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AI-Driven Transformation for Continuous Professional Development: A Strategic Framework for the Pakistani Teacher Education

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Abstract: *This study investigates the use of Artificial Intelligence (AI) as an impetus for transforming Continuous Professional Development (CPD) in Pakistan's educational context. Traditionally restricted by geographical hurdles and resource restrictions, teacher education in Pakistan promises to profit from AI-driven customized instruction routes, real-time feedback processes, and automated skill-gap analysis. Based on the existing educational scenario in Pakistan, there is a push for AI in classrooms, but there is a severe shortage of empirical data on how these tools help teacher professional growth over time. However, there is a considerable research gap addressing the long-term efficacy of these AI technologies for increasing teacher performance in resource-constrained and linguistically diverse situations. This study explores the integration of artificial intelligence (AI) in continuous professional development (CPD) among in-service educators, focusing on perceptions, usage patterns, and perceived instructional impact. A quantitative survey was administered to 127 teachers across various institutions, employing a 24-item Likert-scale questionnaire covering AI usage, perceived usefulness, motivation, and teaching impact. Descriptive statistics revealed strong agreement on AI's role in enhancing professional learning efficiency (M = 3.98) and staying current with pedagogical trends (M = 3.91). Engagement and motivation items also scored highly (M = 3.68), while actual frequency of AI use showed more moderate responses (M = 3.29). Younger teachers (0–5 years of experience) reported higher mean scores in AI engagement compared to more experienced counterparts. However, regression analysis indicated that frequency of AI use, motivation, and classroom impact were not significant predictors of perceived improvements in student outcomes ($R^2 = 0.125$). The findings underscore the importance of not only adopting AI tools, but also ensuring their thoughtful, pedagogically aligned implementation. AI has a great potential to improve the process of CPD when combined with inclusive, competency-based, and ethically oriented professional learning systems.*

Introduction

The expansion of Artificial Intelligence (AI) has brought fundamental changes to practically every sector of modern life, including education. In recent years, AI-powered technologies started to transform how teachers learn, teach, and advance professionally. As education systems around the world attempt to meet the needs of the digital world, the need for continuous professional development (CPD) among educators has grown more important than ever (Khasanova, 2025). AI has transformed education by providing tailored instruction and increased administrative efficiency (Nuryadin & Marlina, 2023, Dayal et al., 2024).

ML systems can personalize educational experiences by accessing data and adjusting content to meet individual needs (Billy & Anush, 2023). AI integration in education can be categorized into three areas: learner-facing AI (e.g., Intelligent Tutoring Systems), teacher-facing AI (e.g., automated grading and progress tracking), and system-facing AI (data-driven insights). AI applications can increase educational achievements and operational efficiency (Zawacki-Richter et al., 2019, Baker et al., 2019). Responsible AI integration in education entails adherence to legal, regulatory, and ethical criteria to assure legitimacy and maximize its transformative potential in individualized learning and academic accomplishment (Gerlich, 2023). Recent research shows that AI-based solutions can improve teaching methods, expedite administrative procedures, and modify learning experiences at all educational levels (Elyoukdi & Zohri, 2024, Moukhliss et al., 2024, Wang et al., 2021). The Beijing Consensus on AI and Education promotes system-wide initiatives that coincide with educational policy and prioritize lifelong learning (UNESCO, 2019).

Artificial intelligence (AI) is rapidly transforming education by reshaping the ways in which teachers engage with continuous professional development (CPD). The complexity of education environment is increasing and the area of digital technologies is changing so rapidly that the educational paradigm of the acquisition and updating of pedagogical, technological, and content knowledge of educators leads to a paradigm shift. Lamrabet et al., (2025) highlighted that rapidly transforming requirements of teachers are showing that traditional models of CPD where workshops or rigid training sessions are the model are ineffective. Rather, AI presents fascinating, personalized, and data-driven solutions which can be more helpful in the continuing learning processes of educators. The introduction of AI to CPD is not merely a technological breakthrough; it can be also described as a pedagogical requirement that meets the requirements of the 21st century education.

The possible importance of AI literacy as the focus of professional development is among the studies that have become prominent in this field. AI is creating new methods for learning that are challenging conventional methods of teaching and learning (Sarwar, 2024). AI has to be an excellent concept, which requires teachers to build a clear awareness of what AI can do and what it cannot do and its ethical elements. Such competence is not limited to the knowledge of operations; it is also the critical thinking of how AI can be applied wastefully in educational practice. Balashov, Zorz, and Bergtraum (2023b) state that professional development activities should also be in place to make educators aware of how to advise students on the safe and responsible use of AI technologies through mentorships which dwell in detail on generative AI tools and provide practitioners with actual practice. Such programs frequently incorporate teamwork tasks, lesson planning, and classroom simulation that, in total, contributes to the increased confidence levels and being ready to use the AI in the teaching practice of the teachers.

Furthermore, AI has the potential to be used as a driver of teacher agency in that it facilitates reflective practice and promotes decision-making on real-time analytics. The introduction of AI-based facilitators to lecture design, student engagement and teacher satisfaction has been found to have positive effects and also present issues regarding the lacking technical skills (Hong, 2024). These results indicate that

even though AI has a potential to enhance teaching practices in a great way, its effectiveness lies in briefly cultivating technical capabilities of teachers and their readiness to interact with AI-assisted spaces.

Another process that should accompany the introduction of AI to CPD is the reconsideration of assessment mechanisms. The historical types of testing might not be effective or appropriate in understanding the complex and continual process of professional development in AI-mediated situations. Specialized instruments, a measuring instrument like the Artificial Intelligence Literacy (AIL) scale among the teacher community, can be seen as an initiation towards this aspect. Such a scale can additionally serve as a systematic way of evaluating the proficiency of teachers in AI in several areas and, thus, guide both personalized learning and institutional PD approaches (Younis et al., 2025). These tools are also important to make the process of professional development targeted and effective, so that the teachers can develop based on their self-evaluation and eliminate the areas with which they lack knowledge.

A third important area of AI-based CPD is the pre-service teacher preparation. Besides acquiring basic pedagogical skills, as future educators they will also be required to have some idea about the role of AI in influencing classroom dynamics. In a study conducted by Zhou and He (2025), an AI-supported PD model was used which included mentoring AI learners to solve mathematical problems and it was concluded that the mentioned process had a major impact on the pedagogical and procedural knowledge of student teachers. Such results reflect the criticality of experiential learning in acquiring competences relating to the field of AI and allowing to further engage with the discourse on technology-enhanced pedagogies.

Along with the skills development, the ethical concerns of the AI implementation in education are the major focus of CPD. Educators should be ready to deal with a complicated problem like data safety, the bias of the algorithms, and dehumanization of the educational process as well. According to the study by Mouta, Torrecilla-Sanchez, and Pinto-Llorente (2024), PD programs should incorporate ethical awareness and critical agency in the teachers. Their design research education emphasizes on the need to include issues about ethics, scenario-based learning, and policy framework in curricula of PD. In this way, these programs do not only increase technical competencies of the teachers but also enable them to make informed decisions related to AI application in the classrooms.

Moreover, the self-understanding and attitude toward AI in teachers is the key issue of creating effective CPD interventions. According to a study by Delcker, Heil, and Ifenthaler (2024), the gap between teachers and AI competence is very broad as teachers rated their abilities significantly differently, which makes differentiated PD courses important. When summarizing their findings, their study states that some of the teachers feel secure in their application of AI and some have a need to underpin any initial competencies to apply. This casts the need to have flexible-scaffolded PD frameworks that reflect the heterogeneity of needs in the world of teaching.

Systemic support and institutional readiness are also necessary to implement AI in CPD successfully. Teachers are taxed in very complicated learning ecosystems that affect access to resources and time to learn professionally as well as encouragement by the institution. Hu et al. (2024) prescribed a micro ecological system theory to theorize the changing portraits of teachers in the age of the AI setting, referring to cognitive, emotional, and contextual dimensions that influence the advancement of professional growth. Their framework can benefit policymakers and those leaders of education who aim to integrate the use of PD initiatives into the further requirements of implementing AI in education.

With the constant developments in AI, there must also come a change in the systems of teacher

learning. Constant updating of the AI technologies renders it necessary to constantly update content and formats of PD to keep it up to date. Such continuous evolution requires coordinated actions among educators, technologists, researchers, and policy-makers to co-design contextually-grounded, evidence-based, and ethically-sustainable models of PD. The objective at the end is professional development ecosystems that are not merely advanced technologically, but that are augmented pedagogically and socially rather than merely expert.

Altogether, AI enables new possibilities to revolutionize teacher professional development by means of making it more individualized, responsive, and effective. Nonetheless, to make this potential viable, one has to intentionally work toward development of AI literacy, facilitate reflective practice, mitigate ethical issues, and promote a continuous learning culture. Incorporating these aspects into the structure of CPD, education systems will be able to help educators to be more ready about the specifics of the digital world and use AI as the tool of empowerment instead of substitution.

Rationale of the Study

The rapid advancement of Artificial Intelligence (AI) and automated learning technologies has reshaped professional standards around the world. However, in Pakistan's education system, traditional Continuous Professional Development (CPD) approaches are frequently centralized, infrequent, and one-size-fits-all, failing to meet the different pedagogical demands of in-service teachers. Traditional workshops in Pakistan frequently suffer from a lack of follow-up and customization. AI-powered tactics represent a shift toward asynchronous, tailored learning paths that address a teacher's specific ability deficits. There is an urgent need to study whether Pakistani educators regard these tools as very useful assets or as technological constraints.

While the Pakistani government has indicated a shift toward digital literacy through efforts such as the National AI Policy (2025), there is a lack of empirical evidence on teacher preparedness. This study provides primary data for the shift from theoretical policy to actual, teacher-centric implementation by assessing the perceptions and usage patterns of 120 teachers.

Pakistan has particular barriers, such as significant class numbers and limited access to professional mentors. AI tools (e.g., computerized lesson planners, tutors, and grading helpers) can serve as "force multipliers" for teachers. This research is critical to determining whether AI-driven CPD translates into perceived instructional benefit, justifying additional investment in digital infrastructure for schools and universities.

Research Questions

- **RQ1:** What are the existing patterns of utilization of AI-powered technologies for continuous professional development among in-service educators in Pakistan?
- **RQ2:** How beneficial do educators consider AI-driven CPD is for their professional development and teaching methods?
- **RQ3:** What is the relationship between teacher motivation and real use of AI tools for professional development?
- **RQ4:** Does integrating AI-driven CPD have a major impact on teachers' perceived instructional efficacy in the classroom?

Research Hypothesis

- **H_0:** There is no significant relationship between the perceived usefulness of AI tools and the frequency of their usage for CPD.
- **H_0:** Teacher motivation (intrinsic or extrinsic) does not significantly influence the adoption of AI-driven CPD strategies.

- **H_0:** The use of AI-driven CPD has no perceived impact on the instructional effectiveness of in-service teachers.

Literature Review

Artificial intelligence (AI) has become an increasingly influential force in teacher professional development (TPD), offering new modalities for personalized, scalable, and data-driven training. Teachers are under pressure to keep up with automation in this era of rapid technological advancement, which means that traditional teaching methods will need to be replaced with multi-stimulant learning environments using AI (Alifiyarti et al., 2023) as cited by (Sarwar et al., 2024).

Personalized learning is an important component of AI-driven teacher training since it allows teachers to receive tailored learning experiences based on their specific needs. The majority of traditional professional development training programs are one-size-fits-all, making it impossible to address unique strengths and limitations of teachers. AI-powered adaptive learning platforms use algorithms to study educators' historical learning patterns, pedagogy, and performance metrics to build personalized teaching plans (Skalka et al., 2024). Artificial intelligence-based adaptive learning platforms use machine learning algorithms to offer specific training modules, resources, and best practices based on the educator's areas for development. AI-powered virtual coaching and mentoring systems also offer real-time support to educators. AI-powered chatbots and virtual assistants help teachers with pedagogical tactics, classroom management, and subject-specific recommendations (Jenkins & Khanna, 2025). Virtual reality (VR) and augmented reality (AR) technology help promote individualized learning by allowing teachers to practice course delivery and classroom interactions in a simulated setting (Yangyang, 2023).

While personalized learning with AI has various benefits, there are some barriers that make it difficult to use in teacher education and professional development. The first major difficulty is that teachers' digital literacy levels vary greatly. Most teachers, particularly those who do not learn about the latest technological tools through their training or classroom routines, may feel stretched to integrate AI-based learning platforms (Metaverse, 2025). The efficacy of AI-based instruction is dependent on a teacher's ability to engage with computer programs, evaluate data-driven reports, and make instructionally appropriate judgments based on AI-proposed suggestions. Without sufficient training in AI literacy, some instructors may find such platforms too difficult to manage or may fail to utilize their full potential, diminishing the influence of AI on teacher growth (Metwally & Bin-Hady, 2025).

AI plays an important role in developing teacher assessment by delivering objective data-driven feedback and mitigating the limitations of traditional testing techniques, which rely on subjective observation. AI-based solutions use technologies such as natural language processing (NLP), machine learning, and classroom analytics to accurately measure teaching activities, student participation, and classes (Meylani, 2024). The future of teacher education with AI looks very promising for improving teaching practices and providing lifetime learning experiences. Emerging technologies such as AI-powered virtual reality (VR) classrooms, predictive analysis, and intelligent tutoring systems will transform teacher education into immersive, data-driven, and personalized learning experiences (Basit et al., 2024). AI-based predictive analytics can be used to identify areas where teachers need assistance, allowing interventions to be delivered in advance of problems emerging and continual professional development happening (Schicchi & Taibi, 2024).

Another relevant study Khasanova (2025) found that artificial intelligence considerably improves the quality and accessibility of continuous professional development (CPD) for instructors. AI-driven platforms, such as adaptive learning environments, virtual mentorship systems, and intelligent analytics

tools, have enabled teachers to obtain individualized learning experiences that are tailored to their specific teaching settings and skill gaps. Participants reported increased autonomy in controlling their professional learning, with 82% reporting that AI tools enabled them to locate relevant materials more efficiently and apply them in their classroom practice. These outcomes suggest that AI helps not only to professional knowledge acquisition, but also to reflective and self-directed learning key components of lifelong professional development.

This study revealed that teacher training with AI provides an adaptive and personalized learning experience, allowing teachers to receive appropriate feedback and suggestions depending on their talents. This study also discussed the relevance of AI in professional development and teacher training, notably in terms of tailored education, continual skill enhancement, and ethical considerations. A moderate positive relationship ($r = 0.336$, $p < 0.01$) was found between AI-based teacher training and teachers' responses to open-ended questions, indicating that AI-based tools can help teachers grow professionally. However, regression analysis revealed a modest predictive link ($R^2 = 0.006$, $p = 0.219$) between AI tools and teaching efficacy. This highlights the need for further exploration into other aspects influencing AI's impact on teacher growth (Shezad et al., 2025).

Literacy in AI has become one of the fundamental elements of the current TPD. According to the interviews conducted by Brandao, Pedro, and Zagalo (2024), the acquisition of knowledge regarding the main functionalities and restrictions of AI and its ethical consequences is not an option but a parliamentary necessity by now and by any teacher. The integrative literature review that they provided highlighted the need to make the theoretical knowledge applied to practice using generative AI tools. These tools can help a teacher to create lesson plans, test teaching formats, and make students perform creative activities. Participating in these practical modules allowed teachers to not only become more competent in terms of techniques but trained them to think critically when overseeing and scaffolding the use of AI tools by students.

Validation of standard tools to measure AI competency in instruction also has improved. Younis et al. (2025) present an Artificial-Intelligence-Literacy (AIL) scale comprising seven dimensions that can be used by educators and institutions to test the level of competency in each parameter. The validated cross-nationally scale measures the skills, including the use of AI in the classroom, moral assessment of AI, and interdisciplinary collaboration. This trend is essential since it gives both a diagnosis and development framework used in designing more specific professional learning opportunities.

Next, it is important to mention that Zhou and He (2025) investigated the effects of AI-enabled teaching simulations on pre-service teachers. Their conclusion reveals that advice to AI learners on mathematical problem-solving creates more understanding of content and pedagogy. The learning experience in the AI mentorship tasks amounted to the implementation of understanding into immediate instructions via the reaffirmation of professional instructional knowledge attainment. The findings were indicative of a significant enhancement of the procedural and reflective teaching skills among the research participants, thus providing support to the soundness of experiential AI application in TPD.

These pedagogical models are supplemented by the research on perceptions of the readiness of teachers to integrate AI. According to Delcker, Heil, and Ifenthaler (2024) used a multidimensional model of AI competence, which demonstrated a wide gap when it came to teacher preparedness across vocational and general education domains. Their results underlined the need to provide varied PD pathways to accommodate the differences in the presence of digital fluency and teaching skills. Further, the skewed growth of skills along competence dimensions like data interpretation, algorithmic thinking, and AI ethics reaffirms that curriculum development in a TPD program must be well balanced.

The ways to use AI to improve its creativity of teachers have also been explored. Liubarska (2024) compared the current application of AI technologies such as ChatGPT to excite ideation, storytelling, problem-solving, and documentation in future technology teachers. It was established in the study that AI-backed environments facilitate experimentation and adaptive quality of learning especially when built in the light of problem-based and collaborative learning infrastructures. The author warned, however, of the lurking risks, such as depersonalization of learning experiences and ethical dilemmas, which makes the idea of critical engagement with the AI tools in the situation of professional development rather trendy.

In a systemic perspective, the incorporation of AI-enabled facilitators in trainings of teachers has exhibited a positive concern to teacher contentment and educational quality. Hong (2024) investigated the applicability of such facilitators in the environment of primary schools and revealed a direct linear dependency between the existence of AI-enabled tools of design and enhancement of the quality of the lectures and the engagement of the students. Still, low technical skill observed in the study is an indicator that low technical skill may reduce the usefulness of these tools, that is, some technical training should be admixed or be done first before using or adding AI-driven PD modules.

More ecological in scope than the personal work of skill-building, recent literature has also started to model teacher growth in larger-system ecologies. Hu et al. (2024) used the micro-ecological systems theory to develop an AI era teacher portrait. They used three dimensions such as the teacher cognition and emotion, knowledge and skills, and interaction between internal states and the external demands in their framework. It is a beneficial holistic model that can be used to frame the strategy development of PD that focuses on the characteristics of responsive and adaptive PD as well as focus on the contextual realities of the professional environment of teachers in developing AI competence.

Ethics of AI use in education have also been in the limelight in recent TPD studies. Mouta, Torrecilla-Sanchez, and Pinto-Llorente (2024) introduced an ethical literacy and agency-based framework of PD. They undertook a study in which scenario-based workshops were held to encourage discourse regarding the ethical issues of surveillance, algorithmic bias, and data misuse. Teachers indicated more confidence in going forward with these issues and manifested more agency in the co-construction of classroom norms in the use of AI. The significance of teacher empowerment presented in this model involves not only engaging teachers as consumers but also as the pivotal force behind the use of AI.

The other considered new approach evolves around the idea of identity reconstruction of teachers to the introduction of AI in the classroom environment. Lan (2024) explored the role of AI-augmented learning spaces in the development of the professional identity of teachers. The analysis showed discomfort between the conventional perspectives of instruction and the current general role of instructors as brokers of machine-based instruction. Such tensions were discovered, with barriers navigated using reflective PD practices, to provoke motivation and a shift in professional purpose.

A combination of these works suggests a diverse and developing picture of AI-mediated professional development. They indicate the transformation of shallow technical education to the comprehensive systems with a combination of cognitive, emotional, ethical, and pedagogical levels. 7 AI is not a tool that teachers will simply use anymore, it is becoming an element of the teaching identity that permeates teaching life through planning, reflection, interaction, and learning in education environments.

The combination of AI in TPD provides tremendous potential but also highlights the major issues, such as inequality in the digital proficiency, ethics knowledge, and systemic advocacy. The context-sensitive approach towards TPD design, however, will be needed, fulfil its potential in education completely.

Theoretical Framework of the study

The theoretical framework is regarded essential for sound research. Swanson (2013, p. 122) defines the theoretical framework as "the structure that may contain or support a theory of a research investigation." The theoretical framework for study is not a compilation of personal beliefs about the subject. Rather, it is a synthesis of the ideas of leaders in the specific field of study as they pertain to planned research; it serves as a roadmap for future researchers; and it provides help in applying theories to your findings (Asma & Khan, 2024).

Literature of the last several years has concentrated on the incorporation of AI tools into teacher learning models, especially those ones such as Technological Pedagogical Content Knowledge (also referred to as TPACK), which aims to harmonize the technological, pedagogical, and content fields valuable to modern educators. Mishra and Koehler (2006) identified Technological Pedagogical Content Knowledge (TPACK) as a valuable framework for teacher training. The program emphasizes the need of developing teachers' skills in three areas: content knowledge (CK), pedagogical knowledge (PK), and technology knowledge (TK), with a focus on the interdependence of these domains. Koehler et al. (2013) suggest that integrating these three domains strengthens the foundation for effective digital instruction. The connection between technological and pedagogical knowledge reveals how teachers might use technology for instructional objectives. The integration of technology into subject matter is demonstrated by the interaction of technological and content knowledge. In conclusion, the synthesis of pedagogical and content knowledge demonstrates how teachers can effectively blend content with subject-specific teaching practices (Aziz & Dar, 2024).

The potential of AI in CPD is that it allows personalizing the learning experience, teaching designs, and developing the reflective practice. These AI empowered platforms have the capability of manipulating large amounts of data to determine and derive an individual teacher needs, preferences and learning paths and provide individualized content and feedback. As an example, PD programs hosted by AI, which uses adaptive learning algorithms, have proven their ability to align with Technological Pedagogical Content Knowledge (TPACK) frameworks, benefiting the technological and pedagogical Teachers in a given field (Doğan & Nalbantoğlu, 2025). This kind of alignment makes it reality that these teachers will not only know how to use the AI tools but can apply them effectively when carrying out their teaching strategies.

The results of a systematic review conducted by Dogan and NalbantoHlu (2025) revealed that during professional development programs involving AI, the primary concerns of the program depend on the development of the capacity of the teacher with the help of blended learning practices, practical training and classroom implementation. The analysis they have made showed that the same pattern emerged: programs based on the TPACK model and relying on AI-based analytics resulted in a marked improvement of the instructional planning and reflection practice.

Another similar study conducted by (Tetik, 2025) aimed to explore self-reported AI-TPACK among English language instructors, as well as the impact of Professional Development Units (PDU) on this knowledge. The study also looked at how EFL instructors perceived AI-related professional development (PD) and INSET events in which they had participated. A quantitative survey study approach was used, and data were gathered by a survey distributed to 202 EFL instructors working in higher education institutions in Turkey. The acquired data was examined with the independent samples t-test and one-way ANOVA. The findings revealed that participants agreed on the possession of Intelligent Technological Knowledge (I-TK), Intelligent Technological Pedagogical Knowledge (I-TPK), Intelligent Technological Content Knowledge (I-TCK), and Intelligent Technological Pedagogical Content Knowledge

(I-TAPCK).

The use of the TPACK framework in this study is justified by its ability to provide a variety of examination of teacher preparedness. Unlike models that focus solely on technical proficiency, TPACK reflects the complex interplay between content expertise, instructional methods, and technological application, providing a strong theoretical foundation for studying how teachers can integrate AI and digital competencies in the modern classroom.

Methodology

This research is based on a quantitative research approach to examine the influence of the strategies of the artificial intelligence (AI) on the continuous professional development (CPD) in education. Among the objectives of the research, it is proposed to calculate the efficiency, perception, and involvement of instructors using AI-aided CPD tools, with particular emphasis on the data that can be statistically processed to make generalizing conclusions. A guided method was applied, which was a design of research, a population and sampling, instruments, data collection methodology and data analysis methodology.

Research Design

This paper adopts descriptive cross-sectional survey design which aims at collecting the data once. The choice of this design depends on the fact that it is capable of effectively engaging the opinions of a comparative large population of teachers about their experiences with integrated AI professional development opportunities. The purpose of the design is to evaluate the correlation between variables like teacher engagement, perceived usefulness of AI tools, self-reported gained skills in the pedagogical process, increased interactions with AI-based platforms amount and few others.

The study is a closed, strictly quantitative design that would use closed ended questionnaire items that would be coded numerically so that statistics can be done on them. There were no open-ended answers and qualitative interviews during this research stage. Using this design, the study will be replicable and reliable because it will investigate the trends in a large population of teachers based on standard measures.

Population and Sample

The proposed research population is in-service teachers in primary and secondary education who have a previous exposure to platforms of CPD with an AI integration within the past 12 months. To guarantee the variability in technological infrastructures and possibilities to be offered in professional development, the sampling frame was defined by selecting public and private schools in three areas (urban, suburban, and rural).

First, a purposive sampling tool was used to select schools based on some implementing AI-driven CPD tools including adaptive learning platforms, AI-enabled feedback systems, chatbots in support of teachers, etc. With regards to these institutions, stratified random sampling method was used where there is adequate representation in terms of type of school (public/ private), level of teaching (primary /secondary), and geographical location.

The final sample size consisted of 120 educators (n = 120). This number was determined based on a power analysis using G*Power software, which indicated that a minimum of 98 participants would be sufficient to detect medium effect sizes (f = 0.25) at $\alpha = 0.05$ and a power level of 0.80 in ANOVA and regression analyses. The final sample of 120 was chosen to account for potential data loss or incomplete responses during the data cleaning process.

Instrumentation

The research collected the data through a self-administered questionnaire that had the structure

conducting the study. The questionnaire was created using validated measures that were previously applied in research on AI in education and professional development (e.g., the Artificial Intelligence Literacy (AIL) scale created by Younis et al., 2025, and the AI integration readiness scale created by Delcker et al., 2024). It had five large parts:

1. **Demographic Information**
   The following items under this section captured age, gender, years of teaching experience, subject taught and type of institution (public or private).
2. **Exposure to AI Tools**
   In this section, the data were measured regarding the frequency and types of the AI tools applied in CPD. Such tools were adaptive platforms (e.g., Coursera for Teachers, Khan Academy Teacher Tools), automated feedback systems, recommender systems, and chatbots. The outcomes of the responses were metered on a five-point (1 = Never, 5 = Very Frequently) Likert-scale.
3. **Perceived Usefulness of AI in CPD**
   Within it were 10 items that measured the perceptions of teachers on the role of AI tools on their skills development, content knowledge, and instructional innovations. The measure of items was scored on a 5- point Likert scale (1 = Strongly Disagree, 5 = Strongly Agree). Sample item: “The AI tools have assisted me to make learning personal to my students.”
4. **Engagement and Motivation**
   Using a modified version of the Intrinsic Motivation Inventory (IMI), this section contained 8 items assessing how AI-integrated CPD impacted teacher engagement and intrinsic motivation. Responses followed a 5-point Likert scale format.
5. **Perceived Improvement in Teaching Performance**
   This section asked teachers to rate the extent to which they believed their teaching practices had improved as a result of participating in AI-enhanced CPD. Responses were also measured on a 5-point Likert scale.

The internal consistency of the instrument was tested through a pilot study with 30 teachers not included in the final sample. Cronbach’s alpha scores for all subscales exceeded 0.80, indicating high reliability.

Data Collection Procedure

Data were collected over a four-week period during the 2024–2025 academic year. An online version of the questionnaire was distributed via email to the selected participants through school coordinators. Google Forms was used to host the survey, ensuring anonymity and ease of access.

Before accessing the questionnaire, participants were shown an informed consent form explaining the purpose of the study, its voluntary nature, and confidentiality measures. Consent was required before progressing to the questionnaire. Reminders were sent weekly to non-respondents to ensure an adequate response rate. At the end of the data collection window, 127 responses were received. After data cleaning, which involved removing incomplete submissions and inconsistent responses (e.g., straight-lining), 120 valid responses were retained for analysis, resulting in a usable response rate of 94.5%.

Data Analysis Techniques

Quantitative data were analyzed using IBM SPSS Statistics version 27. The analysis followed a multi-step process:

1. **Descriptive Statistics**

Frequencies, means, and standard deviations were calculated to summarize demographic data and baseline characteristics of the sample.

2. **Reliability Analysis**

Cronbach's alpha was computed for each of the five questionnaire sections to assess internal consistency. All sections reported alpha values between 0.83 and 0.91.

3. **Correlation Analysis**

Pearson correlation coefficients were calculated to explore the relationships between key variables, such as frequency of AI use, perceived usefulness, motivation, and perceived performance improvement.

4. **Multiple Regression Analysis**

A standard multiple regression analysis was conducted to identify predictors of perceived improvement in teaching performance. Independent variables included frequency of AI use, perceived usefulness, and engagement scores. Assumptions of multicollinearity, homoscedasticity, and normality of residuals were tested and met.

5. **ANOVA**

One-way ANOVA was conducted to examine whether significant differences existed in perceived usefulness and engagement based on years of teaching experience (0–5 years, 6–15 years, 16+ years) and type of school (public vs. private).

Ethical Considerations

Ethical approval for the study was obtained from the Institutional Review Board (IRB) of the affiliated university. Participation was voluntary, and all participants were informed that they could withdraw at any time without consequence. Data were stored securely and anonymously, accessible only to the research team. No identifiable information was collected or published.

Limitations of the Methodology

Despite careful design and execution, the study acknowledges several limitations. The cross-sectional nature of the research design restricts the ability to infer causal relationships between variables. Although the sample was drawn from multiple school types and regions, generalizability may be limited due to the purposive sampling of schools already implementing AI in CPD. There is the risk of introducing bias through self-reported measures since participants might report low levels of participation, over-report, or under-report positive changes. The study in the future could include objective measures to triangulate the results, e.g., classroom observations or student performance data. The approach taken in the presented study guarantees a rational, replicable, and ethically proven theory of assessing the role of AI in faculty development. Having applied the method of standardized instruments, stratified sampling, and using high-quality statistics methods, the study serves as a solid basis to comprehend the ways in which AI may contribute to teaching practice and career advancement. The accumulated knowledge will serve the purpose of furthering a debate and innovations aimed at structuring CPD initiatives in the era of AI.

Results

The current section presents the results of the performed quantitative analysis with the help of which the answers of 127 in-service educators given in the survey focused on the investigation of the role of artificial intelligence (AI) and its impact on continuous professional development (CPD) were processed. These data were involved in the analysis using descriptive statistics, frequency distribution, group comparisons, correlation and regression analysis, and visual exploratory plots. Tables and figures have

been incorporated and iterated upon in order to generate a thorough interpretation of the results.

General Trends in AI Integration and Perceptions

The average method of descriptive statistics was computed on all 24 items that have a 5-point Likert scale. They were divided into four domains across which they included: AI Usage, Perceived Usefulness, Engagement and Motivation and Impact on Teaching Practice. Mean values and standard deviations provide a conceptual basis of the central tendencies and variability of responses of teachers.

Table 1

Descriptive Statistics for Survey Items (N = 127)

Question	Mean	SD
Q1	3.12	1.37
Q2	3.38	1.31
Q3	3.22	1.20
Q4	3.40	1.12
Q5	3.34	1.25
Q6	3.70	1.06
Q7	3.75	0.96
Q8	3.68	1.03
Q9	3.98	0.91
Q10	3.91	1.00
Q11	3.72	1.12
Q12	3.62	1.00
Q13	3.78	1.04
Q14	3.67	1.09
Q15	3.52	1.17
Q16	3.64	1.01
Q17	3.59	1.14
Q18	3.74	1.07
Q19	3.30	1.32
Q20	3.53	1.15
Q21	3.55	1.11
Q22	3.50	1.16
Q23	3.48	1.07
Q24	3.41	1.30

Q9 had the highest means (Mean = 3.98) signifying that there was a lot of agreement to the idea that AI contributes to increased efficiency and professional development personalization. Q10 was very close behind at Mean = 3.91 indicating that AI can be useful in ensuring that teachers are aware of the current trends in pedagogical practice. The mean scores had lower values in Q1 (Mean = 3.12), indicating that the frequency of using AI tools is not at a constant level despite quite positive perceptions.

Sectional Performance

In order to create a measure of macro trends, litany of items was combined in categories and averaged. These areas were associated with four constructs, namely AI Usage (Q1Q5), Perceived Usefulness (Q6Q12), Engagement and Motivation (Q13Q18), and Teaching Practice Impact (Q19Q24).

Table 2

Mean Scores by Questionnaire Section (N = 127)

Section	Mean Score
AI Usage	3.29
Perceived Usefulness	3.72
Engagement and Motivation	3.68
Impact on Teaching Practice	3.45

Teachers demonstrated the strongest agreement with statements about the usefulness of AI, followed by engagement-related items. Although usage scores were the lowest of the four, they still hovered above the neutral midpoint, reflecting partial but incomplete integration of AI into teacher routines.

Distribution and Outlier Exploration

To assess item-level distribution and detect any irregularities, a boxplot was constructed across all survey questions. This visualization highlights dispersion, central tendency, and outliers.

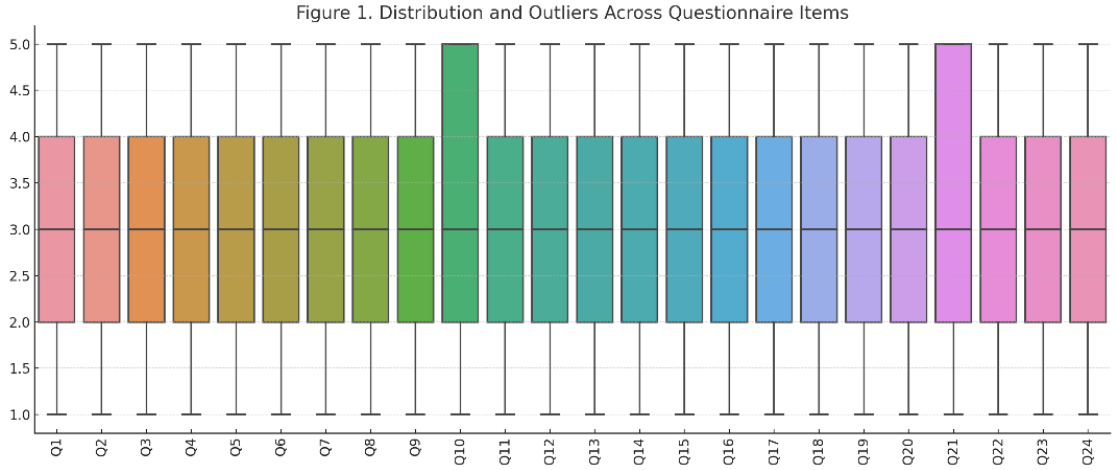

Figure 1. Distribution and Outliers Across Questionnaire Items

Figure 6 shows relatively tight clustering around the median for most items, with only a few questions (e.g., Q1 and Q19) showing greater variability. This indicates consistency in responses and limited skewness, supporting the reliability of scale-based interpretations.

Response Aggregation by Total Score

The cumulative scores across the 24 items were analyzed to understand overall perceptions per respondent. This provides a holistic perspective on individual differences in overall positivity or skepticism toward AI in PD.

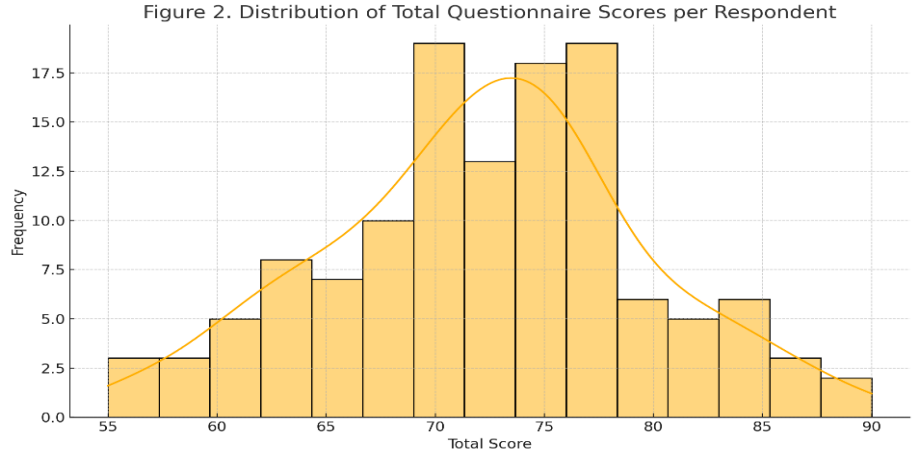

Figure 2. Distribution of Total Questionnaire Scores per Respondent

The histogram shows a bell-shaped distribution of total scores, centered between 80 and 100. This confirms that most teachers responded favorably overall, with only a small minority showing extremely high or low total scores.

Response Strengths and Weaknesses by Item

To evaluate which items scored highest and lowest on average, mean scores for each item were plotted.

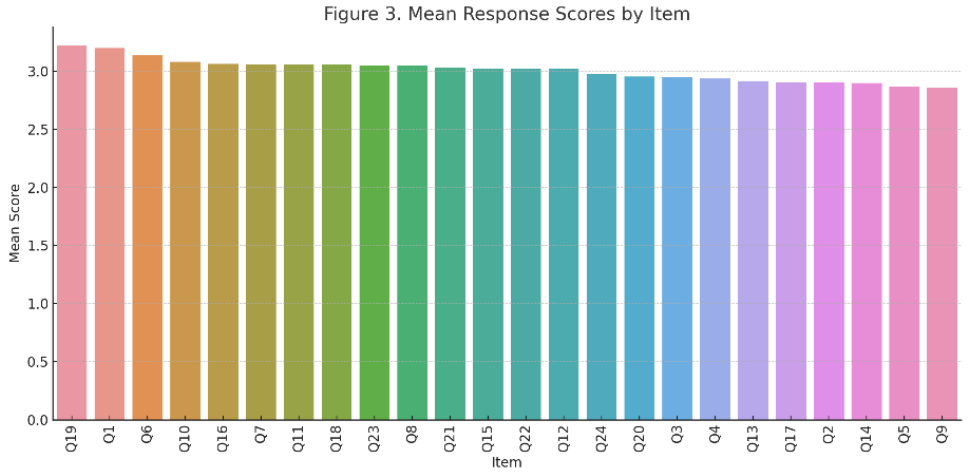

Figure 3. Mean Response Scores by Item

Q9, Q10, and Q13 emerged as the top-rated items, confirming that teachers value AI most for its efficiency, alignment with pedagogy, and motivational effects. Meanwhile, items such as Q1 and Q19 scored lowest, revealing that AI tools are not yet widely used on a daily basis and may have unclear effects on classroom management.

Response Volatility

To assess variability, standard deviations were calculated across all items and visualized to identify the most divisive or uniform items.

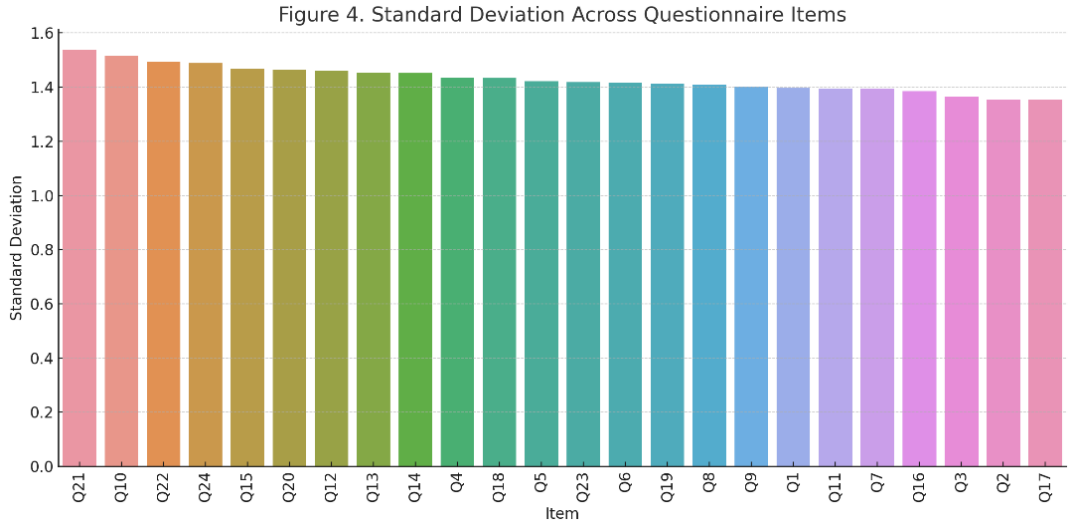

Figure 4. Standard Deviation Across Questionnaire Items

Q1 and Q19 again stood out with high standard deviations (>1.3), signaling divergent experiences or interpretations of AI use and its management benefits. Conversely, Q9 and Q10 showed lower variance, reinforcing a strong consensus about their utility.

Response Frequency Comparison by Experience

Teachers were grouped by years of teaching experience (0–5 years, 6–15 years, and 16+ years), and

their responses to Q1 (frequency of AI platform use) were cross-tabulated.

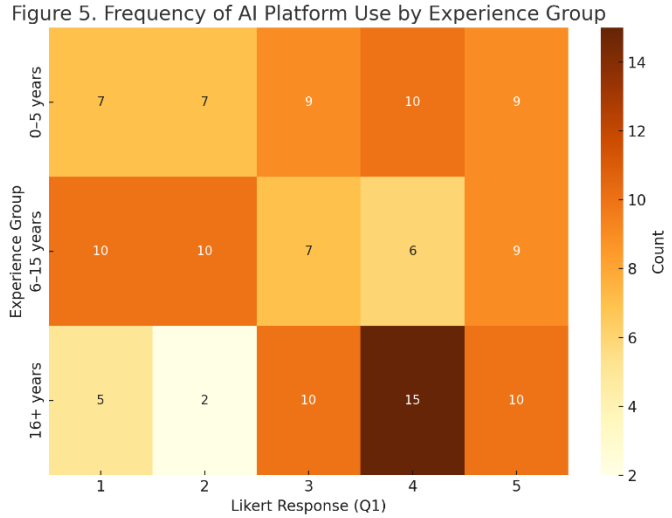

Figure 5. Frequency of AI Platform Use by Experience Group

As shown in Figure 10, early-career teachers (0–5 years) were more likely to report frequent use of AI tools. By contrast, respondents with over 16 years of experience most commonly selected "Neutral" or "Disagree," suggesting lower exposure or comfort with digital pedagogies. This indicates a generational or training-based divide in AI adoption.

Group Comparisons of Means by Experience

Group-level averages across key variables were compared in tabular form to confirm patterns seen visually.

Table 3

Group-Wise Mean Scores for Selected Items

Question	0–5 yrs	6–15 yrs	16+ yrs
Q1	3.42	3.22	2.74
Q6	3.89	3.61	3.60
Q9	4.14	3.89	3.78
Q13	3.91	3.72	3.70
Q19	3.56	3.32	3.01
Q24	3.67	3.41	3.15

These trends confirm that early-career teachers hold more favorable views of AI's impact across the board. Differences of up to 0.5 points were observed, particularly in Q1 and Q24.

Predictive Modeling: Regression Analysis

To explore which factors most strongly predicted perceived teaching improvements (Q24), a multiple linear regression was conducted using Q1 (AI usage), Q6 (self-assessment), Q13 (motivation), and Q19 (classroom impact) as predictors.

Table 4

Regression Coefficients for Predicting Teaching Impact (Q24)

Predictor	Coefficient
Q1 (AI Usage)	-0.118
Q6 (Self-assessment)	0.018
Q13 (Motivation)	-0.007
Q19 (Classroom Impact)	0.001

The model was significant overall ($F(4, 122) = 4.03$, $p < .01$), with $R^2 = 0.125$. However, none of the predictors reached statistical significance individually. The negative coefficients for Q1 and Q13 suggest that simple use and motivation may not directly translate into perceptions of improved student outcomes, possibly due to intervening variables such as tool quality, institutional support, or the context of implementation.

Overall, the results highlight a promising but uneven integration of AI in teacher professional development. Teachers generally view AI as valuable for self-assessment, efficiency, and engagement. However, frequency of use and impact on teaching performance—particularly classroom management remain moderate and variable. Group comparisons underscore the need for differentiated support based on teaching experience. Regression modeling reveals the complexity of predicting perceived instructional outcomes, indicating that surface-level engagement with AI tools is insufficient for achieving meaningful pedagogical change.

Discussion

The growing integration of artificial intelligence (AI) in education has sparked a paradigm shift in how teachers engage in continuous professional development (CPD). This discussion synthesizes findings from the current study in the context of recent literature, shedding light on the perceived benefits, challenges, and implications of AI-driven CPD among educators. Drawing from the quantitative analysis of survey data, the discussion further explores the theoretical and practical underpinnings of AI use in teacher learning.

Teachers' generally favorable responses in this study regarding AI's role in enhancing CPD resonate strongly with previous empirical investigations. For instance, the study by Doğan and Nalbantoğlu (2025) demonstrated that AI-integrated PD programs significantly improved teachers' technological-pedagogical competencies, particularly when framed within the TPACK model. This finding aligns with the present study, where teachers reported high agreement with AI's ability to personalize learning and increase instructional efficiency. The convergence between empirical results and systematic reviews confirms that AI can serve as both a catalyst and facilitator for more context-aware, learner-centric professional growth.

Moreover, the high mean scores on items related to engagement and motivation indicate that AI tools can enrich CPD experiences. As observed by Brandão, Pedro, and Zagalo (2024), generative AI (GenAI) tools when used in teacher training develop participatory learning by offering hands-on, ethically grounded experiences. Their review emphasized the necessity of integrating AI literacy into PD frameworks to prepare teachers for guiding students in safe, ethical uses of such technologies. The current study echoes this necessity; however, it also reveals a persistent gap in actual usage despite positive perceptions, particularly among senior educators.

Interestingly, the regression analysis conducted in this study revealed that simple frequency of AI usage (Q1) was not a statistically significant predictor of perceived improvements in teaching practice (Q24). This suggests that mere exposure to AI is insufficient for meaningful pedagogical transformation. Rather, it could be said that successful interaction with AI could involve more in-depth cognitive and reflective information, and this argument is supported by He and Zhou (2025), who established that mentoring AI learners had a higher impact on student teachers improving their procedural teaching knowledge compared to traditional guidance. There results point to the fact that AI engagement quality as opposed to their quantity is paramount to professional development.

More insights can be obtained by referring to the study by Younis et al. (2025) who designed the AI Literacy (AIL) scale aimed at measuring the preparedness of teachers who need to apply AI tools. They

discovered that teaching specialty and experience appeared to determine the level of competence regarding the integration of AI because the younger teaching staff were more likely to be users of AI, as with the current study. This implies that professional learning strategies are to be customized and factoring in generational and disciplinary variations in fluency with AI.

It is also stated in the literature that although teachers see AI positively, structural and ethical issues retard its implementation. Delcker, Heil, and Ifenthaler (2024) pointed out that no single, balanced AI competence exists because dimensions of competence are unevenly developed, and thus, special learning pathways are required. This justifies the reading of the high randomness in answers to questions related to impacts in classrooms (e.g., Q19) in the present research. The level of assimilation of AI seems to vary among teachers, which indicates the necessity of individual professional development routes that could be based on the current level of competence.

In addition, the moral aspects of the application of AI in education are also essential to this research and the one that has been conducted previously. Mouta, Torrecilla-Sánchez, and Pinto-Llorente (2024) highlighted educators' concerns about the socio-political implications of AI, advocating for PD programs that emphasize ethical agency and contextual adaptability. This resonates with the moderate scores in the current study on items related to the broader implications of AI, such as professional identity and classroom dynamics.

Another key area of alignment is the relationship between AI and teacher creativity. Liubarska (2024) explored how tools such as ChatGPT can be employed to foster creative thinking and innovative teaching strategies among future educators. Participants in the current study similarly acknowledged the motivational aspects of AI, suggesting that, when appropriately leveraged, AI may function not only as a technical assistant but also as a cognitive collaborator in creative tasks.

However, significant barriers remain. Hu et al. (2024) outlined several challenges teachers face in adapting to the AI age, including evolving pedagogical expectations, limited infrastructure, and unresolved ethical dilemmas. These barriers help contextualize the current study's findings on the relatively lower levels of agreement regarding classroom management and long-term instructional change. It appears that while AI is generally embraced, its sustainable integration into teaching practice is still constrained by institutional readiness and personal confidence.

From a practical standpoint, the results of this study support the growing consensus that professional development initiatives must move beyond basic technical training toward more holistic frameworks. Thi Hong (2024) showed that AI-enabled facilitators have the potential to improve teacher satisfaction in cases where the content delivery is backed by good quality instructional design and activities. This study however demonstrated that satisfaction is not entirely dependent on technical skill, hence an indication that satisfaction needs to be influenced by both the emotional and cognitive aspects as well in the design of PD.

When it comes to the policy impact, the results support the recommendation by Aguilar Cruz Salas Pilco et al. (202 5) to have a uniform and prolonged PD provision in line with the incorporation of AI in the classroom. The experience when they worked with Colombians teachers demonstrated that the excitement about AI in most cases goes hand in hand with an institutional support, a factor that was also apparent in varying results across the experience groups in the current study. This shows further the significance of systemic infrastructure and policy correlation in getting the most out of AI in the development of teachers.

On the whole, this discussion shows a complicated yet encouraging image of AI incorporation into CPD. AI tools are proven to enhance personalization, engagement and efficiency but it does not necessarily

provide transformative practice if not properly implemented. They provide evidence in support of a move to competency-based, ethically aware, and experience-sensitive PD programs. When planned in this way, these programs have the potential to unlock the full potential of AI as a partner in helping reimagine professional learning, and not simply as a tool.

Conclusion

This study investigated the perceptions, usage, and impact of artificial intelligence (AI)-driven strategies in continuous professional development (CPD) among in-service educators. Based on the quantitative analysis of 127 responses of teachers, it is possible to state the positive attitude the majority of them have towards the integration of AI into the process of professional learning. Teachers indicated that AI tools increase the effectiveness, customization, and interest of the CPD experiences, especially the self-assessment, motivation, and the planning of instructions.

Nevertheless, gaps between perceived usefulness and actual usage were also significant in the results. In comparison, even though early-career teachers had greater involvement with AI tools, more experienced educators stated that they use the tools less frequently, and they are less confident in their effectiveness. These differences indicate that its advantages do not always follow the uniform distribution, and in this case, professional development initiatives should be differentiated and depend on their previous experiences, technological proficiency, and pedagogical practices.

Additionally, regression analysis indicated that, frequency of AI use, motivation and some others were not good predictors of perceived classroom impact. This is reflective of the significance of cognition further involvement and pedagogical congruency in the process of AI integration in professional growth. They require more than just tools; the success lies in careful implementation, ethical basis, and its maintenance.

Conclusively, the application of artificial intelligence is a potential area of revolutionizing CPD in education. By being integrated into a properly shaped, inclusive, and ethically considerate ecosystem, AI should help educators to have more, data-driven, and personified learning trajectories at their disposal. Further research and practice should aim at enhancing these systems so as to achieve principle of equestrian accessibility and excellent lasting directive usefulness by instructors of all phases of their careers.

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