**Teacher Training for ChatGPT: A Critical Analysis of Its Role in Professional Development**

1. Ali Hayat,    Lecturer: Near East University, Mersin, North Cyprus

Email: ali.hayat@neu.edut.tr      (Corresponding Author)

          2.    Kazim Syed, PhD Student,    Near East University, Mersin,    North Cyprus

Email: kazim.syed@neu.edu.tr

        3.      Dewi Sekar Tanjung, Universitas Sanata Dharma,    Indonesia

Email: dewisekar167@gmail.com

**Abstract**

Teacher training for ChatGPT is a crucial question of this research article, as this paper is written to overview critical perspective for a digital tool (ChatGPT) perquisite training for teachers in education system for their professional development. ChatGPT which had inevitable and eminent role in today’s world where teachers are really concern because they are performing vital role in education system and they are actively interacting with this tool more than anyone else from other professions. Descriptive qualitative analysis has been utilized to give overview of critical analysis and thematic categories are working as research design in this research. Peer-reviewed papers employed from various high impacted indexes as data collection, and found three major critical thematic categories which emerged such as ChatGPT tendency in education, ChatGPT Cultural lag among teachers, ChatGPT integral usage in classroom by teachers. Eventually, this finding highlights explicit demand for teachers training related to ChatGPT usage before they began with their jobs because it is essential with its implications for their professional development.

**Keywords**: Teacher training, ChatGPT, Cultural Lag, Teachers professional development, ChatGPT integral usage, ChatGPT tendency in education

**Introduction**

Training is a fundamental pillar of educational quality, directly shaping societal growth and workforce readiness. Ardichvili, et al., (2024) emphasizes that continuous up skilling of educators ensures they are prepared for rapid advancements in pedagogy and technology. On the other hand, the HRM (Human Resource Management) strategies are evident, as both are the necessity of adaptability, cost-effectiveness, and lifelong learning (Allgood & Musgrave, 2024). At the same time Teacher training plays a vital role in fostering positive student outcomes. It equips educators with the skills and knowledge necessary to meet diverse learner needs and navigate complex classroom environments (Aleandri & Refrigeri, 2014).    Over time, professional development in education has evolved, transitioning from rigid, content-focused training to adaptive, skills-based approaches that emphasize learner-centered practices (Li, Yang, & Wang, 2023). Global advancements in technology and pedagogy have further shifted the focus of teacher training. Today’s educators must be proficient not only in traditional teaching methods but also in integrating digital tools and fostering 21st-century skills such as critical thinking and collaboration (Alexander & Belloni, 2024). These shifts underscore the growing demand for scalable and flexible training models that can prepare teachers for dynamic educational landscapes.

The integration of Artificial Intelligence (AI) in education is reshaping how we think about teaching and learning. Large language Models (LLMs), like ChatGPT, are not just fancy tech buzzwords they’re at the forefront of this transformation (Giordano et al., 2024). Such platforms are already making differences in almost all industries and sectors (Rathore, 2023). Similarly, the education industry has also tested fruits of AI based platforms (Hannan & Liu, (2023) along with other AI based platforms in which ChatGPT is one of the most frequently used AI platforms in education (Ratnam at al., 2023).    Ibrahim et al. (2024) noted that generative AI tools like ChatGPT significantly enhance skill-building, productivity, and equity in education. Similarly, Vorotnykova (2024) highlights that teacher training is critical for equipping educators to integrate new technologies, thus meeting the demands of an increasingly digital world. Moreover, AI as a tool for professional development, offers capabilities that align with these goals by addressing accessibility and scalability challenges (Alexander & Belloni, 2024).

Teacher training is regarded as the backbone of educational industry in general and of educational quality in particular (Li, at al., 2023). With recent advancement in technology, the need for technologically induced training has been higher than ever before. in this regard ChatGPT has a great potential to equip teachers with modern techniques of teaching, enhance their skills and ease their work load. The question is professional development for teacher training, how to use ChatGPT in their professional perspectives. Kiryakova & Angelova, (2023) stresses that students and instructors must learn new digital skills to use AI. Educational institutions should develop strategies and training programs to use generative tools productively and effectively. Similar to this, it is crucial to determine the potential of this developing technology, which includes LLM technologies, to be used in education as a tool for students and teachers. This may require a thorough understanding of the AI-human interaction based on instructors' experiences and impressions of the more sophisticated technology that will be integrated into their profession by (Jeon & Lee, 2023).

However, at the same time it is not very easy to manage teacher training. There are several difficulties associated with it such as geographic barriers, time-consuming processes, and resource constraints (Lan, 2024; Ibrahim at al., 2024).    Advantages of AI tools like ChatGPT in professional development have been applauded in modern era.    but the question remains, does ChatGPT fulfil expected outcomes?    Advocates highlight its potential to align with learner-focused frameworks like Education 4.0 and 5.0, providing on-demand content and dynamic feedback (Alexander & Belloni, 2024). For example, in rural areas of Malaysia, it is already being used to enhance skill-building and bridging inequities (Ibrahim et al., 2024). But at the same time, authors like Lan (2024), suggest not to fully rely on and get carried away with use of AI. Technology might be exciting, but it can’t replace the reflective and nuanced practices foundational to effective teaching. This balancing act between innovation and tradition is where the debate heats up. Can ChatGPT truly transform teacher training, or will it remain a supplementary tool with limitations?

After the emergence of Artificial Intelligence, teacher training such as the use of ChatGPT for professional development, which are already in place such as teaching with ChatGPT, many of such challenges have been escalated. Despite all the use of ChatGPT for professional development and its use in teacher training still remains underexplored. Most of the existing research focuses on student learning rather than educator development (Alexander & Belloni, 2024). Similarly, Whalen & Mouza (2023) noted that there is not enough empirical evidence on ChatGPT’s long-term impact on teaching skills and classroom outcomes.

The following research question is set to be answer in the study as a question statement

for this research article...

Does ChatGPT as a digital tool prerequisite in professional development (teacher training)?

**Literature review**

Teacher training has seen a lot of changes over time. Early teacher training approaches prioritized hands-on content delivery. Pedagogy the how of teaching was rarely emphasized (Schina e al., 2021). For example, apprenticeships and 19th-century teacher training schools focused on rigid curriculum delivery. Skills like managing classrooms or adapting to student needs were sidelined, as Li, Yang, and Wang (2023) highlight. Later, formal programs emerged, stressing teaching methods and student engagement. Progress happened, but problems lingered. Access to quality training has never been equal. Rural and low-resource areas struggle most. Workshops, though helpful, demand time and money many schools lack. Alexander and Belloni (2024) argue such formats ignore teachers’ diverse realities. Universal model rarely works. Think of educators in multilingual schools or underfunded districts—each face unique hurdles. Vorotnykova (2024) notes cookie-cutter training often misses these nuances entirely.

AI tools, such as ChatGPT provide accessible and scalable solutions that can adapt to individual teachers' needs. These tools deliver personalized feedback, lesson-planning support, and classroom simulations, at the same time it eliminates instructor learner base as well. This approach ensures that training is tailored, even for teachers in remote or under-resourced areas (Busuttil & Calleja, 2025). In addition to this accessibility is a great advantage of AI in education. AI-powered platforms can reach educators globally, regardless of their physical location. For example, in Botswana, ChatGPT has been used to support teachers with limited access to professional development opportunities. By generating materials and offering real-time guidance, ChatGPT bridges gaps caused by geographical or infrastructural challenges (Indrawati et al., 2024). Similarly, AI tools like ChatGPT have helped Malaysian educators improve their skills by providing on-demand, cost-effective training (Ibrahim et al., 2024). Similarly, after pandemic, ChatGPT, for instance, has been integrated into online courses to provide consistent, high-quality support for educators (Gharbi & Mohtadi, 2024).

Furthermore, it’s observed that multidisciplinary research is needed to integrate insights from related field such as psychology, HRM, and sociology which can help in addressing factors like cognitive load, motivation, and behavioral change (Gharbi & Mohtadi, 2024). Considering these challenges application of ChatGPT for teacher training can yield better results eventually helping institutions prepared better skilled teachers and at the same time it may lower the load on teachers. Since ChatGPT based teacher training may not only up skill teacher’s kills but also involve them to use its features in developing lesson plans and classroom activities efficiently.

To investigate Teacher training for ChatGPT, some researchers have taken efforts and looked some aspect of the teacher training for ChatGPT, however, it remains a significant gape (Tan & Subramonyam 2023). Some studies suggest that teachers are not applying a standard process to use ChatGPT. For instance, Kang et al., (2023) noted that teachers lack systematic training protocols, integration with established professional development frameworks, and standardized assessment methods. They further observed that nearly 72% of university teachers held critical views of ChatGPT. At the same time about 88 % showed interest in more technical training on who to use ChatGPT for future training. Similarly, Urazbayeva et al., (2024) noted that since inclusion of AI in education is new phenomenon in academia, its short-term outcomes and modest practical improvements have been observed. Though, long-term impact evaluations remain a distant future story (Urazbayeva et al.,2024). Authors have investigated different aspects of teacher training of ChatGPT for example Tan & Subramonyam, (2023) noted that absence of established training protocols for ChatGPT use make it difficult and time consuming for teachers to learn advance functions by themselves. Same as aformentioned, they noted that there is insufficient integration of ChatGPT training into current professional development structures within academia. These findings suggest that while the potential of ChatGPT in teacher professional development is recognized. The research consistently underlines the need for more coherent and contextualized training models (Kang et al., 2023).

**Methodology**

The research methodology revolves around qualitative research, in which descriptive qualitative analysis has been employed as a framework. In addition, we used thematic categories as the research design for this article to analyze the collected data.

**Data Collection Process**

Peer-reviewed articles published in the last three years in the fields of education, management, psychology, and technology indicate the data collection procedure. In this instance, certain particular keywords related to professional development, with ChatGPT serving as a digital tool. However, this professional development is specifically for teacher training. So, numerous keywords had been utilized, such as ChatGPT and teachers, teachers training and digital tools, teacher’s skills in digital tools, teacher education, Teacher development, Teacher and ChatGPT learning or training etc. A systematic research study had been conducted into databases such as Direct Science, Taylor and Francis, Google Scholar, Scopus and Research Gate, among others. For this research, 60 research articles, including books and book reviews, were found. However, we only used 50 prior research articles because they were appropriate for our methodology.

**Analysis and Findings**

After being publically introduced in November 2022 (Eysenbach, 2023), and it had revolutionized every field of life. Users were consciously or subconsciously using it in their everyday lives. However, ChatGPT is primarily used in the education sector worldwide as question statement is concerned.

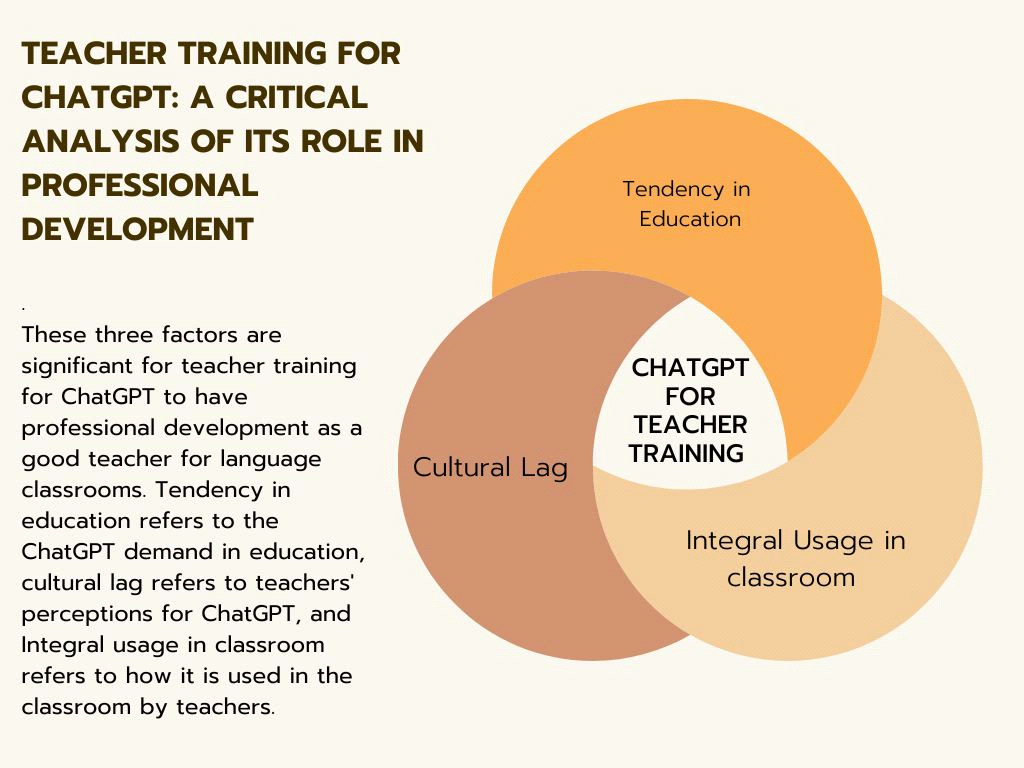
With the assistance of thematic analysis, certain thematic categories had been found, which are mentioned below...

• ChatGPT Tendency in Education

• ChatGPT Cultural Lag among Teachers

• ChatGPT Integral usage in Classroom by Teachers

Figure 1 A Critical Analysis of ChatGPT Role in Teachers Professional Development

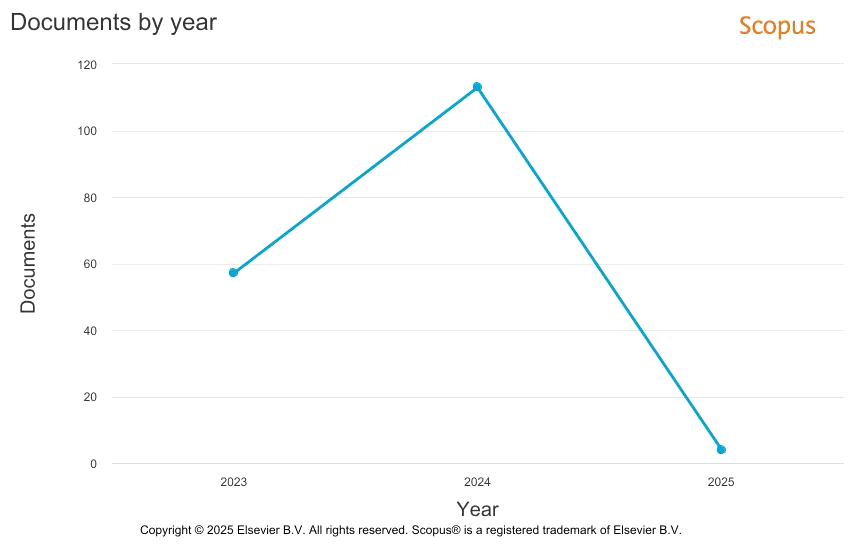


Above mentioned categories are found which are showing the significance of precondition of ChatGPT as a digital tool for teachers training for their professional development.

**ChatGPT Tendency in Education**

The tendency word definition by Collins Dictionary is "A tendency is a typical or repeated habit, action, or belief"(Online Collins Dictionary, n.d.) which is describing ChatGPT believes in education. Similarly, according to Kenton Bell, ed. (2015) it is a noun, an inclination; propensity by ASA – American Sociological Association (5th edition). An inclination of researchers to define ChatGPT can suggest tendency in education. To prove more this tendency there is statistical analysis from Scopus website for "ChatGPT in Education", it interprets that after it is being introduced publically, it has tendency among researcher who wrote its role, significance, characteristics, benefits and flows etc. and this tendency moving forward until the last month of 2024 which shows the tendency to rely on affective responses (e.g. positive or negative feelings) in decision-making (Pachur et al., 2012).

Figure 2. ChatGPT Tendency in Education from Scopus publications



Many researches have examined ChatGPT's use in educational settings in the comparatively short time since its launch (Gill et al., 2024). This cutting-edge technology transforms the teaching and learning environment in higher education, the incorporation of ChatGPT into academia has sparked conversations about its possible benefits and drawbacks (Qadir, 2023).

Similarly, the international research with broader term on ChatGPt and Generative AI has been investigated in various countries around the world e.g. studies have been conducted in United Arab Emirates (ElSayary, 2023),    Hong Kong (Chan & Hu, 2023), Spain (Romero Rodríguez et al., 2023), Thailand (Limna et al., 2023), Kazakhstan (Yilmaz et al., 2023), Indonesia (Firaina & Sulisworo, 2023), Vietnam (Duong et al., 2023), Pakistan (Iqbal et al., 2023), Ukraine (Fiialka et al., 2023), Bulgaria (Kiryakova & Angelova, 2023), United Kingdom (Rodway & Schepman, 2023), United States (Barrett & Pack, 2023), and even it is in cross multiple countries such as Australia , Canada, Sweden, and Turkey (Firat, 2023).

When ChatGPT integrates state-of-the-art AI with education which envision a future where learning transcends time and location and traditional classroom boundaries are extended (Gimpel et al. 2023). By giving teachers a flexible tool for resource provision, question answering, and content development, it transforms instructional techniques (Gill et al., 2024). This helps to bridge the gap between abstract notions and comprehension by enabling the creation of courses that are tailored to the needs of a diverse group of students (Mogavi et al., 2024).

Furthermore, Memarian and Doleck (2023) underscore the value of ChatGPT in supporting complex learning environments and delivering timely feedback, thereby demonstrating its effectiveness in enhancing student engagement and academic performance. They have a more optimistic perspective on ChatGPT's ability to adjust to the unique needs of students by means of asynchronous feedback and communication mechanisms. This signifies a transition from conventional one-way information conveyance to a technologically enhanced, learner-centered, and adaptable educational experience (Yu, 2024).

Meyer et al. (2023) and Zamfroiu et al. (2023) investigate the idea of productive engagement with ChatGPT in the context of pedagogy, offering techniques for teachers to encourage responsible use and create successful integration tactics in classrooms. They emphasize how important the model is for encouraging critical thinking and rethinking evaluation procedures in order to maintain academic integrity. Furthermore, personalized learning, which is intended to modify the learning experience to each person's particular needs, preferences, strengths, and learning pace, is at the heart of ChatGPT's incorporation into education (Rasul et al., 2023). Each student's goals and interests are immediately matched with the tool's ability to generate personalized learning materials, explanations, and practice problems, ensuring that they are extremely pertinent to their particular requirements (Adiguzel et al., 2023). According to Mingsheng Li, ChatGPT has the ability to completely transform teaching and learning in higher education in the future (2024).

**ChatGPT Cultural Lag among Teachers**

For this thematic category, one has to understand what is cultural lag? And, then it is easy to define among teachers. The term "cultural lag" refers to the time it takes cultural traditions and society norms to adjust to technology advances, causing social challenges and disputes (Okediji, 2015). Cultural latency applies to this notion, theoretical frameworks, and explanatory models. It helps detect and explain societal concerns and predict future problems. According to James W. Woodward (1934), material conditions cause adaptive culture to evolve, but not in perfect sync. This delay is called cultural lag. Sociologist William F. Ogburn coined the phrase in 1966.    His cultural delay hypothesis states that non-material cultures maladjusted to new material situations (1957).

Cultural lag is an ethical issue because the failure to reach a consensus on how to use modern technologies may lead to societal strife. Social challenges arise when cultural adaptation and acceptability take a long time to catch up to technological advances, known as "cultural lag".The rapid progression of technology, as demonstrated by ChatGPT, coupled with changes in the educational sector (Wardat et al., 2023), is compelling educators globally, at all levels, to thoroughly reassess their teaching methodologies, especially concerning the incorporation of artificial intelligence (Strzelecki, 2023). The perceptions of educators regarding AI-assisted learning tools, including chatbots, are contingent upon their age. Alharbi and Khalil (2023) found that younger instructors had either a favorable or neutral attitude toward the use of chatbots in the classroom, acknowledging the advantages of artificial intelligence in enhancing efficiency and fostering creativity. On the other hand, instructors who were more experienced expressed a greater degree of opposition, expressing apprehension that artificial intelligence could supplant conventional teaching methods. According to Harini (2023), ChatGPT is a beneficial instrument for educators, as it enhances the instructional process and classroom administration by implementing more effective teaching strategies.

Earlier days of ChatGPT, the employment in educational and academic contexts requires a thorough examination of the ethical ramifications, in conjunction with the technical improvements described in Rosa's (2022) acceleration framework. The lack of sufficient time for contemplation and strategic preparation over the deployment of technology in certain situations may lead to the possibility of unethical behavior and due to their lack of engagement in the innovation of the technology, teachers may be hesitant to use ChatGPT in the classroom (Celik et al., 2022).

However, instructors perceived it as a means of alleviating their daily responsibilities. The chatbot's accuracy, the potential for generating objectionable and biased content, the lack of authentic interaction between educators and students, and issues related to privacy and data security have all been the subject of concern (Atlas, 2023). It is essential for educators to integrate generative intelligence technologies, such as ChatGPT, within the nursing education curriculum to guarantee that students obtain the maximum quality of instruction (Castonguay et al., 2023; Goktas et al., 2024). Teachers and educational institutes are concerned about the potential risk that ChatGPT poses to students, particularly in terms of cheating (Willems, 2023). Moreover, the educators anticipate a signifcant shift in various aspects of education, including the role of teachers (Stokel-Walker, 2023).

The impact of modern digital, information, and communication technologies on our social environment is indisputable.    However, we must not and should not maintain a position of neutrality about the interaction between humans and technology.    A thorough and intentional analysis of this connection is essential in modern culture (De Oliveira Barbosa et al., 2024).

**ChatGPT Integral Usage in Classroom by Teachers**

It is likely that both students and instructors will eventually employ ChatGPT for learning, as it has the potential to revolutionize education (Siemens, 2023). Atlas (2023) suggests that educators may employ ChatGPT in numerous capacities to facilitate their professional development. These include the following: the identification of novel applications for the model; the exploration of its potential applications in unexplored fields; the exchange of knowledge and experiences through publications; the optimization of the model and its capabilities; or the development of instructional materials or mentoring to assist others in comprehending and utilizing ChatGPT. Similarly, ChatGPT facilitates the learning process by offering instances of prior dialogues between engineers and clients. Through participation in these dialogues, students can enhance their pronunciation and grammatical skills. This connection enables ChatGPT to serve as a tailored and engaging conversational partner, assisting students in enhancing their technical English language proficiency. This feature allows ChatGPT to function more like a traditional discussion forum (Ahmed et al., 2023).

This integration can overcome the shortcomings of traditional teaching methods to provide the best education and enhance students' critical thinking, problem-solving skills, and learning satisfaction (Chang et al., 2024). For that reason, universities should clearly announce in academic policies and syllabi supporting the use of ChatGPT in the curriculum (Halaweh, 2023) and provide clear instructions and guidelines for the most ethically appropriate use (Sun and Hoelscher, 2023). Chat Learning Tool

For instance, Nurse educators play a crucial role in mitigating the possible drawbacks of ChatGPT (Karacay et al., 2024) and preparing nursing students for an AI-integrated healthcare environment (Castogunay et al., 2023). They should closely monitor students' use of ChatGPT, require students to present their work in class, and provide clear guidance and instructions on using ChatGPT properly (Cotton et al., 2024). For instance, students could be assigned a task utilizing ChatGPT, such as developing patient educational material. This approach can encourage students to think critically, reflect on their learning, and creatively apply their knowledge (Castogunay et al., 2023).

However, to determine the extent to which AI, it is still too early to say, such as ChatGPT, will influence the quality of education in the long term. However, there is potential for the effective use of AI in education, such as the enhancement and improvement of teacher-student conversations and the enhancement of teaching quality (Tan et al., 2023). Consequently, educators are also apprehensive, particularly in light of their limited involvement in the development of AI-based learning platforms (Celik et al., 2022).

In 2024, Ali, Suchiang, Saikia, and Gulzar demonstrated that the educational experience is improved by a variety of benefits associated with AI use, which may lead to an increase in its use. as a result, the subsequent hypotheses were delineated.

• The perceived advantages and enhanced teaching quality are positively correlated with the future use of ChatGPT in education.

• The utilization of ChatGPT in education is adversely affected by perceived hazards.

Furthermore, ChatGPT can assist educators in efficiently developing learning and evaluation materials, thereby enabling them to focus on more complex course design and pedagogy (Chan & Lee, 2023). Instructors may employ ChatGPT as an ideation facilitator to generate concepts for lectures, presentations, workshop programs, and hands-on courses (Dai et al., 2023) [20]. Lesson preparation may serve as an advantageous starting point for instructors with inadequate qualifications (Gimpel et al., 2023). ChatGPT assists educators in the development of examinations and assignments, their assessment, and the provision of personalized feedback (Farrokhnia et al., 2023) Educators can monitor the progress of students, observe their work and accomplishments with clarity, and respond appropriately by offering timely assistance and employing adaptive teaching methodologies (Adiguzel et al., 2023). The provision of personalized feedback to students enables the identification of problem areas and the pinpointing of performance development initiatives (Farrokhnia et al., 2023). Prompt feedback is particularly important in large groups of students, as it allows them to learn at their own pace, rectify errors, and elucidate complex concepts in real time, without relying solely on the teacher (Dai et al.,2023). Personalized and instant feedback, as well as tailored learning paths, are essential for students with exceptional educational needs, as they enhance motivation and engagement, improve outcomes, and increase learner satisfaction (Adiguzel et al., 2023). ChatGPT can alleviate the administrative burden on instructors by assessing students' assignments and providing feedback (Adiguzel et al., 2023). ChatGPT may be implemented as an evaluation instrument, including essays, to reduce assessment time and provide students with immediate feedback and results (Chan & Hu, 2023). Moreover, Khan et al., (2024) conducted a research to investigate the relationship between academic performance, the use of ChatGPT, and the evaluation of its effectiveness.

ChatGPT poses a significant threat to academic integrity and may also undermine the validity of assessment processes, particularly those that require written assignments (Chan & Hu, 2023). One of the most prevalent apprehensions, as per Rudolph et al. (2023), is that the implementation of ChatGPT may ultimately result in the abolition of essay-writing as an assessment method. Halaweh (2023) asserts that numerous students simply replicate the generated content without conducting a critical analysis or incorporating sources. AlAfnan et al. (2023) assert that ChatGPT adeptly paraphrases generated responses in a manner that is imperceptible to plagiarism detection tools. Numerous universities are prohibiting the utilization of ChatGPT as a precautionary measure. Some propose that the manner in which students are evaluated and assignments be eliminated (Sabzalieva & Valentini, 2023). Furthermore, the utilization of ChatGPT may lead to biased learning evaluations. Ok and Heng (2023) suggest that students who employ ChatGPT to compose academic texts may achieve superior results than those who do not utilize it and instead depend on their own abilities and efforts. However, this approach is likely to have a detrimental impact on their emotional well-being.

Schools and educators have initiated measures to protect students from the potential risks associated with ChatGPT (Roose, 2023). For instance, Kasneci et al. (2023) expressed apprehension that certain educators may become excessively reliant on ChatGPT and fail to offer students opportunities to cultivate their critical thinking, creativity, and problem-solving skills.

They emphasize three significant implications in their work.

• Teachers that were surveyed reported minimal use of ChatGPT in their classrooms. However, AI in the classroom is projected to rise dramatically in the future, and this study gives an initial look at how instructors' opinions affect this.

• Teachers are more likely to employ ChatGPT in the classroom due of its potential. The perceived dangers and future desire to utilize ChatGPT in the classroom are not correlated, suggesting that teachers will employ AI despite the concerns.

• Evidence suggests an affect heuristic. Teachers who assess AI advantages highly tend to rate hazards low and vice versa. Teacher assessment of ChatGPT's potential and dangers is still lacking due to the technology's novelty Kasneci et al. (2023).

ChatGPT underprivileged for language classroom management by Hayat, (2025), he mentioned that there is extensive demand for implicit and explicit policies for ChatGPT usage in language classroom management.

**Discussion**

Comprehensively, after going over a variety of subject matter variations concerning ChatGPT training for the professional development of teachers, it is obvious that there is a need for critical compulsions to examine this phenomenon in each and every educational system across the world. In addition to this, it is a necessary step to go forward since technological breakthroughs are accelerating at a rate that puts instructors on the edge of their seats to establish the boundaries for each and every student for their learning. Therefore, this research has defined its critical interpretation with three demanded progressions from ChatGPT. These progressions are characterized by the fact that instructors are not taught, they are not explained, and they do not have a complete understanding of how to use ChatGPT as a Large Language Model. These are the same as those listed previously, with references and conceptualizations that are crystal obvious.

**Conclusion**

The graduate schooling for teachers who took part, most educators, was identified as the cause of their heightened social commitment, critical-reflective involvement, and research-oriented practices by Mosquera-Pérez & Losada-Rivas (2022). Similar to this, ChatGPT, which is a crucial phenomenon in the education system today, teachers are in internal conflict. Necessity of teacher training for their professional development, as the finding of this research paper concerned that ChatGPT has indubitable participation in education today, second cultural lag among teachers or teaching professionals in every school, college, and university is in affliction. Though, at the same time, it has become an integral necessity to use ChatGPT in the classrooms by teachers. Consequently, it is crystal clear that there is a great demand for prerequisite training for teacher’s professional development, not only for a language teacher but also for every single subject matter whatsoever being taught at school, college, and university level. After then, there will be probabilities to define policies, strategies, and methods to use ChatGPT in the education system.

**References**

Adiguzel, T., Kaya, M. H., & Cansu, F. K. (2023). Revolutionizing education with AI: Exploring the transformative potential of ChatGPT. Contemporary Educational Technology, 15(3), ep429. <https://doi.org/10.30935/cedtech/13152>

Ahmed, S. M. A. A., Taha, A. R. A., Hussain, S., & Hayat, A. (2023). Enhancing the teaching and learning of English for Specific Purposes (ESP) with Chatgpt. International Journal of Technology and Education Research, 1(03), 40–49.

AlAfnan, M. A., Samira Dishari, Marina Jovic, & Koba Lomidze. (2023). ChatGPT as an educational tool: Opportunities, challenges, and recommendations for communication, business writing, and composition courses. Journal of Artificial Intelligence and Technology. <https://doi.org/10.37965/jait.2023.0184>

Alexander, W. R. J., & Belloni, R. (2024). Artificial intelligence and the sustainability of the signaling and human capital roles of higher education. Sustainability, 16(20), 8802. <https://doi.org/10.3390/su16208802>

Alharbi, A. M. (2015). Building vocabulary for language learning: Approach for ESL learners to study new vocabulary. Journal of International Students, 5(4), 501-511. <https://doi.org/10.32674/jis.v5i4.411>

Ali, M. S., Suchiang, T., Saikia, T. P., & Gulzar, D. (2024). Perceived benefits and concerns of AI integration in higher education: Insights from India. Educational Administration Theory and Practices. <https://doi.org/10.53555/kuey.v30i5.5122>

Allgood, M., & Musgrave, P. (2024). Leveraging ChatGPT in public sector human resource management education. Journal of Public Affairs Education, 30(3), 494–510. <https://doi.org/10.1080/15236803.2024.2370455>

Ardichvili, A., Dirani, K., & Jabarkhail, S. (2024). Using generative AI in human resource development: An applied research study. Human Resource Development International, 27(3), 388–409. <https://doi.org/10.1080/13678868.2024.2370456>

Atlas, S. (2023). ChatGPT for higher education and professional development: A guide to conversational AI. Amazon Digital Services LLC.

Babashahi, L., Barbosa, C. E., Lima, Y., Lyra, A., Salazar, H., Argôlo, M., ... & Souza, J. M. D. (2024). AI in the Workplace: A Systematic Review of Skill Transformation in the Industry. Administrative Sciences, 14(6), 127.

Barrett, A., & Pack, A. (2023). Not quite eye to A.I.: Student and teacher perspectives on the use of generative artificial intelligence in the writing process. International Journal of Educational Technology in Higher Education, 20(1), 59. <https://doi.org/10.1186/s41239-023-00427-0>

Bates R. (2004). A critical analysis of evaluation practice: The Kirkpatrick model and the principle of beneficence. Evaluation and Program Planning, 27(3), 341-347.

Beege, M., Hug, C., & Nerb, J. (2024). AI in STEM education: The relationship between teacher perceptions and ChatGPT use. Computers in Human Behavior Reports, 16, 100494. <https://doi.org/10.1016/j.chbr.2024.100494>

Bell, Kenton, ed. 2015. “tendency.” In Open Education Sociology Dictionary. Retrieved January 26, 2025 (<https://sociologydictionary.org/tendency/>).

Birdi K.S. (2005). No idea? Evaluating the effectiveness of creativity training. Journal of European Industrial Training, 29(2), 102-111.

Blundell, R., Dearden, L., Meghir, C., & Sianesi, B. (1999). Human capital investment: the returns from education and training to the individual, the firm, and the economy. Fiscal Studies, 20(1), 1–23.

Bühler, M. M., Jelinek, T., & Nübel, K. (2022). Training and preparing tomorrow’s workforce for the fourth industrial revolution. Education Sciences, 12(11), 782.

Busuttil, L., & Calleja, J. (2025). Teachers’ beliefs and practices about the potential of ChatGPT in teaching Mathematics in secondary schools. Digital Experiences in Mathematics Education, 1–27.

Castonguay, A., Farthing, P., Davies, S., Vogelsang, L., Kleib, M., Risling, T., & Green, N. (2023). Revolutionizing nursing education through AI integration: A reflection on the disruptive impact of ChatGPT. Nurse Education Today, 129, 105916. <https://doi.org/10.1016/j.nedt.2023.105916>

Celik, I., Dindar, M., Muukkonen, H., & J¨ arvela, S. (2022). The promises and challenges of artificial intelligence for teachers: A systematic review of research. TechTrends, 66 (4), 616–630. <https://doi.org/10.1007/s11528-022-00715-y>

Chan, C. K. Y. (2023). A comprehensive AI policy education framework for university teaching and learning. International Journal of Educational Technology in Higher Education, 20(1), 38.

Chan, C. K. Y., & Hu, W. (2023). Students’ voices on generative AI: perceptions, benefits, and challenges in higher education. International Journal of Educational Technology in Higher Education, 20(1). <https://doi.org/10.1186/s41239-023-00411-8>

Chang, C. Y., Yang, C. L., Jen, H. J., Ogata, H., & Hwang, G. H. (2024). Facilitating nursing and health education by incorporating ChatGPT into learning designs. Educational Technology & Society, 27(1), 215–230. <https://doi.org/10.30191/ETS.202401_27(1).TP02>

Chowdhury, S., Dey, P., Joel-Edgar, S., Bhattacharya, S., Rodriguez-Espindola, O., Abadie, A., & Truong, L. (2023). Unlocking the value of artificial intelligence in human resource management through AI capability framework. Human Resource Management Review, 33(1), 100899.

Collins Dictionary (n.d.). Tendency.Collins Dictionary. Retrieved January 26, 2015, from <https://www.collinsdictionary.com/dictionary/english/tendency>

Cotton, D. R., Cotton, P. A., & Shipway, J. R. (2023). Chatting and cheating: Ensuring academic integrity in the era of ChatGPT. Innovations in Education and Teaching International, 61(2), 228-239. <https://doi.org/10.1080/14703297.2023.2190148>

Dai, Y., Liu, A., & Lim, C. P. (2023). Reconceptualizing ChatGPT and generative AI as a student-driven innovation in higher education. Procedia CIRP, 119, 84-90. <https://doi.org/10.1016/j.procir.2023.05.002>

De Oliveira Barbosa, R., Leite Taveira, F. A., & Peralta, D. A. (2024). Entre respostas digitais e saberes experienciais: o ChatGPT e a educação em perspectiva crítica. Revista Pesquisa Qualitativa, 12(30), 01–18. <https://doi.org/10.33361/rpq.2024.v.12.n.30.723>

Duong, C. D., Bui, D. T., Pham, H. T., Vu, A. T., & Nguyen, V. H. (2023). How effort expectancy and performance expectancy interact to trigger higher education students’ uses of ChatGPT for learning. Interactive Technology and Smart Education, 21(3), 356-380. <https://doi.org/10.1108/itse-05-2023-0096>

ElSayary, A. (2023). An investigation of teachers' perceptions of using <scp>ChatGPT</scp> as a supporting tool for teaching and learning in the Digital Era. Journal of Computer Assisted Learning, 40(3), 931-945. <https://doi.org/10.1111/jcal.12926>

Eysenbach, G. (2023). The role of ChatGPT, generative language models, and artificial intelligence in medical education: A conversation with ChatGPT and a call for papers. JMIR Medical Education, 9, e46885. <https://doi.org/10.2196/46885>

Farrokhnia, M., Banihashem, S. K., Noroozi, O., & Wals, A. (2023). A SWOT analysis of ChatGPT: Implications for educational practice and research. Innovations in Education and Teaching International, 61(3), 460-474. <https://doi.org/10.1080/14703297.2023.2195846>

Fiialka, S., Kornieva, Z., & Honchar, T. (2023). Chatgpt in Ukrainian education: Problems and prospects. | international journal of emerging technologies in learning, 18(17), 236. <https://doi.org/10.3991/ijet.v18i17.42215>

Firaina, R., & Sulisworo, D. (2023). Exploring the usage of chatgpt in higher education: Frequency and impact on productivity. Buletin Edukasi Indonesia, 2(1). <https://doi.org/10.56741/bei.v2i01.310>

Firat, M. (2023). What ChatGPT means for universities: Perceptions of scholars and students. Journal of Applied Learning & Teaching, 6(1). <https://doi.org/10.37074/jalt.2023.6.1.22>

Ford, J. K., & Kraiger, K. (1995). The application of cognitive constructs and principles to the instructional systems model of training: Implications for needs assessment, design, and transfer. International review of industrial and organizational psychology, 10, 1-48.

Gharbi, M., & Mohtadi, M. T. (2024). Transforming MOOCs with customized ChatGPT: Scalable personalized learning. International Journal on Technical and Physical Problems of Engineering (IJTPE), 16(4), 343–354. Retrieved from <https://www.iotpe.com/IJTPE/IJTPE-2024/IJTPE-Issue61-Vol16-No4-Dec2024/37-IJTPE-Issue61-Vol16-No4-Dec2024-pp343-354.pdf>

Gimpel, H., Hall, K., Decker, S., Eymann, T., Lämmermann, L., Mädche, A., Röglinger, M., Ruiner, C., Schoch, M., & Schoop, M. (2023). Unlocking the Power of Generative AI Models and Systems such as GPT-4 and ChatGPT for Higher Education: A Guide for Students and Lecturers. Hohenheim Discussion Papers in Business, Economics and Social Sciences, 02.

Giordano, V., Spada, I., Chiarello, F., & Fantoni, G. (2024). The impact of ChatGPT on human skills: A quantitative study on Twitter data. Technological Forecasting and Social Change, 203, 123389. <https://doi.org/10.1016/j.techfore.2024.123389>

Goktas, P., Kuc Ukkaya, A., & Kara    Cay, P. (2024). Utilizing GPT 4.0 with prompt learning ¸ in nursing education: A case study approach based on Benner’s theory. Teaching and Learning in. Nursing, 19(2), e358–e367. <https://doi.org/10.1016/j.teln.2023.12.014>

Google search. (n.d.). <https://www.scopus.com/term/analyzer.uri?sort=plf-f&src=s&sid=ab08dc2dc09b0e13ebb5788ca75f905e&sot=a&sdt=a&sl=37&s=TITLE-ABS-KEY%28%22ChatGPT+in+Education%22%29&origin=resultslist&count=10&analyzeResults=Analyze+results>

Halaweh, M. (2023). ChatGPT in education: Strategies for responsible implementation. Contemporary Educational Technology, 15(2), ep421. <https://doi.org/10.30935/cedtech/13036>

Hannan, E., & Liu, S. (2021). AI: New source of competitiveness in higher education. Competitiveness Review: An International Business Journal, 33(2), 265-279. <https://doi.org/10.1108/cr-03-2021-0045>

Harini, H. (2023). The Role of ChatGPT in Improving the Efficiency of Education Management Processes. Indo-MathEdu Intellectuals Journal, 4(2), 255-267. <https://doi.org/10.54373/imeij.v4i2.199>

Hayat, A. (2025). Language classroom management: Underprivileges of ChatGPT. Journal of Management World, 2025(1), 159-165. <https://doi.org/10.53935/jomw.v2024i4.632>

Holmes, W. (2019). Artificial intelligence in education: Promises and implications for teaching and learning. Center for Curriculum Redesign.

<https://digitalcommons.uri.edu/cba_facpubs/548>

Ibrahim, I., Altahitah, A. N., Ali, K., & Alaghbari, M. A. (2024, January). How Does Chat GPT Influence Human Capital Development Amongst Malaysian Undergraduate Students? 2024 ASU International Conference in Emerging Technologies for Sustainability and Intelligent Systems (ICETSIS) (pp. 213–219). IEEE.

Indrawati, K. P., Letjani, K., Kurniawan, K., & Muthaiyah, S. (2024). Adoption of ChatGPT in educational institutions in Botswana: A customer perspective. Asia Pacific Management Review. <https://doi.org/10.1016/j.apmrv.2024.100346>

Jain, P., Tripathi, V., Malladi, R., & Khang, A. (2023). Data-driven artificial intelligence (AI) models in the workforce development planning. In Designing Workforce Management Systems for Industry 4.0 (pp. 159–176). CRC Press.

Jeon, J., & Lee, S. (2023). Large language models in education: A focus on the complementary relationship between human teachers and ChatGPT. Education and Information Technologies, 28(12), 15873-15892. <https://doi.org/10.1007/s10639-023-11834-1>

Kang, H. G., Kim, E. L., Park, G. H., Song, E. A., & Kim, D. K. (2023). Field teachers’ perception of utilizing ChatGPT in education. Korean Association for Learner-Centered Curriculum and Instruction, 23(19), 567-580.

KARAÇAY, P., GÖKTAŞ, P., YAŞAR, Ö., & KÜÇÜKKAYA, A. (2024). How can nurse educators guide students by using ChatGPT as a teaching tool? Archives of Health Science and Research, 11(3), 140-141. <https://doi.org/10.5152/archealthscires.2024.24043>

Kasneci, E., Sessler, K., Kuchemann, S., Bannert, M., Dementieva, D., Fischer, F., Gasser, U., Groh, G., Gunnemann, S., Hullermeier, E., Krusche, S., Kutyniok, G., Michaeli, T., Nerdel, C., Jurgen, P., Poquet, O., Sailer, M., Schmidt, A., Seidel, T. …, & Kasneci, G. (2023). ChatGPT for good? On opportunities and challenges of large language models for education. Learning and Individual Diferences, 103, 102274. <https://doi.org/10.1016/j.lindif.2023.10227>

Khan, S., Hayat, A., & Hussain, S. (2024). An Investigation of the Influence of ChatGPT on Advanced ELT Education: A correlational study. Harf-o-Sukhan, 8, 902–910.

Kiryakova, G., & Angelova, N. (2023). ChatGPT—A challenging tool for the University professors in their teaching practice. Education Sciences, 13(10), 1056. <https://doi.org/10.3390/educsci13101056>

Kulesz, O. (2024). Artificial intelligence and international cultural relations: Challenges and opportunities for cross-sectoral collaboration. Retrieved from <https://opus.bsz-bw.de/ifa/files/1203/ifa-2024_kulesz_ai-intl-cultural-relations.pdf>

Kusuma, I. P. I., Roni, M., Dewi, K. S., & Mahendrayana, G. (2024). Revealing the potential of ChatGPT for English language teaching: EFL preservice teachers’ teaching practicum experience. Studies in English Language and Education, 11(2), 650-670.

Lan, Y. (2024). Through tensions to identity-based motivations: Exploring teacher professional identity in Artificial Intelligence-enhanced teacher training. Teaching and Teacher Education, 151, 104736. <https://doi.org/10.1016/j.tate.2024.104736>

Lebovitz, S., Levina, N., & Lifshitz-Assaf, H. (2021). IS AI GROUND TRUTH REALLY TRUE? THE DANGERS OF TRAINING AND EVALUATING AI TOOLS BASED ON EXPERTS' KNOW-WHAT. MIS Quarterly, 45(3).

Li, B., Yang, F., & Wang, Q. (2023). Policies, Strategies, and the Evolutionary Logic of Large-Scale Teacher Training in China. ECNU Review of Education, 6(3), 451–468.

Li, M. (2024). The impact of ChatGPT on teaching and learning in higher education. Advances in Information Quality and Management, 1-20. <https://doi.org/10.4018/978-1-6684-7366-5.ch079>

Li, M. (2025). The Impact of ChatGPT on Teaching and Learning in Higher Education: Challenges, Opportunities, and Future Scope. Encyclopedia of Information Science and Technology, Sixth Edition, 1-20.

Limna, P., Kraiwanit, T., Jangjarat, K., Klayklung, P., & Chocksathaporn, P. (2023). In The use of chatgpt in the digital era: Perspectives on chatbot implementation (Vol. 6). <https://doi.org/10.37074/jalt.2023.6.1.32>

Memarian, B., & Doleck, T. (2023). ChatGPT in education: Methods, potentials, and limitations. Computers in Human Behavior: Artifcial Humans, 1(2), (#100022). <https://doi.org/10.1016/j.chbah.2023.100022>

Meyer, J., Urbanowicz, R., Martin, P., O’Connor, K., Li, R., Peng, P.-C., Bright, T., Tatonetti, N., Won, K., Gonzalez-Hernandez, G., & Moore, J. (2023). ChatGPT and large language models in academia: Opportunities and challenges. BioData Mining, 16(1), (20). <https://doi.org/10.1186/s13040-023-00339-9>

Okediji, R. L. (2015). Law and technology. International Encyclopedia of the Social & Behavioral Sciences, 520-527. <https://doi.org/10.1016/b978-0-08-097086-8.86157-7>

Orpen C. (1999). The influence of the training environment on trainee motivation and perceived training quality. International journal of training and development, 3(1), 34-43.

Peachey, N. (2023). ChatGPT in the language classroom. PeacheyPublications.

Qadir, J. (2023). Engineering education in the era of chatgpt: Promise and pitfalls of generative ai for education. In 2023 IEEE global Engineering education Conference (EDUCON) (pp. 1–9). <https://doi.org/10.1109/EDUCON54358.2023.10125121>

Rahman, M. M., & Watanobe, Y. (2023). ChatGPT for education and research: Opportunities, threats, and strategies. Applied Sciences, 13(9), 5783. <https://doi.org/10.3390/app13095783>

Rane, N. (2023). Role and challenges of ChatGPT and similar generative artificial intelligence in human resource management. Available at SSRN.

Rane, N. (2023). Role and challenges of ChatGPT and similar generative artificial intelligence in human resource management. SSRN Electronic Journal. <https://doi.org/10.2139/ssrn.4603230>

Rangel, B., Chung, W., Harris, T.B., Carpenter, N.C., Chiaburu, D.S., & Moore, J.L. (2015). Rules of engagement: The joint influence of trainer expressiveness and trainee experiential learning style on engagement and training transfer. International Journal of Training and Development, 19(1), 18-31.

Rasul, T., Nair, S., Kalendra, D., Robin, M., De Oliveira Santini, F., Ladeira, W. J., Sun, M., Day, I., Rather, R. A., & Heathcote, L. (2023). The role of ChatGPT in higher education: Benefits, challenges, and future research directions. J. Appl. Learn. Teach, 6, 41–56.

Rathore, B. (2023). Future of AI & generation alpha: ChatGPT beyond boundaries. EDUZONE: International Peer Reviewed/Refereed Multidisciplinary Journal (EIPRMJ), ISSN.

Ratnam, M., Sharma, B., & Tomer, A. (2023). ChatGPT: educational artificial intelligence. International Journal, of advanced trends in computer science and engineering, 12(2).

Rodway, P., & Schepman, A. (2023). The impact of adopting AI educational technologies on projected course satisfaction in university students. Computers & Education: Artificial Intelligence, 5, Article 100150. <https://doi.org/10.1016/j.caeai.2023.100150>

Romero-Rodríguez, J., Ramírez-Montoya, M., Buenestado-Fernández, M., & Lara-Lara, F. (2023). Use of ChatGPT at University as a tool for complex thinking: Students’ perceived usefulness. Journal of New Approaches in Educational Research, 12(2), 323-339. <https://doi.org/10.7821/naer.2023.7.1458>

Roose, K. (2023, January 12). Don’t Ban ChatGPT in Schools. Teach With It. The New York Times. <https://www.nytimes.com/2023/01/12/technology/chatgpt-schoolsteachers.htm>

Rosa, H. (2022). Alienação e aceleração: Por uma teoria crítica da temporalidade tardo-moderna. Petrópolis: Editora Vozes.

Rudolph, J., Tan, S., & Tan, S. (2023). ChatGPT: Bullshit spewer or the end of traditional assessments in higher education? Journal of Applied Learning and Teaching, 6(1), 342–363.

Sabzalieva, E., & Valentini, A. (2023). ChatGPT and artificial intelligence in higher education: Quick start guide. United Nations Educational, Scientific and Cultural Organization.

Sadallah, M., Bin-Nashwan, S. A., & Benlahcene, A. (2024). ChatGPT: A transformative role in academia–insights into academic staff performance since adoption. Journal of Information, Communication, and Ethics in Society.

Salloum, S. A. (2024). AI perils in education: Exploring ethical concerns. In Artificial Intelligence in Education: The Power and Dangers of ChatGPT in the Classroom, 669–675.

Salvagno, M., Taccone, F. S., & Gerli, A. G. (2023). Artificial intelligence hallucinations. Critical Care, 27(1), 180.

Saylam, S., Duman, N., Yildirim, Y., & Satsevich, K. (2023). Empowering education with AI: Addressing ethical concerns. London Journal of Social Sciences, 6, 39–48.

Schina, D., Esteve-González, V., & Usart, M. (2021). An overview of teacher training programs in educational robotics: characteristics, best practices and recommendations. Education and Information Technologies, 26(3), 2831-2852.

Siemens, G. (2023). ChatGPT: The AI tech that’s revolutionising teaching. University of South Australia.https://unisa.edu.au/media-centre/Releases/2023/chatgpt-theai-tech-thats-revolutionising-teaching/

Sok, S., & Heng, K. (2023). ChatGPT for education and research: A review of benefits and risks. Cambodian Journal of Educational Research, 3(1), 110-121. <https://doi.org/10.62037/cjer.2023.03.01.06>

Strzelecki, A. (2024). Students’ acceptance of ChatGPT in higher education: An extended unified theory of acceptance and use of technology. Innovative Higher Education, 49(2), 223–245. <https://doi.org/10.1007/s10755-023-09686-1>

Sun, G. H., & Hoelscher, S. H. (2023). The ChatGPT storm and what faculty can do. Nurse Educator. <https://doi.org/10.1097/nne.0000000000001390>

Tan, K., Pang, T., Fan, C., & Yu, S. (2023). Towards applying powerful large AI models in classroom teaching: Opportunities, challenges and prospects. In arXiv [cs.AI]. <http://arxiv.org/abs/2305.03433>

Tan, M., & Subramonyam, H. (2023). More than Model Documentation: Uncovering Teachers’ Bespoke Information Needs for Informed Classroom Integration of ChatGPT (No. arXiv: 2309.14458). arXiv.

Urazbayeva, G., Kussainova, R., Aibergen, A., Kaliyeva, A., & Kantayeva, G. (2024). Innovation Off the Bat: Bridging the ChatGPT Gap in Digital Competence among English as a Foreign Language Teachers. Education Sciences, 14(9), 946.

Vorotnykova, I. P. (2024). Professional development of teachers in conditions of digital transformation of postgraduate pedagogical education. CEUR Workshop Proceedings, 36–46.

Wardat, Y., Alali, R., Jarrah, A. M., & Alzyoudi, M. (2023). Neutrosophic theory framework for building mathematics teachers capacity in assessment of high school students in the United Arab Emirates. International Journal of Neutrosophic Science, 21(1), 33-50. <https://doi.org/10.54216/IJNS.210103>

Weisbrod, B. A. (1962). Education and investment in human capital. The Journal of Political Economy, 70(5, Part 2), 106–123. <https://doi.org/10.1086/258728>

Whalen, J., & Mouza, C. (2023). ChatGPT: Challenges, opportunities, and implications for teacher education. Contemporary Issues in Technology and Teacher Education, 23(1), 1–23.

Willems, J. (2023). ChatGPT at universities – The least of our concerns. SSRN Electronic Journal. <https://doi.org/10.2139/ssrn.4334162>

Yilmaz, H., Maxutov, S., Baitekov, A., & Balta, N. (2023). Student attitudes towards chat GPT: A technology acceptance model survey. International Educational Review, 1(1), 57-83. <https://doi.org/10.58693/ier.114>

Zamfroiu, A., Vasile, D., & Savu, D. (2023). ChatGPT: A systematic review of published research papers. Informatica Economica, 27(1), 46–58. <https://doi.org/10.24818/issn14531305/27.1.2023.01>

Zawacki-Richter, O., Marín, V. I., Bond, M., & Gouverneur, F. (2019). Systematic review of research on artificial intelligence applications in higher education–where are the educators?. International Journal of Educational Technology in Higher Education, 16(1), 1-27.

Zhai, X. (2023). Chatgpt and ai: The game changer for education. In ChatGPT: Reforming Education on Five Aspects. Shanghai Education (pp. 16–17).

Zhong, T., Yang, Z., Liu, Z., Zhang, R., Liu, Y., Sun, H., ... & Chen, J. (2024). Opportunities and Challenges of Large Language Models for Low-Resource Languages in Humanities Research. arXiv preprint arXiv:2412.04497.