

# Beyond Usage Statistics: Segmenting AI Adoption Behaviours in Teaching and Learning

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**Abstract:** *The growing use of artificial intelligence (AI) tools in educational environments has generated increased research interest in how teachers and students develop their understanding of these technologies. Existing research studies focus on specific tools used in particular fields of study but they fail to acknowledge the different ways people adopt artificial intelligence for educational purposes. In this survey-based study, using participant's responses encoded as multi-select indicators, a clustering analysis was performed to identify distinct adoption profiles, complemented by principal component analysis for visualization and interpretability. The results reveal the presence of heterogeneous user segments characterized by differing levels of optimism, scepticism, and resistance toward AI adoption in education. The findings highlight key factors influencing AI acceptance and the need to address the challenges in educational settings.*

**Keywords:** Artificial Intelligence, Clustering Analysis, PCA

## I. INTRODUCTION

The fast development of modern artificial intelligence (AI) tools has created new opportunities for improving teaching and learning activities. Educational institutions use AI-powered technologies to create revolutionary educational tools that provide personalized learning pathways and automatic assessment and content creation capabilities. The growing accessibility of these tools requires educational institutions to study how teachers and students perceive and use them in order to establish effective educational practices. The implementation of artificial intelligence for educational purposes has not been adopted uniformly. Stakeholders differ widely in how they interpret the benefits of AI, the challenges associated with its use, and its role in comparison to traditional instructional approaches. The public evaluation of these elements occurs through a combination of ethical considerations, data privacy issues, infrastructure readiness and pedagogical alignment together with their perceived impact on learning outcomes. The educational community shows different behavioural and attitudinal patterns in AI adoption.

The existing research on artificial intelligence applications [1 – 5] in educational settings mostly studies tool usage statistics or evaluates separate systems that operate in specific educational domains. Educational stakeholders show different ways to understand and adopt new technologies which researchers fail to address. The understanding of different behavioural patterns is crucial to achieve proper AI implementation in educational systems. Motivated by this gap, the present study adopts a perception-driven approach to examine how AI tools are viewed in terms of concerns, implementation challenges, perceived educational impact, and comparisons with traditional teaching methods.

## II. BACKGROUND: ARTIFICIAL INTELLIGENCE IN TEACHING AND LEARNING

Modern AI tools offer innovative solutions to cater diverse student and teacher needs and enhance their efficiency. These tools support a wide range of educational activities, including personalized learning, intelligent content generation, automated assessment and feedback, and learner support through virtual assistants. By leveraging advances in machine learning, natural language processing, and data analytics, AI-driven educational technologies are reshaping how instructional content is delivered, assessed, and supported. One of the central ideas underlying AI-supported



education is personalized learning, which focuses on adapting educational content to individual learner capabilities. In conventional educational settings, such personalization was primarily achieved through one-to-one mentoring. With the evolution of AI, this concept has expanded into intelligent tutoring systems that makes use of computational models to support individualized instruction [6]. Technologies such as intelligent tutoring systems [7] and personalized learning platforms [8] enable students to progress at their own pace, address learning gaps, and develop a deeper understanding of subject matter.

In addition to personalization, AI has significantly influenced the generation and organization of educational content. Techniques based on Natural Language Processing (NLP) allow systems to automatically create instructional resources, including summaries, quizzes, and explanatory materials, from textbooks, lecture notes, and other academic sources by analysing curriculum requirements and user preferences [9]. These AI-generated resources complement traditional teaching materials and provide learners with additional opportunities for revision and reinforcement. Such platforms assist educators in efficiently discovering, organizing, and sharing instructional materials, thereby reducing the time and effort required for lesson planning and curriculum development [10].

AI technologies have also reshaped assessment and feedback mechanisms within educational environments. Conventional assessment practices are often limited by time-intensive grading procedures and delayed feedback. AI-enabled systems address these limitations by automating evaluation processes and offering timely feedback to learners [11]. Machine learning models are capable of assessing assignments, quizzes, and examinations with considerable accuracy, allowing educators to allocate more time to instructional and mentoring activities [12]. Beyond automated grading, AI-based feedback systems analyse learners' progress in detail, identify areas requiring improvement, and provide personalized recommendations [13].

Another growing application of AI in education involves virtual teaching assistants and chatbots, which are increasingly used to support instructional and administrative tasks [14]. These systems can respond to student queries, offer explanations, and provide guidance related to coursework and assignments by employing Natural Language Understanding (NLU). Additionally, data collected through student interactions with these systems can help educators detect recurring questions, misconceptions, and learning difficulties, contributing to more informed instructional decision-making.

### III. METHODOLOGY

This study uses a quantitative exploratory research design to investigate how education stakeholders adopt artificial intelligence technology in their teaching and learning practices. Data were collected through a structured online questionnaire distributed among teachers, researchers and students in higher education institutions.

Several questions in the survey allowed respondents to select multiple options. Each response option from these multi-select questions was transformed into a binary variable, indicating the presence or absence of that choice for a given respondent. This preprocessing step resulted in a high-dimensional feature space in which each respondent was represented by a binary vector reflecting their perceptions and attitudes toward AI adoption.

Prior to advanced modelling, descriptive frequency analysis was conducted to examine the distribution of responses across key perception variables. This step provided an initial overview of respondents' views regarding the benefits, concerns, challenges, and comparative effectiveness of AI tools in teaching and learning. Unsupervised cluster analysis was then performed directly in the high-dimensional binary feature space to segment respondents based on similarities in their AI-related perceptions and adoption behaviours. The number of clusters was selected empirically by examining cluster interpretability and separation, yielding distinct and meaningful behavioural segments within the dataset. Following clustering, Principal Component Analysis (PCA) was applied to present intuitive visual inspection of cluster structure.

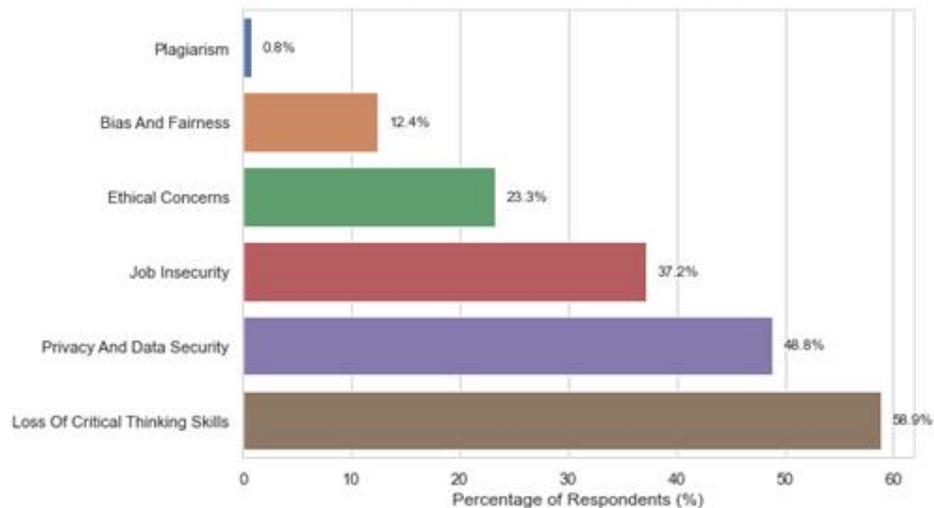


#### IV. RESULTS AND DISCUSSION

This section presents the empirical findings of the study and discusses respondents' perceptions of AI tools in teaching and learning contexts. The results highlight key concerns, perceived challenges and impacts, and comparative advantages of AI-enabled approaches over traditional teaching methods. Together, these findings provide an overview of prevailing attitudes toward AI adoption in education and form the basis for subsequent cluster-based segmentation of adoption behaviours.

##### 4.1 Concerns Regarding the Use of AI in Education

The distribution of respondents' concerns related to the adoption of AI tools in educational settings is illustrated in Figure 1. The most frequently reported concerns were **loss of critical thinking skills** and **privacy and data security**, indicating apprehension about over-reliance on AI systems and the protection of sensitive academic data. **Job insecurity** also emerged as a notable concern, reflecting fears regarding the potential displacement of educators or academic support roles. Concerns related to **ethical issues** and **bias and fairness** were reported by a moderate proportion of respondents, suggesting awareness of algorithmic transparency and equity issues.



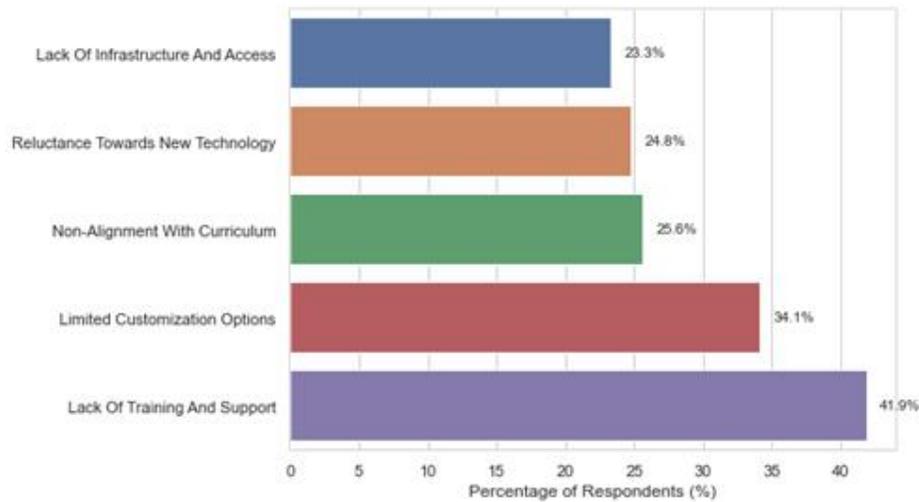
**Figure 1: Concerns regarding use of AI in Education**

In contrast, **plagiarism** was selected by comparatively fewer respondents, implying that concerns extend beyond academic misconduct to broader pedagogical and societal implications. Overall, the results indicate that while AI tools are increasingly visible in educational contexts, their adoption is accompanied by substantial apprehension related to cognitive, ethical, and data-related risks.

##### 4.2 Challenges in AI adoption

The integration of AI technologies into teaching and learning is accompanied by a range of practical and institutional challenges that influence their effective adoption. As shown in Figure 2, the most prominent challenge identified was **lack of training and support**, highlighting the need for institutional capacity building and professional development initiatives. **Limited infrastructure and access** was another major barrier, particularly relevant in resource-constrained educational environments. Respondents also reported **reluctance toward new technologies** and **non-alignment with existing curricula**, suggesting that resistance is not solely technological but also pedagogical in nature. **Limited customization options** further point to concerns about the flexibility of AI tools in addressing diverse instructional needs. These findings suggest that successful AI integration requires not only technological availability but also systematic support, curriculum alignment, and user readiness.

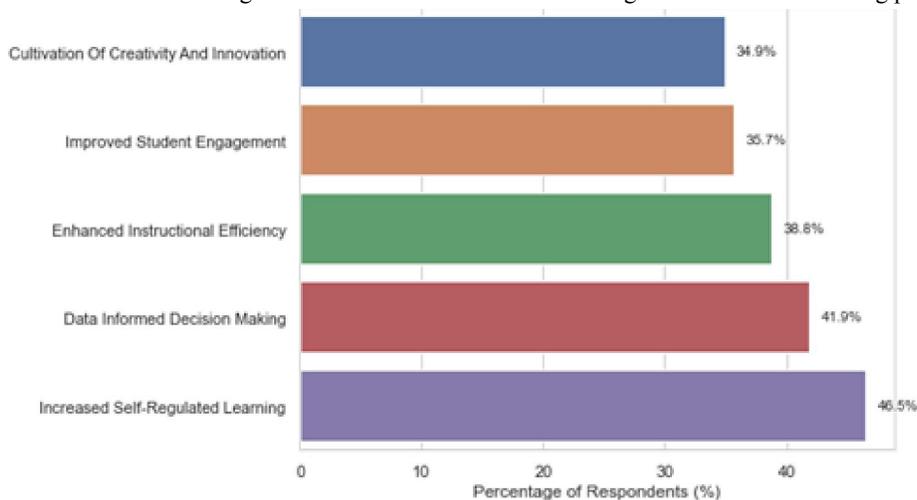




**Figure 2: Challenges in implementing AI Technologies in Education**

#### 4.3 Perceived Impact of AI Tools on Teaching and Learning

Respondents expressed largely positive expectations regarding the impact of AI tools on educational outcomes. As depicted in Figure 3, the most frequently reported benefit was increased self-regulated learning, indicating a strong perception that AI technologies can support learner autonomy and adaptive pacing. A substantial proportion of respondents indicated that AI can enhance **instructional efficiency** and support **data-informed decision making**, underscoring the role of AI in reducing administrative workload and enabling evidence-based teaching practices.



**Figure 3: Perceived impact of AI tools on teaching and learning outcomes**

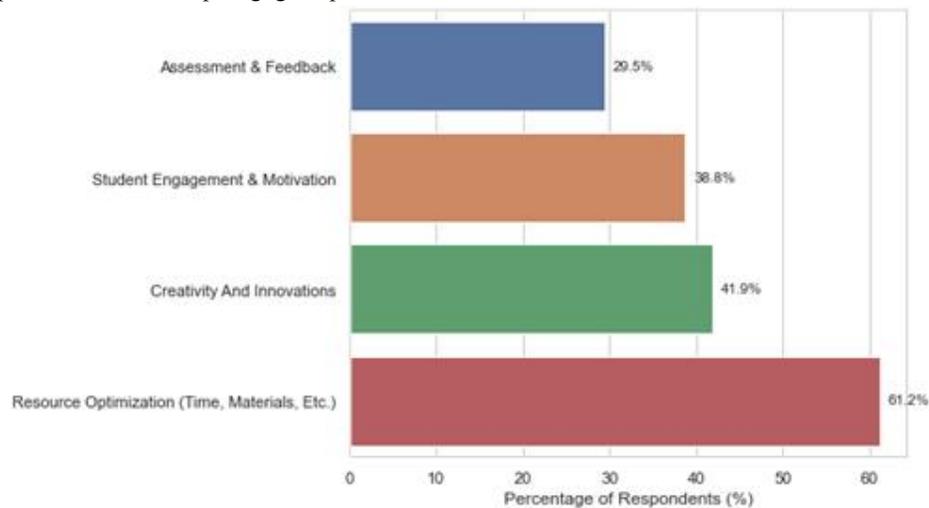
Additionally, respondents acknowledged the contribution of AI to the **cultivation of creativity and innovation**, although to a slightly lesser extent. Overall, these results reflect a cautiously positive outlook on the pedagogical benefits of AI, provided that its integration is thoughtfully managed.

#### 4.4 AI Tools Compared to Traditional Teaching Methods

Respondents were asked to indicate the teaching and learning aspects they believe are better addressed by modern AI tools when compared to traditional approaches. The results reveal a clear perception that AI tools offer notable



advantages in resource optimization, particularly in terms of time management, instructional planning, and efficient access to learning materials. Creativity and innovation, along with student engagement and motivation, were also frequently identified as areas where AI tools are perceived to outperform traditional methods. These findings suggest that respondents associate AI-driven technologies with more interactive and adaptive learning environments. Respondents also reported favourable perceptions of AI tools in terms of **assessment and feedback**, highlighting the ability of AI-based systems to provide timely, personalized, and scalable feedback compared to traditional manual evaluation methods. However, the variation in response percentages across different dimensions indicates that respondents do not uniformly perceive AI as superior in all aspects. Instead, AI is largely perceived as an augmentative tool that complements traditional pedagogical practices.



**Figure 4: Teaching & learning aspects perceived to be better supported by AI tools compared to traditional methods**

#### 4.5 Clustering Analysis and Visualization

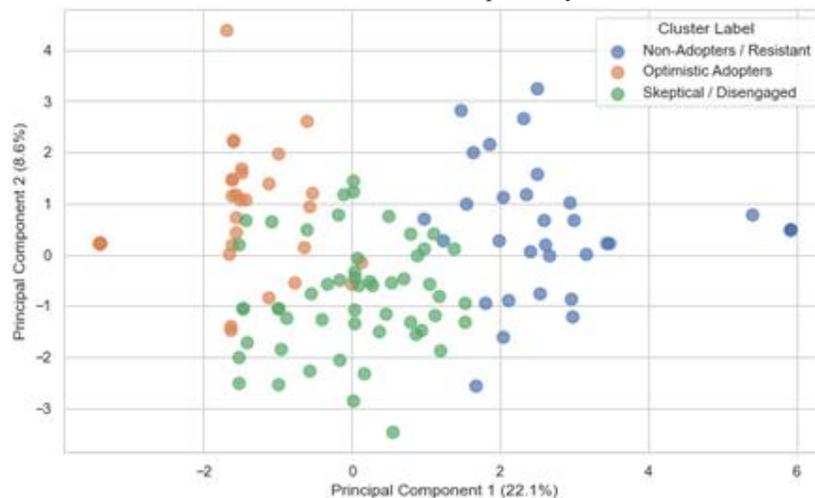
To identify distinct patterns in respondents' perceptions of artificial intelligence in teaching and learning, a clustering analysis was conducted using survey responses related to perceived concerns, implementation challenges, anticipated impact, and comparisons with traditional teaching approaches. All variables were encoded as binary indicators derived from multiple-choice selections, and clustering was performed on a standardized feature space to ensure that each dimension contributed equally to the analysis. K-means clustering was applied in the original high-dimensional feature space to ensure that the full complexity of respondents' response patterns was preserved during cluster formation. The number of clusters was set to three ( $k = 3$ ) to achieve a balance between data-driven segmentation and interpretability. From a conceptual standpoint, technology adoption literature [15] commonly distinguishes between optimistic adopters, sceptical or disengaged users, and resistant or non-adopters. This tripartite structure aligns well with the nature of AI adoption in teaching and learning contexts, where perceptions tend to polarize around these three behavioural profiles.

The resulting clusters reveal three distinct AI adoption personas. The largest cluster represents respondents who express consistently high levels of concern while simultaneously acknowledging several positive impacts of AI. This group reflects a cautious stance toward AI adoption and is therefore characterized as **Non-Adopters / Resistant**. Respondents in this cluster appear aware of AI's potential benefits but remain apprehensive due to ethical, infrastructural, and pedagogical concerns. A second cluster is characterized by strong endorsement of AI's positive impact across instructional efficiency, student engagement, creativity, and decision-making, accompanied by relatively lower



emphasis on challenges and concerns. This cluster represents **Optimistic Adopters**, who perceive AI tools as effective enhancements to traditional teaching methods. The third cluster comprises respondents with minimal selection across concerns, challenges, perceived impact, and comparative dimensions. Rather than indicating neutrality, this pattern reflects limited engagement with AI altogether. Accordingly, this group is interpreted as **Sceptical / Disengaged**, representing respondents who neither strongly oppose nor actively endorse AI tools. This pattern may reflect limited exposure to AI technologies and lower awareness of their potential.

For visualization purposes, Principal Component Analysis (PCA) was subsequently employed to project the high-dimensional data onto a two-dimensional space. PCA reduces dimensionality by identifying orthogonal components that capture the maximum variance in the data, enabling visual inspection of cluster separation. The first two principal components accounted for 22.1% and 8.6% of the total variance, respectively.



**Figure 5: PCA based Cluster Visualization of AI Adoption Segments**

Despite the dimensionality reduction, the PCA visualization reveals discernible grouping tendencies corresponding to three segments, supporting the adequacy of  $k = 3$  for capturing meaningful variation in respondents' AI adoption perspectives as shown in Figure 5. This visualization demonstrates that respondents grouped together by K-means in the original multidimensional space remain proximally aligned in the reduced PCA projection.

## V. CONCLUSION

Through a combination of descriptive analysis, clustering, and visualization techniques, the paper provides insights into how AI tools are perceived by educational stakeholders. These insights can inform educators, policymakers, and system designers about existing barriers and support the development of better AI-enabled educational strategies. The findings highlight that AI adoption in teaching and learning is not uniform, but shaped by distinct attitudinal and behavioural patterns. Recognizing these different adoption profiles is essential for designing targeted interventions, capacity-building initiatives, and policy frameworks that promote responsible and effective integration of AI in education. Overall, the study underscores the importance of moving beyond usage statistics to develop a more refined understanding of how educational stakeholders interact with emerging AI technologies.

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