ADOPTION OF ARTIFICIAL INTELLIGENCE IN HIGHER EDUCATION: EXPERIENCES OF TEACHERS IN INDIA

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ABSTRACT

Purpose: This research focuses on the behavioral intention and usage of AI-based educational technology by the teachers of India using the UTAUT2 model. Some of the constructs which are considered for this research are (1) Performance Expectancy, (2) Effort Expectancy, (3) Social Influence, (4) Facilitating Conditions, (5) Hedonic Motivation, (6) Price Value and (7) Habit. The UTAUT2 model has been further extended through two more constructs, i.e., (8) Perceived Risk, and (9) Personal Innovativeness. In addition to the UTAUT2 Model Framework, the questionnaire has been developed to gauge perceptions, attitudes, and challenges of the teachers in using AI.

Methodology: The research utilizes the mixed method research design. Convenience sampling was applied while the data was collected using Google form to come up with 150 participants that were adequate for the analysis. In addition to that, this questionnaire looked at various aspects including the awareness, usage frequency, benefits, ethics and possible risks. Furthermore, thematic analysis will be used in qualitative analysis.

Findings: This study provides empirical evidence on AI adoption in higher education and offers insights about the used and adoption of AI in Indian higher education in particular.

Limitations: Limitations of this study include the use of a convenience sample comprising 150 higher education teachers from India. Further, the use of self-reports could also lead to problems relating to response biases.

Practical implications: The study will provide guidance to policymakers, institutions of higher education, teacher educators, and educational technology developers for formulating policies, developing programmes, and creating institutional supports that enable successful integration of AI in higher education.

Originality/Value: The paper makes a new contribution by extending the UTAUT2 model, and offers context-specific results for the adoption of AI by university faculty in India.

Keywords: AI, Higher Education, Teachers, India, Technology Model

INTRODUCTION

Artificial Intelligence (AI) technology is considered among the greatest innovations of the twenty-first century. AI technology allows machines to do what only people have been capable of doing; these include decision-making, problem-solving, language processing, and personalized advice provision. AI technologies used in higher education include intelligent tutoring, computerized testing, adaptive learning systems, chatbots, predictive analytics, and generative AI systems.

Online Learning (OL) dominates the entire world particularly after the Post COVID-19 pandemic. Even in India, online courses are considered as regular ones under the purview of the University Grants Commission (UGC) from 2024 onwards (UGC, 2024). Behavior and preparedness for accepting changes should be studied in an analytical way whether the learners, teachers and researchers are able to justify the usability of various online platforms and tools such as google, Augmented Reality (AR) and Artificial Intelligence (AI) to enrich their knowledge and information to become global citizens as well as global practitioners in the 21st century. A number of researches conducted across developing countries in the world reveal that online and digital education provides enriched teaching and learning experiences during COVID-19 thus putting the traditional models of education into scrutiny. Besides, the study also help to inform policymakers, edtech developers, and educators on AI readiness integration strategies, strengthening digital inclusion and educational equity through evidence-based recommendations. Thus, the world has seen the rapid integration of Artificial Intelligence (AI) into the educational fabric which is precipitating a fundamental shift in pedagogical paradigms across the globe. This paper specifically examines the intersection of generative AI based on UTAUT2 Model Framework, investigating how these technologies are reconfiguring traditional learning discourses in higher educational academic transaction, the perceptions of teachers towards the AI-driven teaching –learning process. While historical barriers such as infrastructure deficits and the digital divide persist, AI offers a compensatory mechanism for personalized, scalable, and inclusive education that transcends formal institutional boundaries.

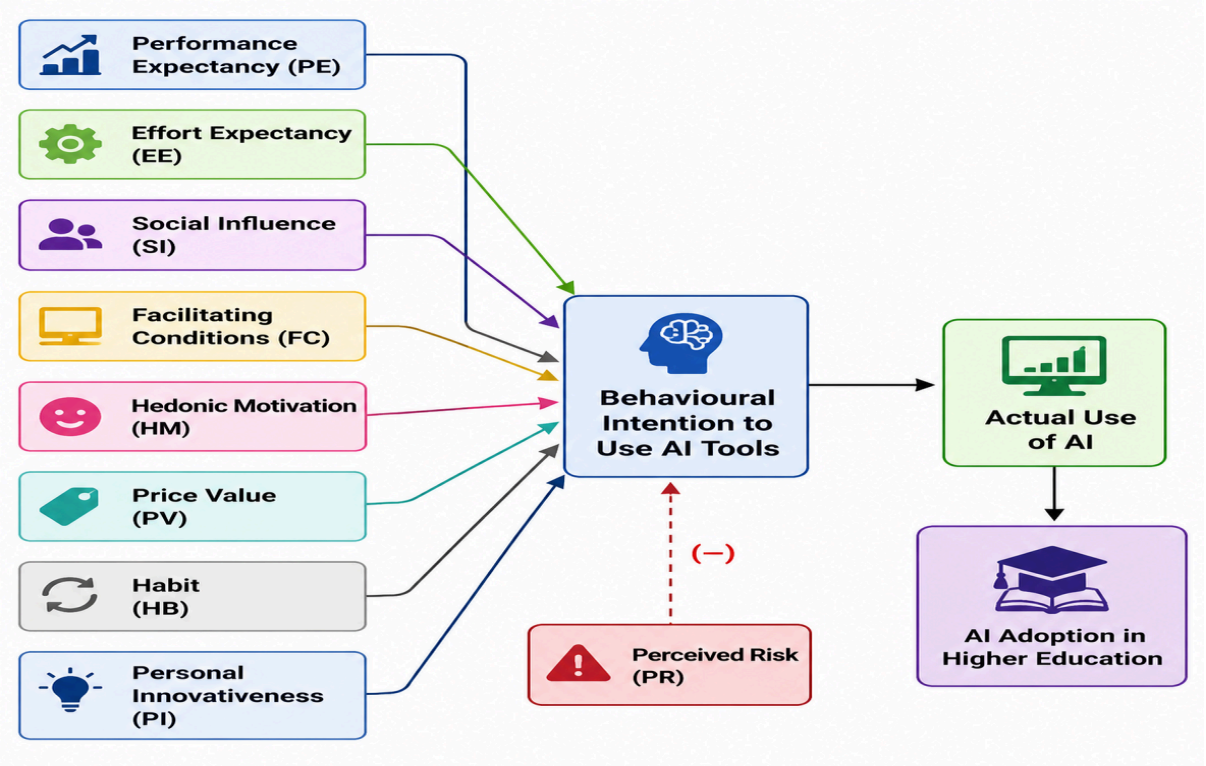
With the invention of AI-based generative technology like ChatGPT, discussions about the future of learning and teaching have become intense. More and more teachers are incorporating AI systems into their pedagogy for creating learning content, developing test items, offering personalized feedback, and supporting research processes. Nonetheless, issues related to academic honesty, security, ethical considerations, reliability of data, and technological capability persist.

THEORETICAL AND CONCEPTUAL FRAMEWORK

With the advent of Artificial Intelligence (AI), there is an imminent transformation in the delivery of education globally. AI can offer several benefits like personalized learning, automation, and enhancement of academic performance. This research paper aims at closing this gap by using the UTAUT2 framework to explore relevant factors associated with adoption in India. The Unified Theory of Acceptance and Use of Technology 2 (UTAUT2) offers a strong foundation for investigating adoption of technology from the perspective of users (Dhiman et al., 2020; Faraon et al., 2025; Koivisto et al., 2016; Strzelecki, 2023).

Figure 1

Conceptual Framework of AI Adoption among Teachers and ODL Learners



Source: Adapted from Venkatesh et al. (2012) and modified by the researcher.

Research Questions

RQ1: What are the key factors influencing the adoption of Artificial Intelligence (AI) among teachers based on UTAUT2 constructs influence AI adoption in higher education institutions in India?

RQ2: What are the major issues and challenges associated with the integration of AI in academic transactions and deliberations in higher education?

RQ3: What institutional and policy measures can enhance the effective and responsible adoption of AI-enabled learning in higher education?

Objectives

The objectives of this paper are to:

- To assess the key factors influencing AI adoption among Teachers in the context of India based on UTAUT 2 Model Framework.
- To explore the issues and challenges to AI integration in academic transaction and deliberations
- To provide recommendations for institutions environments. and policymakers to enhance AI-enabled learning in higher education.

Research Methodology

Method: In the current study, mixed methods research design has been adopted where quantitative as well as qualitative approaches have been used to gather an all-round insight about the adoption of AI by teachers in higher educational institutions of India. Quantitative methods were adopted to gauge perceptions, attitudes, behavioral intentions, and the use pattern of AI technologies using survey responses. With the help of quantitative data, important factors affecting the adoption of AI have been identified based on constructs of UTAUT2.

Population: The study population consists of teachers in higher educational institutions in India, including universities, colleges, open universities, and other tertiary-level educational institutions.

Sampling Method: The research employed the convenience sampling method for selecting the participants. Participants who were easily accessible and willing to take part in the research were included in the sample group. The online data collection method allowed the researcher to access teachers from various parts easily.

Sample Size: Overall, 150 questionnaires were distributed to teachers who are working in different higher education institutes in India through of online survey. The total number of questionnaires

received is 100 out of 150 distributed, making the overall response rate 66.67%. These respondents come from different fields and institutes as well as occupy different job positions.

Tools and techniques: The data were collected through the use of a questionnaire. The questionnaire was designed in accordance with the requirements of the current study following the factors of the Extended UTAUT2 model. The questionnaire comprised closed-ended questions and open-ended questions and was done on Google Forms.

REVIEWS

Chatterjee & Bhattacharjee (2020) highlighted how AI in higher education would help in reducing burdens, improving education and making decisions more promptly amid massification. This study, based on theoretical frameworks like the Unified Theory of Acceptance and Use of Technology, designed and tested a conceptual framework through a survey involving 329 respondents. Wang et al. (2024) conducted a systematic review of literature on the subject and found out that AI in education evolved into different perspectives and has been explored for its various applications, adaptive learning systems and personalized tutoring and profiling techniques.

In the work of Molefi Matsieli and Stephen Mutula (2024), it is important to note that while the effects of the COVID-19 pandemic affected all developed and developing countries, students from poor families were hit especially hard by it. It can be said that according to the results of their research, while digital transformation in higher education has opened numerous opportunities and possibilities, at the same time, it has led to difficulties in acquiring knowledge. Higher education institutions (HEIs), along with the respective governments, have a critical role to play in overcoming these challenges.

Similarly, Tlili et al. (2023) carried out a case study on how early adopters within the field of education have been adopting and effectively using chatbots. Specifically, the study sought to carry out an investigation on the use of ChatGPT in education among early adopters using a qualitative instrumental case study design. Three stages have been carried out in this study. Stage one of the study shows that in terms of public discourse, there is positivity and excitement about the use of ChatGPT in education. However, there are voices that have been cautious of the application of ChatGPT in the field of education. Stage two of the study analyses ChatGPT using perspectives of education transformation, response quality, usefulness, personality and emotions, and ethics. The final stage of the study analyses user experience in education by applying ten scenarios and finds issues such as cheating, honesty, and truthfulness of ChatGPT, privacy, misleading and manipulation.

Kalınkara & Özdemir, 2024; AI Farsi, 2023 highlighted in their study that even though some limitations of employing UTAUT2 model framework exist, the ability to predict through UTAUT2 is based on its basic constructs. These constructs help explain the behavioral intention and the effective usage of technologies by both students and teachers, including performance expectancy, effort expectancy, social influence, facilitating conditions, and hedonic motivation. The value of this theoretical-analytical model cannot be overstated when discussing the opportunities to find out how to optimize the application of digital innovations in the process of teaching and learning. When it comes to university education, it can be noted that the UTAUT2 theory was used more and more often as an analytical tool. The researchers applied the UTAUT2 to assess how different technological innovations were received at universities, from mobile internet by faculty members to artificial intelligence by future teachers. The results confirm that UTAUT2 constructs like performance expectancy, effort expectancy, and hedonic motivation also have a strong impact on higher education.

It has been found out through recent studies that the key factors of UTAUT2 model like performance expectation, effort expectation, facilitating conditions, and hedonic motivation have a positive impact on the use and acceptance of digital platforms within the context of higher educational settings. MARLINA et al. (2021) have asserted that the factors of the Model considerably increase the universities' capability of predicting their technology-related intentions and behaviors.

Therefore, it should be pointed out that a number of studies dedicated to the problem of technology adoption in higher education has been carried out through the utilization of the UTAUT2 theory, which proved that such factors as performance expectancy, effort expectancy, facilitating conditions, and hedonic motivation affect the use reactions towards digital innovations of students and lecturers. However, at the moment, there is no sufficient empirical evidence concerning the effects of the use of artificial intelligence in university education (O'dea, and O'Dea, 2023). Thus, the analysis of the factors of AI acceptance according to the UTAUT2 framework will help introduce artificial intelligence appropriately and contribute to the innovation of university pedagogical practices. The purpose of the study is the analysis of the factors of AI acceptance in universities.

ANALYSIS AND INTERPRETATION OF DATA

The factors affecting the acceptance of AI technology by teachers within the Indian educational system have been evaluated based on teachers' usage behavior, attitudes toward AI, the type of AI technology used, reasons for using AI technology, and motivations. In doing so, the Extended

UTAUT2 model has been considered as the theoretical framework for understanding the acceptance of technologies based on variables such as performance expectancy, effort expectancy, facilitating conditions, social influence, habit, and perceived risk. The results are presented in the tables below.

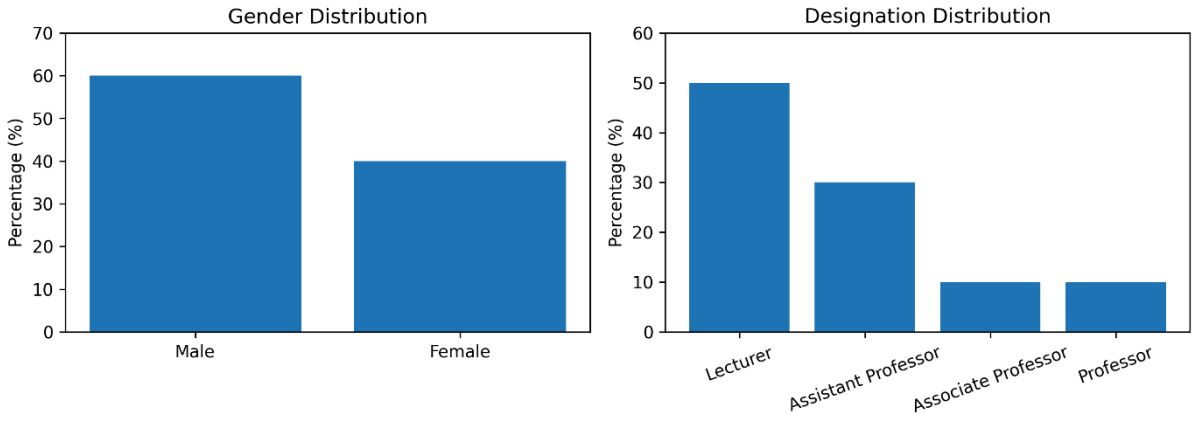
Table 1

Demographic Profile of AI Users (n = 100)

Variable	Category	Frequency	Percentage (%)
Gender	Male	60	60.00
	Female	40	40.00
Designation	Lecturer	50	50.00
	Assistant Professor	30	30.00
	Associate Professor	10	10.00
	Professor	10	10.00

Figure 2

Figure 2. Demographic Profile of AI Users (n = 100)



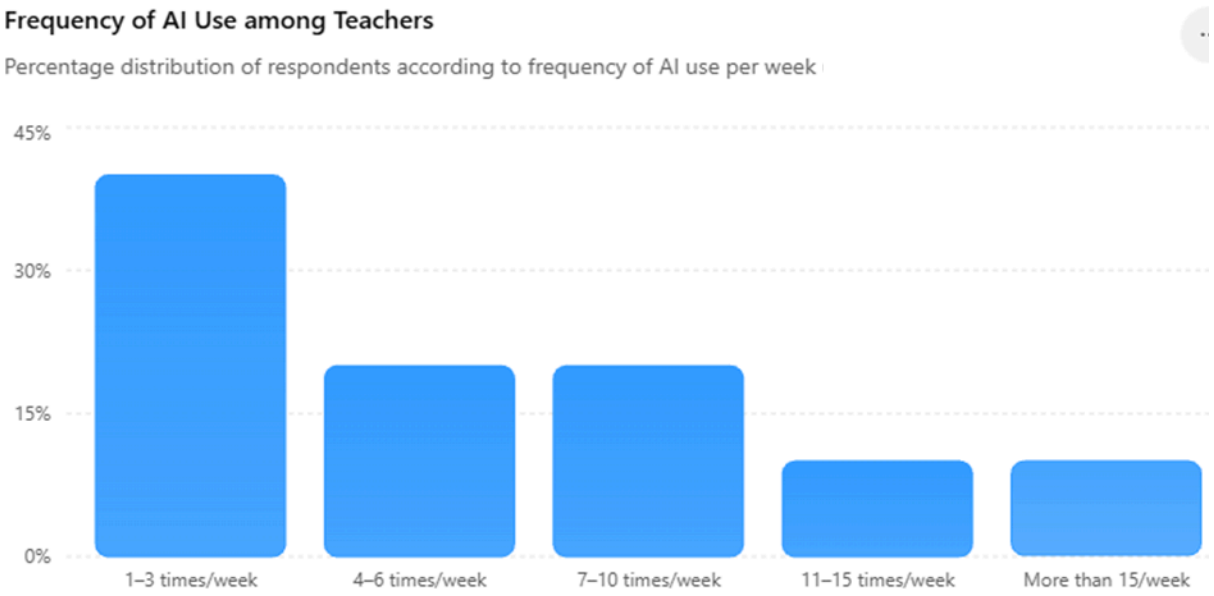
The demographic profile of the teachers adopting AI technologies is illustrated in Table 1 and Figure 1. It is evident from the data that male teachers formed the bulk of AI adopters (60%), whereas female teachers were 40% of the respondents. As far as designation is concerned, most of the respondent students were categorized as lecturers (50%) while assistant professors comprised 30% of the total respondents. 10% of the respondents were associate professors while another 10% comprised of professors. As far as gender is concerned, from the graph presented in Figure 1, it is evident that AI was used more extensively by male educators.

Table 2

Frequency of AI Use among Teachers (n = 100)

Frequency of Use	Frequency	Percentage (%)
1–3 times per week	40	40.00
4–6 times per week	20	20.00
7–10 times per week	20	20.00
11–15 times per week	10	10.00
More than 15 times per week	10	10.00
Total	**100**	**100.00**

Figure 3



The usage of AI in academic activities by teachers is shown in Table 2 and Figure 2. According to the results, the biggest percentage of respondents (40%) employed AI once to three times per week. An equal number of respondents (20% each) reported using AI from four to six and from seven to ten times a week. Ten percent of respondents stated that they used AI from eleven to fifteen times a week. The remaining 10% utilized AI technology more than fifteen times a week. From the provided graph, it can be noted that there is a decrease in percentage with the rise of usage frequency. This suggests that, despite the widespread implementation of AI among teachers, AI use occurs in moderation.

Table 3

Teachers' Attitudes toward AI Technologies

Statement	Mean Score
I am prepared and enthusiastic to use AI technologies.	4.40
I prefer AI technologies over traditional methods.	3.90
I am nervous and anxious to use AI technologies.	2.40
Using AI for distance learners is the right decision.	4.20
I happily suggest learners use AI ethically when needed.	4.50

Figure 4

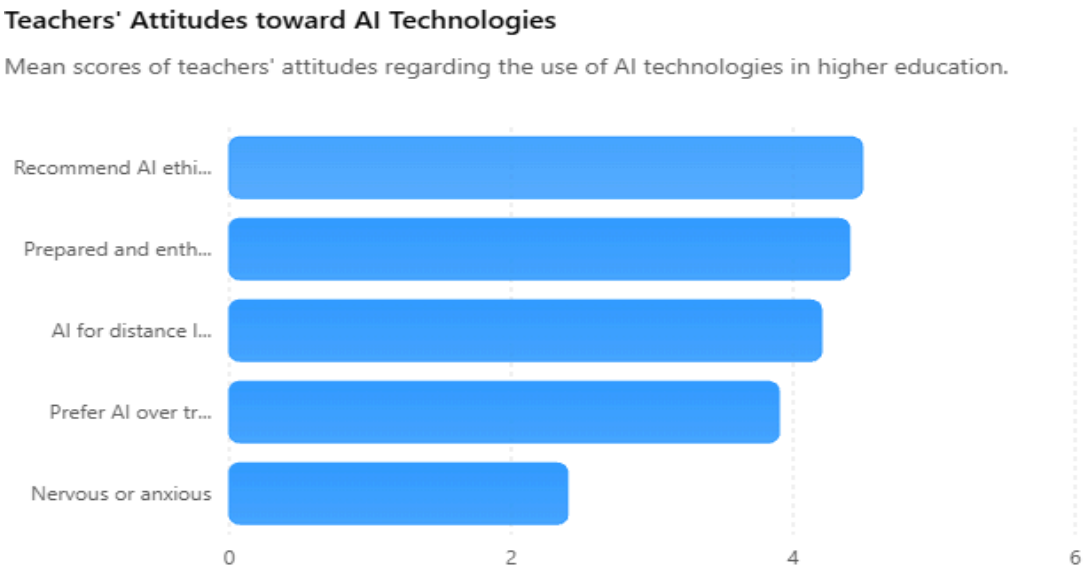


Table 3 and Figure 3 show positive attitudes towards the AI technologies on the part of teachers. The highest score was achieved with respect to the statement "I would willingly encourage my learners to use AI technology in an ethical manner" (Mean = 4.50), while the second-highest mean score concerned the willingness and enthusiasm of using the technologies (Mean = 4.40). Moreover, it has been noted that teachers consider the choice of using AI technologies as proper in respect of distant learning (Mean = 4.20). A rather low mean score relates to the preference to AI compared to conventional ways of teaching (Mean = 3.90), which indicates that conventional methods have not

lost their relevance for the educators. Finally, the lowest score concerns nervousness/anxiety related to AI (Mean = 2.40).

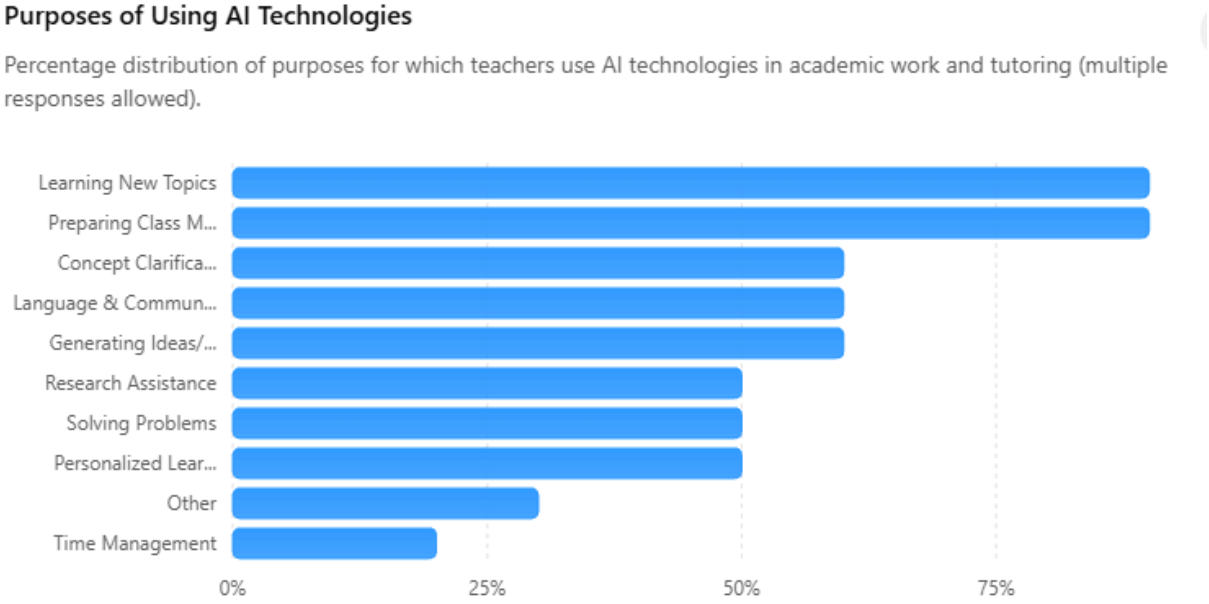
Table 4

Purposes of Using AI Technologies in Academic Work and Tutoring (n = 100)*

Purpose of Using AI	**Frequency**	**Percentage (%)**
Learning New Topics	90	90.0
Preparing Class Materials	90	90.0
Concept Clarification and Tutoring	60	60.0
Language and Communication Skills	60	60.0
Generating Ideas/Critical Thinking	60	60.0
Research Assistance	50	50.0
Solving Problems (Assignments, Programming, Mathematics, etc.)	50	50.0
Personalized Learning Support	50	50.0
Other Purposes	30	30.0
Time Management (AI Planners, Scheduling, etc.)	20	20.0
Concept Clarification and Tutoring	60	60.0
Language and Communication Skills	60	60.0

*Multiple responses were permitted; therefore, percentages exceed 100%.

Figure 5



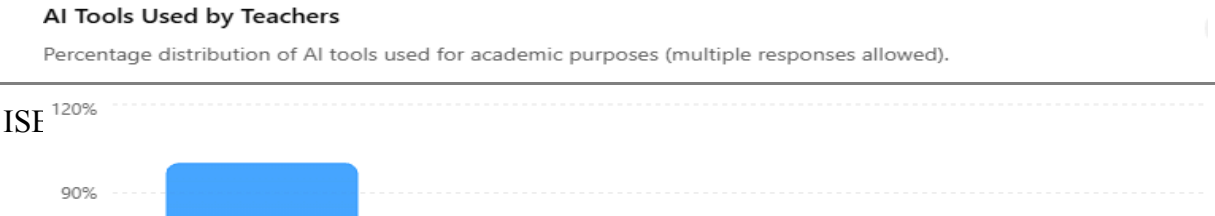
Purposes for which teachers employ AI technologies are summarized and illustrated in Table 4 Figure 4. The majority of responses indicated learning something new (90%) and preparation of materials for classes (90%). This means that the primary purpose of using AI technologies is learning. Among other purposes, clarifying concepts/tutoring (60%), developing language/communication skills (60%), and brainstorming/critical thinking (60%) were mentioned. One out of two respondents used AI to facilitate research, problem solving, and personalized learning. Time management appeared to be the least mentioned objective of applying AI (20%). It is evident from Figure 4 that the use of AI for instructional and knowledge-related purposes prevailed over its application for administrative purposes.

Table 5

AI Tools Used by Teachers for Academic Purposes (n = 100)*

AI Tool	Frequency	Percentage (%)
ChatGPT	100	100.0
Gemini	80	80.0
Microsoft Copilot	40	40.0
Other AI Tools	30	30.0

Figure 6



Tables 5 and Figure 5 show the use of the AI platforms most frequently adopted by teachers. It was found that 100% of all participants used ChatGPT as an AI platform, which makes ChatGPT the most popularly adopted AI technology. Secondly, 80% of the respondents have used Gemini as an AI technology platform. 40% of the participants used Microsoft Copilot, while 30% of them used other AI technologies. The above figure shows the absolute dominance of ChatGPT over other AI platforms.

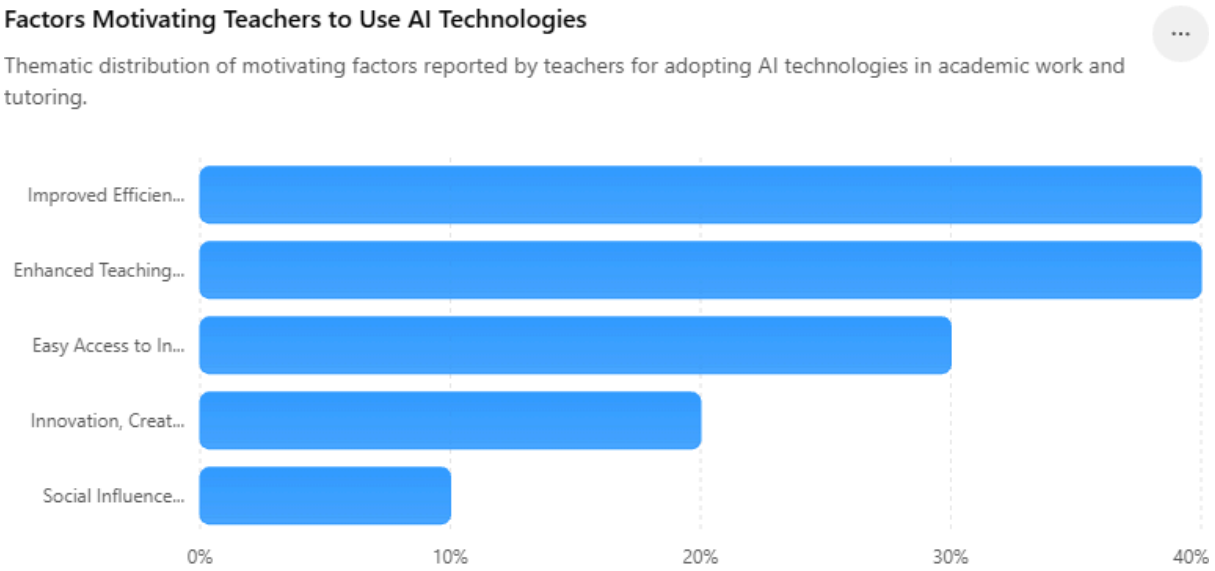
Table 6

Thematic Analysis of Factors Motivating Teachers to Use AI Technologies in Academic Work and Tutoring (n = 100)

Theme	**Illustrative Responses**	**Frequency**	**Percentage (%)**
Improved Efficiency and Time Saving	"Time saving", "Time factors"	40	40.0
Enhanced Teaching and Learning Support	"Personalized learning", "Improve learning outcomes", "Differentiated instruction", "Real-time feedback"	40	40.0
Easy Access to Information and Academic Resources	"Easily available materials", "Authentic data", "Easy to access"	30	30.0
Innovation, Creativity and Professional Growth	"Explore new horizons in methodology", "Creative ideas"	20	20.0
Social Influence and Peer Usage	"Many of my colleagues use AI tools"	10	10.0

Percentages exceed 100% because some responses contained multiple themes.

Figure 7



The most crucial motivational factors encouraging teachers to implement AI technologies have been shown in Table 6 and Figure 6 below. Increased efficiency/time saving (40%) and teaching/learning facilitation (40%) have been determined as the most compelling motivators. Information/academic resource availability for easy acquisition (30%), innovation and creativity (20%) were the motivating forces, while social influence was the least motivating factor (10%). As seen from the chart above, tangible gains outweigh social influences in terms of motivating teachers towards AI adoption. It can be concluded that motivation towards AI implementation is driven primarily by usefulness/performance considerations.

Table 7

Thematic Analysis of Factors Preventing Teachers from Using AI Technologies in Academic Work and Tutoring (n = 10)

Theme	**Illustrative Responses**	**Frequency**	**Percentage (%)**
Ethical and Academic Integrity Concerns	Plagiarism, misuse of AI, over-dependence on AI	50	50.0
Reliability and Accuracy Issues	Incorrect information, hallucinated responses, lack of authenticity	40	40.0

Lack of Technical Knowledge and Training	Insufficient skills, inadequate training opportunities	30	30.0
Data Privacy and Security Concerns	Confidentiality, data protection issues	20	20.0
Limited Access and Infrastructure	Internet connectivity, lack of institutional facilities	20	20.0
Cost and Subscription Constraints	Paid services, affordability issues	10	10.0

Percentages exceed 100% because multiple themes were identified from individual responses.

Figure 8

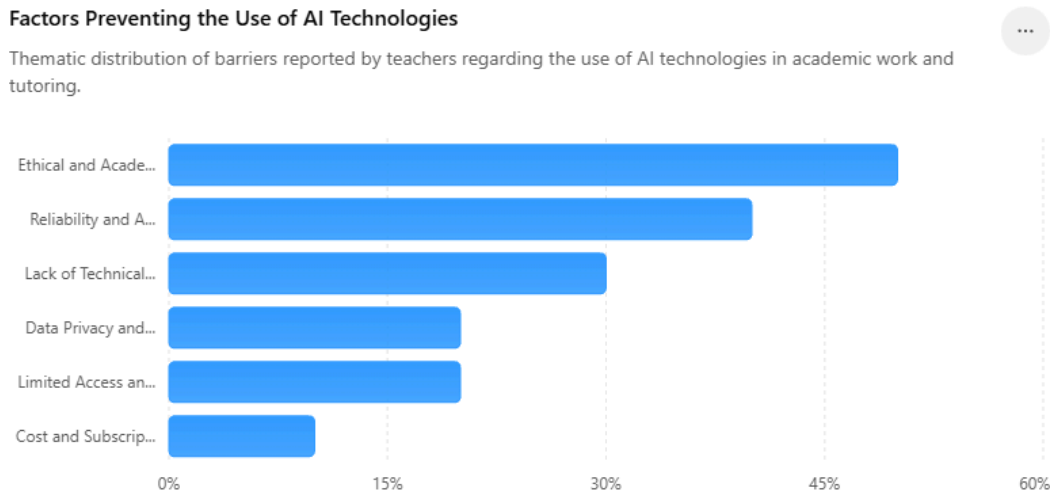


Table 7 and Figure 7 highlight the obstacles that prevent the use of AI by teachers. The ethical aspect and problems with academic integrity constituted the most commonly mentioned obstacle (50%), while reliability and accuracy were the second most mentioned concern (40%). The lack of technical expertise and education on how to operate the technology was the problem for 30% of the participants. The worries about the lack of data privacy and security and insufficient infrastructure were named by 20% of the respondents, while cost-related concerns were raised by only 10%. It is obvious from the figure that the ethical issues and doubt about the accuracy of the information constitute the primary obstacles to the introduction of AI into the university teaching process.

Table 8

Suggestions for Enhancing AI Adoption in Higher Education (n = 10)

Theme	Illustrative Responses	Frequency	Percentage (%)
Training and Capacity Building	AI workshops, faculty development programmes, skill enhancement	60	60.0
Institutional Support and Infrastructure	Better internet facilities, access to AI tools, technical support	50	50.0
Development of AI Policies and Guidelines	Ethical frameworks, institutional regulations, responsible AI use	40	40.0
Awareness and Orientation Programmes	Awareness campaigns, demonstrations of AI applications	30	30.0
Affordable Access to Premium AI Tools	Institutional subscriptions and financial support	20	20.0

Percentages exceed 100% because responses contained multiple suggestions.

Figure 9

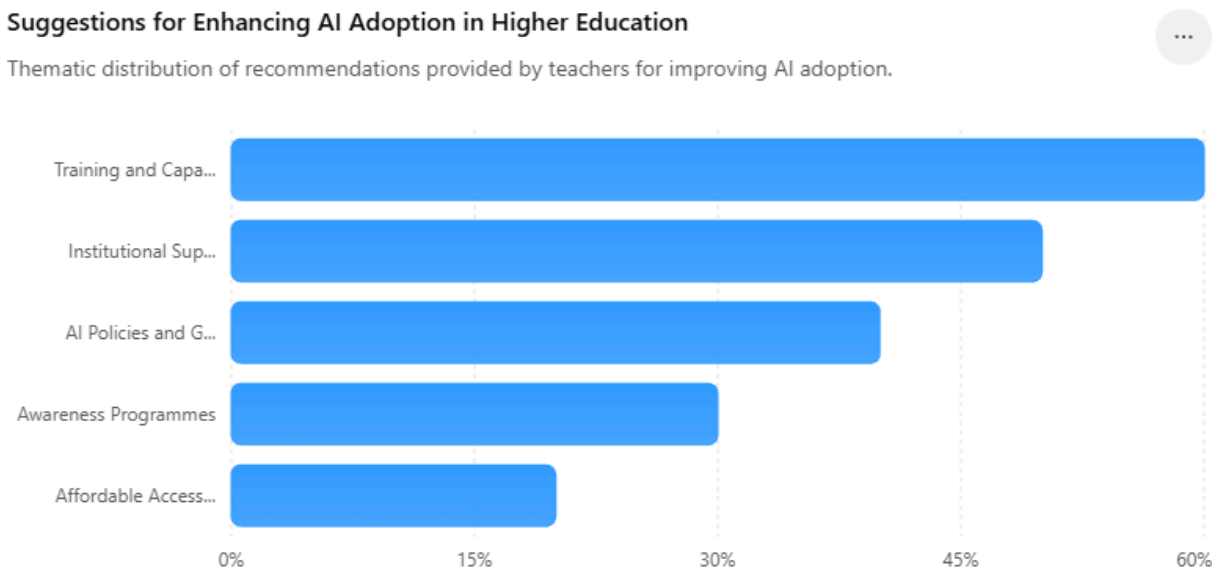


Table 8 and Figure 8 present respondents' suggestions on ways to promote AI use in higher education. Professional development and capacity building have been mentioned as the most prominent measures for promoting the use of AI in universities by 60% of participants. Institutional and infrastructure development ranked second among proposed solutions (50%). Thirty percent of respondents recommended developing policies related to AI in higher education institutions, and 20% pointed to the need to develop programs promoting awareness and orientation related to the technology under discussion. Access to high-quality AI resources at affordable prices was mentioned by 20% of participants. The graph shows that professional development and institutional support remain the primary conditions for successful AI implementation.

The major factors influencing the adoption of Artificial Intelligence (AI) among teachers through the UTAUT2 framework.

The findings indicate that several technological, motivational, and environmental factors contribute significantly to AI adoption. The thematic analysis revealed that improved efficiency and time-saving (40%) and enhanced teaching-learning support (40%) were the most prominent factors motivating AI usage. These findings correspond closely with the UTAUT2 construct of Performance Expectancy, suggesting that users adopt AI when they perceive it as useful for improving academic performance and productivity.

It can be seen from the fact that the usage of AI systems for learning a topic (90%) and for creating study materials (90%) that users perceive AI as an educational tool that can help enhance one's efficiency and results in academia. Moreover, the usage of AI systems for clarifying concepts, providing assistance in learning, developing language skills and critical thinking ability also indicates the usefulness of AI in helping individuals learn on their own. The construct of Effort Expectancy comes from the fact that the availability of information is appreciated by most people. In fact, more than 30% of users said that AI helps get information quickly.

As for the social influence, it can be noted that 10% of the participants associated the motivation for the use of AI with the usage of such tools by peers. This means that there are no social expectations which compel the individuals to adopt the innovation.

The relevance of facilitating conditions was established based on the respondents' suggestions. It can be said that half of them (50%) highlighted the significance of improving their institutions in terms of better internet access, availability of AI instruments, and technical assistance from specialists. Thus, it became clear that the supportive environment plays an important role in the promotion of

artificial intelligence. The influence of hedonic motivation and personal innovativeness can also be seen in this case study. 20% of the participants mentioned their desire to apply AI to explore new teaching approaches and come up with innovations.

The high frequency of AI technology use, especially the use of ChatGPT (100%) and Gemini (80%), implies the presence of Habit in that students are using AI in their academic pursuits. The high frequency of usage is likely to reinforce intentions to use AI technologies and further usage.

On the other hand, a few factors impeding the adoption of AI were identified too. These include ethical and academic integrity issues (50%), reliability and accuracy issues (40%), lack of technical skills (30%), and issues regarding data privacy (20%). These issues can be grouped under Perceived Risk.

CONCLUSION

AI is gaining rapid prominence as a crucial aspect of higher education. The effective utilization of these technologies by teachers is contingent upon several technology-related, organization-related, and psychological determinants. Utilizing a modified version of the extended UTAUT2 model, the current research aims to investigate that performance expectancy, effort expectancy, facilitating conditions, social influence, habit, hedonic motivation, and personal innovativeness have a positive impact on AI adoption, whereas perceived risk hinders adoption. By identifying the important determinants, this will help the relevant stakeholders to frame effective policies regarding the adoption of AI in Indian higher education.

REFERENCES:

- Al Farsi, G., 2023. The Efficiency of UTAUT2 Model in Predicting Student's Acceptance of Using Virtual Reality Technology. Int. J. Interact. Mob. Technol. 17, 17–27.
- Kalınkara, Y., Özdemir, O., 2024. Anatomy in the metaverse: Exploring student technology acceptance through the UTAUT2 model. Anatomical Sciences Ed 17, 319–336. https://doi.org/10.1002/ase.2353
- MARLINA, E., TJAHJADI, B., NINGSIH, S., 2021. Factors Affecting Student Performance in E-Learning: A Case Study of Higher Educational Institutions in Indonesia. The Journal of Asian Finance, Economics and Business 8, 993–1001. https://doi.org/10.13106/JAFEB.2021.VOL8.NO4.0993
- Molefi Matsieli and Stephen Mutula. (2024). COVID-19 and Digital Transformation in Higher Education Institutions: Towards Inclusive and Equitable Access to Quality Education. Retrieved from: https://www.researchgate.net/publication/382600598_COVID-19_and_Digital_Transformation_in_Higher_Education_Institutions_Towards_Inclusive_and_Equitable_Access_to_Quality_Education
- O'dea, X., O'Dea, M., 2023. Is artificial intelligence really the next big thing in learning and teaching in higher education?: A conceptual paper. Journal of University Teaching and Learning Practice 20, 1–17.
- Union Budget, Govt. of India. (2021). Retrieved from: https://www.indiabudget.gov.in/
- University Grants Commission (UGC). (2024). Notices.
- Sheshadri Chatterjee and Kalyan Kumar Bhattacharjee (2020). Adoption of artificial intelligence in higher education: a Quantitative analysis using structural equation modelling. Education and Information Technologies 25 (3). DOI: DOI: 10.1007/s10639-020-10159-7
- Tlili, A., Shehata, B., Adarkwah, M.A., Bozkurt, A., Hickey, D.T., Huang, R. and Agyemang, B. (2023). What if the devil is my guardian angel: ChatGPT as a case study of using chatbots in education", Smart Learning Environments. Vol. 10 No. 1, p. 15, doi: 10.1186/s40561-023-00237-x.
- Viswanath Venkatesh, Thong, J. Y. L., & Xu, X. (2012). Consumer acceptance and use of information technology: Extending the Unified Theory of Acceptance and Use of Technology. *MIS Quarterly, 36*(1), 157–178. https://doi.org/10.2307/41410412

- Wang, S., Wang, F., Zhu, Z., Wang, J., Tran, T., and Du, Z. (2024). Artificial intelligence in education: A systematic literature review. *Expert Systems with Applications, 252* (Part A),124167. https://www.sciencedirect.com/science/article/pii/S0957417424010339