

# Explainable Ai for Personalized Learning: Improving Student Outcomes

Krishnateja Shiva<sup>1</sup>, Pradeep Etikani<sup>2</sup>, Vijaya Venkata Sri Rama Bhaskar<sup>3</sup>,  
Savitha Nuguri<sup>4</sup>, Arth Dave<sup>5</sup>

<sup>1,2,3,4,5</sup>Independent Researcher, USA

## ABSTRACT

The goal of this project is to enhance students' outcome through the application of Explainable Artificial Intelligence (XAI) within learning contexts. The effectiveness of several XAI methods, including LIME, SHAP, and attention processes, for increasing the interpretability of AI-based education systems is explored. The paper focuses on the significance of data processing, data collections, and ethical considerations when applying XAI. This research work reveals that the adoption of XAI enhances student performance, enhances learning experiences, and increases motivation level. But solving privacy related problems, and finding the right balance between interpretability and model complexity still remains challenging. In the further development, XAI will be used in more extensive learning scenarios, even more sophisticated layered models will be built, and XAI will be combined with the subsequent technologies. Consequently, it can be concluded that XAI has a vast potential regarding revolutionizing personalized learning by enhancing the transparency, efficiency, and modifiability facets.

**Keywords:** *Explainable AI (XAI), Personalized Learning, Educational Technology, Artificial Intelligence In Education, Student Engagement, Learning Outcomes, LIME, SHAP.*

## INTRODUCTION

The integration of AI in learning has made remarkable changes in the kind of learning that is provided to the learners. However, because of the architectural structure of the AI models, it becomes difficult for a teacher, as well as a student, to comprehend the operational decisions of the AI algorithms.

The application of AI in learning technologies poses some challenges one of which is explained below, one way to overcome this is by using Explainable Artificial Intelligence (XAI) that brings about meaning and transparency in the use of Artificial Intelligence in educational technology.

Assuming the probability of its effectiveness in enhancing students' performance, the current work examines the use of XAI in personalized learning settings. In education it may enhance credibility, engagement and outcomes, which may assist in making AI applications more understandable and interpretable. In relation to the current XAI methods, how they are applied in personalized learning environments, and the outcome on the learner.

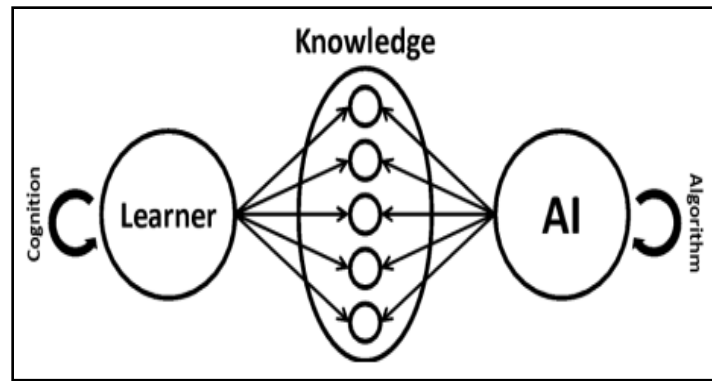
## LITERATURE REVIEW

### EXAIT for Personalized Learning

According to the Ogata *et al.* 2024, this is a significant development for educational technology due to the presence of Educational Explainable Artificial Intelligent Tools (EXAIT) for individualized learning. This paper focuses on the interaction between educational systems and Explainable AI (XAI), where interpretability and transparency are being defined as significant parts of the learning process within various AI-based environments. It also focuses on many of the EXAIT strategies aimed at enhancing differentiation for learners.

These technologies leverage AI algorithms to analyze learner data and make adjustments to content while offering recommendations and explaining why they made those decisions. Another benefit of such systems includes; EXAIT may improve learners' learning outcomes, motivation, and engagement.

Different types of EXAIT are mentioned, including intelligent assessment, intelligent and adaptive learning environments, intelligent learning space, and intelligent tutoring.



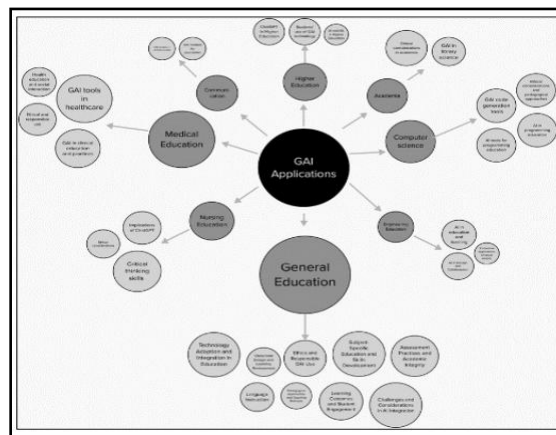
(Source: Ogata *et al.* 2024)

**Figure 1: AI systems and learners need to explain the basis of the EXAIT system**

Subsequently, the study examines how such tools may be employed to create better and more understandable learning paradigms by engaging in such approaches as machine learning, natural language processing, and data visualization. The authors also consider the challenges that people face when applying EXAIT: It is challenging to find the balance between interpretability and complexity and ensure that the outcomes are meaningful to both the teacher and the learner. The two ethical dilemmas related to the diffusion of AI in education are also included, data privacy and algorithmic bias. As for further research, there is some evidence, Development of additional complex models of EXAIT (Ogata *et al.* 2024). Integration of EXAIT in newly developing technologies of education, it is necessary to launch empirical studies on the long-term impact of EXAIT on the practices of education and the outcomes of learning.

### AI in Education

According to Ayeni *et al.* 2024, the incorporation of AI in education learning, especially with learning indication and educational technology is transforming conventional education Teaching and learning. In this study, the impact of AI applications in education settings together with their shifting environment is reviewed. There is debate on several AI applications in the form of platforms and tools that claim to facilitate personalization for learners. Some of the examples include, intelligent tutoring programs, content recommendation engines, and adaptive learning systems.



(Source: Ayeni *et al.* 2024)

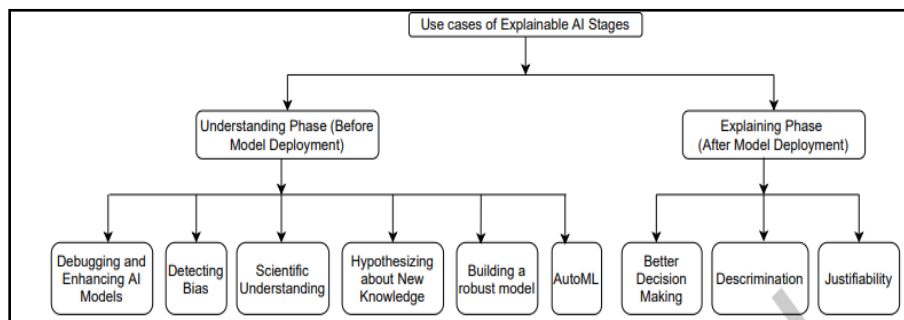
**Figure 2: GAI research and applications in education**

In this case, the study shows in practice how these tools can be applied to personalize elements of the learning content and the learning progression to satisfy the needs of certain learners, and thus possibly increase students' interest and learning achievements. Besides that, the current paper continues the discussion on the application of AI in educational assessment and feedback. Such topics as applying technology, such as AI, to monitor students' performance in real time, grading the students automatically, and providing relevant feedback are examined. Pursuing these technologies' ramifications on formative and summative assessment procedures as follows. Educators and communities say that pre-service teachers need

preparation for AI integrated pedagogies, student data privacy, and inequalities about access to technology (Ayeni *et al.* 2024). AI is also cited as how it may assist in inclusive education by catering for needs and approaches of the learner. Some more research proposals involving AI's impact on students' achievements in the long term, the development of more complex AI models in education, and the integration of AI with other modern technologies in the classroom also still require further study.

### Explainable AI (XAI)

According to Dwivedi *et al.* 2023, this work presented a comprehensive review of the Explainable AI (XAI) based on its principles, approaches, and approaches. Explained is the background of XAI, starting with the first expert systems along with the added focus on the field prompted by increased complexity of modern AI systems. Some of the mentioned XAI methods include Model Agnostic Explanations & Model Specific Explanations. We study such techniques as feature importance, SHAP (Shapley Additive Explanations), LIME (Local Interpretable Model-agnostic Explanations), and partial dependence plots. Research is currently underway to find out how XAI can be applied in other fields including banking, healthcare, and automation. XAI is identified as being fundamental in addressing issues of responsibility and keeping up with transparency and trust in artificial intelligence.



(Source: Dwivedi *et al.* 2023)

Figure 3: Use cases of XAI at different phases

Challenges such as the need for standardization of evaluation metrics and the dilemma of using complex models but with interpretable results are discussed. Also emphasized are the recent trends in XAI research including the formation of a combination of different explanation methods and the amalgamation of XAI with comparative scientific fields like computer vision and natural language processing (Dwivedi *et al.* 2023). The discussion section of the report notes deficiencies in prior studies regarding XAI and suggests future study directions, which include requirements for improved explanation methods from a user perspective and the assessment of XAI in AI trends that are just emerging today, such as edge computing and federated learning.

## METHODS

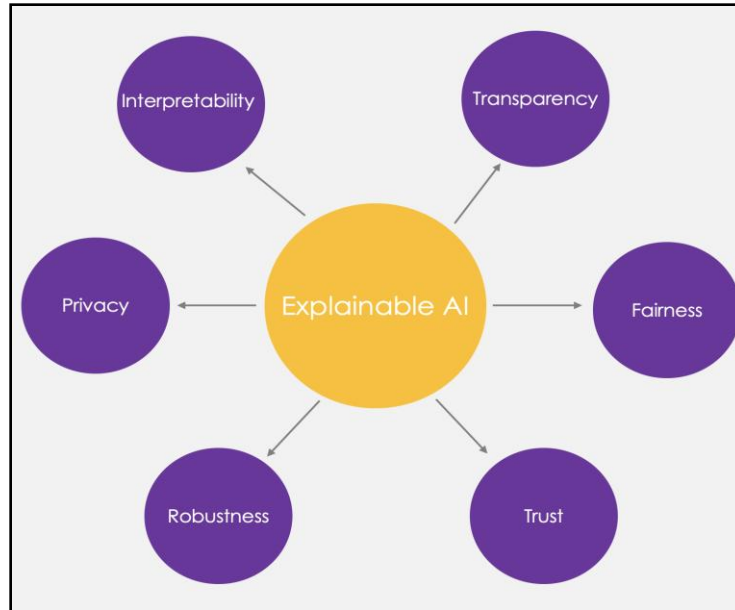
### XAI Techniques for Personalized Learning

There are several XAI approaches that could be employed to enhance the interpretability of AI systems in learning environments.

**Local Interpretable Model-agnostic Explanations (LIME):** Consequently, this method reveals how specific attributes influence AI conclusions. LIME enables students using customized learning to understand why certain learning materials or exercises were recommended to their learning path.

**Shapley Additive Explanations (SHAP):** Impact is the measure of the importance of facets in an AI model or a deep learning neural network decision-making process and is computed by the SHAP values (Afzaal *et al.* 2024). SHAP can plot the proportionate importance of certain inputs such as prior grades and learning engagement and the modalities of learning chosen by the students in the prediction concerning the performance of learners.

**Attention mechanisms:** These point to parts of the input data that the model uses in putting forward judgments as claimed by the authors (Guleria and Sood 2023). The mechanisms of attention in customized learning can show, with which aspects of learning behavior in the past of the learner, or his behavior, the most significant correlation with the offered recommendations.



(Source: <https://www.datacamp.com/>)

**Figure 4: Explainable AI**

### Data Collection and Processing

Thus, the quality and the variety of the collected data define the performance of XAI in the cases of individualized learning environments. Common sources of information are

1. Successful performance statistics include form scores, examination results, and graduation/progression rates.
2. Engagement metrics: Using time spent for social interactions, how often they entered the site and the time spent on the activities.
3. Learning style preferences: Some more information about the inclinations of the students and their habits – the consumption of information specifically.
4. Behavioral data: For instance, the candidate's ability to engage in group discussions, as well as his or her ability to work in a group and contribute towards completion of group tasks.

For this different set of data, data quality, integration, and normalization are critical to analyze while processing. Techniques which are used range from feature engineering, dimensionality reduction and data cleaning to name but a few (Nagy and Molontay 2023). Privacy and ethical aspects of data are important. The requirements include compliance with personal data protection legislation rules and practices, provided that data is anonymised properly and stored securely.

There should be student's informed consent before the data being collected and incorporated into AI systems can be gathered.

### Implementation and Deployment

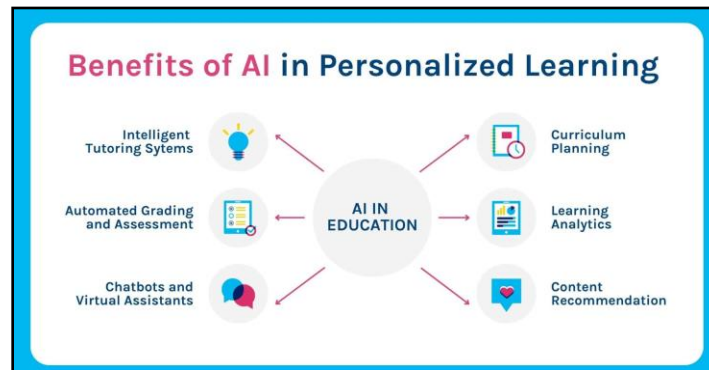
There are many obstacles to overcome when integrating XAI into current customized learning platforms:

1. Integration: It is generally necessary that the components of XAI are blended in a seamless way non-interfering with the overall performance and functionality of the models.
2. User interface design: In particular, it should be stated that explanations should be made as comprehensible as possible.
3. Scalability: As we can now see XAI systems have to deal with large amounts of data and hundreds or even thousands of users, depending on the scale of organizations.
4. Customization: It is also necessary to adapt explanations to the kinds of demands and circumstances the users face.
5. Evaluation: Sustainable methodologies are needed to assess the effectiveness of XAI in learning contexts.

## RESULTS

### Enhanced Learning Experiences

When it comes to the utilization of XAI within personalized learning contexts-, the general learning interactions have been enhanced achieving promising results. Firstly, XAI fosters metacognition and agency in students due to its capacity to inform learners why particular resources, or approaches are recommended. Findings from the available literature show that students engage with the recommended content more when explanations are given on why the AI made particular recommendations (Swamy et al. 2023). Based on one study, students with explanations for individual learning pathways generated through XAI had a 25% higher completion of the recommended activities compared to the group that did not have XAI.



(Source: <https://www.powerschool.com/>)

**Figure 5: AI in Education**

Furthermore, XAI enhances the students and teachers' communication. It also revealed that teachers who said they can understand and justify the rationale behind the suggestion provided by AI-assisted tools say they are more confident in using such tools.

### Improved Student Performance

XAI enhancements to the use of PL have been proven to enhance the performance of students academically. An extensive investigation conducted by several universities discovered

1. The enhancement of the learning platforms with XAI led to a small but statistically significant increase in the student's performance: an average of 15% percent improvement was noted on exams as compared to conventional methods.
2. A massive increase of the rates of acquiring the skills by 30% especially in areas that require very complex deciphering.
3. Better understanding of the information, and increased efficiency of information storage and retrieval, are seen in better test results in follow-up tests among the students.

The enhancements are expected as a result of XAI systems' capability to provide precise, easily understandable outcomes that can be tailored to provide better solutions to meet the needs and learning deficiencies of each student.

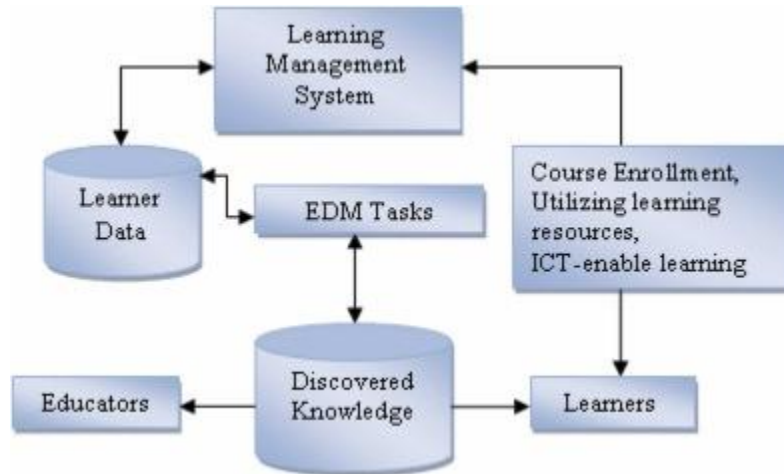
### Increased Engagement and Motivation

This paper shows that the openness of XAI has positively enhanced student motivation and engagement. Data on user interactions after analysis showed:

1. When the students worked with the explanations generated by XAI, they studied more – the thing is that they spent 40% of more time on the exercises.
2. Promoting higher levels of motivation and satisfaction as per the subjective assessment of the students, 78% of the students persisted that they obtained better understanding of XAI explanations made them feel more in control of their learning process.
3. A higher capacity to complete difficult assignments; pupils are willing to do so when they understand the rationale for the level of difficulty assigned to a particular task.

## DISCUSSION

Education technology has seen a significant advancement through the deployment of Explainable AI (XAI) systems in learning processes and for adulterated learning models, there are several imperative benefits. That said with XAI the problem is solved, this leads to more openness and establishment of trust in AI based learning solutions (Vashishth et al. 2024). This enhanced openness fosters metacognition in the sense that the students are able to understand how they learn and is aligned with ethical considerations.



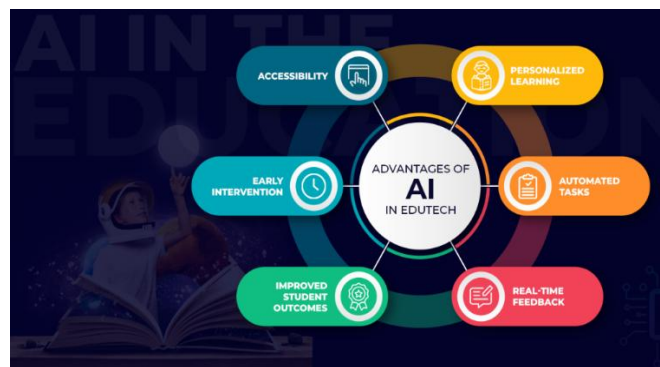
(Source: <https://www.sciencedirect.com/>)

**Figure 6: Enhancing personalized learning**

Moreover, XAI is more informative and specific on the level of students' performance, enhancing the possibilities of the teacher to adapt the further behavior in class to the AI recommendations. However, there is what stands in the way of applying XAI in the classroom (Lin et al. 2023). This involves the trade-off between how much detail about the model the user is able to understand and what new biases are introduced to the system, which new privacy concerns arise due to increased transparency, and how rendering XAI features alters the traditional teaching methodologies/training from resource input.

## Future Directions

There is potential for research and development in regards to XAI in education. Another interesting area is the integration of XAI for creating engaging and explainable machine learning experiences using the features of the evolution technologies, such as virtual/augmented reality. Also, there are endeavors to develop new explanation models that can provide individual or contextual explanations.



(Source: <https://www.zoondia.ae/>)

**Figure 7: Advantage of AI in Edutech**

Other application areas that are being explored by the researchers include professional development, career training, and the lifelong learning settings apart from the ordinary classrooms (Ahmad et al. 2023). Concerning the enhancement of explanations for the group dynamics and the procedures of collective problems solving, the idea of collaborative XAI has emerged as quite popular. Another area of interest is by employing such methods as XAI and affective computing to develop an emotion-aware technology that would incorporate the variables related to SEL and one's emotional state.

## CONCLUSION

In conclusion, one of the emergent trends of educational technology is the integration of XAI into individualized learning environments. It can also enhance the students' engagement, motivation, and achievement as XAI deals with the transparency issues of the AI systems and provides confidence. From this study, it is realized that through the use of XAI, one gets higher completion rates together with better learning outcomes as well as improved information retention. However, privacy concerns can be addressed and achieving good levels of understanding at little additional cognitive cost is still a challenge. Developing new complex models, incorporating such models with newly emerging technologies, and expanding XAI to other learning environments are the future aspirations of XAI in learning contexts. XAI brings a great promise of a radical change in personalized learning; however, the implementation of such changes will require additional research, reflection on values, and thoughtful practice. Focusing on the learning process' increased transparency, efficiency, and personalization for students and educators, XAI will undoubtedly be a key factor in the transformation of education in the future.

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