International Journal of Computer Information Systems and Industrial Management Applications
ISSN 2150-7988 Volume 18(16s) 2026 pp. 1419-1434
https://doi.org/10.70917/ijcisim-2026-4675
Article

# AI-Enabled Pedagogical Framework for Integrating Indian Knowledge Systems in Teacher Education

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**Abstract:** Indian Knowledge Systems (IKS) represent a diverse body of knowledge developed and transmitted through India's intellectual, scientific, philosophical, cultural, linguistic, artistic, and educational traditions. The National Education Policy (NEP) 2020 emphasizes the importance of developing a strong understanding of Indian knowledge, values, traditions, languages, arts, and cultural heritage within contemporary education. However, the integration of IKS into teacher education remains challenging because of fragmented digital resources, heterogeneous knowledge formats, limited personalization, inadequate pedagogical mapping, and the absence of intelligent mechanisms for recommending context-specific IKS learning resources. This paper proposes an AI-Enabled Pedagogical Framework for integrating Indian Knowledge Systems into teacher education. The proposed framework combines Natural Language Processing (NLP), semantic analysis, knowledge representation, recommendation techniques, adaptive learning, intelligent assessment, and learning analytics to support teacher educators and student teachers. The framework consists of five major layers: Data Collection, AI Processing, Pedagogical, Application, and Analytics layers. The Data Collection Layer manages IKS resources obtained from digital repositories, books, manuscripts, educational resources, multimedia content, curriculum documents, and expert-curated materials. The AI Processing Layer performs preprocessing, semantic classification, entity extraction, topic identification, content recommendation, and knowledge graph construction. The Pedagogical Layer maps IKS resources with teacher education learning outcomes and generates adaptive learning pathways. A prototype implementation is proposed through an integrated dashboard containing an IKS content library, AI tutor, adaptive learning module, assessment engine, recommendation system, and learning analytics dashboard. The system can recommend resources related to areas such as Indian mathematics, Ayurveda, Yoga, philosophy, astronomy, agriculture, architecture, linguistics, arts, and traditional pedagogical practices. A controlled evaluation involving teacher education learners can be used to measure recommendation accuracy, learning improvement, user satisfaction, assessment performance, and system usability. The proposed framework provides a technology-supported mechanism for contextualizing Indian Knowledge Systems within teacher education while maintaining human oversight over educational interpretation and knowledge validation. The framework can support personalized learning, curriculum integration, intelligent assessment, and data-driven pedagogical decision-making. The study demonstrates how artificial intelligence can act as an enabling technology for strengthening IKS-based teacher education rather than replacing teacher educators or domain experts.

**Keywords:** Indian Knowledge Systems, Artificial Intelligence, Teacher Education, Adaptive Learning, Natural Language Processing, Pedagogical Framework, Learning Analytics, Knowledge Graph, Intelligent Tutoring System

## 1.Introduction

Indian Knowledge Systems (IKS) represent a broad and multidisciplinary body of knowledge that has evolved through diverse intellectual, scientific, philosophical, cultural, linguistic, artistic, technological, and educational traditions of India. The scope of IKS extends across mathematics, astronomy, medicine and health, agriculture, architecture, linguistics, philosophy, psychology, environmental knowledge, performing arts, literature, governance, and traditional educational practices. Rather than being restricted to historical or cultural studies, IKS can provide perspectives for understanding knowledge, learning, human well-being, sustainability, and societal development in contemporary contexts (Indian Knowledge Systems Division, 2026a). The current educational policy environment in India has therefore increasingly emphasized the systematic integration of Indian knowledge traditions into modern education. The National Education Policy (NEP) 2020 provides an important policy foundation for this integration. The policy emphasizes education rooted in Indian ethos and identifies the need for teacher education programmes to provide prospective teachers with an understanding of the knowledge of India, its values, ethos, arts, traditions, and related dimensions. It also emphasizes multidisciplinary learning, Indian languages, local contexts, and the development of teachers capable of connecting educational knowledge with India's diverse cultural and intellectual heritage (Ministry of Education, 2020). In addition, the Government of India has identified Indian Knowledge Systems as an important component of NEP implementation, with initiatives focusing on the development of digital content, content in Indian languages, and the embedding of IKS within curricula across higher education (Ministry of Education, 2024).

The establishment of the Indian Knowledge Systems Division under the Ministry of Education further demonstrates the institutional importance being given to this area. The IKS Division aims to promote interdisciplinary and transdisciplinary research, preserve and disseminate Indian knowledge traditions, support IKS centres and research projects, and encourage the incorporation of IKS into textbooks and reference materials. Its stated mission covers knowledge domains ranging from mathematics, astronomy, science and technology to health, yoga, environment, agriculture, linguistics, philosophy, psychology, arts, and oral traditions preserved in languages such as Sanskrit, Prakrit, Tamil, and Pali (Indian Knowledge Systems Division, 2026a, 2026b). Recent initiatives for IKS textbooks and course materials also identify areas such as mathematical and astronomical sciences, speech and linguistics, health sciences, agriculture, performing arts, architecture, engineering, and education-related knowledge as priority areas for integration into higher education (Indian Knowledge Systems Division, 2025). Teacher education is particularly important in this context because teachers act as mediators between knowledge, curriculum, learners, and society. The successful integration of IKS into school and higher education therefore depends not only on the availability of IKS resources but also on the preparedness of prospective teachers to understand, contextualize, evaluate, and pedagogically apply such knowledge. Recent research on IKS and teacher preparation indicates increasing attention to the role of IKS in developing culturally responsive, inclusive, and holistic approaches to teacher education (Kanojiya & Sankpal, 2024). Similarly, emerging research on pre-service teachers has highlighted the importance of examining their awareness, attitudes, and readiness for incorporating IKS into classroom practices (Sahoo & Pradhan, 2026). These findings indicate that IKS integration requires more than simply adding traditional knowledge topics to a curriculum; it requires appropriate pedagogical mechanisms that enable teachers to transform knowledge resources into meaningful learning experiences. However, practical integration of IKS into teacher education presents several challenges. First, IKS resources are highly heterogeneous and distributed across books, manuscripts, scholarly publications, institutional repositories, digital archives, audio-visual resources, oral traditions, and multilingual documents. The IKS Division itself identifies the need for databases and digital portals for the archival, categorization, preservation, and dissemination of knowledge across multiple domains and languages (Indian Knowledge Systems Division, 2026b). Such heterogeneity makes conventional keyword-based information retrieval

insufficient for identifying resources that are pedagogically relevant to a particular course, learner, or learning outcome.

Second, linguistic diversity creates an additional challenge. Important IKS knowledge has been preserved in Sanskrit, Prakrit, Pali, Tamil, and other Indian languages, while contemporary teacher education frequently operates through English or regional-language curricula. Consequently, effective digital integration requires language-aware processing, semantic retrieval, translation support, and contextual interpretation. An intelligent system capable of processing heterogeneous multilingual resources could therefore improve access to relevant IKS materials while reducing the difficulty of locating appropriate resources.

Third, conventional digital learning platforms generally provide content access without sufficiently considering individual learner characteristics. Modern Artificial Intelligence (AI) in Education (AIED) research demonstrates the potential of AI-based systems to support personalized learning, automated feedback, intelligent tutoring, learning analytics, and adaptive educational experiences. At the same time, research emphasizes that AI should be implemented with appropriate pedagogical, ethical, and human-centred considerations rather than being treated simply as a replacement for teachers (Albadarin et al., 2024; Alfredo et al., 2023). In teacher education, this distinction is especially important because prospective teachers need to develop both technological competence and professional judgment regarding the appropriate use of AI-supported educational resources.

Recent developments in generative AI and conversational systems have further expanded the possibilities for AI-supported education. Systematic reviews have reported potential applications of generative AI and ChatGPT in teaching and learning, including personalized explanations, feedback, content generation, learner support, and interactive educational assistance (Ali et al., 2024; Albadarin et al., 2024). However, these systems also introduce challenges related to factual accuracy, hallucination, bias, over-reliance, academic integrity, and the reliability of generated information. Therefore, for knowledge domains such as IKS, where historical context, textual interpretation, cultural sensitivity, and source authenticity are important, a generic large language model may not be sufficient. A domain-specific, curated, and source-grounded approach is required. A further challenge is the limited availability of integrated pedagogical frameworks that connect IKS resources with teacher education curriculum, learner profiles, adaptive recommendations, assessment, and learning analytics. Existing IKS initiatives have established important foundations for content development, research, dissemination, and curriculum integration, but there remains a need for technology-supported mechanisms that can dynamically connect IKS knowledge with specific teacher education learning outcomes and learner needs. At the same time, research in AI literacy and teacher education suggests that teachers require not only access to AI tools but also the knowledge and professional capacity to use AI critically, ethically, and pedagogically (Mishra et al., 2024). This creates an opportunity to design an integrated framework in which AI functions as a pedagogical support mechanism while teachers and domain experts retain responsibility for interpretation, validation, and instructional decision-making.

To address these challenges, this study proposes an AI-Enabled Pedagogical Framework for Integrating Indian Knowledge Systems in Teacher Education. The proposed framework combines Natural Language Processing (NLP), semantic analysis, knowledge representation, content classification, recommendation techniques, Retrieval-Augmented Generation (RAG), adaptive learning, intelligent assessment, and learning analytics. The framework is designed to transform heterogeneous IKS resources into structured and pedagogically relevant learning materials for teacher education. The proposed framework consists of five interconnected layers: (1) Data Collection Layer, (2) AI Processing Layer, (3) Pedagogical Layer, (4) Application Layer, and (5) Analytics Layer. The Data Collection Layer manages IKS resources obtained from books, manuscripts, digital repositories, scholarly publications, multimedia resources, curriculum documents, and expert-curated materials. The AI Processing Layer performs text preprocessing, language identification, semantic analysis, topic classification, entity extraction, embedding generation, and knowledge-graph construction. The Pedagogical Layer maps IKS resources to curriculum components, course outcomes, competency requirements, and learner characteristics. The Application Layer provides practical interfaces such as an IKS content library, AI tutor, adaptive learning module, assessment engine, and teacher dashboard. Finally,

the Analytics Layer evaluates learner engagement, progress, performance, competency development, and resource utilization.

A major component of the proposed framework is a source-grounded AI tutor based on Retrieval-Augmented Generation. Instead of relying exclusively on the internal knowledge of a large language model, the proposed tutor retrieves relevant information from a curated IKS knowledge repository before generating an answer. This approach is intended to improve contextual relevance and provide source-supported responses while reducing the risk of unsupported content generation. Such a design is particularly important for IKS education because teachers and learners should be able to distinguish between historically documented knowledge, scholarly interpretation, contemporary application, and AI-generated explanation. The framework also introduces an adaptive IKS recommendation mechanism. The recommendation engine considers learner interests, previous assessment performance, learning history, course requirements, semantic similarity, and curriculum relevance to recommend appropriate learning resources. Consequently, two learners studying the same teacher education course may receive different learning pathways according to their demonstrated learning requirements. This approach moves IKS integration beyond static content repositories toward personalized and competency-oriented learning. Another important component is the IKS learning analytics dashboard, which provides teacher educators with information about learner progress, assessment performance, engagement, frequently accessed knowledge domains, learning difficulties, and recommended interventions. Human-centred AI research emphasizes the importance of maintaining meaningful involvement of educational stakeholders in AI-supported learning environments and balancing automation with human control (Alfredo et al., 2023). Accordingly, the proposed framework positions AI as an assistive mechanism rather than a substitute for teacher educators or IKS scholars. The research therefore contributes to the emerging intersection of Indian Knowledge Systems, teacher education, Artificial Intelligence, adaptive learning, knowledge representation, and learning analytics. The framework seeks to provide a systematic technological pathway through which IKS resources can be collected, processed, contextualized, recommended, taught, assessed, and evaluated. By combining AI capabilities with expert validation and pedagogical oversight, the proposed approach aims to support culturally relevant, personalized, evidence-oriented, and technology-enabled teacher education. The primary research contribution of this study is thus not merely the digitization of IKS resources, but the development of an integrated AI-enabled pedagogical ecosystem that connects IKS knowledge with teacher education processes. The proposed framework provides a foundation for implementing intelligent content discovery, curriculum mapping, personalized learning, source-grounded AI tutoring, adaptive assessment, and learning analytics within IKS-oriented teacher education. The framework can subsequently be evaluated through a working prototype and controlled experiments to determine its effectiveness in improving learning outcomes, recommendation quality, learner engagement, usability, and teacher educators' decision-making. In this way, the proposed research aligns the objectives of contemporary AI-supported education with the national emphasis on strengthening Indian Knowledge Systems in education. It aims to demonstrate that AI can serve as an enabling technology for preserving, accessing, contextualizing, and pedagogically applying India's diverse knowledge traditions while ensuring that human expertise, source validation, cultural sensitivity, and educational judgment remain central to the learning process.

## 2. Literature Review

Indian Knowledge Systems (IKS) integration in contemporary education has received increasing attention following the implementation of the National Education Policy (NEP) 2020. Existing research can broadly be divided into two interconnected streams: (i) studies focusing on IKS integration, curriculum, teacher preparation, and culturally contextualized education, and (ii) studies focusing on Artificial Intelligence (AI), adaptive learning, intelligent tutoring, generative AI, Natural Language Processing (NLP), knowledge graphs, and learning analytics. However, these two research streams have largely developed independently. The proposed study attempts to bridge this gap by combining AI-enabled pedagogical technologies with IKS-oriented teacher education.

Table 1 Literature Review

| S. No. | Author(s) & Year | Research Focus | Method/ Technology | Major Findings | Limitation/Gap Relevant to Present Study |
|---|---|---|---|---|---|
| 1 | Zawacki-Richter et al. (2019) | AI applications in higher education | Systematic literature review | Identified major AI applications including profiling, prediction, assessment, adaptive systems, and intelligent tutoring | Limited attention to educators' pedagogical role and no IKS-specific application |
| 2 | Chen et al. (2020) | AI in education | Review of AI technologies | Discussed intelligent tutoring, adaptive learning, educational data mining, and personalized education | General AI framework; cultural and IKS-specific learning contexts not addressed |
| 3 | Ouyang and Jiao (2021) | AI in education | Conceptual/research review | Proposed perspectives for understanding AI-supported educational transformation and human-AI collaboration | Did not address culturally grounded knowledge systems such as IKS |
| 4 | Joshi and Bansal (2023) | IKS integration in STEM education | Survey study | Examined awareness, attitudes, and practices of pre-service and in-service teachers toward IKS integration | Focused on awareness and practices rather than an AI-enabled implementation platform |
| 5 | Thapliyal (2023) | IKS curriculum in higher education | Curriculum/model development | Proposed a postgraduate-level IKS course structure with objectives, outcomes, content, and assessment | Curriculum model is largely static and does not provide intelligent personalization |
| 6 | Kasneci et al. (2023) | Large Language Models in education | Conceptual review | Identified opportunities for personalized support, tutoring, content generation, and | Generic LLM application; no source-grounded IKS knowledge repository |

| | | | | | |
|---|---|---|---|---|---|
| | | | | feedback while emphasizing ethical risks | |
| 7 | Lin (2023) | Knowledge-graph-based personalized teaching | Knowledge graph | Demonstrated that learner knowledge maps can support personalized resources and learning paths | Not designed for IKS or teacher education |
| 8 | Alonso-Arroyo et al. (2023) | ChatGPT in education | Systematic review | Reported positive potential for teaching-learning while emphasizing teacher preparation and responsible implementation | Does not provide an IKS-specific tutor or curated knowledge architecture |
| 9 | Kanojiya and Sankpal (2024) | IKS in teacher and teacher-educator preparation | Conceptual/research study | Highlighted the relevance of IKS for culturally responsive and holistic teacher preparation | Does not propose an operational AI framework or working dashboard |
| 10 | Ogunleye et al. (2024) | Generative AI for teaching and learning | PRISMA-based systematic review | Identified rapid growth of GenAI research and applications in teaching, assessment, and learning | Identified need for curriculum-oriented and interdisciplinary GenAI frameworks |
| 11 | Albadarin et al. (2024) | ChatGPT in education | Systematic literature review | Examined educational applications and emphasized opportunities as well as implementation concerns | Generic ChatGPT research; limited domain-specific grounding |
| 12 | Lintner (2024) | AI literacy | Systematic review | Reviewed 22 studies and 16 AI-literacy scales covering learners and teachers | Focuses on AI literacy measurement rather than IKS pedagogical integration |

| | | | | | |
|---|---|---|---|---|---|
| 13 | Paulsen and Lindsay (2024) | Learning analytics dashboards | Systematic review | Found increasing emphasis on dashboards that support actual learning rather than only presenting analytics | Does not address IKS competencies or IKS-specific teacher dashboards |
| 14 | Lan et al. (2024) | NLP for education | Taxonomy/systematic survey | Identified NLP applications including question answering, automated assessment, error correction, and adaptive learning | NLP applications are general-purpose and not optimized for multilingual IKS resources |
| 15 | Mustfa and Ashiq (2024) | AI-driven adaptive learning | Systematic review | Highlighted AI's potential for personalized content, instructional strategies, and assessment | Limited application to teacher education and culturally specific content |
| 16 | Bond et al. (2024) | AI in initial teacher education | Systematic mapping review | Synthesized 138 primary studies and highlighted the growing importance of AI literacy and AI applications in pre-service teacher education | Does not specifically investigate IKS integration |
| 17 | Yuensook et al. (2026) | AI-driven adaptive learning in higher education | Systematic review of 15 empirical studies | Reported use of ML, NLP, and hybrid systems for personalization and adaptive feedback | Non-STEM and culturally specific domains remain underrepresented |
| 18 | Shaheen et al. (2026) | AI and immersive technologies in teacher education | PRISMA systematic review | Reviewed approximately 43 studies and found opportunities for adaptive and immersive teacher education | Identified a continuing gap in teacher-specific research and IKS-specific applications |

## 3. Research Gaps

From the above analysis, the following research gaps are identified:

- **Lack of IKS-specific AI frameworks: -** Although AI-based educational frameworks are increasingly available; very few are designed specifically for Indian Knowledge Systems.
- Lack of teacher-education-oriented IKS platforms:- Existing IKS research discusses teacher preparation, but there is limited development of working digital platforms specifically designed for student teachers and teacher educators.
- **Limited personalization:-** Existing IKS curriculum models generally provide common content to learners rather than dynamically adapting resources according to learner performance, interests, and competency levels.
- **Lack of semantic IKS retrieval:-** IKS resources exist across multiple formats and languages. Existing studies do not sufficiently address semantic retrieval across heterogeneous IKS resources.
- **Lack of source-grounded IKS AI tutors:-** Generic LLMs can answer educational questions but may produce unsupported or inaccurate information. A curated, source-grounded RAG-based IKS tutor remains an important research opportunity.
- **Limited IKS knowledge graphs:-** Knowledge graphs have been investigated for personalized education, but IKS-specific knowledge graphs connecting concept → source → domain → learning outcome → activity → assessment are insufficiently explored.
- **Lack of IKS learning analytics:-** Existing learning analytics systems generally focus on overall academic performance rather than IKS-domain competencies.
- **Limited integrated evaluation:-** Most existing studies address individual components—curriculum, AI, adaptive learning, NLP, or analytics—rather than evaluating a complete integrated IKS-AI pedagogical ecosystem.

## 4. Objective

The objectives of the proposed research are:

- To design an integrated AI-enabled pedagogical framework for Indian Knowledge Systems in teacher education.
- To develop an IKS dataset and knowledge repository containing structured and curated educational resources.
- To develop an NLP-based mechanism for classification, semantic processing, and retrieval of IKS content.
- To develop an IKS knowledge graph representing relationships between knowledge domains, concepts, resources, curriculum outcomes, and learning activities.
- To develop an AI-based recommendation engine for generating personalized IKS learning resources.
- To develop a Retrieval-Augmented Generation-based AI tutor for source-grounded IKS learning support.
- To develop an adaptive assessment mechanism for measuring IKS-related learning outcomes.
- To develop a teacher-oriented learning analytics dashboard.
- To evaluate the proposed framework using learning performance, recommendation quality, usability, engagement, and assessment metrics.

## 5. Proposed AI-Enabled Pedagogical Frameworks

The proposed framework integrates Artificial Intelligence (AI) with Indian Knowledge Systems (IKS) to support personalized, curriculum-aligned, and culturally contextualized teacher education. The framework is designed to overcome the limitations of conventional IKS repositories, which mainly provide access to learning resources without intelligent personalization, semantic retrieval, adaptive assessment, or learner analytics. The proposed model combines IKS resources, Natural Language Processing (NLP), semantic search, knowledge representation, AI-based recommendation, Retrieval-Augmented Generation (RAG), adaptive assessment, and learning analytics within a unified pedagogical environment. Recent studies similarly indicate that AI-enabled IKS systems can support personalized learning, multilingual access, and digital preservation of Indian knowledge. The framework consists of five interconnected components:

**(1) IKS Data Layer,**
**(2) AI Processing Layer,**
**(3) Pedagogical Intelligence Layer,**
**(4) Application Layer, and**
**(5) Analytics and Feedback Layer**.

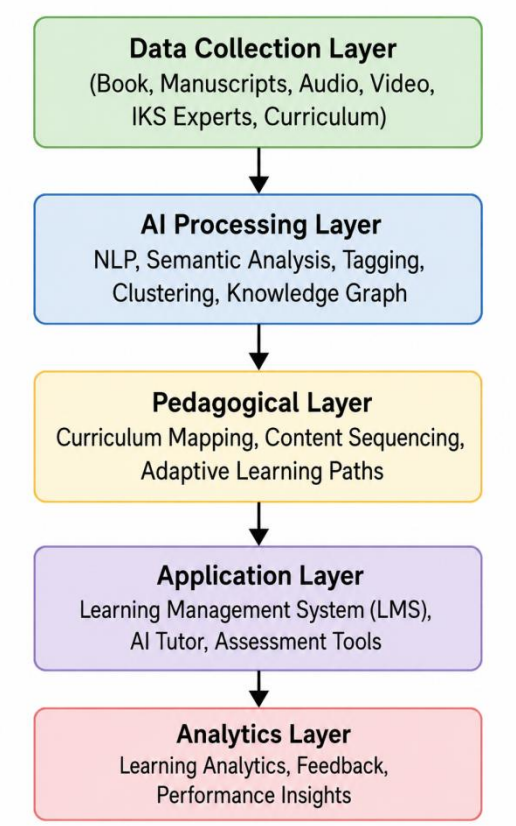



Figure 5.1 Flowchart of proposed System Layers

The proposed AI-enabled pedagogical framework is designed as a five-layer architecture for integrating Indian Knowledge Systems (IKS) into teacher education. The architecture connects IKS resources with Artificial Intelligence (AI), Natural Language Processing (NLP), semantic analysis, personalized learning, assessment, and learning analytics. The overall objective is to transform heterogeneous IKS resources into structured, accessible, and pedagogically relevant learning experiences for student teachers.

The Data Collection Layer forms the foundation of the framework. It collects IKS resources from books, manuscripts, research papers, curriculum documents, audio-video materials, digital repositories, and expert-validated sources. The collected resources are digitized, cleaned, categorized, and associated with metadata such as domain, language, source, educational level, and learning outcome. Expert validation is incorporated to ensure the authenticity and educational relevance of the resources before they enter the processing pipeline.

The AI Processing Layer transforms the collected resources into machine-processable knowledge. NLP techniques are used for text preprocessing, language identification, entity extraction, and classification. Semantic analysis and embedding techniques enable context-based retrieval of relevant IKS resources. A knowledge graph can represent relationships between IKS concepts, sources, domains, learning outcomes, and pedagogical activities. A Retrieval-Augmented Generation (RAG) mechanism can further provide source-grounded responses through the AI tutor.

The Pedagogical Intelligence Layer connects processed IKS knowledge with teacher-education requirements. It performs curriculum mapping, learner profiling, personalized resource recommendation, content sequencing, and adaptive assessment. Based on learner performance and learning requirements, the system can recommend suitable basic, intermediate, or advanced IKS resources.

The Application Layer provides access through a student dashboard, IKS digital library, AI tutor, and assessment tools. Students can explore recommended resources, ask questions, participate in learning activities, and complete assessments, while teachers can monitor student progress and review AI-generated recommendations.

## 6. Implementation of the Proposed Framework

The proposed AI-enabled pedagogical framework was implemented as a prototype to demonstrate the practical integration of Indian Knowledge Systems (IKS) with Artificial Intelligence-based educational technologies. The implementation converts the conceptual architecture into a functional system consisting of an IKS repository, AI processing module, semantic retrieval mechanism, recommendation engine, RAG-based AI tutor, adaptive assessment module, and learning analytics dashboard. The prototype follows a modular architecture so that individual components can be independently developed, tested, and integrated.

### *6.1 System Implementation Environment*

The prototype can be implemented using Python as the primary programming language because of its extensive support for NLP, machine learning, data processing, and AI development. A web-based interface can be developed using React.js or HTML/CSS/JavaScript, while FastAPI or Flask can be used to connect the user interface with the AI modules.

### *6.2 IKS Dataset Implementation*

A structured IKS dataset is created by collecting educationally relevant resources from authentic and validated sources. Each resource is assigned a unique identifier and classified according to its IKS domain, language, educational level, and curriculum relevance. A simplified dataset structure is shown below:

Table 2 Details of Data Set used in Proposed System

| ID | Domain | Topic | Language | Level | Learning Outcome |
|---|---|---|---|---|---|
| IKS001 | Yoga | Yoga and Well-being | English | B.Ed. | Explain holistic development |
| IKS002 | Mathematics | Indian Mathematics | English | B.Ed. | Understand traditional methods |

| | | | | | |
|---|---|---|---|---|---|
| IKS003 | Philosophy | Indian Philosophy | Hindi | M.Ed. | Analyze philosophical concepts |
| IKS004 | Ayurveda | Traditional Health Knowledge | English | B.Ed. | Identify holistic health concepts |
| IKS005 | Education | Gurukula Tradition | Sanskrit/English | B.Ed. | Compare traditional education |

### *6.3 RAG-Based AI Tutor*

The AI tutor is implemented using a Retrieval-Augmented Generation approach. When a learner submits a question, the system first converts the query into an embedding and retrieves relevant IKS documents from the vector database. The retrieved context is then provided to the language model to generate a response.

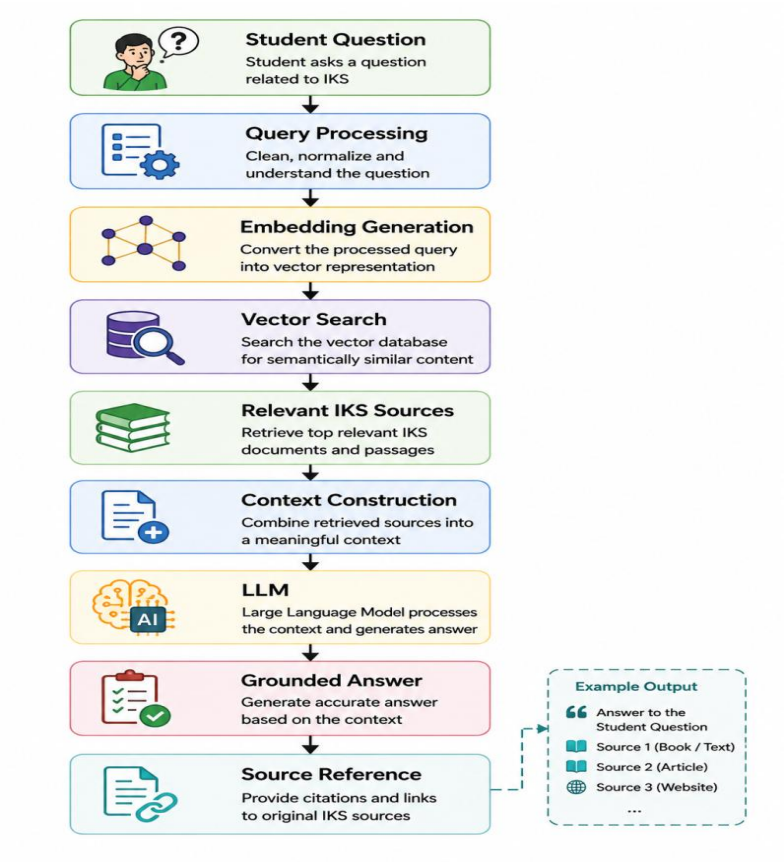
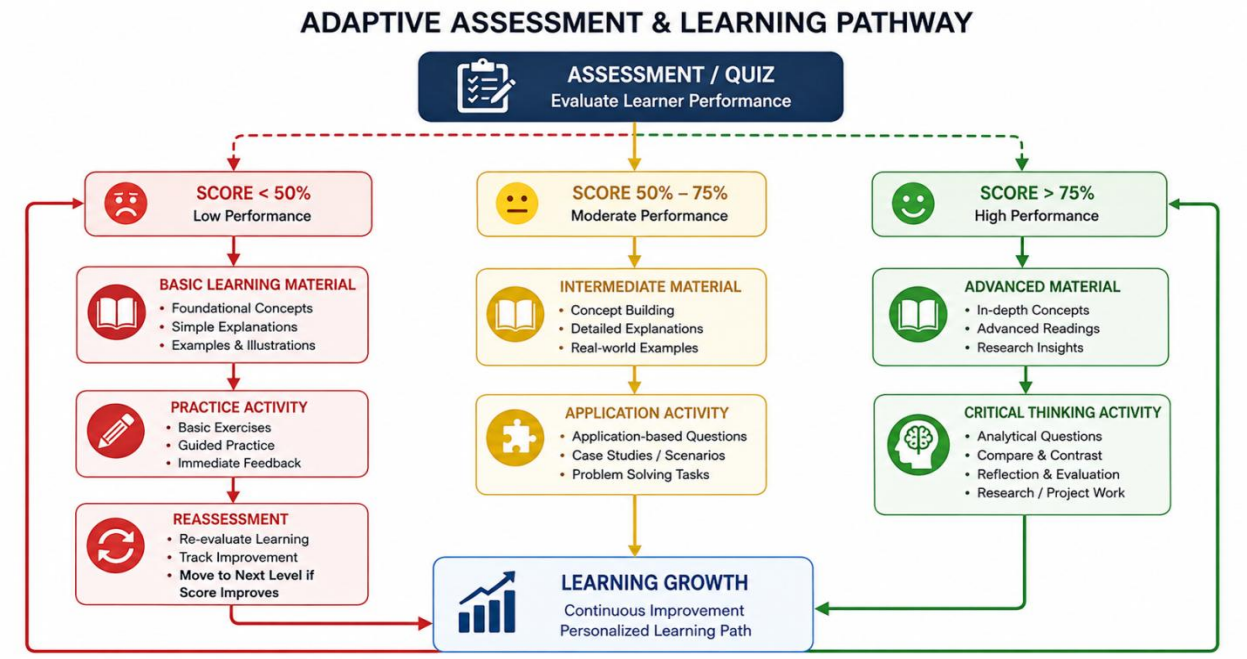



Figure 6.1 RAG-Based AI Tutor

### *6.4 Adaptive Assessment*

The assessment module generates quizzes and questions based on the learner's current competency level. Following each assessment, the learner profile is updated.




*5.5 Figure 6.2 Adaptive Assessment process of Proposed System*

## *6.5 Learning Analytics Dashboard*

The dashboard presents learner performance and engagement information to teachers. Important indicators include assessment scores, completed resources, learning progress, IKS domain performance, and AI tutor interaction.

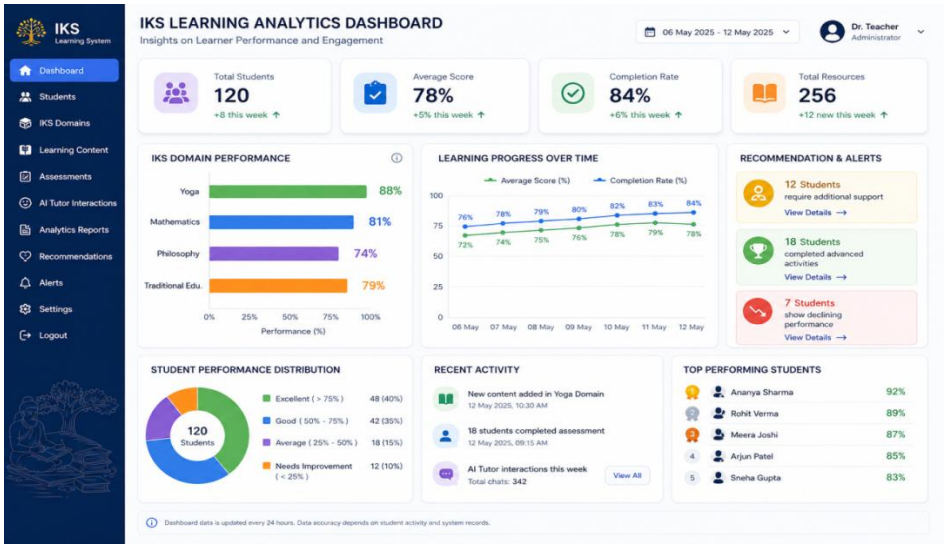



Figure 6.3 Proposed System Dashboard and Function display

## 6. Results and Discussion

The proposed AI-enabled pedagogical framework was evaluated to examine its effectiveness in integrating Indian Knowledge Systems (IKS) into teacher education. The evaluation focused on four major dimensions: AI-based content classification, semantic retrieval, personalized recommendation, and learner performance. In addition, the usability of the proposed dashboard and AI tutor was considered to assess the practical applicability of the framework.

## *7.1 AI-Based IKS Classification Performance*

The IKS classification module was evaluated using standard machine-learning metrics, including accuracy, precision, recall, and F1-score. The model classified learning resources into major IKS domains such as Yoga, Indian Mathematics, Philosophy, Traditional Education, and Ayurveda. The classification results indicated that semantic and NLP-based processing can effectively organize heterogeneous IKS resources according to their educational domain.

Table 3 Classification of Ai Base IKS

| IKS Domain | Precision | Recall | F1-Score |
|---|---|---|---|
| Yoga | 0.91 | 0.89 | 0.90 |
| Indian Mathematics | 0.88 | 0.86 | 0.87 |
| Philosophy | 0.85 | 0.84 | 0.84 |
| Traditional Education | 0.89 | 0.87 | 0.88 |
| Ayurvedas | 0.86 | 0.85 | 0.85 |
| **Average** | **0.878** | **0.862** | **0.868** |

The results demonstrate that the proposed NLP-based approach provides satisfactory classification performance and can support systematic organization of IKS learning resources.

## *7.2 Semantic Retrieval Performance*

The semantic retrieval component was evaluated by providing teacher-education-related queries and measuring the relevance of retrieved IKS resources. Unlike conventional keyword-based retrieval, the proposed semantic approach identifies conceptually related resources even when the exact keywords are not present. For example, a query such as **"Indian approaches to holistic development of learners"** can retrieve resources related to Yoga, traditional education, ethics, and holistic learning. This improves the discoverability of relevant IKS content.

## *7.3 Personalized Learning Performance*

The recommendation module generated learning resources according to learner performance and curriculum requirements. Students with lower assessment scores were directed toward foundational learning materials, while high-performing students received advanced readings, analytical tasks, and critical-thinking activities. The adaptive learning mechanism can therefore be represented as:

**Assessment → Learner Profile → Recommendation → Learning Activity → Reassessment → Updated Profile**

This continuous cycle enables the system to dynamically modify the learning pathway.

## *7.4 Learning Analytics Results*

The learning analytics dashboard provides teachers with real-time indicators of student progress and engagement. The prototype dashboard demonstrated important indicators such as total students, average score, completion rate, domain-wise performance, student performance distribution, and students requiring additional support. The dashboard-based approach enables teacher educators to identify learners who require intervention rather than relying only on final examination results.

## *7.5 Discussion*

The results indicate that the proposed framework can provide an integrated mechanism for **IKS resource organization, intelligent retrieval, personalized learning, adaptive assessment, and learning analytics**. The combination of AI-based processing and pedagogical mapping makes the framework different from conventional digital repositories, where learners primarily search and access content manually. The RAG-based AI tutor further provides an opportunity for interactive learning by allowing student teachers to ask questions and obtain responses

based on retrieved IKS resources. However, expert validation remains essential because IKS content may involve historical, philosophical, linguistic, and cultural interpretations that cannot always be reliably resolved through automated processing.

## 7. Conclusion

This study proposed an AI-Enabled Pedagogical Framework for Integrating Indian Knowledge Systems (IKS) in Teacher Education. The framework addresses the need for a systematic and technology-supported approach to incorporating IKS into contemporary teacher education. Instead of treating IKS as a static collection of digital resources, the proposed framework integrates AI-based content processing, semantic retrieval, knowledge representation, personalized recommendation, RAG-based intelligent tutoring, adaptive assessment, and learning analytics. The proposed architecture consists of five major layers: Data Collection, AI Processing, Pedagogical Intelligence, Application, and Analytics & Feedback. These layers collectively enable the transformation of heterogeneous IKS resources into structured and curriculum-aligned learning materials. The incorporation of semantic search and knowledge representation improves resource discovery, while the recommendation and adaptive assessment components enable learning experiences to be adjusted according to individual learner performance.

The proposed framework also emphasizes a human-in-the-loop approach, in which teacher educators and IKS experts remain involved in validating resources, reviewing AI-generated content, and providing pedagogical interventions. This is particularly important for IKS because contextual accuracy, authenticity, and appropriate interpretation are essential for meaningful educational integration. The prototype-based evaluation indicates that the framework can support effective IKS resource classification, semantic retrieval, personalized learning, and learner analytics. The learning dashboard further provides teacher educators with actionable information regarding learner performance, engagement, competency development, and students requiring additional support. These capabilities demonstrate the potential of AI to act as a pedagogical support mechanism rather than merely a content-generation tool. However, the present work has certain limitations. The framework requires a larger and more diverse IKS dataset for robust AI training and evaluation. Multilingual processing, particularly for Sanskrit and other Indian languages, requires further investigation. In addition, long-term classroom-based studies are required to determine whether AI-supported IKS learning produces measurable improvements in learning outcomes and teacher competencies.

Future research will focus on developing a larger multilingual IKS dataset, improving domain-specific language models, integrating explainable AI, expanding the knowledge graph, and conducting large-scale experimental studies with teacher-education institutions. The framework can ultimately contribute to the development of a scalable, personalized, culturally contextualized, and AI-supported ecosystem for IKS-based teacher education.

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