logs	Can be adapted using citizens' occupational categories
2014	Granada, Spain	University digital library	Popularity-based quality model	Need for initial quality inputs	Ethics: "first do no harm"	Automated collection representation techniques	Helps citizens find best-selling yet high-quality books
2026	Guangdong, China	University	GNN; Knowledge Graph	Minimal borrowing history required (at least 3 events)	Explainable recommendation paths for librarians	Popularity bias in diversification	Relevant for mitigating community filter bubbles
2020	Hamadan, Iran	Medical university	CRISP-DM standard methodology	Need for automated transaction updates	Research ethics code IR.UMSHA.REC.1396.27	Static database analysis	Helps librarians anticipate peak service demand

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Discussion

Recommender System Applications and Library Service Integration (RQ1)

The synthesis indicates that recommender systems (RS) primarily support book and collection discovery (6 studies), research resource recommendations (4 studies), program and service recommendations (2 studies), and collection management and service optimization (2 studies). Their integration extends beyond online public access catalogs (OPACs) to digital library platforms, learning management systems, and research collaboration environments, reflecting their expanding role in scholarly resource discovery (Widayanti et al., 2023; Zhang et al., 2023). Effective integration also requires alignment with users' information needs, usability, and existing digital interfaces (Susilana, 2022).

Beyond resource discovery, RS can support acquisition and evidence-informed weeding through bibliographic metadata, user preferences, and external ratings (Rhanoui et al., 2022). Hybrid models integrating resources from multiple publishers further demonstrate their potential for cross-platform discovery (Jomsri et al., 2024). These findings highlight the dual role of RS in user-oriented services and collection management, although evidence of operational effectiveness remains limited.

Service Quality Outcomes and Evaluation Practices (RQ2)

The reviewed studies assessed service quality through heterogeneous indicators, including precision, recall, F1, RMSE, MAE, and NDCG, alongside user satisfaction, recommendation relevance, and search efficiency. Although algorithmic metrics provide evidence of predictive and ranking performance, they do not necessarily capture improvements in users' information-seeking experiences. This distinction is consistent with research emphasizing the importance of combining technical evaluation with user-centered assessments (Jannach, 2023; Zhang et al., 2023).

Explainability represents an additional dimension of recommendation quality. Providing understandable explanations may help users evaluate suggested resources, particularly in research-oriented environments. However, explanations do not automatically strengthen trust, as their effectiveness depends on how users interpret recommendation outputs and the appropriateness of interaction design (Naiseh et al., 2021). The findings therefore indicate that algorithmic performance, perceived usefulness, and observable service outcomes should be evaluated separately. Related evidence-synthesis research in digital education similarly supports distinguishing different outcome dimensions rather than treating perceived benefits and actual performance as equivalent (Rullyana et al., 2025). Integrating offline metrics with user feedback and operational indicators may consequently improve the interpretability and practical relevance of library RS evaluations.

User Engagement and Library Resource Utilization (RQ3)

User engagement was commonly assessed through clicks, resource accesses, repeated system use, borrowing activity, and exploration of recommended materials. Some studies also considered responses to recommended research collaborations. These indicators represent different forms of participation, suggesting that immediate digital interactions should be distinguished from behaviors reflecting sustained library engagement. One included study reported a 269.5% increase in borrowing activity following RS integration, illustrating the potential relationship between personalized

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recommendations and physical collection use. However, this context-specific finding does not establish a generalizable effect across library environments. Similarly, improved recommendation accuracy does not necessarily imply increased engagement or sustained resource utilization.

Related research on microlearning emphasizes the importance of organizing digital content around users' learning needs and engagement experiences (Susilana et al., 2022). Although derived from an educational context, this perspective supports evaluating library RS through meaningful user activities rather than interaction counts alone. For public and regional libraries, combining digital indicators with borrowing, repeated use, and community participation measures may provide a more comprehensive assessment, while longitudinal evaluation remains necessary to establish sustained effects.

Algorithmic Approaches, Data Sources, and Technical Challenges (RQ4)

Hybrid approaches dominated the reviewed studies (8 studies), followed by association rule mining (3 studies), while the remaining studies employed collaborative filtering, content-based methods, and knowledge graph or graph neural network models. Hybrid methods combine circulation histories with bibliographic metadata to mitigate sparsity and cold-start challenges, although their effectiveness depends on data availability and quality (Aljunid et al., 2025). Library applications further demonstrate the integration of user preferences and external information (Jomsri et al., 2024; Rhanoui et al., 2022), while association rules identify borrowing patterns (Zhang & Zhang, 2023).

More advanced approaches incorporate multi-granularity preferences, knowledge-based representations, and graph embeddings to model complex user–resource relationships (Uta et al., 2024; Ye et al., 2023; Zhang et al., 2024). These findings suggest that algorithm selection should consider metadata quality, data readiness, computational resources, and maintenance capacity. Hybrid models may offer a practical baseline, whereas advanced approaches require stronger infrastructure. Differences in evaluation designs also underscore the need for transparent reporting of datasets, baselines, and evaluation protocols.

Implementation Enablers, Barriers, and Data Governance (RQ5)

The principal implementation enablers identified in the synthesis include data availability, metadata quality, integration with existing library information systems, and institutional technical capacity. Conversely, sparse interaction histories, cold-start conditions, heterogeneous user preferences, legacy system integration, and privacy concerns represent recurring barriers. These challenges may be particularly consequential for public and regional libraries serving diverse populations with varying patterns of resource use.

Beyond technical constraints, RS implementation raises questions regarding algorithmic fairness and transparency. Recommendation models may reproduce biases embedded in historical interactions, potentially creating unequal exposure to resources (Deldjoo et al., 2024). Popularity bias may further reinforce frequently accessed materials while limiting the visibility of less popular collections (Klimashevskaia et al., 2024). However, the reviewed library studies provide limited direct evidence concerning the magnitude of these risks in operational settings.

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Privacy governance is equally important because personalization may involve sensitive borrowing histories and behavioral information. Research on consumer-side fairness emphasizes evaluating recommendation outcomes across different user groups rather than relying exclusively on aggregate performance (Vassøy & Langseth, 2024). Accordingly, libraries should incorporate responsible data processing, transparent recommendations, access controls, and institutional oversight into implementation planning, while evaluating their effectiveness under local operational conditions.

Research Gaps and Practical Recommendations for Public and Regional Libraries (RQ6)

Three principal gaps emerge from the synthesis. First, only three of the 14 studies examined public, regional, or national library contexts, limiting the transferability of findings from university and digital libraries. Second, heterogeneous service quality and engagement indicators constrain cross-study comparisons. Third, privacy governance, recommendation transparency, and long-term operational evaluation remain insufficiently examined. Broader recommendation research similarly emphasizes the need to connect technical evaluation with user-centered and operational outcomes (Jannach, 2023; Zhang et al., 2023).

For public and regional libraries, a phased implementation strategy could begin with a hybrid baseline integrating bibliographic metadata and circulation records, followed by OPAC interaction data, contextual information, and explainability features as institutional capacity develops. Such development should be adapted to local data readiness and service objectives. Potential applications include thematic collection discovery, community-oriented recommendations, and literacy-related services. Research on digital information and learning applications provides complementary perspectives on aligning technology with usability, accessibility, and institutional requirements (Susilana, et al., 2022).

Future studies should evaluate these approaches using complementary offline metrics, user feedback, and operational indicators, including resource accesses, borrowing activity, and repeated use. Evidence-synthesis research further underscores the importance of identifying implementation conditions before translating technological approaches into institutional practice (Johan et al., 2025). For Indonesian public and regional libraries, including those in West Java, the proposed recommendations should therefore be treated as context-sensitive implementation options requiring empirical validation rather than established evidence of effectiveness.

Conceptual Framework of Library Recommender Systems

Based on the synthesis of the included studies, Figure 2 presents a conceptual framework integrating the technological and institutional components associated with RS implementation in library services. The framework comprises four interconnected elements: Input and Enablers, Process: RS Algorithms, Implementation and Use Cases, and Outcomes and Evaluation. It conceptualizes RS development as a process connecting institutional readiness and data resources with recommendation mechanisms, service applications, and measurable outcomes.

The conceptual framework comprises four interconnected components: Input and Enablers, Process: RS Algorithms, Implementation and Use Cases, and Outcomes and

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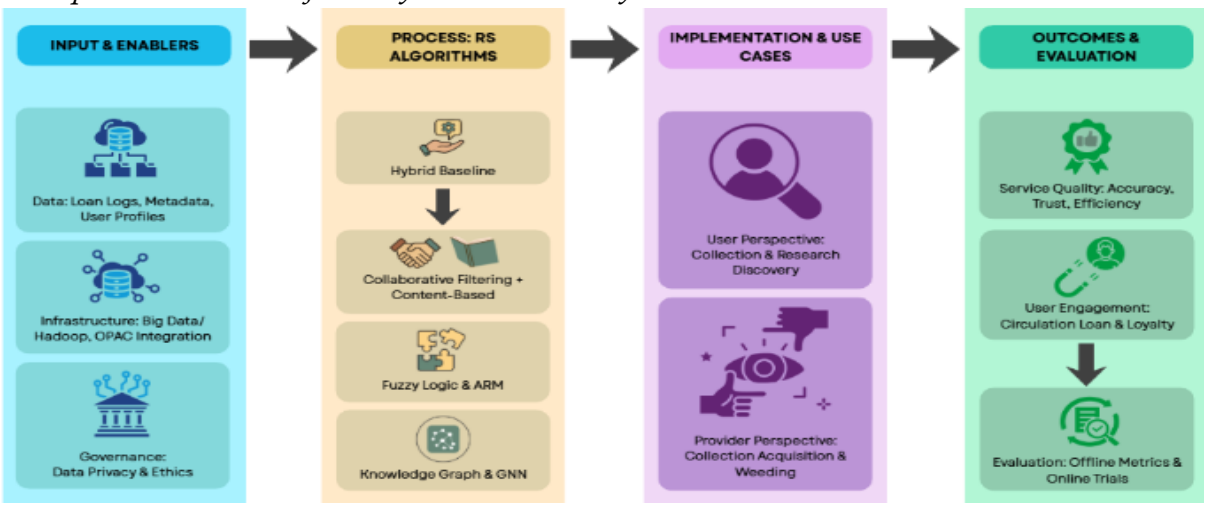
Evaluation. The first component identifies the data and institutional requirements for RS implementation, including circulation records, bibliographic metadata, user profiles, system integration capabilities, scalable infrastructure, and privacy governance. The second component encompasses algorithmic approaches, emphasizing hybrid models that combine collaborative and content-based filtering, supported by association rule mining and fuzzy methods for identifying resource relationships and addressing incomplete preferences. Knowledge graphs and graph neural networks represent advanced alternatives where sufficient data and technical capabilities are available. The third component connects these approaches with library services, including personalized discovery of books, e-books, and research resources through catalogs, OPACs, and digital portals, alongside decision support for collection acquisition and evidence-informed weeding.

Figure 2

Conceptual Framework of Library Recommender System



The fourth component integrates service quality, user engagement, and collection management outcomes. Algorithmic performance is assessed through precision, recall, RMSE, MAE, and NDCG, while user-centered indicators include perceived usefulness, recommendation relevance, explainability, and trust. Engagement is evaluated through resource accesses, clicks, borrowing activity, and repeated use, whereas collection management outcomes concern acquisition prioritization, collection relevance, and weeding decisions. These dimensions require complementary technical, behavioral, and institutional indicators rather than relying solely on recommendation accuracy. Overall, the framework highlights the interdependence of data readiness, algorithmic selection, system integration, governance, and outcome evaluation. By synthesizing these elements, it provides a conceptual foundation for developing and evaluating library RS, although empirical validation remains necessary to establish their effectiveness in operational library environments.

CONCLUSION

This study concludes that recommender systems have become a central pillar in the information transformation of modern libraries by enabling personalized collection discovery, supporting research resource recommendation, and strengthening data-driven

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managerial decision-making. Across the SLR findings, hybrid approaches emerge as the dominant paradigm because they can effectively combine behavioral and content signals to mitigate sparsity and cold-start while balancing recommendation accuracy with topic diversity, as reflected in improvements in recommendation-quality metrics, user satisfaction, and, in some cases, substantial increases in physical circulation.

The synthesis of all research questions further indicates that successful RS deployment depends heavily on data infrastructure readiness, including scalable pipelines and, where applicable, Big Data technologies such as Hadoop, as well as on the system's ability to provide explainable recommendations that foster trust and actionable use. However, empirical studies in public and regional library contexts remain limited, highlighting the need for more evidence in operational government service settings. For public and regional libraries in Indonesia, strategic priorities should focus on establishing integrated data pipelines that

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Author contributions statement

LRD: Conceptualization, methodology, investigation, data curation, formal analysis, visualization, writing – original draft. RG: Conceptualization, methodology, validation, supervision, writing – review & editing. DRAKK: Methodology, validation, formal analysis, supervision, writing – review & editing.

Conflict of interest statement

Authors state no conflict of interest.

REFERENCES

Aljunid, M. F., Manjaiah, D. H., Hooshmand, M. K., Ali, W. A., Shetty, A. M., & Alzoubah, S. Q. (2025). A collaborative filtering recommender systems: Survey. *Neurocomputing, 617*, 128718. https://doi.org/10.1016/j.neucom.2024.128718

Amin, S., Uddin, M. I., Mashwani, W. K., Alarood, A. A., Alzahrani, A., & Alzahrani, A. O. (2023). Developing a personalized e-learning and MOOC recommender system in IoT-enabled smart education. *IEEE Access, 11*, 136437–136455. https://doi.org/10.1109/ACCESS.2023.3336676

Anwar, K., Siddiqui, J., & Sohail, S. S. (2020). Machine learning-based book recommender system: A survey and new perspectives. *International Journal of*

Copyright © 2026, Author, E-ISSN: 2528-2182, P-ISSN: 2089-6549

Intelligent Information and Database Systems, 13(2–4), 231–248. https://doi.org/10.1504/IJIIDS.2020.109457

Bourkoukou, O., & El Bachari, E. (2022). A big-data oriented recommendation method in e-learning environment. *International Journal of Emerging Technologies in Learning, 17*(10), 74–84. https://doi.org/10.3991/ijet.v17i10.27861

Çano, E., & Morisio, M. (2017). Hybrid recommender systems: A systematic literature review. *Intelligent Data Analysis, 21*(6), 1487–1524. https://doi.org/10.3233/IDA-163209

Deldjoo, Y., Jannach, D., Bellogín, A., Difonzo, A., & Zanzonelli, D. (2024). Fairness in recommender systems: Research landscape and future directions. *User Modeling and User-Adapted Interaction, 34*, 59–108. https://doi.org/10.1007/s11257-023-09364-z

Dhage, K. J., & Verma, C. B. (2025). AI-driven library systems: Transforming information seeking behaviour and satisfaction in the digital era. *International Journal of Research in Library Science, 11*(2), 332–340. https://doi.org/10.26761/ijrls.11.2.2025.1906

Hikmatyar, M., & Ruuhwan. (2020). Book recommendation system development using user-based collaborative filtering. *Journal of Physics: Conference Series, 1477*(3), Article 032024. https://doi.org/10.1088/1742-6596/1477/3/032024

Jannach, D. (2023). Evaluating conversational recommender systems: A landscape of research. *Artificial Intelligence Review, 56*, 2365–2400. https://doi.org/10.1007/s10462-022-10229-x

Johan, R. C., Rullyana, G., Susilana, R., & Emilzoli, M. (2025). Micro-credentials in higher education: A review and bibliometric. *Journal of Education and Learning, 19*(2), 1103–1116. https://doi.org/10.11591/edulearn.v19i2.21281

Jomsri, P., Prangchumpol, D., Poonsilp, K., & Panityakul, T. (2024). Hybrid recommender system model for digital library from multiple online publishers [Version 3]. *F1000Research, 12*, 1140. https://doi.org/10.12688/f1000research.133013.3

Klimashevskaia, A., Jannach, D., Elahi, M., & Trattner, C. (2024). A survey on popularity bias in recommender systems. *User Modeling and User-Adapted Interaction, 34*, 1777–1834. https://doi.org/10.1007/s11257-024-09406-0

Koren, Y., Rendle, S., & Bell, R. M. (2022). Advances in collaborative filtering. In F. Ricci, L. Rokach, & B. Shapira (Eds.), *Recommender systems handbook* (3rd ed., pp. 91–142). Springer. https://doi.org/10.1007/978-1-0716-2197-4_3

Li, Z. (2024). Information service innovation in college libraries based on big data analysis. *Applied Mathematics and Nonlinear Sciences, 9*(1), 20231212. https://doi.org/10.2478/amns.2023.2.01212

Morawski, J., Stepan, T., Dick, S., & Miller, J. (2017). A fuzzy recommender system for public library catalogs. *International Journal of Intelligent Systems, 32*(10), 1062–1084. https://doi.org/10.1002/int.21884

Naiseh, M., Al-Thani, D., Jiang, N., & Ali, R. (2021). Explainable recommendation: When design meets trust calibration. *World Wide Web, 24*, 1857–1884. https://doi.org/10.1007/s11280-021-00916-0

Copyright © 2026, Author, E-ISSN: 2528-2182, P-ISSN: 2089-6549

Najafabadi, M. K., Mohamed, A., & Onn, C. W. (2019). An impact of time and item influencer in collaborative filtering recommendations using graph-based model. *Information Processing & Management, 56*(3), 526–540. https://doi.org/10.1016/j.ipm.2018.12.007

Nykänen, A. (2021). *A novel hybrid recommendation system for library book selection* [Master's thesis, University of Oulu]. OuluREPO. https://oulurepo.oulu.fi/handle/10024/18684

Page, M. J., McKenzie, J. E., Bossuyt, P. M., Boutron, I., Hoffmann, T. C., Mulrow, C. D., Shamseer, L., Tetzlaff, J. M., Akl, E. A., Brennan, S. E., Chou, R., Glanville, J., Grimshaw, J. M., Hróbjartsson, A., Lalu, M. M., Li, T., Loder, E. W., Mayo-Wilson, E., McDonald, S., . . . Moher, D. (2021). The PRISMA 2020 statement: An updated guideline for reporting systematic reviews. *BMJ, 372*, Article n71. https://doi.org/10.1136/bmj.n71

Pal, G. (2022). An efficient system using implicit feedback and lifelong learning approach to improve recommendation. *The Journal of Supercomputing, 78*(14), 16394–16424. https://doi.org/10.1007/s11227-022-04484-6

Pal, M. (2025). Relationship between collection development theory and user-centered library services. *Kavya Setu, 1*(11), 1–11. https://kavyasetu.com/index.php/j/article/view/97

Porcel, C., & Herrera-Viedma, E. (2010). Dealing with incomplete information in a fuzzy linguistic recommender system to disseminate information in university digital libraries. *Knowledge-Based Systems, 23*(1), 32–39. https://doi.org/10.1016/j.knosys.2009.07.007

Rhanoui, M., Mikram, M., Yousfi, S., Kasmi, A., & Zoubeidi, N. (2022). A hybrid recommender system for patron driven library acquisition and weeding. *Journal of King Saud University - Computer and Information Sciences, 34*(6), 2809–2819. https://doi.org/10.1016/j.jksuci.2020.10.017

Rullyana, G., Siregar, E., & Kustandi, C. (2025). A bibliometric and meta-analytic review of the impact of MOOCs in higher education. *Zbornik Instituta za Pedagoška Istraživanja, 57*(1), 119–146. https://doi.org/10.2298/ZIPI2501119R

Sakib, N., Ahmad, R. B., Ahsan, M., Based, M. A., Haruna, K., Haider, J., & Gurusamy, S. (2021). A hybrid personalized scientific paper recommendation approach integrating public contextual metadata. *IEEE Access*, *9*, 83080-83091. https://doi.org/10.1109/ACCESS.2021.3086964

Serrano-Guerrero, J., Herrera-Viedma, E., Olivas, J. A., Cerezo, A., & Romero, F. P. (2011). A Google Wave-based fuzzy recommender system to disseminate information in university digital libraries 2.0. *Information Sciences, 181*(9), 1503–1516. https://doi.org/10.1016/j.ins.2011.01.012

Simović, A. (2018). A Big Data smart library recommender system for an educational institution. *Library Hi Tech*, *36*(3), 498-523. https://doi.org/10.1108/LHT-06-2017-0131

Subudhi, K. A., Mohanty, N., Das, M. K., Mohanty, D., Mukherjee, I., & Nath, T. S. (2025). A hybrid book recommendation framework to address the cold start problem using weighted fusion of content-based and collaborative filtering. In *2025 IEEE 3rd International Symposium on Sustainable Energy, Signal Processing and*

Copyright © 2026, Author, E-ISSN: 2528-2182, P-ISSN: 2089-6549

Cybersecurity (iSSSC) (pp. 1–6). IEEE. https://doi.org/10.1109/ISSSC66652.2025.11388983

Susilana, R., Dewi, L., Rullyana, G., Hadiapurwa, A., & Khaerunnisa, N. (2022). Can microlearning strategy assist students' online learning? *Cakrawala Pendidikan, 41*(2), 437–451. https://doi.org/10.21831/cp.v41i2.43387

Susilana, R., Rullyana, G., Ardiansah, & Wulandari, Y. (2022). Pedagogia dictionary: Web application development. *International Journal of Instruction, 15*(1), 197–218. https://doi.org/10.29333/iji.2022.15112a

Uta, M., Felfernig, A., Le, V.-M., Tran, T. N. T., Garber, D., Lubos, S., & Burgstaller, T. (2024). Knowledge-based recommender systems: Overview and research directions. *Frontiers in Big Data, 7*, 1304439. https://doi.org/10.3389/fdata.2024.1304439

Vassøy, B., & Langseth, H. (2024). Consumer-side fairness in recommender systems: A systematic survey of methods and evaluation. *Artificial Intelligence Review, 57*, Article 101. https://doi.org/10.1007/s10462-023-10663-5

Wang, H., Zhao, M., Xie, X., Li, W., & Guo, M. (2019). Knowledge graph convolutional networks for recommender systems. In *Proceedings of the World Wide Web Conference (WWW '19)* (pp. 3307–3313). Association for Computing Machinery. https://doi.org/10.1145/3308558.3313417

Widayanti, R., Chakim, M. H. R., Lukita, C., Rahardja, U., & Lutfiani, N. (2023). Improving recommender systems using hybrid techniques of collaborative filtering and content-based filtering. *Journal of Applied Data Sciences, 4*(3), 289–302. https://doi.org/10.47738/jads.v4i3.115

Wu, S., Sun, F., Zhang, W., Xie, X., & Cui, B. (2023). Graph neural networks in recommender systems: A survey. *ACM Computing Surveys, 55*(5), Article 97. https://doi.org/10.1145/3535101

Xia, Y., Zhang, L., Yang, Z., Zhang, C., & Guo, T. (2025). Temporal-aware neural networks for balancing dynamic preferences and long-term interests in recommendation systems. *Journal of Computing and Information Technology, 33*(2), 123–138. https://doi.org/10.20532/cit.2025.1006009

Xia, Y., Zhang, L., Yang, Z., Zhang, C., & Guo, T. (2025). Temporal-aware neural networks for balancing dynamic preferences and long-term interests in recommendation systems. *Journal of Computing and Information Technology, 33*(2), 123–138. https://doi.org/10.20532/cit.2025.1006009

Xiao, J., Wu, L., Zhong, F., & Zhang, J. (2026). Knowledge-aware neighbor collaborative multi-relationship multi-interest comparative recommender system for diversified book recommendations. *Expert Systems with Applications, 297*, Article 129235. https://doi.org/10.1016/j.eswa.2025.129235

Xiao, J., Wu, L., Zhong, F., & Zhang, J. (2026). Knowledge-aware neighbor collaborative multi-relationship multi-interest comparative recommender system for diversified book recommendations. *Expert Systems with Applications, 297*, 129235. https://doi.org/10.1016/j.eswa.2025.129235

Ye, X., Liu, D., & Li, T. (2023). Multi-granularity sequential three-way recommendation based on collaborative deep learning. *International Journal of Approximate Reasoning, 152*, 434–455. https://doi.org/10.1016/j.ijar.2022.11.011

Copyright © 2026, Author, E-ISSN: 2528-2182, P-ISSN: 2089-6549

Zarindast, A., & Wood, J. (2021). A data-driven personalized lighting recommender system. *Frontiers in Big Data, 4*, 706117. https://doi.org/10.3389/fdata.2021.706117

Zhang, J.-C., Zain, A. M., Zhou, K.-Q., Chen, X., & Zhang, R.-M. (2024). A review of recommender systems based on knowledge graph embedding. *Expert Systems with Applications, 250*, Article 123876. https://doi.org/10.1016/j.eswa.2024.123876

Zhang, X., & Zhang, J. (2023). Analysis and research on library user behavior based on Apriori algorithm. *Measurement: Sensors, 27*, 100802. https://doi.org/10.1016/j.measen.2023.100802

Zhang, Z., Patra, B. G., Yaseen, A., Zhu, J., Sabharwal, R., Roberts, K., Cao, T., & Wu, H. (2023). Scholarly recommendation systems: A literature survey. *Knowledge and Information Systems, 65*, 4433–4478. https://doi.org/10.1007/s10115-023-01901-x

Zhu, G., Bin, C., Gu, T., Chang, L., Sun, Y., Chen, W., & Jia, Z. (2019). A neural user preference modeling framework for recommendation based on knowledge graph. In A. C. Nayak & A. Sharma (Eds.), *PRICAI 2019: Trends in artificial intelligence* (Lecture Notes in Computer Science, Vol. 11670, pp. 176–189). Springer. https://doi.org/10.1007/978-3-030-29908-8_14

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