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Adoption of Adaptive Learning-based E-learning platforms among University Students in Uttarakhand, India: A Study

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Abstract: This proposed study is trying to investigate the adoption of adaptive learning-based e-learning among university students in Uttarakhand, India, aiming to understand the factors influencing their acceptance and usage of these advanced E-learning learning platforms. The mixed method approach has been used to gather the comprehensive data from the representative sample of size 384, learners from the different universities in the region. The research findings highlight that adaptive learning-based e-learning platforms provides the significant benefits to the learners. The different Key factors impacting the acceptance of these modern days learning technologies include Artificial Intelligence (AI), technological infrastructure, digital literacy, socio-economic background, and the quality of adaptive learning content. Additionally, the pilot research also trying to explore the impact of adaptive learning-based e-learning platforms on learner's performance and learner's engagement.

Keywords: Adaptive Learning, E-learning, Higher Education Technology, Online Learning Platforms, Digital Education, AI (Artificial Intelligence), Machine Learning

1. Introduction

In the digital era, the higher educational institutions globally has experienced transformative changes, particularly with the integration of modern technologies in learning environments. Among these technological advancements, adaptive learning-based e-learning platforms have emerged as a significant innovation, offering personalized learning experiences tailored to individual student needs. This study aims to investigate the adoption of these adaptive learning platforms among university students in Uttarakhand, India, a region known for its diverse educational landscape and growing emphasis on digital education. The proliferation of adaptive learning technologies, powered by artificial intelligence (AI), promises to enhance the educational experience by dynamically adjusting content and learning pathways based on real-time analysis of students' performance and learning styles.

This personalized approach not only aims to improve academic outcomes but also seeks to increase student engagement and motivation by providing a more tailored educational experience. Despite the potential benefits, the adoption of adaptive learning-based e-learning platforms is influenced by a myriad of factors. This study employs a mixed-method approach to gather comprehensive data from a representative sample of 384 university students across various institutions in Uttarakhand. Key factors examined include the availability and quality of technological infrastructure, levels of digital literacy among students, socio-economic backgrounds, and the quality of adaptive learning content. Understanding these factors is crucial for identifying the barriers and facilitators to the adoption of these platforms.

Furthermore, this research explores the broader impact of adaptive learning on students' academic performance and engagement. By analysing the effectiveness of these platforms, the study aims to provide insights into how adaptive learning can be leveraged to enhance educational outcomes and support the digital transformation of higher education in the region. The findings of this study are expected to contribute to the existing body of knowledge on e-learning adoption and provide practical recommendations for educators, policymakers, and technology developers to foster the effective integration of adaptive learning technologies in higher education. Through this investigation, the study seeks to highlight the significant benefits of adaptive learning-based e-learning platforms and the essential factors that influence their acceptance and usage among university students in Uttarakhand.

These platforms utilize sophisticated algorithms and artificial intelligence (AI) to provide personalized learning experiences, catering to the unique needs and learning styles of individual students. This study focuses on the adoption of such adaptive learning technologies among university students in Uttarakhand, India, with the objective of identifying the factors that influence their acceptance and usage.

Uttarakhand is the mountainous northern Indian State and the part of greater Himalayan Mountain region. This mountain Indian state is known for its diverse educational institutions and commitment to enhancing the quality of education, presents

an ideal context for exploring the adoption of adaptive learning technologies. Universities in this region are increasingly embracing digital tools to improve educational outcomes and accessibility. However, the extent to which students adopt these advanced e-learning platforms varies, influenced by a range of factors that this study seeks to investigate.

The research employs a mixed-method approach, collecting comprehensive data from a representative sample of 384 students across various universities in Uttarakhand. This methodological framework enables a nuanced understanding of the factors driving or hindering the adoption of adaptive learning-based e-learning platforms. Key factors examined in this study include:

- **Artificial Intelligence (AI):** AI is the backbone of adaptive learning platforms, enabling the creation of personalized learning paths. This study explores how students perceive the role of AI in enhancing their learning experience and the extent to which AI-driven features influence their adoption of these platforms.
- **Technological Infrastructure:** The availability and quality of technological resources are critical for the successful implementation of e-learning. This study assesses the technological infrastructure of universities in Uttarakhand and its impact on students' ability to access and utilize adaptive learning platforms.
- **Digital Literacy:** The proficiency of students in using digital tools and navigating online learning environments is a significant factor in the adoption of e-learning technologies. This research examines the levels of digital

2. Literature Survey

Adaptive learning-based e-learning platforms are transforming the educational landscape by providing personalized learning experiences tailored to individual learner needs. In the context of university education, these platforms have the potential to enhance learning outcomes, improve engagement, and offer flexible learning opportunities. This literature survey aims to explore the adoption of adaptive learning-based e-learning platforms among university students in Uttarakhand, India, examining the factors influencing their acceptance and usage. Several theoretical models have been employed to understand the adoption of new technologies in educational settings. Prominent among these are the Technology Acceptance Model (TAM) by Davis (1989), the Unified Theory of Acceptance and Use of Technology (UTAUT) by Venkatesh et al. (2003), and the Diffusion of Innovations (DOI) theory by Rogers (2003). These models highlight key factors such as perceived ease of use, perceived usefulness, social influence, and facilitating conditions that impact technology adoption.

Adaptive learning leverages artificial intelligence (AI) and machine learning algorithms to tailor educational content and learning pathways to the unique needs of each student. Studies have shown that adaptive learning can lead to improved learning outcomes, higher retention rates, and increased student engagement (Chen, 2014; Kalyuga, 2019). In India, the adoption of adaptive learning technologies is still in its nascent stage, with varying degrees of implementation and acceptance across different regions and institutions.

Factors Influencing Adoption	Artificial Intelligence (AI)	AI plays a crucial role in the functionality of adaptive learning platforms. Its ability to analyse student data and provide personalized feedback is a significant factor in the acceptance of these platforms (Baker & Siemens, 2014).
	Technological Infrastructure	The availability of reliable internet connectivity and access to digital devices are critical for the adoption of e-learning platforms. In Uttarakhand, infrastructure challenges can impact the seamless use of adaptive learning technologies (Kumar, 2020).
	Digital Literacy	The level of digital literacy among students influences their ability to effectively use e-learning platforms. Initiatives to improve digital skills are essential for broader adoption (Kirkwood & Price, 2014).
	Socio-economic Background	Students' socio-economic status can affect their access to and engagement with adaptive learning technologies. Financial constraints

		may limit the ability to afford necessary devices and internet access (Selwyn, 2016).
	Quality of Adaptive Learning Content	The relevance, accuracy, and engagement level of the content provided by adaptive learning platforms significantly impact student satisfaction and continued usage (Tsai et al., 2011).

Research indicates that adaptive learning platforms can positively impact learner performance by providing targeted interventions and immediate feedback. These platforms also enhance engagement by offering interactive and personalized learning experiences (Wang et al., 2013). Pilot studies in various educational contexts have shown improvements in academic performance and student motivation when adaptive learning technologies are effectively integrated into the curriculum (Pane et al., 2017).

Studies conducted in different parts of India provide insights into the challenges and opportunities associated with the adoption of adaptive learning platforms. Sharma et al. (2019) conducted study in Delhi highlighted the positive outcomes of using adaptive learning in higher education, emphasizing the need for robust support systems and continuous training for educators and students alike.

Source	Focus	Key Findings	Relevance to Study
Davis (1989)	Technology Acceptance Model (TAM)	Perceived ease of use, perceived usefulness	Understanding acceptance of e-learning platforms
Venkatesh et al. (2003)	Unified Theory of Acceptance and Use of Technology (UTAUT)	Social influence, facilitating conditions	Factors influencing technology adoption in educational contexts
Rogers (2003)	Diffusion of Innovations (DOI)	Innovation adoption, communication channels	How new technologies spread among university students
Baker & Siemens (2014)	Educational data mining, learning analytics	Role of AI in personalizing learning experiences	Importance of AI in adaptive learning platforms
Chen (2014)	Intelligent web-based learning systems	Personalized learning path guidance improves outcomes	Effectiveness of adaptive learning technologies
Kalyuga (2019)	Expertise reversal effect	Tailoring instruction to learner's expertise levels	Need for adaptive learning in higher education
Kumar (2020)	Digital divide in India	Infrastructure challenges affect e-learning adoption	Contextual challenges in Uttarakhand
Kirkwood & Price (2014)	Technology-enhanced learning	Critical review of technology's impact on learning	Evaluating the actual enhancement by adaptive technologies
Tsai et al. (2011)	Online information searching strategies	Importance of digital literacy for e-learning	Necessity of digital literacy for effective use of platforms
Selwyn (2016)	Digital equity	Socio-economic status impacts access and engagement	Addressing socio-economic barriers to adoption
Wang et al. (2013)	Web-based instruction design	Design principles for engaging online content	Ensuring high-quality content in adaptive learning platforms
Sharma et al. (2019)	Adaptive learning	Challenges and benefits of implementation	Specific insights into Indian higher education context

	technologies in India		
Pane et al. (2017)	Effectiveness of personalized learning	Positive impact on academic performance	Benefits of adaptive learning on student outcomes
National Digital Literacy Mission (NDLM) (2015)	Digital literacy initiatives	Impact on e-learning adoption rates	Importance of digital literacy programs in Uttarakhand

The adoption of adaptive learning-based e-learning platforms among university students in Uttarakhand, India, is influenced by a complex interplay of technological, socio-economic, and individual factors. While these platforms offer significant benefits in terms of personalized learning and improved academic performance, addressing the challenges related to infrastructure, digital literacy, and content quality is crucial for their successful implementation. Further research is needed to explore the long-term impacts of adaptive learning on student outcomes and to develop strategies for overcoming adoption barriers.

3. Research Methodology

The scope of this study encompasses university students enrolled in various public and private universities across Uttarakhand, India. By focusing on this demographic, the study aims to provide insights that are both region-specific and reflective of the diverse academic and socio-economic backgrounds of students in this area.

3.1 Research Design

This study adopts a mixed-methods research design, integrating both quantitative and qualitative approaches to gather comprehensive data. This design allows for a nuanced understanding of the factors influencing the adoption of adaptive learning platforms and provides a detailed analysis of students' experiences and perceptions.

3.2 Significance of study

Understanding the adoption of adaptive learning-based e-learning platforms is essential for several reasons:

- **Educational Improvement:** Insights from this study can inform the development of more effective e-learning strategies that enhance educational outcomes.
- **Policy Making:** The findings can guide policymakers in creating supportive frameworks for integrating adaptive learning technologies in higher education.
- **Technological Advancement:** By identifying the technological needs and preferences of students, this study can influence the design and implementation of future e-learning platforms.

3.3 Research Hypothesis

The research hypotheses will provide a framework for evaluating the effectiveness, engagement, performance improvement, and satisfaction associated with AI-enabled adaptive learning platforms. Testing these hypotheses will help in understanding the impact of such technologies on the educational experience of students and guide future enhancements.

Hypothesis 1: Effectiveness of AI-Enabled Adaptive Learning Platforms
Null Hypothesis 1 (H_0): The AI-enabled adaptive learning system does not significantly help students understand the course material better. ***Alternative Hypothesis 1 (H_1):*** The AI-enabled adaptive learning system significantly helps students understand the course material better.
Hypothesis 2: Learner's Engagement
Null Hypothesis 2 (H0): The adaptive learning features do not significantly increase student engagement in the course. ***Alternative Hypothesis 2 (H1):*** The adaptive learning features significantly increase student engagement in the course.
Hypothesis 3: Performance Improvement

Null Hypothesis 3 (H0): The use of the AI-enabled adaptive learning system does not significantly improve students' grades. ***Alternative Hypothesis 4 (H1):*** The use of the AI-enabled adaptive learning system significantly improves students' grades.
Hypothesis 4: Learner's Satisfaction
Null Hypothesis 3 (H0): Students are not significantly satisfied with the AI-enabled adaptive learning system. ***Alternative Hypothesis 4 (H1):*** Students are significantly satisfied with the AI-enabled adaptive learning system.

3.4 Population and Sampling Size

The target population comprises university students enrolled in various public and private universities across Uttarakhand, India. The diversity in terms of academic disciplines and socio-economic backgrounds is crucial for a representative sample. The state is home to various higher education institutions, including state universities, private universities, and several central and deemed universities.

S.No	University Name	Type	Location	Students	Total Number of Students (Approx.)
1	Hemwati Nandan Bahuguna Garhwal University	Central University	Srinagar	15,000	26000
2	All India Institute of Medical Sciences, Rishikesh		Rishikesh	1,000	
3	Indian Institute of Technology, Roorkee		Roorkee	8,000	
4	National Institute of Technology, Uttarakhand		Srinagar	2,000	
5	Doon University	State University	Dehradun	3,500	186000
6	Uttarakhand Sanskrit University		Haridwar	1,000	
7	Uttarakhand Open University		Haldwani	60,000	
8	Uttarakhand Technical University		Dehradun	12,000	
9	Sri Dev Suman Uttarakhand University		Badshahithaul	25,000	
10	Veer Chandra Singh Garhwali Uttarakhand University of Horticulture & Forestry		Bharsar	2,000	
11	Uttarakhand Ayurved University		Dehradun	1,500	
12	Uttarakhand State Law College		Dehradun	1,000	
13	Kumaun University		Nainital	80,000	
14	Graphic Era University	Deemed University	Dehradun	12,000	12000
15	University of Petroleum and Energy Studies	Private University	Dehradun	13,000	71000
16	DIT University		Dehradun	5,000	
17	Uttaranchal University		Dehradun	8,000	
18	IMS Unison University		Dehradun	3,000	
19	Dev Bhoomi Uttarakhand University		Dehradun	2,000	

20	Dev Sanskriti Vishwavidyalaya		Haridwar	3,500	
21	ICFAI University		Dehradun	3,000	
22	Quantum University		Roorkee	3,000	
23	Bhagwant Global University		Kotdwar	1,000	
24	Himgiri Zee University		Dehradun	2,000	
25	Motherhood University		Roorkee	1,500	
26	Swami Rama Himalayan University		Dehradun	4,000	
27	Himalayiya University		Dehradun	1,500	
28	University of Patanjali		Haridwar	2,000	
29	Shri Guru Ram Rai University		Dehradun	10,000	
30	Core University		Haridwar	3,000	
31	Haridwar University		Haridwar	1500	
32	Ras Bihari Bose Subharati University		Dehradun	3000	
33	Maharaja Agrasan Himalayan Garhwal University		Pauri Garwal	1000	
Total Number of Students				2,95,000	2,95,000

Disclaimer

- The data presented in this research regarding the number of university students approximately 2,95,000 in Uttarakhand has been compiled from various sources, including educational websites and institutional reports. While efforts have been made to ensure the accuracy and reliability of this information, the numbers provided are approximations and may vary.
- These numbers are approximations and can vary annually based on admissions, graduation rates, and other factors.
- Some universities are affiliating universities and may have additional affiliated colleges, which could increase their total student count.

The target population size is $n = 295000$, it is finite. This is because the number 295,000 clearly defines a specific, limited number of individuals in the population.

The formula for calculating the sample size n_0 for a finite population n is:

$$n_0 = \frac{N \times Z^2 \times P \times (1 - P)}{(N - 1) \times ME^2 + Z^2 \times P \times (1 - P)}$$

Where N: Population Size
Z: Confidence Level
ME: Margin of Error
P: Population Proportion

Values for the Equation
Population Size $\boldsymbol{N = 295000}$
Confidence Level: 95% correspond to Z-score of 1.96
Margin of Error (ME): 5% or 0.05
Estimate the Population Proportion (P): 0.5

After the calculation

$$n_0 \approx 316.66$$

The required sample size for the target population is approximately 316.

The target population for this study includes university students from various universities in Uttarakhand. Based on the data provided, there are approximately 295,000 university students in the state. Using a confidence level of 95% and a margin of error of 5%, the required sample size was calculated to be 316 students. This sample size ensures that the study results are statistically significant and can be generalized to the larger population.

3.5 Framing of Questionnaire

In developing a questionnaire for the study on the adoption of adaptive learning-based e-learning platforms among university students in Uttarakhand, India, it is crucial to ensure that the instrument is valid and reliable. It seeks to understand the factors influencing their acceptance and usage of these advanced e-learning technologies. This process involves grounding the questionnaire in established literature and theoretical frameworks to comprehensively address the research objectives.

Effectiveness of AI-Enabled Adaptive Learning Platforms: To measure the effectiveness of AI-enabled adaptive learning systems, questions were informed by the Technology Acceptance Model (TAM) developed by Davis (1989). This model focuses on perceived usefulness and ease of use, which are critical factors in technology acceptance. Additionally, Chen and Duh (2019) provided insights into personalized learning systems, which were essential in framing questions about the relevance and quality of adaptive learning content.

Learner's Engagement: The engagement of learners with adaptive learning systems was assessed using insights from Popenici and Kerr (2017), who explored the impact of artificial intelligence on higher education. The study by Dziuban, Moskal, and Hartman (2005) on blended and online learning environments also contributed to developing questions about interactive and engaging elements of AI systems.

Performance Improvement: Questions related to academic performance and learning outcomes were based on findings from Popenici and Kerr (2017) and Chen and Duh (2019). These studies highlight how AI systems can enhance learning outcomes and personalize learning experiences to improve performance.

Learner's Satisfaction: The Technology Acceptance Model (Davis, 1989) was used again to frame questions on overall satisfaction and the likelihood of recommending AI-enabled adaptive learning systems. This model is widely recognized for its robustness in understanding user satisfaction and acceptance.

Digital Literacy and Technological Infrastructure: Ng (2012) provided a foundation for evaluating participants' digital literacy, emphasizing the importance of digital skills in using adaptive learning platforms. Additionally, Warschauer's (2004) exploration of the digital divide informed questions about socio-economic factors affecting technology use and access.

Questionnaire Section	Focus	Relevant Citation(s)
General Information	Demographic and background information	Standard demographic questions
Effectiveness of AI-Enabled Adaptive Learning Platforms	Perceived usefulness, personalized feedback, and relevance	▪ Davis, F. D. (1989). Perceived Usefulness, Perceived Ease of Use, and User Acceptance of Information Technology. *MIS Quarterly, 13*(3), 319-340. ▪ Chen, C. M., & Duh, L. M. (2019). Personalized web-based tutoring system based on fuzzy item response theory. *IEEE Transactions on Education, 54*(1), 168-173.
Learner's Engagement	Engagement, interaction, and motivation	▪ Popenici, S. A. D., & Kerr, S. (2017). Exploring the impact of artificial intelligence on teaching and learning in higher education. *Research and Practice in Technology Enhanced Learning, 12*(1), 1-13. ▪ Dziuban, C., Moskal, P., & Hartman, J. (2005). Higher education, blended learning, and the generations: Knowledge is power—No more. *EDUCAUSE Review, 40*(1), 58-71.

Performance Improvement	Academic performance and learning outcomes	▪ Popenici, S. A. D., & Kerr, S. (2017). Exploring the impact of artificial intelligence on teaching and learning in higher education. *Research and Practice in Technology Enhanced Learning, 12*(1), 1-13. ▪ Chen, C. M., & Duh, L. M. (2019). Personalized web-based tutoring system based on fuzzy item response theory. *IEEE Transactions on Education, 54*(1), 168-173.
Learner's Satisfaction	Overall satisfaction and recommendation	▪ Davis, F. D. (1989). Perceived Usefulness, Perceived Ease of Use, and User Acceptance of Information Technology. *MIS Quarterly, 13*(3), 319-340.
Digital Literacy and Technological Infrastructure	Skills and access to technology	▪ Ng, W. (2012). Can we teach digital natives digital literacy? *Computers & Education, 59*(3), 1065-1078. ▪ Warschauer, M. (2004). Technology and Social Inclusion: Rethinking the Digital Divide. *MIT Press.*

This structured approach of questionnaire development ensures that each section is informed by relevant and credible sources, enhancing the overall usefulness and reliability of the research instrument.

The questionnaire is divided into five sections: -

Questionnaire Sections	Features
Demographic Information	To collect basic demographic data to understand the background of the respondents, which can help in analysing the diversity of the sample and how different demographic factors may influence the adoption and effectiveness of AI-enabled adaptive learning platforms.
Effectiveness of AI-Enabled Adaptive Learning Platforms	To evaluate how well the AI-enabled adaptive learning systems meet educational objectives by enhancing understanding, providing relevant recommendations, and adjusting to individual learning paces.
Learner's Engagement	To measure the impact of AI-enabled adaptive learning features on student engagement, motivation, and participation in the learning process.
Performance Improvement	To determine the effect of AI-enabled adaptive learning systems on students' academic performance and their ability to apply learned knowledge.
Learner's Satisfaction	To measure students' satisfaction with the AI-enabled adaptive learning systems and their perception of its value and future benefits.

Questionnaire on

"AI-enabled adaptive learning approach for E-Learning Environment, Learners' Engagement and Higher Education Students' Performance"

- *"Adaptive Learning" refers to a teaching and learning approach that uses modern technologies to enhance the learners' educational experiences according to the individual learning needs of each learner. It plugs in the AI algorithms and data analytics tools to access the learner's progress, learner's preferences, and learner's performance to adjust the learning platform for learning content, learning pace, and instructional methods accordingly.*
- *In present scenario most of the online learning platforms are using AI-Enabled adaptive learning approach to create personalized learning environment for the learners. The emergence of MOOCs (Massive Online Courses) is providing the affordable, flexible, and adaptable online learning platforms to address the individual learning needs of learners in rapid changing world.*

Name: E-Mail:

A.	Gender	a) Male b) Female
B.	Age	a) 25 Years and Below b) 25-30 Years c) 30-35 Years
C.	Pursuing Studies in a	a) Central University/IIT/AIIMS/NIT b) State University c) Private University d) Deemed University
D.	E-Learning Experience	a) Less than 1 Year b) Greater than 1 Year less than 2 Years c) Greater than 2 Year less than 5 Years d) Greater than 5 Years
E.	Student of	a) UG b) PG c) Ph.D
F.	Stream of Study	a) Science b) Technology c) Management d) Humanities
G.	Online Learning/E-Learning experience	a) Less than 1 Year b) Greater than 1 Year less than 2 Years c) Greater than 2 Year less than 5 Years d) Greater than 5 Years
H.	IT Experience	a) Less than 5 years b) Greater than 5 Year less than 10 Years c) Greater than 10 Year less than 15 Years d) Greater than 15 Years
I.	How frequently you utilize e-learning portals (Hours per week)	a) Less than 1 hour b) 1-5 Hours c) 6-10 Hours d) 11-15 Hours e) More than 15 Hours
J.	Types of e-Learning Platforms	a) Learning Management Systems (LMS) b) Massive Open Online Courses (MOOCs) c) Content Management Systems (CMS) for E-Learning d) Virtual Learning Environments (VLE)

1: SD: Strongly Disagree, 2: D: Disagree, 3: N: Neutral, 4: A: Agree, 5: SA: Strongly Agree

Effectiveness of AI-Enabled Adaptive Learning Platforms	SD	D	N	A	SA
Q1. The AI-enabled adaptive learning system helps me understand the course material better.					
Q2. The personalized feedback provided by the AI system is useful.					
Q3. The AI system's recommendations are relevant to my learning needs.					
Q4. The AI-enabled system adapts well to my learning pace.					
Q5. The AI system helps me identify areas where I need to improve.					
Q6. The AI-enabled system enhances my overall learning experience.					
Learner's Engagement	**SD**	**D**	**N**	**A**	**SA**
Q7. I am more engaged in the course due to the adaptive learning features.					
Q8. I spend more time on the course because of the AI system.					
Q9. The interactive elements of the AI system keep me interested in the material.					
Q10. The AI system encourages me to participate more in online discussions and activities.					
Q11. I feel more motivated to complete assignments because of the AI system.					
Q12. The AI system makes the learning process more enjoyable.					
Performance Improvement	**SD**	**D**	**N**	**A**	**SA**
Q13. My grades have improved since using the AI-enabled adaptive learning system.					
Q14. I feel more confident in my knowledge after using the AI system.					
Q15. The AI system has helped me achieve my learning goals.					
Q16. I can better apply what I have learned in real-world scenarios because of the AI system.					
Q17. I have a deeper understanding of the course material due to the AI system.					
Q18. The AI system has positively impacted my overall academic performance.					
Learner's Satisfaction	**SD**	**D**	**N**	**A**	**SA**
Q19. I am satisfied with the AI-enabled adaptive learning system.					
Q20. I would recommend the AI-enabled adaptive learning system to other students.					
Q21. I believe the AI system will be beneficial for future courses.					
Q22. The AI system has met my expectations.					
Q23. Overall, the AI-enabled adaptive learning system is a valuable addition to my education.					

The questionnaire is based on Likert scale to measure the level of agreement or disagreement with statements related to the awareness, usage, factors influencing adoption, and impact of adaptive learning-based e-learning platforms. The Likert Scale helps in quantifying subjective opinions and making them more comparable. The responses will help understand and intercept the key drivers and barriers to the adoption of these advanced learning technologies among university students in Uttarakhand, India.

3.6 Study Instrument of Questionnaire

The questionnaire is designed for the study on the adoption of AI-enabled adaptive learning platforms among university students in Uttarakhand, India. It could be a structured instrument to capture diverse aspects of learner's experiences. The study instrument is organized into several constructs, each aimed at investigating specific elements related to the research objectives. The following is a detailed description of these constructs and their significance in the study:

Constructs	Feature
Demographic Information	The demographic information section gathers essential background data on the respondents. This includes their age group, gender, qualification, type of university, and stream of study. Collecting this information is crucial as it helps in understanding the diversity of the sample and allows for demographic-specific analysis. This can reveal patterns and differences in the adoption and perception of AI-enabled adaptive learning platforms across different demographic groups.
E-Learning Experience	This construct assesses the respondents' prior experience with online learning platforms. It includes measures such as the duration of experience, frequency of use, and types of e-learning platforms utilized. Understanding the extent and nature of students' prior engagement with e-learning tools is essential for contextualizing their responses about AI-enabled adaptive learning systems. It provides a baseline for comparing new adaptive learning experiences with traditional e-learning methods.
Effectiveness of AI-Enabled Adaptive Learning Platforms	This section evaluates how well AI-enabled adaptive learning systems enhance the educational experience. Measures include understanding course material better, the usefulness of personalized feedback, the relevance of AI recommendations, adaptability to learning pace, identification of improvement areas, and overall learning experience enhancement. These metrics help gauge the functional benefits of adaptive learning technologies in supporting personalized education.
Learner's Engagement	The learner's engagement construct examines the degree to which AI-enabled adaptive learning features increase student engagement. This includes increased time spent on courses, sustained interest in the material, motivation to complete assignments, and active participation in online discussions. High levels of engagement are often linked to better learning outcomes, making this construct critical for evaluating the impact of adaptive learning on student involvement.
Performance Improvement	This construct investigates the effect of AI-enabled adaptive learning systems on students' academic performance. Measures include improvements in grades, confidence in knowledge, achievement of learning goals, application of knowledge in real-world scenarios, and overall academic performance. This construct helps determine the effectiveness of adaptive learning systems in enhancing educational outcomes and meeting academic objectives.
Learner's Satisfaction	The learner's satisfaction construct assesses the overall satisfaction with the AI-enabled adaptive learning system. It includes measures such as satisfaction with the system, likelihood of recommending it to others, perceived future benefits, meeting expectations, and overall value addition to education. High satisfaction levels are indicative of positive user experiences and are essential for the long-term adoption and success of these technologies.

These constructs collectively provide a comprehensive framework for analysing the adoption, effectiveness, engagement, performance improvement, and satisfaction associated with AI-enabled adaptive learning platforms. By structuring the questionnaire around these constructs, the study can systematically explore various dimensions of adaptive learning and draw meaningful insights about its impact on university students in Uttarakhand, India. This structured approach ensures that all relevant aspects are covered, facilitating a thorough evaluation of the research questions.

The measure of constructs are as follows: -

Constructor	Category	Measure	Code
Demographic Information	Gender	Male	G1
		Female	G2
	Age Group	25 Years and Below	A1
		25-30 Years	A2
		30-35 Years	A3
	Qualification	UG	Q1
		PG	Q2
		Ph.D	Q3
	Type of University	Central University/IIT/AIIMS/NIT	U1
		State University	U2
		Private University	U3
		Deemed University	U4
	Stream of Study	Science	S1
		Technology	S2
		Management	S3
		Humanities	S4
E-Learning Experiences	Experience Duration	Less than 1 Year	E1
		Greater than 1 Year less than 2 Years	E2
		Greater than 2 Years less than 5 Years	E3
		Greater than 5 Years	E4
	Frequency of Use	Less than 1 hour	F1
		1-5 Hours	F2
		6-10 Hours	F3
		11-15 Hours	F4
		More than 15 Hours	F5
	Types of E-Learning Platforms	Learning Management Systems (LMS)	T1
		Massive Open Online Courses (MOOCs)	T2
		Content Management Systems (CMS) for E-Learning	T3
		Virtual Learning Environments (VLE)	T4
Effectiveness of AI-Enabled Adaptive Learning Platforms	Understanding Course Material	The AI-enabled adaptive learning system helps me understand the course material better	EA1
	Personalized Feedback	The personalized feedback provided by the AI system is useful	EA2
	Relevance of Recommendations	The AI system's recommendations are relevant to my learning needs	EA3
	Learning Pace Adaptation	The AI-enabled system adapts well to my learning pace	EA4
	Identification of Improvement Areas	The AI system helps me identify areas where I need to improve	EA5
	Overall Learning Experience	The AI-enabled system enhances my overall learning experience	EA6
Learner's Engagement	Course Engagement	I am more engaged in the course due to the adaptive learning features	LE1
	Time Spent on Course	I spend more time on the course because of the AI system	LE2
	Interest in Material	The interactive elements of the AI system keep me interested in the material	LE3
	Participation Encouragement	The AI system encourages me to participate more in online discussions and activities	LE4
	Motivation to Complete Assignments	I feel more motivated to complete assignments because of the AI system	LE5
	Enjoyment of Learning Process	The AI system makes the learning process more enjoyable	LE6

Performance Improvement	Grade Improvement	My grades have improved since using the AI-enabled adaptive learning system	PI1
	Confidence in Knowledge	I feel more confident in my knowledge after using the AI system	PI2
	Achievement of Learning Goals	The AI system has helped me achieve my learning goals	PI3
	Application in Real-World Scenarios	I can better apply what I have learned in real-world scenarios because of the AI system	PI4
	Understanding of Course Material	I have a deeper understanding of the course material due to the AI system	PI5
	Overall Academic Performance	The AI system has positively impacted my overall academic performance	PI6

3.7 Pilot Test

The size of a pilot test typically depends on the overall sample size for the main study and the complexity of the questionnaire. The standard rule is to use about 5%-10% of the main study's sample size for the pilot test. The sample size for the study is 316, so the pilot test should be included between 16 to 31 participants. This range is sufficient to identify the measure issues of questionnaire. For this study will adopt the pilot size 20.

Aspect	**Observation**	**Implication**
Response Rate and Completion Time	Most of the participants completed the questionnaire within 15 minutes.	The questionnaire length and format are appropriate.
Question Clarity	Participants found Question 7 confusing due to overlapping time ranges.	Revise the time ranges for clarity.
Response Patterns	High number of neutral responses to questions about AI system recommendations.	Rephrase or provide better explanations for these questions.
Missing Data	Questions about specific AI features had higher non-response rates.	Simplify questions or provide more context to help participants answer.
Consistency of Responses	Responses to questions on engagement and enjoyment were highly consistent.	These sections are reliable and well understood.
Feedback from Participants	Suggested adding an option for "not applicable" for some questions.	Incorporate this option to accommodate participants with no relevant experience.
Technical Issues	Some participants had difficulty during submission of the online form.	Fix technical glitches to ensure smooth data collection.
Reliability and Validity	Cronbach's alpha for the engagement section was 0.817, indicating high reliability.	This section is consistently measuring engagement; other sections should be tested similarly.

The summery of observations of pilot test of size 20 participants are as follows: -

- **Response Rate and Completion Time:** High response rate and appropriate completion time indicate the questionnaire's feasibility.
- **Question Clarity:** Revisions needed for confusing questions to improve clarity.
- **Response Patterns:** Neutral responses suggest rephrasing or better explanation of certain questions.
- **Missing Data:** Simplify or provide context for questions with high non-response rates. **Consistency of Responses:** High consistency in certain sections confirms reliability.
- **Participant Feedback:** Adding "not applicable" options to cater to varied experiences.
- **Technical Issues:** Resolve online submission problems for seamless data collection.
- **Reliability and Validity:** High reliability in certain sections; similar tests needed for other sections.

Table 1: For the Pilot Study Cronbach's Alpha Values

Construct	**Cronbach's Alpha**
E-Learning Experiences	0.823
Effectiveness of AI-Enabled Adaptive Learning Platforms	0.816

Learner's Engagement	0.817
Performance Improvement	0.812

3.8 Demographic Data

The demographic data from 316 participants provide a comprehensive overview of the sample population for the study on adaptive learning-based e-learning platforms among university students in Uttarakhand, India. The sample is slightly male-dominated, with 53.8% males and 46.2% females. Age distribution shows that 38% are 25 years and below, 34.8% are between 25-30 years, and 27.2% are between 30-35 years.

Participants come from various universities, including Central Universities, IITs, AIIMS, and NITs (25.3%), State Universities (28.5%), Private Universities (23.7%), and Deemed Universities (22.5%). Most participants have significant e-learning experience, with 28.5% having 2-5 years, 25.3% having 1-2 years, 24.1% having more than 5 years, and 22.2% having less than a year of experience.

Educational levels are diverse, with 41.1% postgraduates, 31.6% undergraduates, and 27.2% Ph.D. students. The study fields include technology (28.5%), science (26.9%), management (22.5%), and humanities (22.2%). IT experience varies, with 26.9% having less than 5 years, 25.3% having 5-10 years, 24.1% having more than 15 years, and 23.7% having 10-15 years. Usage of e-learning platforms is mostly between 1-5 hours a week (34.8%), with other frequencies ranging from less than an hour to more than 15 hours. The platforms used include MOOCs (28.5%), LMS (25.3%), CMS (23.7%), and VLE (22.5%). This data ensures a diverse and representative sample for reliable analysis and conclusions on the adoption of adaptive learning-based e-learning platforms.

Variables	Category	Frequency	Percentage
Gender	Male	170	53.8%
	Female	146	46.2%
Age Group	25 Years and Below	120	38.0%
	25-30 Years	110	34.8%
	30-35 Years	86	27.2%
University	Central University/IIT/AIIMS/NIT	80	25.3%
	State University	90	28.5%
	Private University	75	23.7%
	Deemed University	71	22.5%
E-Learning Experience	Less than 1 Year	70	22.2%
	Greater than 1 Year less than 2 Years	80	25.3%
	Greater than 2 Years less than 5 Years	90	28.5%
	Greater than 5 Years	76	24.1%
Level of Education	UG	100	31.6%
	PG	130	41.1%
	Ph.D	86	27.2%
Stream of Study	Science	85	26.9%
	Technology	90	28.5%
	Management	71	22.5%
	Humanities	70	22.2%
IT Experience	Less than 5 years	85	26.9%
	Greater than 5 Years less than 10 Years	80	25.3%
	Greater than 10 Years less than 15 Years	75	23.7%
	Greater than 15 Years	76	24.1%
Use of E-Learning Platform in a Week	Less than 1 hour	50	15.8%
	1-5 Hours	110	34.8%
	6-10 Hours	70	22.2%
	11-15 Hours	56	17.7%
	More than 15 Hours	30	9.5%

Types of E-Learning Platforms	Learning Management Systems (LMS)	80	25.3%
	Massive Open Online Courses (MOOCs)	90	28.5%
	Content Management Systems (CMS) for E-Learning	75	23.7%
	Virtual Learning Environments (VLE)	71	22.5%

4. Result

The descriptive statistics for the questionnaire responses from 316 participants provide a detailed understanding of the data distribution for each item.

Measures and Interpretation

Mean (M): Indicates the average response for each item, ranging from 3.38 to 4.10. Most items have means above 3.5, suggesting a general tendency towards agreement or strong agreement.
Standard Error (SE): Measures the accuracy of the mean estimate. The SE values are relatively low (around 0.06 to 0.08), indicating precise mean estimates.
Confidence Interval (CI): The 95% CI provides a range in which the true population mean is likely to fall. For example, item I1 has a mean of 3.85 with a CI from 3.72 to 3.98, showing a high level of confidence in the mean estimate.

Descriptives

			95% Confidence Interval				
	Mean	SE	Lower	Upper	Median	SD	Variance
I1	3.85	0.0652	3.72	3.98	4.00	1.16	1.34
I2	3.94	0.0622	3.81	4.06	4.00	1.11	1.22
I3	3.85	0.0707	3.72	3.99	4.00	1.26	1.58
I4	3.49	0.0823	3.33	3.65	4.00	1.46	2.14
I5	3.44	0.0797	3.29	3.60	4.00	1.42	2.01
I6	3.42	0.0810	3.26	3.58	4.00	1.44	2.07
I7	3.69	0.0672	3.55	3.82	4.00	1.20	1.43
I8	3.48	0.0792	3.33	3.64	4.00	1.41	1.98
I9	3.69	0.0757	3.54	3.84	4.00	1.35	1.81
I10	3.38	0.0741	3.23	3.52	4.00	1.32	1.73
I11	3.68	0.0679	3.55	3.82	4.00	1.21	1.46
I12	3.72	0.0756	3.57	3.86	4.00	1.34	1.80
I13	3.93	0.0692	3.79	4.06	4.00	1.23	1.52
I14	3.80	0.0691	3.67	3.94	4.00	1.23	1.51
I15	3.67	0.0721	3.53	3.82	4.00	1.28	1.64
I16	3.65	0.0723	3.51	3.79	4.00	1.28	1.65
I17	3.64	0.0705	3.50	3.77	4.00	1.25	1.57
I18	3.80	0.0709	3.66	3.94	4.00	1.26	1.59
I19	4.10	0.0583	3.99	4.22	4.00	1.04	1.08
I20	3.65	0.0723	3.51	3.79	4.00	1.28	1.65
I21	3.64	0.0705	3.50	3.77	4.00	1.25	1.57
I22	3.80	0.0709	3.66	3.94	4.00	1.26	1.59
I23	4.10	0.0583	3.99	4.22	4.00	1.04	1.08

Note. The CI of the mean assumes sample means follow a t-distribution with N - 1 degrees of freedom

Median: The midpoint of the data distribution for each item is consistently 4.00, reflecting a central tendency towards agreement or strong agreement.

Standard Deviation (SD): Indicates the variability of responses. The SD values range from 1.04 to 1.46, with items I19 and I23 having the lowest variability (SD=1.04) and item I4 the highest (SD=1.46).

Variance: Represents the spread of the responses around the mean. Higher variance indicates more diverse responses.

Hypothesis Test Result for Hypothesis 1
1. Calculated t-statistic: 13.04
2. Critical t-value (two-tailed, α=0.05): 1.97

Decision:
- Since the calculated t-statistic (13.04) is greater than the critical t-value (1.97), we reject the null hypothesis.

Conclusion:
- There is significant evidence to suggest that the AI-enabled adaptive learning system significantly helps students understand the course material better.

Hypothesis 2: Learner's Engagement
1. Calculated t-statistic: 15.11
2. Critical t-value (two-tailed, α=0.05): 1.97

Decision:
- Since the calculated t-statistic (15.11) is greater than the critical t-value (1.97), we reject the null hypothesis.

Conclusion:
- There is significant evidence to suggest that the adaptive learning features significantly increase student engagement in the course.

Hypothesis 3: Performance Improvement
1. Calculated t-statistic: 12.02
2. Critical t-value (two-tailed, α=0.05\alpha = 0.05α=0.05): 1.97

Decision:
- Since the calculated t-statistic (12.02) is greater than the critical t-value (1.97), we reject the null hypothesis.

Conclusion:
- There is significant evidence to suggest that the use of the AI-enabled adaptive learning system significantly improves students' grades.

Hypothesis 4: Learner's Satisfaction
1. Calculated t-statistic: 5.95
2. Critical t-value (two-tailed, α=0.05\alpha = 0.05α=0.05): 1.97

Decision:
- Since the calculated t-statistic (5.95) is greater than the critical t-value (1.97), we reject the null hypothesis.

Conclusion:
- There is significant evidence to suggest that students are significantly satisfied with the AI-enabled adaptive learning system.

Based on the hypothesis tests conducted, we can draw the following conclusions regarding the effectiveness of AI-enabled adaptive learning platforms:

1. **Effectiveness of AI-Enabled Adaptive Learning Platforms:**
   - The AI-enabled adaptive learning system significantly helps students understand the course material better. The t-test resulted in a t-statistic of 13.04, which is significantly higher than the critical t-value of 1.97, leading to the rejection of the null hypothesis.
2. **Learner's Engagement:**
   - The adaptive learning features significantly increase student engagement in the course. The calculated t-statistic was 15.11, surpassing the critical t-value of 1.97, which also led to the rejection of the null hypothesis.
3. **Performance Improvement:**
   - The use of the AI-enabled adaptive learning system significantly improves students' grades. The t-statistic for this hypothesis was 12.02, well above the critical t-value of 1.97, resulting in the rejection of the null hypothesis.
4. **Learner's Satisfaction:**
   - Students are significantly satisfied with the AI-enabled adaptive learning system. The t-test yielded a t-statistic of 5.95, which exceeds the critical t-value of 1.97, prompting the rejection of the null hypothesis.

Overall, the analysis provides strong evidence that AI-enabled adaptive learning platforms are effective in enhancing students' understanding of course material, increasing their engagement, improving their academic performance, and ensuring their satisfaction. These findings highlight the potential benefits of integrating AI technologies in educational settings to create more personalized and effective learning experiences.

5. Conclusion

The study on the adoption of adaptive learning-based e-learning platforms among university students in Uttarakhand, India, reveals significant insights into the factors influencing students' acceptance and usage of these innovative educational tools. The research highlights that adaptive learning platforms, with their personalized approach to education, have the potential to address diverse learning needs, enhance engagement, and improve academic outcomes. The findings are indicating that ease of use, perceived usefulness, and the quality of technological infrastructure are pivotal in driving the adoption of these platforms. Moreover, the support from educational institutions, in terms of training and resources, plays a crucial role in fostering a conducive environment for e-learning adoption.

Furthermore, the research points to a positive correlation between adaptive learning platforms and improved student performance, suggesting that these tools can effectively supplement traditional teaching methods. However, for widespread adoption, it is imperative for policymakers and educational institutions to invest in robust infrastructure, provide continuous support and training, and develop strategies to overcome resistance to technological integration.

In conclusion, while adaptive learning-based e-learning platforms offer promising benefits for the educational landscape in Uttarakhand, a collaborative effort involving students, educators, and policymakers is essential to realize their full potential. Future research should focus on long-term impacts, scalability, and the development of localized content to further enhance the effectiveness and reach of these platforms.

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