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SYSTEMATIC LITERATURE REVIEW ON THE USE OF INTELLIGENT TUTORING SYSTEMS IN LEARNING

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Abstract

This study aims to systematically review the development and implementation of Intelligent Tutoring Systems (ITS) in education using a Systematic Literature Review (SLR). Literature searching was conducted through Publish or Perish using Google Scholar and Scopus databases with four ITS-related keyword combinations. Following the PRISMA flow, 864 studies were identified, screened through title-abstract evaluation, and filtered through full-text eligibility, resulting in 20 final articles published between 2018 and 2024. Data extraction covered educational fields, ITS tools, system purposes, user interfaces, evaluation methods, and reported impacts. The findings show that ITS is widely applied in general education, computer science, and mathematics. Most ITS implementations employ web-based platforms and various customized tools. ITS is predominantly used to support adaptive learning, automated assessment, feedback generation, and cognitive skill development. University students and school learners are the primary target users. Evaluation methods commonly include technical assessments, questionnaires, observations, and pre-test/post-test approaches. Overall, the review concludes that ITS continues to evolve as an AI-supported learning environment that enhances personalization, learning effectiveness, and student engagement.

Keywords: intelligent tutoring systems; adaptive learning; personalized learning; web-based learning; educational technology.

Introduction

Advances in artificial intelligence (AI) technology over the past decade have brought significant changes to educational innovation. One of the most rapidly developing AI applications in the education sector is the Intelligent Tutoring System (ITS), an adaptive learning system designed to mimic the role of a human tutor through automated feedback, student modeling, personalized content, and context-based assessment. Various studies indicate that ITS can enhance learning effectiveness, learning outcomes, motivation, and the efficiency of the learning process across various educational levels (Adelana & Akinyemi, 2021; Surahman et al., 2022; Erdemir, 2019). These improvements are primarily due to ITS's ability to adapt content to user profiles in real-time and provide personalized, measurable interactions (Alfaro et al., 2020).

Although the potential of ITS is immense, the literature indicates that there are significant gaps regarding the utilization of ITS across various educational fields, the technological models employed, and the methods used to evaluate the system's effectiveness. Several studies have focused on student and teacher readiness to adopt ITS, as evidenced by findings that student awareness and readiness regarding intelligent tutoring systems still vary despite their positive perceptions of the benefits (Adelana & Akinyemi, 2021).

On the other hand, conceptual research highlights that the adoption of ITS and AI in education requires a mature ecosystem, such as infrastructure readiness, teacher competence, and systematic technology integration (Aggarwal et al., 2023).

Other studies have placed greater emphasis on the design and implementation of web-based ITS, IoT, and machine learning approaches to enhance personalized learning (Chalermdit et al., 2019; Alrakhawi et al., 2023). Meanwhile, research focusing on the implementation of ITS in science and technical learning shows that ITS systems can yield significant improvements in learning outcomes compared to conventional methods, as seen in studies of ITS for biology lab sessions (Surahman et al., 2022) and undergraduate-level physics (Erdemir, 2019). A similar trend was also found in the application of ITS in technical drawing instruction, which demonstrated improvements in students' academic performance and learning interest (Hassan et al., 2023).

Nevertheless, findings from various studies also indicate fragmentation in ITS research, particularly regarding variations in learning domains, system design, research methods, and participant characteristics. This situation creates a research gap in the form of a lack of comprehensive mapping regarding:

1. Which fields of education most frequently implement ITS;
2. The technologies, architectures, and learning approaches used;
3. The primary objectives and functions of ITS in current research;
4. The types of interfaces used in ITS;
5. The impact of ITS in learning outcomes and user experience; and
6. The evaluation methods used to test the effectiveness of ITS.

In addition, several recent studies have sought to integrate cognitive and affective aspects into ITS, such as the development of emotion-based performance prediction models (Emotional ITS) and IoT-based ITS to enhance students' technical competencies (Chalermdit et al., 2019; Alrakhawi et al., 2023). This indicates that the direction of ITS development is increasingly moving toward holistic, adaptive, and multimodal learning systems.

The novelty of this study lies in its effort to re-map the development of ITS research through a Systematic Literature Review (SLR) of 20 recent international articles covering various fields of education, technological approaches, learning functions, and evaluation methods. Unlike previous studies that focused solely on a single domain or type of technology, this study combines conceptual, implementation, and empirical analyses to provide a comprehensive overview of trends, gaps, and opportunities for ITS development.

This study aims to: (1) identify fields of education that utilize ITS; (2) examine the technologies and approaches used in the development of ITS; (3) analyze the primary objectives and functions of ITS; (4) categorize the types of user interfaces implemented; (5) evaluate the impact of ITS use on learning outcomes; and (6) map the evaluation methods used in ITS research. The main contribution of this study is to provide a strong conceptual and empirical foundation for researchers, developers, and education practitioners in designing ITS that is more effective, adaptive, and relevant to modern learning needs.

Research Methodology

This study employed a Systematic Literature Review (SLR) method in accordance with the guidelines of the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (Page et al., 2021). The SLR was chosen to obtain a comprehensive overview of the application of Intelligent Tutoring Systems (ITS) in educational contexts based on published studies. This method includes the stages of formulating research questions, determining search strategies, the selection process, data extraction, as well as thematic and bibliometric analysis. The selection and data extraction processes were conducted systematically by referring to predefined inclusion and exclusion criteria to ensure consistency in study selection.

1. **Research Questions**

Research questions (RQs) are formulated to define the scope and focus of the study. The following RQs were used in this study:

1) In which fields of education are Intelligent Tutoring Systems (ITS) implemented?
2) What tools, techniques, or technologies are used in the development of ITS?
3) What are the primary objectives and functions of ITS in the studies reviewed?
4) What types of user interfaces are used in ITS?
5) What are the impacts or effects of using ITS in education?
6) What evaluation methods are used to assess the effectiveness of ITS?

These six questions form the basis for determining the search strategy, article screening, data extraction process, and final analysis.

2. **Determining the Data Population and Article Sources**

The literature search was conducted using the Publish or Perish (PoP) application with two main databases: Google Scholar and Scopus. The keywords used in the search were:

a) Intelligent Tutoring System AND education*
b) AI tutor AND learning*
c) Intelligent programming tutor*

The asterisk (*) is used for truncation, which expands search results to include various word variations. For example:

a. *education* → education, educational, educating
b. *learning* → learning, learner, learn

This ensures that the search is more comprehensive and not limited to a single word form. The publication years used are 2018–2024. The article format used is journal articles.

3. **Inclusion and Exclusion Criteria**

Exclusion Criteria

a) The article discusses Intelligent Tutoring Systems (ITS).
b) The study was conducted in an educational context (formal or non-formal).
c) The article is in English or Indonesian.
d) The full text is available.
e) It contains information on ITS tools, methods, evaluation, or effects.

Exclusion Criteria

a) The article is not an empirical or systematic study.
b) The topic is not relevant to ITS or education.
c) The research design is unclear or cannot be evaluated.
d) Duplicate or identical versions of the same publication..

4. **Screening and Eligibility**

The screening process is carried out through four PRISMA stages, namely identification, screening, eligibility, and inclusion.

a) Total A total of 864 articles were initially identified through the Google Scholar and Scopus databases.
b) 364 duplicate articles were removed before screening, consisting of:
c) Manually identified duplications: 4
d) Duplications identified by Covidence: 360

e) Marked as ineligible by automated tools: 0
f) 500 articles were screened based on title and abstract.
g) 472 articles were excluded during the screening stage due to irrelevance.
h) 28 articles entered the full-text review stage.
i) 28 articles were evaluated for eligibility.
j) No articles were inaccessible to the full text (n = 0).

There were 8 articles issued at the eligibility stage, with the following reasons:

a. Inappropriate results (n = 3)
b. Indication/topic irrelevant (n = 1)
c. Inappropriate research design (n = 3)
d. Inappropriate implementation method (n = 1)

k) The articles that passed as the final corpus for analysis in the systematic review numbered 20 articles.
l) This process is depicted in the PRISMA Diagram (Figure 1).

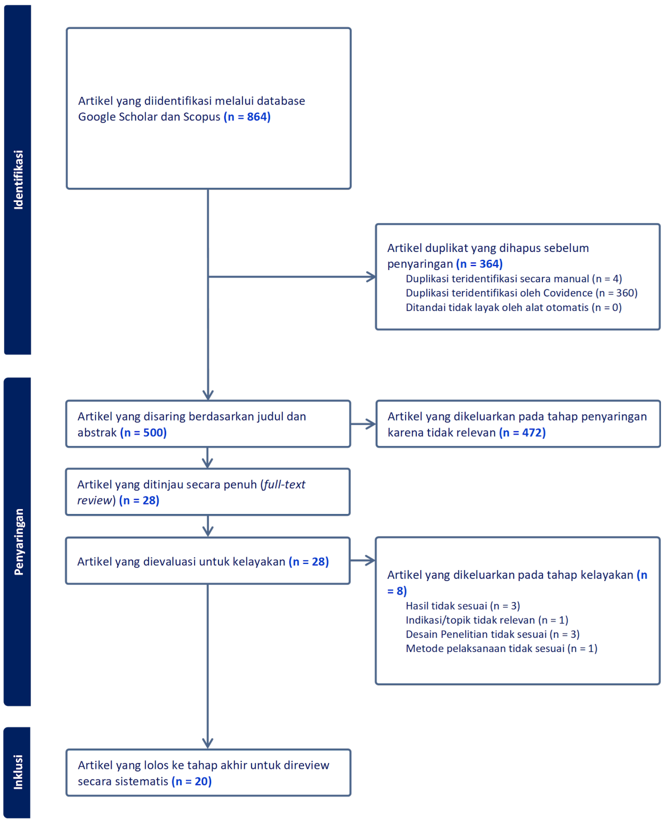

Figure 1. PRISMA diagram

5. Performing Data Extraction from Articles

The fifth stage is data extraction using a specially designed analysis sheet. Each article is reviewed in depth to gather the following information:

a) Educational Field
b) ITS Technology/Architecture
c) ITS Goals and Functions
d) User Interface Types
e) Research Methods
f) Participants
g) ITS Results and Impacts
h) Evaluation Methods Used

Extraction was performed manually through full reading to ensure consistency and accuracy.

6. Analyzing Data

The sixth stage is data analysis with the following approaches:

A. Qualitative Thematic Synthesis

It is done in the following way:

a) Classifying educational fields (RQ1)
b) Identifying ITS technologies (RQ2)
c) Assessing the goals and functions of ITS (RQ3)
d) Categorizing interface types (RQ4)
e) Summarizing the impact of ITS (RQ5)
f) Identifying evaluation methods (RQ6)

The synthesis results are then presented in the form of tables and Excel graphs.

Research Results and Discussion

1. Data Extraction Results

The following factors were extracted at this stage to address the research objectives. These factors include article identification (author, year, title, article type, journal, and source), the name or type of ITS used, the educational field, the research participants, the evaluation method, and the effects of ITS use in educational contexts. A complete summary of the extraction results is presented in Tables 1, 2, and 3.

Table 1. Data extraction form

No	Author (Year)	Title	Article Type	Journal Name	Source
1	Adelana, O. P.; Akinyemi, A. L. (2021)	Artificial Intelligence-Based Tutoring Systems Utilization for Learning: A Survey of Senior Secondary Students' Awareness and Readiness in Ijebu-Ode, Ogun State	Journal	Unizik Journal of Educational Research and Policy Studies	Google Scholar
2	Aggarwal, D.; Sharma, D.; Saxena, A. B. (2023)	Adoption of Artificial Intelligence (AI) For Development of Smart Education as the Future of a Sustainable Education System	Journal	Journal of Artificial Intelligence, Machine Learning and Neural Network (JAIMLNN)	Google Scholar
3	Alfakihuddin, M. L. B.; Surahman, E.; Haryani, F. (2022)	The Application of Inquiry Intelligent Tutoring System in Biology Practicum	Journal	Journal of Education Technology (JET), Vol.6 No.4	Google Scholar
4	Alfaro, L.; Rivera, C.; Castañeda, E.; Zúñiga-Cueva, J.; Rivera-	A Review of Intelligent Tutorial Systems in Computer and Web based Education	Journal / Review	International Journal of Advanced Computer Science and	Google Scholar

	Chavez, M.; Fialho, F. (2020)			Applications (IJACSA)	
5	Almarzuki, H. F., Samah, K. A. F. A., Rahim, S. K. N. A., Ibrahim, S., & Riza, L. S. (2024).	Enhancement of Prediction Model for Students' Performance in Intelligent Tutoring System.	Journal	Journal of Artificial Intelligence and Technology (JAIT), Vol.4 No.3	Google Scholar
6	Alrakhawi, H. A., Jamiat, N. U. R. U. L. L. I. Z. A. M., & Abu-Naser, S. S. (2023).	Intelligent tutoring systems in education: a systematic review of usage, tools, effects and evaluation.	Systematic literature review	Journal of Theoretical and Applied Information Technology (JATIT), Vol. 101 No. 4	Google Scholar
7	Al-Shanfari, L., Abdullah, S., Fstnassi, T., & Al-Kharusi, S. (2023)	Instructors' perceptions of intelligent tutoring systems and their implications for studying computer programming in Omani higher education institutions.	Journal	International Journal of Membrane Science and Technology, 10(2),	Google Scholar
8	Amanda, N., Andersen, F., Christian, R., Warnars, H. L. H. S., Ramadhan, A., Putra, A. S., ... & Utomo, W. H. (2021).	Learning Math for 1st Grade Primary School Students using Intelligent Tutoring Systems.	Experimental/implementation article	Turkish Journal of Computer and Mathematics Education, 12(6),	Google Scholar
9	Assielou, K. A., Haba, C. T., Gooré, B. T., Kadjo, T. L., & Yao, K. D. (2020).	Emotional Impact for Predicting Student Performance in Intelligent Tutoring Systems (ITS)	Journal	nternational Journal of Advanced Computer Science and Applications (IJACSA), Vol. 11 No. 7	Scopus
10	Baig, A., Cressler, J. D., & Minsky, M. (2024).	The future of ai in education: Personalized learning and intelligent tutoring systems.	Conceptual/review paper	AlgoVista: Journal of AI and Computer Science, 1(1),	Google Scholar
11	Chalermdit, J., Nilsook, P., & Wannapiroon, P. (2019).	Analysis of an Intelligent Graphical Tutoring System Using the Internet of Things (IoT) to Develop the	Journal article	International Journal of Online and Biomedical	Scopus

		Competency of Embedded Systems		Engineering (iJOE)	
12	Cornejo, A. A. S., Requena, D. T. V., Mendoza, J. C. H., Rodríguez, J. L. M., & Rodriguez, W. (2024).	An intelligent tutoring system for identification of learning styles and assignment educational strategies.	Research article	International Journal of Combinatorial Optimization Problems and Informatics, 15(1),	Google Scholar
13	Dahbi Manar (2023)	Integrating an Intelligent Language Tutoring System in Teaching English Grammar	Empirical study	Arab World English Journal (AWEJ), Vol. 14 No. 4	Scopus
14	Díaz-Parra, O., Fuentes-Penna, A., Ruiz-Jaimes, M. A., Toledo-Navarro, Y., Lezama-León, M., & Lezama-León, E. (2018).	Intelligent Tutor System for the Learning of Otomí Language.	Journal article	International Journal of Combinatorial Optimization Problems & Informatics, 9(3).	Google Scholar
15	EL-Gamal, A. (2020)	Integration of Brain Based Learning and Intelligent Tutoring System for Developing Pedagogical Software	Original study	Mansoura Engineering Journal, Vol. 31 Issue 2	Google Scholar
16	Erdemir, M. (2019)	Using Web-based Intelligent Tutoring Systems in Teaching Physics Subjects at Undergraduate Level	Research article / opinion-based analysis	Universal Journal of Educational Research, 7(7)	Google Scholar
17	Hassan, A. M. (2023).	Web-Based Intelligent Tutoring System On Students Achievement And Interest In Technical Drawing In Niger State.	Journal article	Journal of Information Systems and Technology Research, 2(1)	Google Scholar
18	Khairunnisa, K., & Rismayanti, R. (2020).	Designing Intelligent Tutoring System as an Innovative Effort in Structured Programming Learning	Applied development study	Jurnal Sistem Informasi, Vol. 4 No. 1 (2020)	Google Scholar

19	Marouf, A. M., & Abu-Naser, S. S. (2019).	Intelligent tutoring system for teaching computer science I in Al-Azhar University, Gaza.	Journal article / applied system	International Journal of Academic and Applied Research (IJAAR), Vol. 3 Issue 3	Google Scholar
20	Niño-Rojas, F., Lancheros-Cuesta, D., Jiménez-Valderrama, M. T. P., Mestre, G., & Gómez, S. (2024).	Systematic Review: Trends in Intelligent Tutoring Systems in Mathematics Teaching and Learning.	Systematic review	International Journal of Education in Mathematics, Science and Technology (IJEMST) 12(1)	Google Scholar

Table 2. IT tools used and fields of education

No.	Author (Year)	ITS Name	ITS Tool / Technique	Education Field / Subject Area	Course Content / Usage
1	Adelana, O. P.; Akinyemi, A. L. (2021)	AI-based tutoring systems	Survey of perceptions and readiness; no specific ITS identified	Upper secondary education	Measuring students' awareness and readiness for ITS usage
2	Aggarwal, D.; Sharma, D.; Saxena, A. B. (2023)	No specific ITS (conceptual)	AI, adaptive learning, virtual tutors (bahasan konseptual)	General education / smart education	Overview of AI use for personalized learning
3	Alfakihuddin, M. L. B.; Surahman, E.; Haryani, F. (2022)	Inq-ITS (Inquiry Intelligent Tutoring System)	Platform web-based, scaffolding, guided inquiry	Biology practicum	Used for inquiry-based biology practicums, lab reports, and pre-test & post-test
4	Alfaro, L.; Rivera, C.; Castañeda, E.; Zúñiga-Cueva, J.; Rivera-Chavez, M.; Fialho, F. (2020)	Multiple ITS reviewed (e.g., AutoTutor, BRCA Gist, Bayesian Network-based ITS)	Student modelling, rule-based systems, Bayesian models, web-based ITS	Computer and web education	Literature review on various ITS architectures and techniques
5	Almarzuki, H. F., Samah, K. A. F. A., Rahim, S. K. N. A., Ibrahim, S., & Riza, L. S. (2024).	iBKT (Individualized Bayesian Knowledge Tracing)	Model prediksi, parameter kepercayaan P(C), RMSE benchmarking	Intelligent tutoring systems (general)	Modeling student performance and assessing abilities based on probabilistic parameters

6	Alrakhawi, H. A., Jamiat, N. U. R. U. L. L. I. Z. A. M., & Abu-Naser, S. S. (2023).	Beragam ITS: AutoTutor, ITSB, web/mobile ITS	Web-based systems, authoring tools, sequencing engines, personalization engines	Multi-domain (programming, mathematics, health, engineering)	Used for self-paced tutoring, question generation, tutor–student dialogue, progress monitoring, and adaptive assessment
7	Al-Shanfari, L., Abdullah, S., Fstnassi, T., & Al-Kharusi, S. (2023)	Intelligent Tutoring System	AI tools, adaptive algorithms	General education	Discussion on the application of AI and ITS in education
8	Amanda, N., Andersen, F., Christian, R., Warnars, H. L. H. S., Ramadhan, A., Putra, A. S., ... & Utomo, W. H. (2021).	MITS (Mathematic Intelligent Tutoring Systems	A multimedia-based system with visual elements, interactive quizzes, and adaptive navigation	Elementary mathematics education	Provides early numeracy materials, counting exercises, image-assisted tasks, and instant assessment for young learners
9	Assielou, K. A., Haba, C. T., Gooré, B. T., Kadjo, T. L., & Yao, K. D. (2020).	(No specific ITS name; focus on predictive models)	A multi-relational matrix factorization model incorporating emotional features and student interaction mapping	General domain (ITS performance prediction)	Used to predict academic performance based on behavioral and emotional data captured during digital learning interactions
10	Baig, A., Cressler, J. D., & Minsky, M. (2024).	(Not specifically mentioned)	Personalization engines, AI ethics, and adaptive platforms	Future education (policy)	Focuses on recommendations for AI implementation and personalized learning
11	Chalermdit, J., Nilsook, P., & Wannapiroon, P. (2019).	(IoT-based Graphical Tutoring System)	An ITS integrating IoT, graphical programming tools, IoT sensors, and a visual interface	Electrical engineering / programming	Used to teach robotic control, visual programming, and IoT concepts
12	Cornejo, A. A. S., Requena, D. T. V., Mendoza, J. C. H., Rodríguez, J. L. M., & Rodriguez, W. (2024).	ITS for Learning Styles	Fuzzy logic, learning styles detection, adaptive recommendation	Primary and secondary education	Determines learning styles and provides recommendations for learning activities

13	Dahbi Manar (2023)	ILTS (Intelligent Language Tutoring System)	A language learning system with instant feedback, automated assessment, visual aids, and pedagogical agents	English (ESP / master's level)	Provides advanced grammar exercises, contextual examples, color visualization, and comprehension-based activities
14	Díaz-Parra, O., Fuentes-Penna, A., Ruiz-Jaimes, M. A., Toledo-Navarro, Y., Lezama-León, M., & Lezama-León, E. (2018).	Gamified ITS	Gamification mechanics (point, reward, badges), interactive tasks	Primary education (children)	ITS uses games to enhance learning motivation and engagement
15	EL-Gamal, A. (2020)	Basic Intelligent Tutoring System	Integration of Brain-Based Learning and ITS; modelling of pedagogical tools; digital content featuring animations, graphics and virtual experiments	Engineering / technical education	The system is designed to support the delivery of engineering content using a BBL (Brain-Based Learning) approach with automatic adaptation based on learning needs
16	Erdemir, M. (2019)	WBITS (Web-based Intelligent Tutoring System)	Web-based system, structured programming; teacher-like features (immediate feedback, activity tracking, automatic assessment)	Physics (undergraduate level)	Provides basic physics modules with animations, virtual experiments, transitional problems, and student ability tracking
17	Hassan, A. M. (2023).	ITS for Technical Education	Web-based ITS, practice modules, adaptive feedback	Vocational / technical education	Students' perceptions of ITS in vocational programs
18	Khairunnisa, K., & Rismayanti, R. (2020).	Structured Programming Intelligent Tutoring System (ITS)	A desktop application with animated visuals, automatic assessment and content navigation	Computer programming (structured programming)	Provides basic programming materials, multiple-choice exercises, and immediate evaluation through an interactive application

19	Marouf, A. M., & Abu-Naser, S. S. (2019).	Intelligent Tutoring System for Computer Science I	ITSB Authoring Tool, rule-based model, structured lesson sequencing	Computer Science (introductory programming)	Presents content in 21 modules, including examples, randomized exercises, automated hints, and progress tracking that determines completion of each unit
20	Niño-Rojas, F., Lancheros-Cuesta, D., Jiménez-Valderrama, M. T. P., Mestre, G., & Gómez, S. (2024).	Various ITS maths programmes: PAT2Math, RadarMath, etc.	Adaptive learning, student modelling, deep learning, rule-based reasoning	Matematika (HEI & secondary)	Used for algebra, geometry and problem-solving exercises, personalised learning pathways, error tracking, and adaptive interfaces.

Table 3. Participants, evaluation methods, and results

No	Author (Year)	Participants	Evaluation Method	Country	Relationship with RQ	Results and Effects
1	Adelana, O. P.; Akinyemi, A. L. (2021)	N = 304 high school students (270 male, 34 female)	Questionnaires (awareness & readiness), descriptive analysis, t-test, ANOVA	Nigeria	RQ1, RQ5, RQ6	Students demonstrate high awareness and readiness for ITS usage; no significant differences based on gender or grade level
2	Aggarwal, D.; Sharma, D.; Saxena, A. B. (2023)	No participants (conceptual paper)	Theoretical review and narrative analysis	India	RQ2, RQ3, RQ4, RQ5	Explains how AI can support smart education, personalized learning, and improved access; no empirical data provided
3	Alfakihuddin, M. L. B.; Surahman, E.; Haryani, F. (2022)	N = 40 university students (20 experimental, 20 control)	Pre-test and post-test, lab reports, N-gain, observation of scaffolding use	Indonesia	RQ1, RQ3, RQ5, RQ6	Inq-ITS shows significant improvement (N-gain = 0.76); the experimental group outperforms

						the control group in cognitive indicators and lab report skills
4	Alfaro, L.; Rivera, C.; Castañeda, E.; Zúñiga-Cueva, J.; Rivera-Chavez, M.; Fialho, F. (2020)	No participants (literature review)	Systematic/thematic review	Peru	RQ1, RQ2, RQ3, RQ4, RQ5, RQ6	Concludes that ITS has been widely used, improves learning outcomes, and employs various modeling and evaluation techniques
5	Almarzuki, H. F., Samah, K. A. F. A., Rahim, S. K. N. A., Ibrahim, S., & Riza, L. S. (2024).	ASSISTments and KDD datasets	RMSE comparison, predictive model validation	Malaysia and Indonesia	RQ2, RQ5, RQ6	The addition of parameter P(C) reduces RMSE (improves accuracy)
6	Alrakhawi, H. A., Jamiat, N. U. R. U. L. L. I. Z. A. M., & Abu-Naser, S. S. (2023).	36 final studies after selection, with varied samples in each study	Systematic mapping, data extraction, ITS technique classification	Malaysia and Palestina	RQ1, RQ2, RQ3, RQ4, RQ5, RQ6	Findings indicate significant improvement in learning quality across most studies; web-based ITS is most dominant; evaluations are mainly conducted through surveys and pre/post experiments
7	Al-Shanfari, L., Abdullah, S., Fstnassi, T., & Al-Kharusi, S. (2023)	Not specified (conceptual article)	Desk analysis, literature review	Oman	RQ1, RQ2, RQ3, RQ4, RQ5	Discusses the growth of AI in education, including the potential of ITS

8	Amanda, N., Andersen, F., Christian, R., Warnars, H. L. H. S., Ramadhan, A., Putra, A. S., ... & Utomo, W. H. (2021).	Grade 1 elementary school students	Learning observation, guided trials, evaluation of usage outcomes	Indonesia	RQ1, RQ3, RQ5	ITS helps students understand basic numeracy through color/object visualization; students more quickly recognize patterns and numbers in interactive activities
9	Assielou, K. A., Haba, C. T., Gooré, B. T., Kadjo, T. L., & Yao, K. D. (2020).	Uses experimental dataset	Model accuracy testing, comparison with baseline, matrix factorization performance evaluation	Not specified	RQ2, RQ5, RQ6	The addition of emotional features improves performance prediction accuracy compared to standard models, indicating that affective responses contribute significantly
10	Baig, A., Cressler, J. D., & Minsky, M. (2024).	No sample (conceptual paper)	Conceptual analysis	United States of America	RQ2, RQ3, RQ4, RQ5	Highlights personalized learning and AI ethics issues
11	Chalermdit, J., Nilsook, P., & Wannapiroon, P. (2019).	No empirical sample (technical study)	IoT implementation analysis, feature-based evaluation	Thailand	RQ2, RQ3, RQ4	IoT-based ITS enhances graphical interaction, strengthens sensor-based learning, and expands students' competencies in IoT technology

12	Cornejo, A. A. S., Requena, D. T. V., Mendoza, J. C. H., Rodríguez, J. L. M., & Rodriguez, W. (2024).	Primary and secondary school students	Fuzzy logic validation, student trials	Latin America	RQ3, RQ5, RQ6	Identification of learning styles helps predict appropriate learning strategies for students
13	Dahbi Manar (2023)	Postgraduate students	Perception questionnaires, descriptive analysis	Morocco	RQ3, RQ5, RQ6	Most students show increased motivation and grammar understanding; ILTS is considered effective, provides quick feedback, and enhances independent learning
14	Díaz-Parra, O., Fuentes-Penna, A., Ruiz-Jaimes, M. A., Toledo-Navarro, Y., Lezama-León, M., & Lezama-León, E. (2018).	Elementary school children	Observations, questionnaires, gamification experiments	Mexico	RQ1, RQ3, RQ5	Gamification increases children's interest and focus in ITS
15	EL-Gamal, A. (2020)	Not specified (design/development study)	Software design analysis, integration of BBL and ITS models	Egypt	RQ2, RQ3, RQ4, RQ6	The study emphasizes that combining BBL and ITS improves content structure, enables personalization, and produces more adaptive pedagogical tools

16	Erdemir, M. (2019)	No empirical sample used (opinion paper)	Literature analysis, author experience, and prior research findings	Turkey	RQ1, RQ2, RQ3, RQ4, RQ5	WBITS increases flexibility in learning physics, enables remote access, provides instant feedback, and addresses limited classroom time
17	Hassan, A. M. (2023).	Vocational students	Perception surveys, ITS effectiveness evaluation	Nigeria	RQ5, RQ6	Students perceive ITS as helpful in understanding engineering materials and providing instant feedback
18	Khairunnisa, K., & Rismayanti, R. (2020).	No participants involved (application development study)	System demonstration, feature explanation, usage trials	Indonesia	RQ2, RQ3, RQ4	ITS programming applications present materials, exercises, and automated evaluation; they enhance engagement and support independent practice for beginners
19	Marouf, A. M., & Abu-Naser, S. S. (2019).	A number of students and lecturers as system evaluators	System testing, system quality questionnaires, feature evaluation, final testing	Palestine	RQ3, RQ4, RQ6	The system facilitates mastery of Computer Science I; automated sequencing and hints accelerate understanding for novice learners

20	Niño-Rojas, F., Lancheros-Cuesta, D., Jiménez-Valderrama, M. T. P., Mestre, G., & Gómez, S. (2024).	43 documents (2012–2022) covering studies with various participants	SLR protocol (Kitchenham), coding, bibliometric mapping	Colombia	RQ1, RQ2, RQ3, RQ4, RQ5, RQ6	Mathematics ITS significantly improves conceptual understanding; dominant trends include adaptation, user modeling, and pre/post-test-based evaluation

2. **Publication Year**

The analysis results in Figure 2. Year of Article Publication show that research related to ITS experienced a significant increase in 2020, 2023, and 2024. 2023 was the year with the most publications, namely 5 articles, followed by 2020 and 2024 each with 4 articles. This finding indicates the increasing attention of researchers to the development of ITS, especially after the emergence of rapid developments in artificial intelligence (AI) in the world of education. In contrast, publications in 2018-2019 were relatively lower, indicating that the initial adoption of ITS was not as intense as it is now.

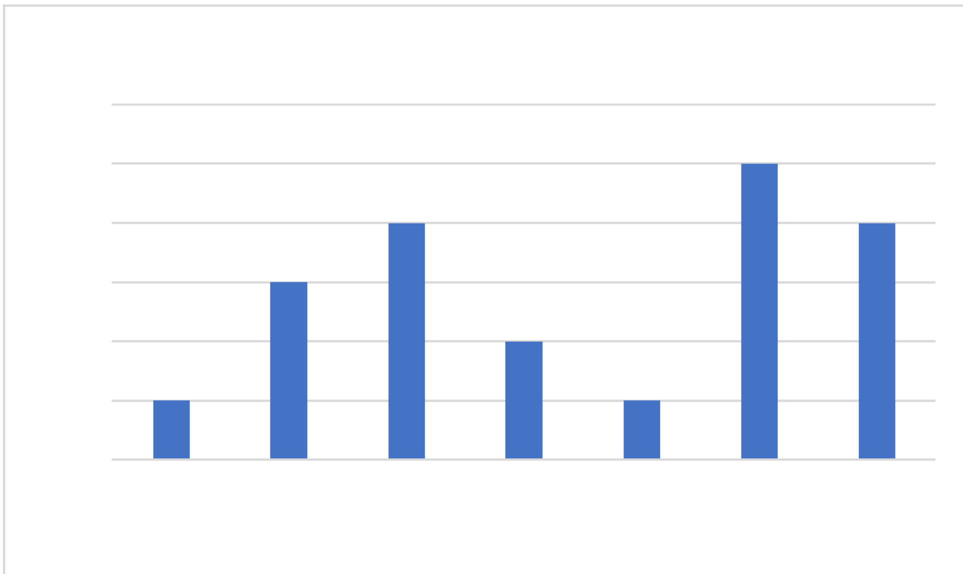

Figure 2. Year of Article Publication

3. **Country of Origin of Research**

Country of Origin Figure Research shows that ITS research originates from a wide range of countries, with the largest number coming from the Other Countries category (12 publications). Countries that frequently appear include Indonesia (4 studies), Malaysia (2), Palestine (2), Nigeria (2), and Peru (1). The wide variety of countries indicates that ITS is a global technology adopted across a wide range of educational contexts.

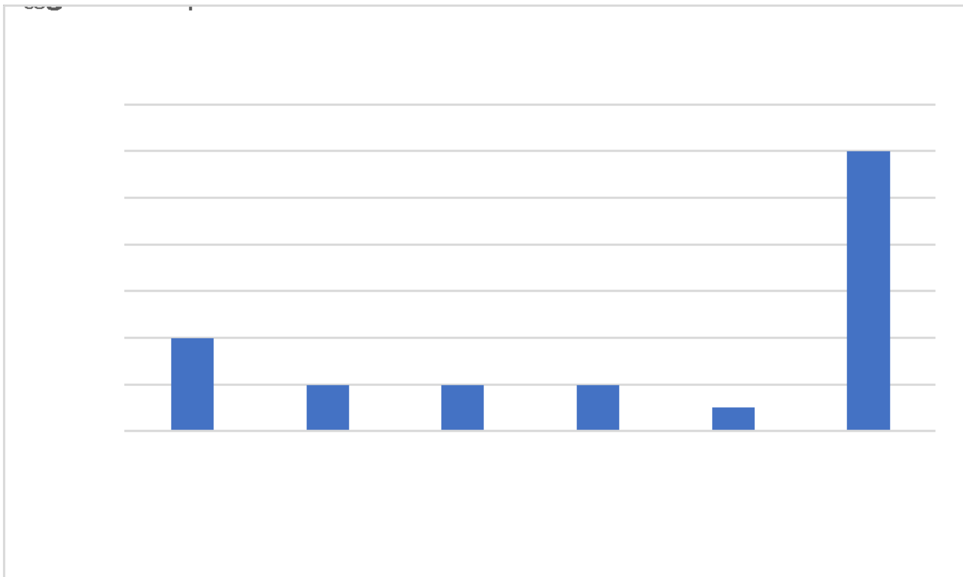

Figure 3. Country of Origin of Research

4. **Tools, Techniques, or Technologies**

Figure 4. ITS Tools, Techniques, or Technologies shows that the majority of studies used the Other Tools category (12 studies), followed by web-based ITS (5 studies), Auto Tutor (2 studies), and Inq-ITS (1 study). The "Other Tools" category indicates many new technology variants such as machine learning-based tutoring, rule-based tutoring, or ITS platforms developed independently by researchers. This aligns with previous literature that mentions the diversity of ITS architectures (Alrekhawi et al., 2023).

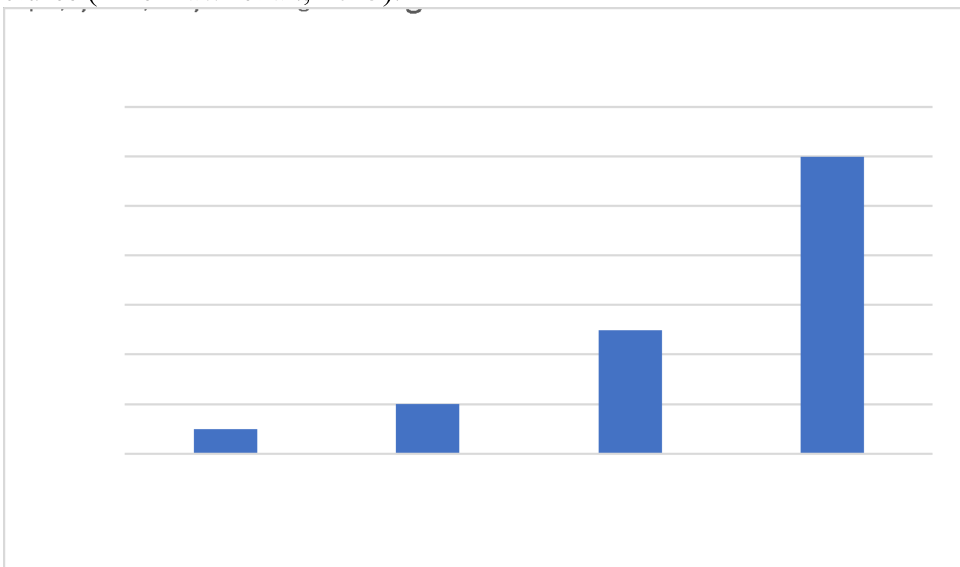

Figure 4. Tools, techniques or technology used

This diversity of technologies reflects the application of the Technological Pedagogical Content Knowledge principle, where the integration of technology with pedagogical approaches and learning content is key to designing effective learning systems. Furthermore, the adaptive use of ITS is also in line with Constructivism theory, as it allows students to actively construct knowledge through interaction with the system. Furthermore, the structured and gradual system design of some ITS also reflects the principle of Cognitive Load Theory in managing students' cognitive load for optimal learning.

5. **Field of education**

Figure 5. Education Sector shows that the most ITS applications were found in General Education (8 studies), followed by Computer Science and Informatics (5 studies), Other Education Sectors (5 studies), Mathematics (3 studies), and Biology (1 study). These findings indicate that ITS is widely used, but most dominantly in general education and computer science, in line with the need for personalized learning and ITS's ability to provide adaptive feedback.

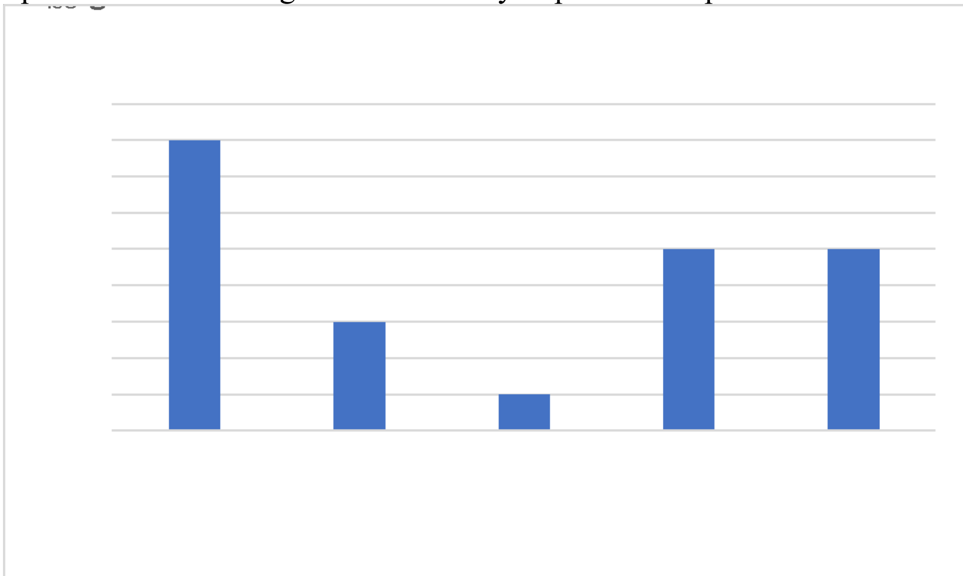

Figure 5. Education Sector

6. Article Type

Figure 6. Article Type shows that 55% of publications come from journal articles, 10% are research articles, and 35% come from other categories such as conference proceedings. The dominance of journal articles indicates that ITS research has been widely published through reputable scientific channels, indicating that ITS studies have become an established concern in the international academic literature.

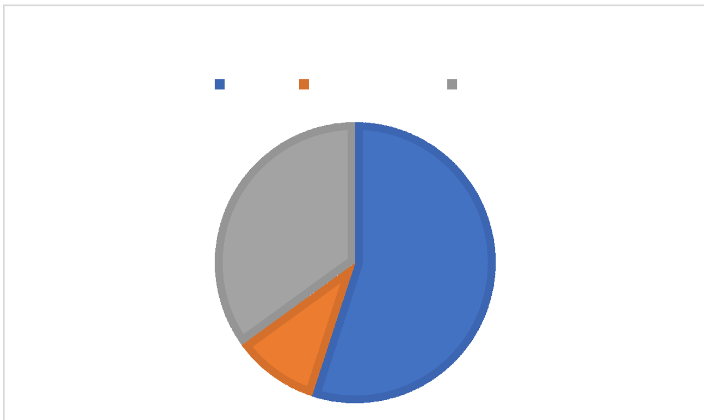

Figure 6. Article Types

7. Article Source

As seen in Figure 7, 85% of the articles came from Google Scholar, while the other 15% came from Scopus. This aligns with the search strategy, which focused on Google Scholar through the Publish or Perish (PoP) application. Nevertheless, the proportion of articles from Scopus still contributed to the overall quality of the literature synthesis. However, the dominance of sources from Google Scholar indicates that most articles did not come entirely from curated databases. Unlike Scopus, which has a more stringent selection and indexing process, Google Scholar indexes various types of documents with varying levels of curation. Therefore, the proportion of articles from Scopus remains important in maintaining the quality and credibility of the overall literature synthesis. Going forward, the use of indexed databases such as Scopus can be further optimized to improve the quality of literature selection.

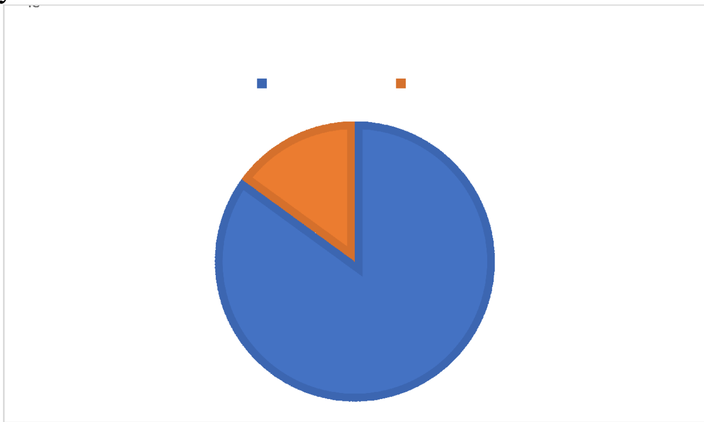

Figure 7. Article Source

8. **Research Participants**

Based on Figure 8, the majority of research participants involved the Other Participants category (60%), such as teachers, instructors, or general users. College and university students each accounted for 20%. This indicates that ITS is not only used by students but is also evaluated from the perspective of educators and other users in the educational ecosystem.

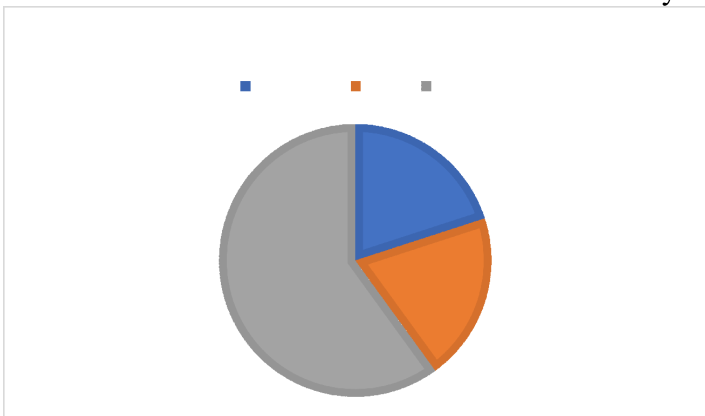

Figure 8. Research Participants

9. **Evaluation Method**

Figure 9, Evaluation Methods, shows that the most dominant evaluation methods are other categories (60%), such as system performance testing, usability testing, or task-based testing. Questionnaires were used in 20% of studies, observations in 15%, and pre-tests and post-tests in 5%. This indicates that ITS evaluations are not only oriented towards student learning outcomes but also examine software quality and user experience.

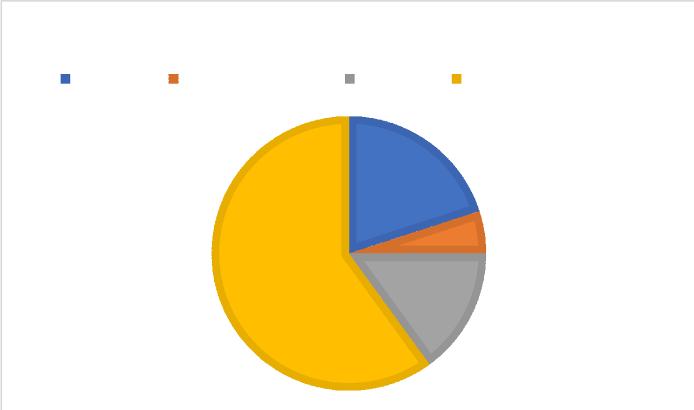

Figure 9. Evaluation Method

10. Synthesis of Findings

a. RQ1 (Educational fields that use ITS)

The analysis shows that Intelligent Tutoring Systems (ITS) have been utilized in various educational fields, with a predominance in general education, as well as computer science and mathematics. This dominance is due to the characteristics of these fields, which have a clear conceptual structure and are oriented towards problem-solving, making them easier to integrate with adaptive ITS technology. This trend is also related to the development of ITS technology (RQ2), where these fields are more rapidly adopting technological innovations to support structured, logic-based learning.

b. RQ2 (ITS tools or technology)

A variety of technologies are used in ITS development, with the "Other Tools" category dominating, demonstrating the breadth of innovation, including deep learning tutors, expert systems, and generative AI-based ITS. This diversity reflects not only technological advancements but also the need to adapt systems to the characteristics of the learning field (RQ1). From a Technological Pedagogical Content Knowledge perspective, this demonstrates that technology selection in ITS is highly dependent on its suitability to the content and pedagogical approach used.

c. RQ3 (ITS objectives and functions)

The primary goal of ITS is to support personalized and adaptive learning, realized through features such as automated feedback, interactive simulations, and self-assessment. This functionality is a direct result of the technological advancements used (RQ2) and is also the reason why ITS is widely applied in certain fields (RQ1). From a constructivist perspective, ITS's ability to adapt learning enables learners to actively construct knowledge through meaningful interactions.

d. RQ4 (ITS user interface)

The majority of ITS are web-based, followed by mobile and desktop platforms, indicating that accessibility is a critical factor in ITS implementation. This interface selection closely aligns with the ITS objective (RQ3), which is to provide flexible and accessible learning. Furthermore, a simple and adaptive interface design also supports the principles of Cognitive Load Theory, where systems are designed to reduce users' cognitive load for more effective learning.

e. RQ5 (ITS Impact)

ITS has been proven to have a positive impact on student learning outcomes, motivation, and engagement. This impact is the result of the integration of technology (RQ2), adaptive functionality (RQ3), and supportive interface design (RQ4). In other words, the effectiveness of ITS does not stand alone, but rather results from the synergy of various components within the system. This reinforces the fact that ITS-based learning can optimally support independent and personalized learning.

f. RQ6 (ITS evaluation method)

The diverse ITS evaluation methods demonstrate that system effectiveness is assessed from various perspectives, both technical and pedagogical. The use of usability testing, questionnaires, and performance metrics reflects efforts to measure the relationship between system design (RQ4), learning functionality (RQ3), and its impact on learning outcomes (RQ5). This demonstrates that ITS evaluation focuses not only on the final outcome but also on the user's learning process and experience.

Conclusion and Recommendations

This study shows that Intelligent Tutoring Systems (ITS) have become widely used learning technologies, particularly in general education, computer science, and mathematics, while other fields such as biology remain relatively underexplored. Various ITS development tools and techniques are dominated by the "Other Tools" category, indicating that innovation in ITS is becoming increasingly diverse and is moving toward more flexible, adaptive, and intelligent systems. ITS are consistently utilized to support adaptive learning, provide automated feedback, offer simulations, facilitate automated assessment, and enhance students' cognitive skills. Most systems use web-based interfaces, followed by mobile and desktop platforms, and have been proven to positively impact learning outcomes, motivation, and learner autonomy. Evaluation of ITS across studies has been conducted using a combination of technical methods, questionnaires, observations, and pre-test/post-test designs, which generally confirm the effectiveness of ITS in modern learning contexts. Based on these findings, this study recommends expanding ITS development into educational fields that still show low levels of adoption, while continuing to explore emerging technologies such as generative artificial intelligence and adaptive machine learning to create more personalized and contextual learning systems. In addition, evaluation methods should be further diversified to provide a more comprehensive understanding of ITS effectiveness. Educational institutions are also encouraged to integrate ITS into curricula and instructional design, for example by implementing ITS-based adaptive learning in subjects such as mathematics and computer science. Furthermore, teachers should be encouraged to design learning activities that utilize ITS as a supporting tool for providing automated feedback and fostering students' independent learning.

From a policy perspective, educational institutions and stakeholders need to develop a phased strategy for ITS implementation, including the provision of technological infrastructure, teacher training, and the development of guidelines for ITS use in learning. With these measures, ITS can be optimized as part of a long-term learning system that is more personalized, adaptive, and aligned with 21st-century demands. However, this study has several limitations that should be noted. First, the number of articles analyzed is still limited and does not fully represent the global development of ITS research. Second, the article selection process was based on specific inclusion and exclusion criteria, which may have influenced the scope of the selected literature. Third, the research data sources were dominated by Google Scholar, which is not a fully curated database compared to Scopus, which applies stricter selection processes. Therefore, future research is recommended to expand both the number and variety of data sources, as well as to utilize indexed databases to enhance the quality and validity of the literature synthesis.

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