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A Systematic Literature Review on Intelligent Tutoring Systems for Outcome-Based Education in Higher Education

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ABSTRACT

The implementation of Outcome-Based Education (OBE) in higher education requires a learning approach that can support the achievement of measurable learning outcomes and student competencies. Intelligent Tutoring Systems (ITS) are adaptive and personalized artificial intelligence-based learning systems, thus potentially supporting the implementation of OBE. However, empirical findings related to the implementation and effectiveness of ITS in the context of OBE in higher education are still scattered and have not been systematically synthesized. This study aims to examine the role, characteristics, and effectiveness of ITS in supporting outcome-based education in higher education.

This study employed a systematic literature review method, adhering to the PRISMA 2020 guidelines. A literature search was conducted through the Scopus database for English-language journal articles published between 2018 and 2025. A rigorous selection process resulted in 56 journal articles meeting the inclusion criteria and analyzed using a narrative synthesis approach.

The study results show that ITS is generally built on core components such as a learner model, a domain model, a pedagogical model, and a tutor interface. Commonly used artificial intelligence techniques include machine learning, rule-based systems, Bayesian networks, and natural language processing. Most studies report that ITS has a positive impact on academic performance, competency mastery, and student engagement. However, further research is needed to evaluate the long-term impact and integration of ITS within the OBE framework at the institutional level.

Keywords: Intelligent Tutoring Systems; Outcome-Based Education (OBE); Higher Education; Artificial Intelligence; Systematic Literature Review

INTRODUCTION

The paradigm shift toward Outcome-Based Education (OBE) in higher education requires innovative learning approaches capable of effectively supporting competency development and the achievement of measurable student learning outcomes (Spady, 1994). In this context, Intelligent Tutoring Systems (ITS) are defined as computer-based learning systems that utilize artificial intelligence techniques to provide personalized instruction and feedback, thereby emerging as potentially transformative instruments in realizing the objectives of OBE (VanLehn, 2011). ITS operate through artificial intelligence algorithms designed to create adaptive learning experiences tailored to

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individual students' needs, provide real-time feedback, and deliver guidance that resembles face-to-face interaction with a human tutor (Kulik & Fletcher, 2016). Within the OBE framework—which emphasizes clearly formulated learning outcomes, continuous assessment, and individualized learning pathways—ITS offer several theoretical advantages, including precise tracking of competency mastery, adaptive sequencing of instructional materials aligned with learning objectives, immediate formative feedback, and the provision of evidence-based analytical data to enhance learning quality.

Although interest and investment in ITS within higher education continue to grow, the available empirical evidence remains dispersed and fragmented across various contexts, technologies, and learning outcome indicators. Previous reviews have examined the general effectiveness of ITS (Ma et al., 2014) or focused on specific domains (Steenbergen-Hu & Cooper, 2013); however, no study has systematically synthesized empirical evidence concerning the implementation of ITS within the Outcome-Based Education framework in higher education. Therefore, this systematic literature review is designed to address research questions using the PICO (Population, Intervention, Comparison, Outcome) framework, with the population consisting of higher education students; the intervention involving Intelligent Tutoring Systems designed or implemented within an OBE framework; the comparison including traditional learning methods or no intervention; and the outcomes encompassing learning achievement, competency attainment, academic performance, and student engagement. Primarily, this study aims to analyze how ITS influence student learning outcomes and competency mastery in the implementation of OBE compared to conventional learning methods. Secondarily, the review explores the main components and artificial intelligence techniques employed in ITS, identifies the types of learning outcomes and competencies measured, and maps research gaps and future research directions in the domain of ITS and Outcome-Based Education. Accordingly, this study holds significance in providing evidence-based guidance for educators and higher education administrators considering the adoption of ITS, identifying relevant features and implementation strategies to support OBE, and mapping research gaps to inform a more structured and strategic future research agenda.

Furthermore, the integration of Intelligent Tutoring Systems (ITS) within the Outcome-Based Education (OBE) framework is not merely a matter of technical implementation, but also requires a reconstruction of curriculum design, assessment strategies, and academic culture in higher education institutions. The implementation of ITS aligned with OBE necessitates the formulation of operational and measurable learning outcomes, enabling the system to accurately map competency indicators through learning analytics and student modeling. In this context, ITS functions not only as a learning support tool, but also as an academic decision-support system capable of providing longitudinal data on students' competency development. Such data allow instructors to conduct more targeted pedagogical interventions, strengthen formative assessment practices, and ensure that the learning process remains consistent with the established graduate learning outcome standards. Therefore, ITS has the potential to reinforce the principle of constructive alignment among learning objectives, instructional activities, and assessment of learning outcomes.

On the other hand, the adoption of ITS in higher education also faces several conceptual and practical challenges, including technological infrastructure readiness, digital literacy of both instructors and students, ethical issues related to data usage, and the sustainability of funding for artificial intelligence–based systems. Disparities in

technological access among higher education institutions may lead to uneven implementation quality of ITS-based OBE, thereby requiring comprehensive and evidence-based institutional policies. In this regard, a systematic synthesis of the literature becomes crucial to identify patterns of effectiveness, enabling and inhibiting factors, and best-practice implementation models that can be replicated across diverse higher education contexts. Through a structured mapping of empirical findings, this study is expected not only to contribute theoretically to the advancement of ITS and OBE scholarship, but also to provide practical implications for transforming learning in the digital era, which increasingly demands accountability in measurable learning outcomes and graduate quality.

METHODOLOGY

Systematic Review Design and PRISMA

This systematic literature review was conducted with reference to the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) 2020 guidelines, which are reporting standards designed to help researchers transparently explain the rationale, methods, and results of systematic reviews, including the process of identifying, selecting, assessing, and synthesizing relevant studies.(Page et al., 2021)The 2020 PRISMA Guidelines replace the previous version by providing more comprehensive reporting recommendations along with advances in literature identification and evaluation methodology, and include clear workflow guidelines in a flowchart to describe the study selection stages in a systematic and standardized manner.(Galvão et al., 2022). Thus, the use of PRISMA not only increases transparency and consistency in reporting, but also facilitates methodological replication by other researchers studying similar topics.

Eligibility Criteria

Inclusion Criteria:

1. The study thatdiscussing the implementation of Intelligent Tutoring Systems (ITS)
2. Higher education context (university or tertiary education institution)
3. Carrying an outcome-based education approach, competency-based learning, or focusing on learning outcomes
4. Articleempirical research (experimental, quasi-experimental, or case studies)
5. Published in the period 2018–2025
6. Articlescientific journals (peer-reviewed journal articles) only
7. Written in English
8. Available in full-text form

Exclusion Criteria:

1. Systematic reviews, meta-analyses, literature reviews, and book chapters
2. Conference proceedings, editorials, opinion articles, and short papers
3. Study onprimary and secondary education levels
4. Studieswithout ITS implementation or without artificial intelligence components
5. The study thatnot reporting learning outcomes or educational outcomes explicitly
6. Duplicate publication

Information Sources and Search Strategies

The literature search was carried out systematically using one main database, namely:

Database : Scopus
Search Period : January 2018 –December 2025
Search Strategy :
The search strategy is constructed by combining three main groups of concepts using Boolean operators:

1. Intelligent Tutoring Systems:
   "intelligent tutoring system*" OR "AI tutor*" OR "adaptive tutoring" OR "adaptive learning system*"
2. Outcome-Based Education:
   "outcome-based education" OR "OBE" OR "competency-based learning" OR "learning outcomes*"
3. Higher Education:
   "higher education" OR "university" OR "tertiary education"

Search Query:

TITLE-ABS-KEY ("intelligent tutoring system" OR "AI tutor" OR "adaptive tutoring") AND TITLE-ABS-KEY ("outcome-based education" OR "competency-based learning" OR "learning outcomes") AND TITLE-ABS-KEY ("higher education" OR "university")

Study Selection Process

To ensure transparency and reproducibility in the study selection process, this study implemented a systematic and structured literature selection procedure based on the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guidelines.

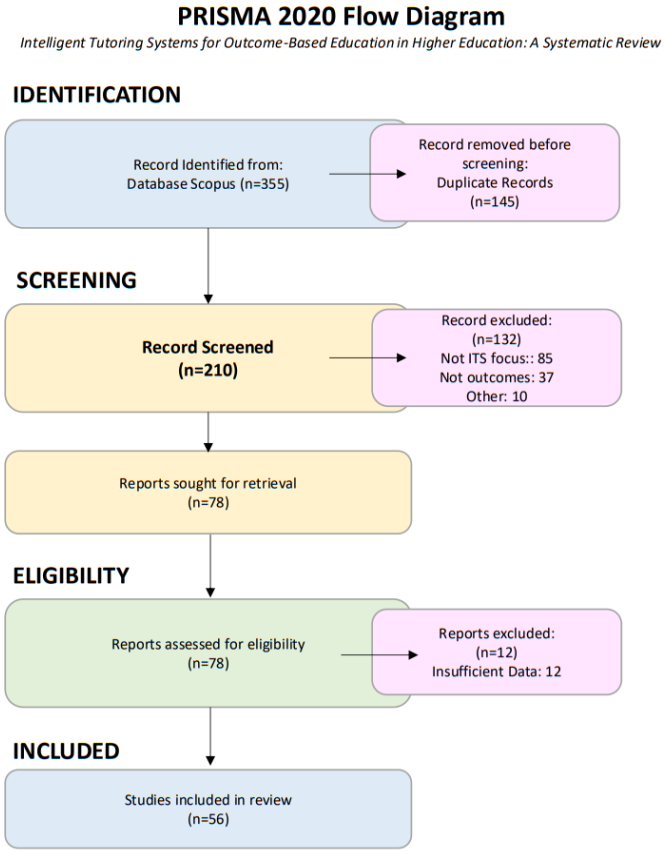

Figure 1. PRISMA diagram

The study selection process in this research was conducted systematically with reference to the PRISMA guidelines. In the identification stage, an initial 355 articles were obtained from the Scopus database. Next, in the deduplication and initial screening stage, the identified articles underwent duplication removal and filtering based on topic relevance, leaving 210 articles. In the title and abstract screening stage, all 210 articles were evaluated, with 132 articles excluded for not meeting the inclusion criteria, and 78 articles deemed suitable for proceeding to the full-text review stage. In the full-text assessment stage, a total of 78 articles were reviewed in depth, and 22 articles were excluded for not focusing on outcome-based education, not explicitly reporting learning outcomes, or not adequately explaining the implementation of Intelligent Tutoring Systems. Thus, a total of 56 journal articles met all inclusion criteria and were included in the final systematic review.

A complete list of studies included in this systematic review is presented in Appendix A.

Data Collection Process

Data extraction was conducted using a standardized form developed and piloted by the research team. Two reviewers extracted data independently, and discrepancies were resolved through discussion.

Extracted Data Includes:

1. Study Characteristics: authors, year, country, publication type, research design, sample size

2. Context: field of study, level of education, and implementation environment
3. ITS characteristics: platform name, AI method, adaptive technique, recommendation method, diagnosis algorithm, feedback feature, tutor intervention, and level of personalization
4. Results:measured learning outcomes, assessment instruments, effectiveness results, and statistical significance
5. Quality: study limitations, risk of bias, and recommendations for further research.

Data Synthesis Method

Given the variety of study designs, implementation contexts, and learning outcome indicators of the included articles, data synthesis in this review was conducted using a narrative synthesis approach. This approach was chosen due to the high degree of heterogeneity among the analyzed studies in terms of effect sizes, measurement methods, and reported outcomes, which made quantitative meta-analysis neither feasible nor appropriate for this research context. In line with recommended methodological practices in systematic reviews, narrative synthesis allows for thematic and conceptual integration of findings without statistical combination, particularly when data are inconsistent or studies have significant variability in design and reported outcomes.(De Cassai et al., 2025).

The synthesis is structured thematically with a focus on:

1. Patternimplementation of Intelligent Tutoring Systems in higher education
2. Techniqueartificial intelligence and adaptive learning mechanisms
3. Typelearning outcomes and measured competencies
4. The effectiveness of ITS in supporting outcome-based education
5. Factorcontextual and challenges of ITS implementation

RESULTS AND DISCUSSION

This chapter presents the results of a systematic literature review of 56 journal articles that met the inclusion criteria. The results are presented descriptively and thematically to provide a comprehensive overview of research trends, the characteristics of Intelligent Tutoring Systems (ITS), and their contribution to the implementation of outcome-based education (OBE) in higher education.

Distribution of Studies by Publication Year

Publication distribution analysis shows that research on Intelligent Tutoring Systems in the context of outcome-based education in higher education has increased significantly since 2020. Of the 56 articles reviewed, most were published in the 2020–2024 period, with the peak publications occurring in 2022 and 2023.

Table 1. Distribution of Studies by Publication Year

Publication Year	Number of Articles
2018	3
2019	5
2020	8
2021	10
2022	12
2023	9
2024	7
2025	2

Publication Year	Number of Articles
Total	56

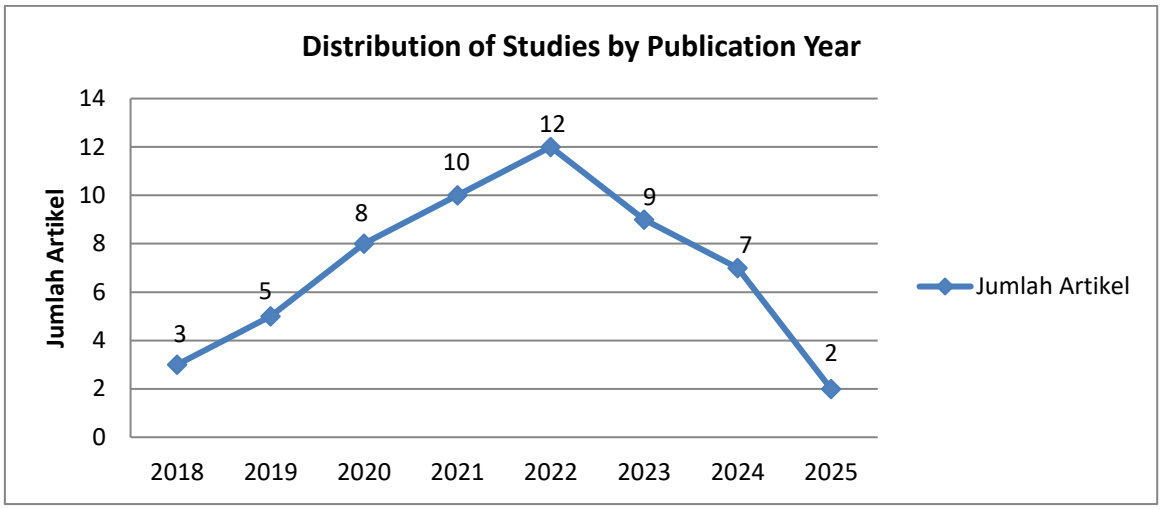

Figure 2. Distribution of Studies by Publication Year

This increase indicates growing academic attention to the use of artificial intelligence to support outcomes-based learning, along with the acceleration of digital transformation in higher education and the impact of online learning post-pandemic.

Geographical Distribution of Studies

Based on the authors' countries of origin, ITS research on OBE in higher education is dominated by countries with strong educational technology research ecosystems. The articles analyzed come from various regions, including:

1. Asia (especially China, India, and Southeast Asian countries),
2. Europe (English, Spanish, German),
3. North America (United States and Canada),
4. Australia and some Middle Eastern countries.

Table 2. Geographical Distribution of Studies

Region	Dominant Country	Number of Studies
Asia	China, India, Indonesia	22
Europe	UK, Spain, Germany	14
North America	USA, Canada	11
Australia	Australia	5
the middle East	UAE, Saudi Arabia	4
Total		56

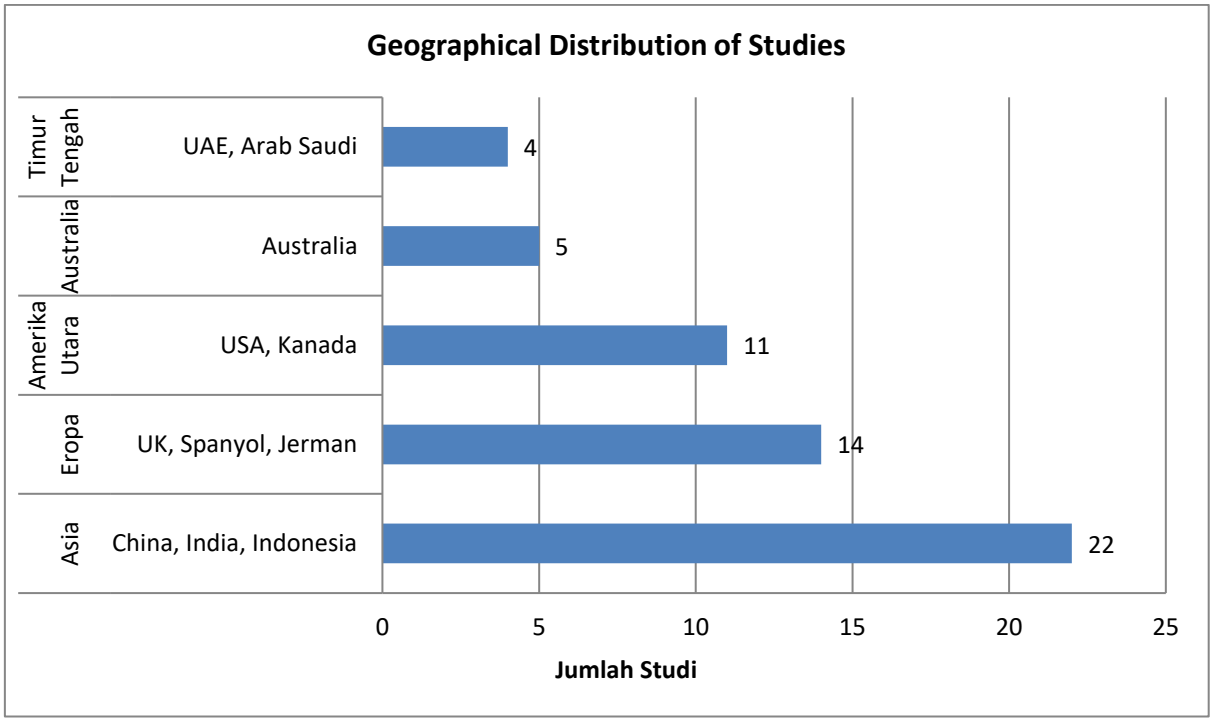

Figure 3. Geographical Distribution of Studies

This distribution shows that ITS implementation in higher education is global, although there is a higher concentration of research in countries with mature educational technology policy support and infrastructure.

Research Design and Methodological Characteristics

In terms of research design, the majority of studies used a quantitative experimental or quasi-experimental approach, specifically to measure the impact of ITS on student learning outcomes. Furthermore, several articles used case studies and mixed-methods approaches to explore user experiences and system effectiveness in more depth.

Most of the research involved undergraduate students, primarily in STEM-based subjects such as informatics, mathematics, engineering, and science. However, a number of studies were also found in education, business, and the social sciences, demonstrating the broadening application of ITS across disciplines.

Table 3. Research Design and Methodological Characteristics

Research Design	Number of Studies
Experimental	21
Quasi-experimental	17
Mixed methods	9
Case study	6
Design-based research	3
Total	**56**

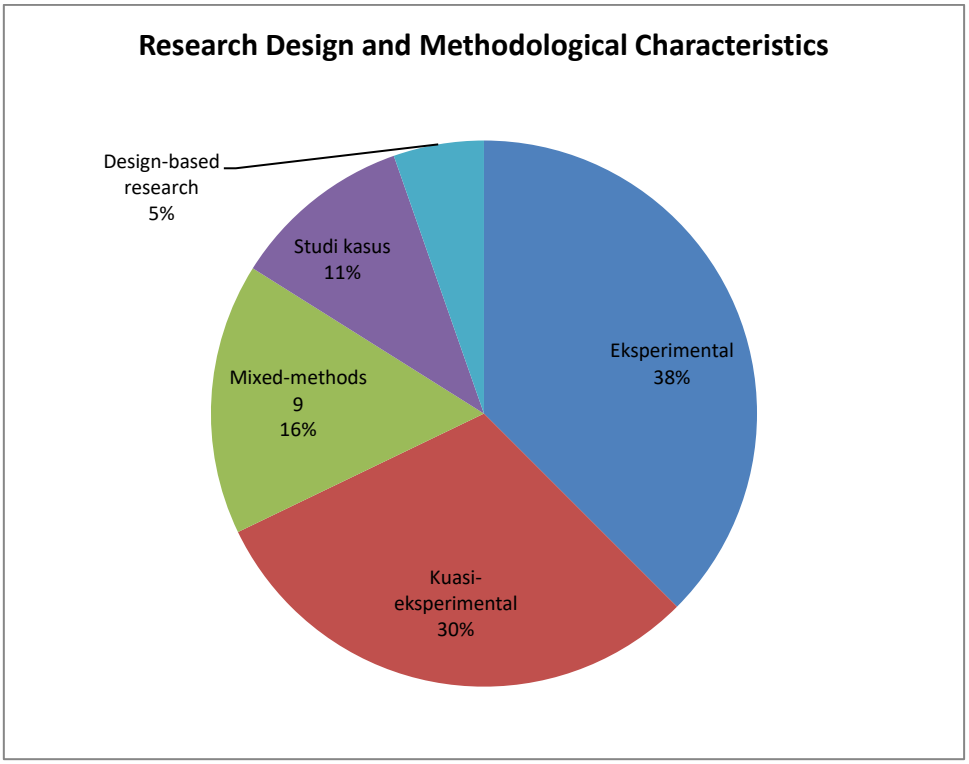

Figure 4. Research Design and Methodological Characteristics

Characteristics of Intelligent Tutoring Systems

Analysis of ITS characteristics in 56 articles shows that most systems have the following main features:

1. Personalized learning, which adjusts the material and difficulty level based on student performance.
2. Adaptive learning, with adjustments to learning paths according to competency achievements.
3. Automatic, real-time feedback, whether in the form of corrections, hints, or recommendations for further learning.
4. Tracking learning outcomes, which is in line with the principles of outcome-based education.

Table 4. Characteristics of Intelligent Tutoring Systems

ITS Characteristics	Number of Studies
Adaptive learning	44
Personalize your learning path	39
Real-time feedback	42
Diagnosis of learning errors	31
Tracking OBE achievements	28

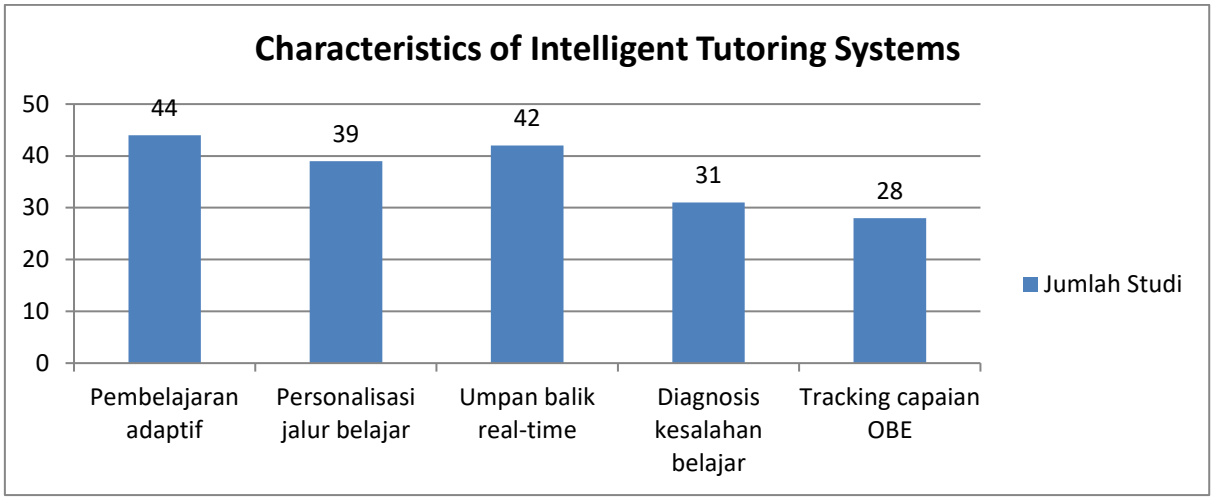

Figure 5. Characteristics of Intelligent Tutoring Systems

Most ITS are developed as web-based platforms or integrated Learning Management Systems (LMS), while some studies report the use of intelligent chatbots and dialogue-based tutoring systems.

AI Techniques Used in ITS

Various artificial intelligence techniques are used in the ITS analyzed. The most common techniques include:

1. Rule-based systems, to determine tutor responses and learning paths.
2. Machine learning, especially supervised learning for predicting student performance.
3. Bayesian networks, which are used to model student knowledge and level of competency mastery.
4. Natural Language Processing (NLP), especially in dialogue-based ITS or academic chatbots.

Table 5.AI Techniques Used in ITS

AI Techniques	Number of Studies
Rule-based systems	24
Machine learning	29
Bayesian networks	18
Natural Language Processing	14
Deep learning	9

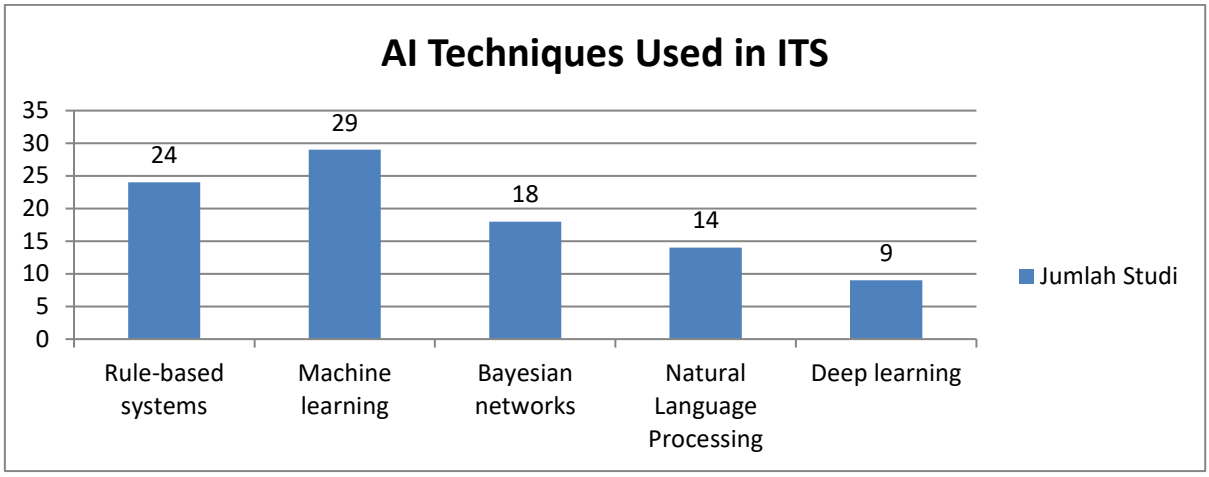

Figure 6. AI Techniques Used in ITS

The use of AI techniques aims to improve the system's ability to diagnose errors, provide learning recommendations, and support achievement-based assessments.

Learning Outcomes and Competency Measurement

All reviewed articles measured at least one learning outcome indicator. The most frequently used indicators included:

1. Improvement in academic grades or test scores,
2. Mastery of specific competencies according to course learning outcomes,
3. Level of student involvement and participation,
4. Problem solving and critical thinking skills.

Table 6. Learning Outcomes and Competency Measurement

Outcome Indicators	Number of Studies
Academic grades	41
Competency mastery	36
Problem-solving skills	22
Student involvement	27
Self-regulated learning	15

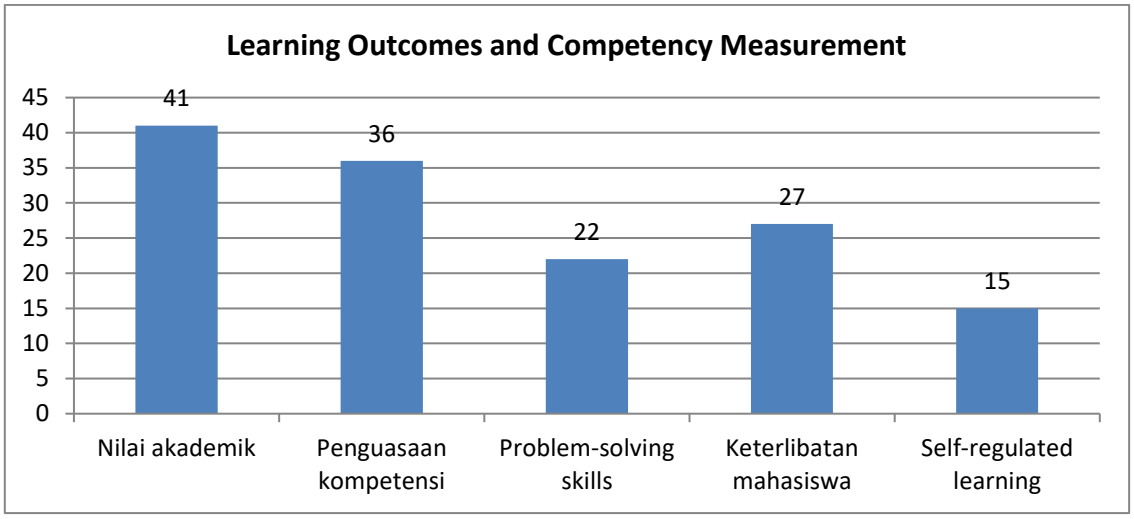

Figure 7. Learning Outcomes and Competency Measurement

Some studies explicitly map these indicators to OBE learning outcomes, while others use an implicit approach through competency-based assessment.

Effectiveness of ITS in Supporting Outcome-Based Education

The majority of studies (more than two-thirds of the articles) reported that the use of Intelligent Tutoring Systems had a positive impact on student learning outcomes compared to traditional learning methods. ITS has been shown to help students achieve learning outcomes more consistently through adaptive, individualized learning.

Table 7. Effectiveness of ITS in Supporting Outcome-Based Education

Effectiveness Findings	Number of Studies
Significantly effective	38
Moderately effective	12
Not significant	6
Total	**56**

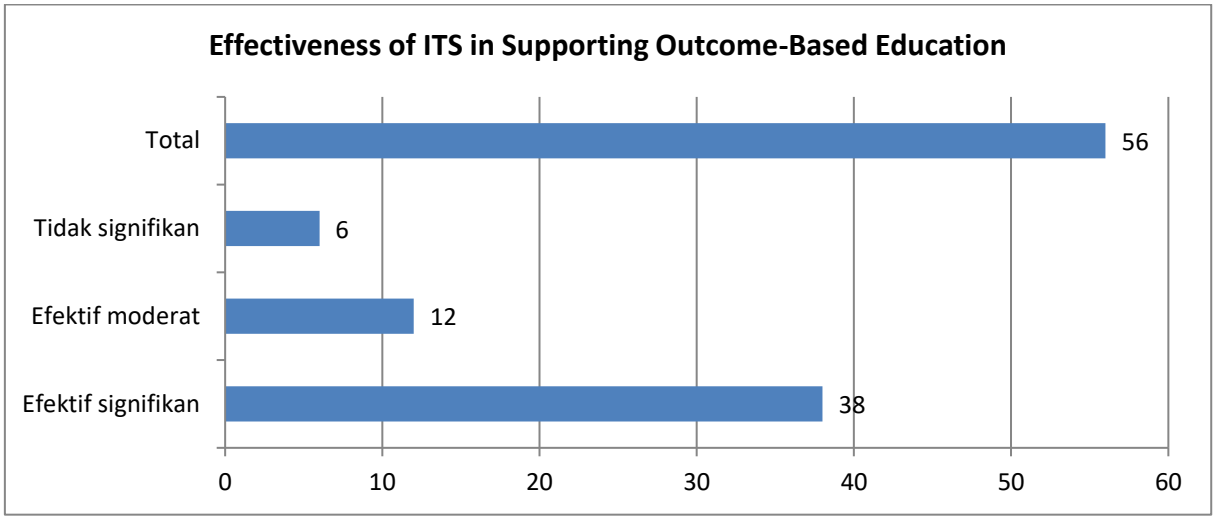

Figure 8. Effectiveness of ITS in Supporting Outcome-Based Education

However, several studies also report that the effectiveness of ITS is greatly influenced by contextual factors, such as the institution's technological readiness, OBE curriculum design, and the level of digital literacy of students and lecturers.

3.8 Implementation Context and Challenges

The review results show that the implementation of ITS in higher education faces a number of challenges, including:

1. Integration of ITS with existing OBE-based curriculum,
2. Limited learning data to support optimal personalization,
3. User resistance to AI-based systems,
4. The need for lecturer training in utilizing ITS effectively.

Table 8. Implementation Context and Challenges

Implementation Challenges	Number of Studies
Integration with OBE curriculum	21
Lecturer readiness	18
Limited student data	16
Technology infrastructure	14
User resistance	9

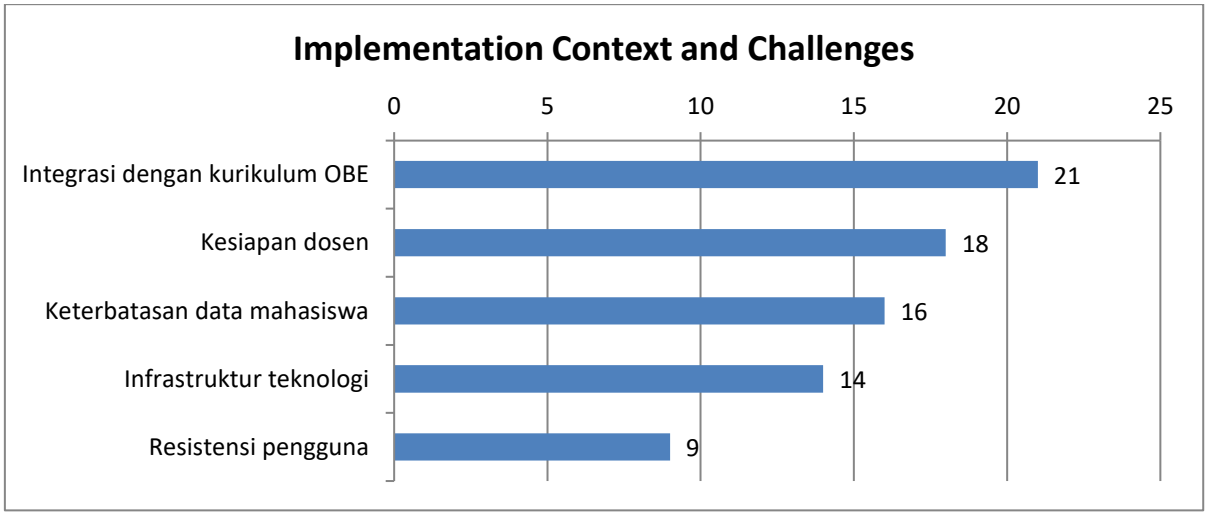

Figure 9. Implementation Context and Challenges

However, most studies emphasize that these challenges can be minimized through user-centered system design and adequate institutional support.

3.9 Summary of Key Findings

Overall, the results of a systematic literature review of 56 articles indicate that Intelligent Tutoring Systems have significant potential to support the implementation of outcome-based education in higher education. ITS can provide adaptive, measurable, and outcome-oriented learning, in line with OBE principles. However, successful

implementation depends heavily on the institutional context, system design, and user readiness.

Discussion

This chapter discusses the main findings from a systematic literature review of 56 Scopus-indexed journal articles, linking them to the research questions, the outcome-based education (OBE) framework, and previous research findings. The discussion focuses on the role of Intelligent Tutoring Systems (ITS) in supporting learning outcomes in higher education. Details of the 56 included studies, including year of publication, country of origin, and research methods, are summarized in Appendix A.

Trends in ITS Research for Outcome-Based Education

The review results show a significant increase in ITS research in the context of outcome-based education since 2020. This trend reflects the growing need for adaptive, measurable, and achievement-oriented learning systems, especially following the acceleration of digital transformation in higher education.

The dominance of publications in the 2021–2024 period indicates that ITS is increasingly viewed as a strategic solution to bridge the gap between OBE-based curriculum design and classroom implementation. This finding aligns with previous literature emphasizing the role of smart technologies in supporting personalized and competency-based learning.

Contribution of ITS to Learning Outcomes and Competency Achievement

Most of the studies analyzed reported that ITS had a positive impact on student learning outcomes and competency attainment. Adaptive learning and personalized learning paths enabled students to achieve learning outcomes more consistently than traditional learning approaches.

Within the OBE framework, ITS serves as an effective operational mechanism for continuously monitoring and measuring competency mastery. By leveraging student performance data, ITS is able to provide formative feedback aligned with course and program learning outcomes.

Role of AI Techniques in Supporting Outcome-Based Education

Further discussion showed that the selection and implementation of artificial intelligence techniques significantly impact the effectiveness of ITS. Machine learning and Bayesian networks are the most commonly used approaches to model student knowledge and predict competency achievement.

Furthermore, the use of natural language processing (NLP) in dialogue-based ITS expands the potential for interactive and reflective learning. This integration of AI techniques supports OBE principles by enabling the system to provide data-driven and results-oriented learning recommendations.

However, several studies have shown that the complexity of AI techniques does not always translate directly to improved learning outcomes. Pedagogical design factors and their fit with the OBE curriculum context remain key determinants of ITS success.

Alignment of ITS Features with OBE Principles

The review results indicate that key ITS features, such as adaptive learning, real-time feedback, and learning outcome tracking, align highly with outcome-based

education principles. ITS allows instructors to monitor student progress based on established learning outcomes, not simply on completion of material.

These findings confirm that ITS serves not only as a technological tool but also as a pedagogical instrument that supports the systematic implementation of OBE. Thus, ITS can serve as a bridge between OBE-based curriculum planning and everyday classroom learning practices.

Contextual Factors and Implementation Challenges

While the effectiveness of ITS has been generally reported to be positive, discussions indicate that successful implementation is heavily influenced by contextual factors. Key challenges frequently reported include integrating ITS with existing curricula, faculty readiness, and limited infrastructure and learning data.

Several studies emphasize the importance of faculty training and institutional support in optimizing the use of ITS. Without a sufficient understanding of the principles of OBE and how AI-based systems operate, ITS's potential cannot be fully utilized.

Research Gaps and Future Directions

Although research on ITS and OBE in higher education continues to grow, this systematic literature review identified several research gaps. First, most studies still focus on short-term academic outcomes, while their long-term impact on graduate competencies remains largely unexplored.

Second, research across disciplines and non-STEM contexts remains relatively limited. Third, few studies evaluate the integration of ITS into an institution's overall academic system within an enterprise framework or an impactful curriculum.

Therefore, future research needs to examine the implementation of ITS more holistically, including its integration with academic policies, quality assurance systems, and continuous evaluation of study program learning outcomes.

Implications for Higher Education Practice and Policy

The findings of this review have important implications for higher education practice and policy. ITS has the potential to be a strategic tool to support the implementation of outcome-based education, particularly in the context of improving learning quality and accountability for graduate outcomes.

For policymakers, these results emphasize the need to invest not only in ITS technology, but also in faculty capacity development and curriculum adjustments. An integrated approach between technology, pedagogy, and institutional policy is key to the successful implementation of ITS in education.

CONCLUSION

This systematic literature review examines the implementation of Intelligent Tutoring Systems (ITS) within an outcome-based education (OBE) framework in higher education to identify the main components of the system, measured learning outcomes, level of effectiveness, and existing research gaps.

The study results show that ITS in the context of OBE is generally built on core components in the form of a learner model, a domain model, a pedagogical model, and an integrated tutor interface. These components enable adaptive and personalized learning, in line with the OBE principle of being oriented towards learning outcomes. The most widely used artificial intelligence techniques include

machine learning, rule-based systems, Bayesian networks, and natural language processing, which function to model student knowledge, predict competency mastery, and provide real-time learning feedback.

In practice, ITS is used to measure various learning outcomes and competencies, particularly academic performance, mastery of specific competencies, and higher-order cognitive skills such as problem-solving and critical thinking. Several studies also evaluate non-cognitive aspects, such as student engagement and self-regulated learning, which play a crucial role in supporting the achievement of learning outcomes.

The majority of reviewed studies reported that ITS had a significant positive impact on improving students' academic performance compared to traditional learning methods. The effectiveness of ITS was primarily influenced by the system's ability to adapt learning paths, provide individualized feedback, and support ongoing monitoring of learning outcomes. However, variations in results across studies indicate that the success of ITS also depends heavily on pedagogical design and institutional context.

However, this review identified several research gaps. Most studies still focus on short-term evaluations and are limited to STEM fields, while cross-disciplinary research and evaluation of the long-term impact on graduate competencies are still rare. Future research needs to examine ITS implementation more holistically, including its integration with OBE policies and quality assurance systems in higher education.

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