Evaluating Artificial Intelligence from the CHAT Framework Perspective

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Abstract—This study aims to evaluate Artificial Intelligence-based pedagogy from the Cultural Historical Framework perspective for exploring the art of teaching in future education. Bibliometric analysis and systematic review were conducted to explore the artificial intelligence in education and cultural-historical activity theory. It is revealed that the main areas are teaching, partnership, language education, learning, machine learning, human-centered approach, teaching, learning activities, deep learning, language, computer-mediated instruction, and ethics in AI. AI-supported teaching is used as object. Subjects are teachers, peers, educational leaders, professors, mentors, children, students, and school leaders. Communities as stakeholders in implementing AI pedagogy. The division of labour refers to collaboration between educators, teachers, school leaders and educators as stakeholders in the design, implementation, and teaching of AI pedagogy. Translation materials, drawing formats, text annotations, and teaching methods utilizing AI technologies are tools. Assignments, e-textbooks, e-learning courses, a comprehensive human-AI collaborative instructional design model, review of existing research studies, drawing, and collaborative word analysis techniques are also tools. Theoretical frameworks become rules, and outcomes are interactive, personalized, and equitable. Teaching-learning experiences are essential to develop critical thinking, higher-order skills, improve engagement, communication, and expansive learning. It is underlined that strategic planning policy in schools, design policy, collaboration and team teaching, capacity building in ethics, culture, and background in the use of AI are key focuses for the quality of AI pedagogy in future studies.

Index Terms—Artificial intelligence, Cultural Historical Activity Theory, Learning, Pedagogy, Teaching.

I. INTRODUCTION

Teaching covers the whole of learning and teaching activities [5] Education, which is carried out in order to meet the expectations of society and the individual, brings change and adaptation with the philosophy of lifelong education and digital transformation. In this context, teaching has become a state-of-the-art in increasing equality of opportunity, inclusion, and access opportunities in education by using developing technologies as a tool [30].

The realisation of the act of teaching is extremely important in the realisation of learning activities. In order to realise learning and teaching activities on the basis of quality and satisfaction, it is important to evaluate learner characteristics and learning environments [27]. The studies conducted are based on learner characteristics, teacher opinions, and add value to the current structure of educational systems and strategies. However, conditions and environments can also reveal that technology is around in a structure that protects and develops. For this reason, carrying out educational activities on the basis of human values and taking decisions with participatory management approaches constitute the basis of sustainability and quality in education [8], [15]. Sustainable development is a multidimensional, dynamic set of concepts consisting of the combination of the words sustainability and development [11] This concept is formulated as the state of maximizing the individual's own and ecological well-being [14]. Therefore, it is emphasized that well-being is one of the main components of sustainable development [23]. It covers the concept of sustainable development that affects the whole life of human beings, including natural, social, and economic dimensions.

In the development of societies in line with sustainable development goals, the solution in the most core structure is to increase the quality of teaching. In order to increase the quality of teaching, it is an important focus in research to know and evaluate the conditions and environments in which the concept of pedagogy has changed [20]. It can be emphasized that quality education plays a key and decisive role in ensuring sustainable development. On the other hand, it can be said that the number of domestic literature studies on the concept of quality education for sustainable development is still limited. In addition, the fact that sustainable development is primarily related to the economy and the environment may cause a limited number of studies that address this concept in terms of quality education [12].It is seen that the theory and practice in the literature on how to define quality education from a sustainable development perspective and how to realize this education is based on the understanding of inclusion, equality and lifelong continuity of education [25]

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Among the goals of quality education and digital education policies, the introduction of assistive technologies, especially artificial intelligence-integrated education policies, is a key objective [32], [3]. Use of artificial intelligence (AI) technologies in education has increased both theoretically and in practice with a high level during the past several years, and has come to be a powerful tool for transforming teaching and learning processes. However, this transformation is generally reached only technologically and individually, and frequently without pedagogic viewpoints [31]. The applications of AI technologies in education have increased exponentially, theoretically and practically, in the past few years and have changed the powerful processes of instruction and learning. But this change, traditionally, is only measured by technological effectiveness and individual achievements, primarily without any pedagogical context. Learning is a complex process, not limited to internal psychological processes alone but shaped by social and cultural environments, and constructed through inter-subjective relationships. Here, viewing AI-based instruction methods solely on the functional level might lose sight of the cultural, social, and historical dimensions of learning, which might adversely affect the development of higher-level cognitive abilities [18]

If these issues are not solved, education systems will be at risk of becoming AI algorithm-led structures and controlled by mechanistic and reduced learning processes. In this regard, the issue of how to assess educational technologies from a pedagogical perspective is crucial [26]. Unless these issues are tackled, education systems are at risk of becoming institutions based on artificial intelligence (AI) algorithms and run by mechanized and simplified learning processes. Under these circumstances, the question of how to assess educational technologies pedagogically is of utmost significance. In order to study the impact of artificial intelligence-based methods and create novel learning environments, a theoretical model that addresses the interrelation among individuals, culture, society, and history is necessary [33]

The research under discussion used Cultural-Historical Activity Theory (CHAT) as its evaluation framework. The CHAT framework studies learning processes by examining people`s educational development through their historical experiences and social connections, and cultural artifacts [16]. The research evaluation was conducted using Cultural-Historical Activity Theory (CHAT). CHAT explores human learning by exploring the relationship between cultural tools, social relationships, and historical contexts. The methodology allows for deeper levels of analyses of complex educational contexts and educational processes than individualistic approaches offer. In this case, the focus of this study is to analyze AI-based pedagogies through a cultural-historical teaching and pedagogical evaluation orientation. The overarching research questions look to assess artificial intelligence-based pedagogies from the Cultural-Historical Activity Theory coordinates, and ultimately the development of an evaluation system for AI-based pedagogies to promote quality educational improvement.

When the stated objectives and sub-objectives are taken into account, it is seen that societies collectively will attach importance to technology integration in creating a culture of solidarity with equality and justice. In this context, it will be seen from the experiences and related studies that artificial intelligence technologies will be the basis of the pedagogy to be applied at all levels of education [28].

Art of teaching is shaped by the effects of emerging technologies and changing learning needs of generations. Digital transformation has shaped the context of learning and teaching process. In this respect, the ways of teaching have changed its structure. Especially AI gave different direction to pedagogy for sustainable education [21].

One study puts an emphasis on the intersection between technology and pedagogy, by the factors of mobility, interactivity, artificial intelligence (AI), and technological learning tools, creating the basis of educational transformation [1]. In addition, strategic integration of mobility, pedagogy, and technology, educators make a base of new pedagogy, especially technology-driven pedagogy and AI pedagogy. One of the studies gives insights into analogy-based pedagogical approach with the conventional direct instructional approach in all three dimensions of AI knowledge, skills, and ethical awareness [9].

As the study of Brusilovsky (2024) puts an emphasis on learner control and AI-human collaboration, it is seen that there is an intensified need to evaluate AI pedagogy to make future directions [6]. In this respect, the study of Kim (2024) underlines AI-teacher collaboration, which suggests that making AI ready culture for schools is needed [17].

In light of these experiences and studies, it is extremely important to analyze artificial intelligence applications in depth and to draw lessons from applications. It is necessary to develop a scientific basis with theoretical frameworks in order to understand and reapply applications and experiences, and to transform pros, cons, and opportunities into strategies.

II. THE NEED OF THE STUDY

AI pedagogy can affect the future of education in terms of engagement of learners and professional development of teachers in their capacity building. Especially, the culture of teaching will require the art of teaching to meet the needs of learners for sustainable education. Digital education reforms point out the use of AI in the learning and teaching process for enriching the future of education. In this respect, the 17 Sustainable Development Goals promote strong collaborative team teaching and learning in shaping the development of competencies and skills for cultivating global citizenship. The key is to foster the use of AI in education and establish a new pedagogy through merits of AI [19].

Cultural Historical Activity Theory refers to finding interconnections between subject, tools, object, rules, community, division of labor, and outcomes for exploring AI pedagogy and teaching in sustainable education. In this framework, the subject refers to those involved in AI pedagogy and teaching studies. Tools refer to educational strategies, programmes, and learning activities, teaching methods to provide AI pedagogy. The object includes the aim of studies in relation to AI pedagogy. Rules include the accepted practices, procedures for evaluating learning outcomes that the community refers to the interaction among people in AI-supported instruction (e.g., learners, family, teachers, professionals, school managers) and settings (e.g., schools, training centers, etc.). Division of Labor refers to distributing duties among students, teachers, unions, and other stakeholders in practice. Outcome covers students' and teachers' performance in target skills as evaluated by performance measures [29].

Although several studies have focused on discussing AI in education and tools in using learning, most of them focused on a specific perspective, such as learning perceptions, tools, and created programs [24], [21]. AI pedagogy is needed to pay attention to the fact that different dimensions need to be considered in order to better analyze in changing practices for the quality of education. As pedagogy encompasses both learning and teaching strategies, considering AI in learning in studies remains partial. The study of Kim (2024) underlined that AI competency development for teachers should offer a learning sciences-centered account, a scientific, humanistic, and critical understanding of learning, as well as engage in the design and implementation of learning [17]. Pedagogy can start

with the art of teaching that team teaching to foster learning through AI needs to be underlined through the lens of Cultural-Historical Activity Theory (CHAT) in order to give insights on challenges and opportunities to use AI in education [10]. CHAT gives an insight into the whole look among interconnected components by integrating cultural activities and human behavior. This framework fosters analyzing detailed perspectives on challenges, opportunities, and future projections for the best practice. As AI relies on digital transformation in education and puts an emphasis on subject, object, tools, community, rules, and division of labor, outcomes [10] is essential to provide a wider perspective for the future of education. This study fills the gap by conducting a systematic review on AI pedagogy and teaching from the CHAT perspective, integrating the existing body of knowledge to future directions.

III. METHODOLOGY

The aim of this study is to analyze artificial intelligence-based pedagogies from a cultural-historical teaching and pedagogical evaluation perspective and to develop an evaluation system based on the Cultural-Historical Activity Theory (CHAT) framework. The aims of this study is to analyze artificial intelligence-based pedagogies from a cultural-historical teaching and pedagogical evaluation perspective and to develop an evaluation system based on the Cultural-Historical Activity Theory (CHAT) framework. In this direction, the literature scanning and analysis process was carried out with the following steps.

In this study, PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analyses) guide for systematic literature review (Moher et al., 2010) is based on this study, PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analyses) guide for systematic ln this study, PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analyses) guide for systematic literature review (Moher et al., 2010) is based on. This method standardizes the selection process of documents in order to ensure transparency and reproducibility. Web of Science (WOS), academic databases were searched using the keywords ("artificial intelligence" OR "machine learning" O "deep learning" OR AI OR AIEd) AND (pedagogue* OR teaching OR education OR learning) AND ("culture* history* activ* theor*" OR "activ* theor*") initially determined. Scanning criteria are publication year, peer-reviewed articles, conference papers, review studies and English articles.

Using the PRISMA diagram, an initial selection of 850 studies was first narrowed down to 150 through title and abstract review, followed by full-text assessment, ultimately including 26 studies. "PRISMA is a critical tool for ensuring consistent and transparent source selection in systematic reviews" (Moher et al., 2010).

Bibliometric mapping is effective in visualizing thematic evolution and scholarly collaborations in research fields [2]. The aim of this study is to analyze AI-based pedagogies from a cultural-historical teaching and pedagogical assessment perspective and to develop an assessment system based on the Cultural-Historical Activity Theory (CHAT) framework.

IV. LITERATURE REVIEW

The CHAT model is a framework for observing learning processes in a historical, cultural, and social context, originating from Vygotsky's sociocultural theory. According to Engeström (2001) [10], the theory takes into account learning activities and interaction among participants with elements such as tools, rules, community, and division of labor. From this perspective, it is instrumental to investigate AI-based teaching methods since these technologies serve as "tools" within learning processes and themselves become part of cultural

practices. Luckin (2010) [22] opines that the use of AI as a "tool" in learning environments could support cognitive and social development for students, although it should harmonize with the cultural context.

Another prominent dimension discussed during CHAT application analyses concerns the ways in which these technologies affect social relationships and power dynamics. Cole and Engeström (1993) [7] say that the transformation of learning processes depends both on the technological tool and social structures and cultural norms. Foot (2014) [13] suggests that AI-based instruction systems may well deepen contradictions located within an activity system if they fail to be sensitive to the local cultural practices of the learners. So, from the perspective of CHAT, one needs to consider cultural diversity and social justice while designing AI instructional models.

This study conducts a systematic review and bibliometric analysis on AI pedagogy based on the Cultural Historical Activity Theory perspective. This review follows the PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analyses) guidelines (Moher et al., 2009).

A. Search Strategy and Inclusion/Exclusion Process

Specifically, the search query (("artificial intelligence" OR "machine learning" OR "deep learning" OR AI OR AIEd) AND (pedagog* OR teaching OR education OR learning)) AND ("cultur* histor* activ* theor*" OR "activ* theor*") - was undertaken in the Web of Science (WOS) Core Collection database on 26th of July 2024. After this database search, two authors analyzed the retrieved papers by titles, abstracts, and, if necessary, by full text, based on pre-defined inclusion and exclusion criteria. An article was excluded if: (1) the full-text was not available online, (2) it was not in English, and (3) it did not employ an AI-based education methodology within the CHAT framework. This research yielded a total of 101 articles. After applying another topic filter (title, abstract, and keywords) to obtain more accurate results, 57 papers remained. Fifty-seven papers were then omitted based on screening of title and abstract, which were considered and assessed as full texts. About 31 of these papers did not pass the inclusion and exclusion criteria. Thus, a total of 26 eligible research studies were included in the final review process. Figure 1 presents the study selection process as recommended by the PRISMA group.

The selection process is recommended by the PRISMA group. The bibliometric analysis was performed with R! Programming Language with Bibliometrix library [2] and the mapping software, VOSviewer [34]. In addition, WOS analyser was used where necessary support was needed. The analysis conducted on the obtained data was aimed at addressing the following points:

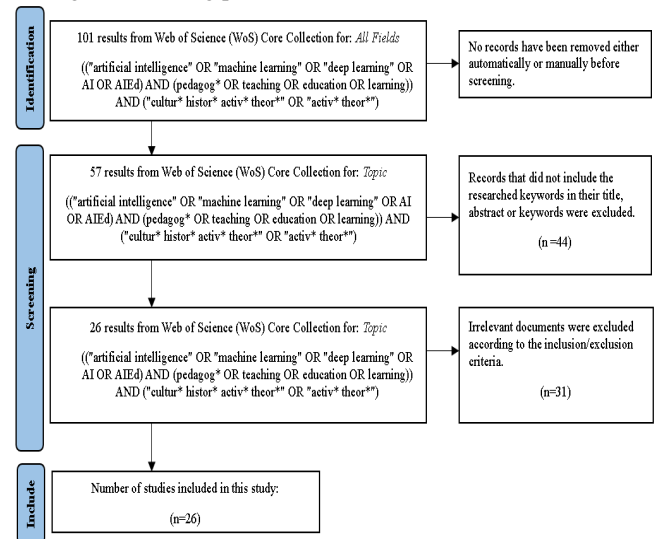| Identification	101 results from Web of Science (WoS) Core Collection for: *All Fields* (("artificial intelligence" OR "machine learning" OR "deep learning" OR AI OR AIEd) AND (pedagog* OR teaching OR education OR learning)) AND ("cultur* histor* activ* theor*" OR "activ* theor*")	No records have been removed either automatically or manually before screening.
Screening	57 results from Web of Science (WoS) Core Collection for: *Topic* (("artificial intelligence" OR "machine learning" OR "deep learning" OR AI OR AIEd) AND (pedagog* OR teaching OR education OR learning)) AND ("cultur* histor* activ* theor*" OR "activ* theor*")	Records that did not include the researched keywords in their title, abstract or keywords were excluded. (n =44)
	26 results from Web of Science (WoS) Core Collection for: *Topic* (("artificial intelligence" OR "machine learning" OR "deep learning" OR AI OR AIEd) AND (pedagog* OR teaching OR education OR learning)) AND ("cultur* histor* activ* theor*" OR "activ* theor*")	Irrelevant documents were excluded according to the inclusion/exclusion criteria. (n=31)
Include	Number of studies included in this study: (n=26)	

Fig. 1. Prisma.

The distribution of documents in terms of publication year (1.1) and document type (1.2).

The productivity of the countries (2.1) and the bibliometrics of these countries (2.2).

The current trends in terms of research themes (3.1), research areas (3.2), and keywords (3.3).

Selected 26 research studies were analyzed based on CHAT framework components, which are object, subject, division of labor, tools and community, rules and outcomes.

V. RESULT

A. The Publication Year Distribution of the Documents

The first scope of analysis was to investigate the publication years of the documents related to AI-based education methodologies within the CHAT framework. It is observed that the first ever mention of an AI-based education model and CHAT framework was in the year 2006. However, until the year 2018, there is no notable number of publications except the years 2008 and 2012, which makes a total of 3 publications from the first mention until 2018. The number of publications in the years 2018 and 2019 showed a promising increase, but in the rest of the years until 2023, the number of publications gives an implication that not enough focus was given to this topic. When the date of this research is considered, 3 documents were published within the year 2024 until July, which still leaves the year 2024 an opportunity to become the year the most documents published so far.

B. The Publication Year Distribution of the Documents

Analysis shows that 11 documents out of 26 are articles and 10 documents are proceeding papers, accounting for around 80% in total. When compared to articles, the number of proceeding papers is nearly the same, which indicates that the research is still in the preliminary stage. The rest of the recorded documents are early access (n=3) and review articles (n=2).

C. The Productivity of the Countries

The analysis revealed no surprises, and the top 2 of most productive countries in the field are the USA (f=7) and China (f=6). As Table 1 illustrates, a total of only 16 countries have contributed to the literature on the topic of investigation. Following China, countries such as Australia and Canada appear with a frequency of 3, Spain and the UK appear with a frequency of 2, and France and Germany appear with a frequency of 1 in the productivity list.

TABLE I COUNTRIES

Region / Country	Frequency
USA	7
CHINA	6
AUSTRALIA	3
CANADA	3
MALAYSIA	3
ROMANIA	3
SOUTH AFRICA	3
FINLAND	2
SPAIN	2
SWEDEN	2
UK	2
FRANCE	1
GERMANY	1
ICELAND	1
USA	7

D. Bibliometric Coupling Analysis of the Countries

The bibliometric coupling (the interaction between the countries) analysis has shown some interesting facts. For instance, while the most productive country, the USA, has received the most citations (n=67), China, the second most productive country, has received only one citation. Vice versa, although Germany was one of the least contributors in terms of productivity, they have received the second highest number of citations (n=50). The rest of the top 5 most cited countries are South Africa (n=26), Australia (n=25), and Canada (n=17), respectively. The bibliometric coupling map of the countries. The bibliometric coupling map revealed 4 clusters. Countries such as China and the UK are placed in the most crowded cluster (red cluster), but their interaction both within their cluster and other clusters seems to be very low. The USA, Germany, and Sweden are placed within the same cluster (blue cluster) and possess the strongest links between each other. Similarly, Canada and France (yellow cluster) and Australia, Malaysia, and South Korea (green cluster) are in the same cluster and strongly interact with each other. Additionally, it is worth mentioning that, unlike the red cluster countries, the USA and Canada have a considerably strong interaction. This kind of interaction is also observed between Australia and the yellow cluster countries, Canada and France.

E. Current Trends in the Research Themes

The theme analysis was performed to enlighten and investigate the current research trends, needs, and the ignored topics in the field. Thematic map analysis is divided into four quadrants. Starting with the Niche Themes quadrant (top-left), the "expansive learning" theme is the only term seen in this quadrant. Niche Themes quadrant shows the themes that do not possess high importance, giving an insight that expansive learning is not considered as an important point within the research analyzed. "Machine learning" theme is placed in the Emerging or Declining Themes quadrant (bottom-left), and when the increase in interest in this field is considered, this gives an indication of how machine learning related topics are promising and emerging as of today, rather than declining. Basic Themes quadrant (bottom-right) consists of "activity theory", "artificial intelligence", and "cultural historical activity theory". This leads to the interpretation that these themes carry high importance and need more investigation. Lastly, the Motor Themes quadrant (top-left) gives an indication on the themes that are highly explored and possess substantial structure, which are "education", "teachers", and "mathematics education".

F. Research Area Analysis

In order to assist the insights obtained in the themes, another analysis was also conducted on the research areas. It is observed that half of the analyzed researches are conducted in "Education Educational Research" (n=8, ~31%) and "Computer Science" (n=5, ~19%) fields. Two papers were recorded in "Engineering" field and rest of the research areas have only one paper published per field.

G. Keyword Analysis

The network map of the most frequently used author keywords analysis is represented. The analysis found that a total of ten different keywords were used by the authors. The most preferred keyword was activity theory (f=14), followed by artificial intelligence (f=5), and education (f=4) to represent the top 3. Machine learning and teachers appeared 3 times as keywords, while cultural historical activity theory, expansive learning, and mathematics education appeared 2 times.

H. CHAT Framework Analysis on AI Pedagogy: Reflection from Existing Body of Knowledge

TABLE I I OBJECT

Study	Area	Object
Study 1	Ethics in AI	Human Values
Study 2	Interactive documentary learning game	Interprofessional games
Study 3	human + machine assistive assemblages emerging in professional work	Deep learning
Study 4	Work based learning	Collaboration
Study 5	Conceptual learning	Digital learning materials
Study 6	Ethical Challenges in AI	Learning agents and deep learning
Study 7	Language learning	Collaboration
Study 8	Language learning	Communication and collaboration
Study 9	Games	Instruction
Study 10	Language	Translation
Study 11	Computer mediated instruction	Personalized learning
Study 12	Instruction	Collaborative conversations, deep learning
Study 13	Effective educational retention strategies	Online activities
Study 14	Security	Opensource security
Study 15	AI learning environment	professional instructional guidance, higher order thinking skills
Study 16	Change Room Practice	Teachers' agencies, Student Voices
Study 17	Learning System, human centric approach	Interactive, personalized, and equitable teaching-learning experiences
Study 18	Students learning of machine learning technology	Context, culture
Study 19	Educational AI (AIEd) systems	adaptivity and human facilitators
Study 20	Learning activities	Social Robots
Study 21	Artificial intelligence (AI) in teaching and learning	Organizational change and by reimaging learning activities with AI as a collaborative partner, team
Study 22	Mixed-Reality Emotive Virtual Human System Platform	Cyberlearning at the human/technology frontier
Study 23	Preschool language education	Smart learning environment
Study 24	Learning in physical neural systems	Optimal learning in deep neural architectures
Study 25	Patient-educator partnerships for learning	Social care
Study 26	Teaching of mathematics change with modern digital textbooks	Change in teaching, collaboration

Based on an evaluation of 26 selected studies, the main areas that studies conducted are teaching, partnership, language education, learning, machine learning, human-centric approach, instruction, learning activities, deep learning, language, computer-mediated instruction, ethics in AI. Based on CHAT framework analysis, objects are considered as change in teaching, collaboration, optimal learning, smart learning environment, social care and ethics, reimaging learning, culture, interactive, personalized, and equitable teaching-learning experiences, teacher agencies, student voices, professional instructional guidance, higher order thinking skills, human values. Object-focused studies that AI-supported instruction is used to reach objects.

AI pedagogy can be successful based on key role players in the educational system. Analysis of studies based on CHAT frameworks, subjects are teachers, peers, training leaders, professors, mentors, children, students, and school leaders. This shows how collaboration and partnership is essential among stakeholders in the practice of AI pedagogy for sustainable education.

1) Community

Studies are evaluated, and the community consists of teachers, school leaders, students, children, young people, educators, patients, professors, mentors, and training leaders. The context includes schools, online learning platforms, social media, higher education institutions, security systems, and preschools. Studies considered all communities as stakeholders for implementing AI pedagogy and empowering teaching in AI [32], [24], [21]. It is seen that teachers' intervention and configuration of AI-supported language learning in the pedagogical design play an important role in the effectiveness of learning.

2) Division of Labor

The division of labor relies on role categories and responsibilities in the practice of AI pedagogy, as reflected in selected studies. Designer needs to reevaluate existing design frameworks and regulations for ensuring fairness in AI, and they need to understand fairness to understand values by allowing stakeholders control in the situation. Developing an interactive narrative is another responsibility to make practices better. Making an expansion of pedagogical vision, pedagogical mediation, relational expertise, and cross-disciplinarity sheds light on the different role categories and responsibilities in AI pedagogy and teaching studies. Capacity building in knowledge and skills of teachers is a core responsibility in order to facilitate learning and teaching. Establishing collaboration among educators, teachers, school leaders, and trainers as stakeholders on designing, implementing AI pedagogy, and teaching is important. For effective school reforms based on digital transformation, making agents is essential to increase awareness and effectiveness in AI pedagogy for inclusive, accessible, and sustainable education. Setting regulations, rules, and skills for data privacy, ethics, and interoperability between learning systems are roles of all stakeholders for a deep and dynamic learning and teaching system.

3) Tools

Tools are used in AI pedagogy in designing and facilitating learning and teaching. Multi-user educational online games have been used to foster learning in mathematics [9], [21]. Translation materials, forms of drawings and text descriptions, and AI technologies in instruction are also used to foster learning [24], [30], [21]. The internet, digital resources and classroom technologies are used to support learning in early grades [24]. Educational programs and training are other tools in AI pedagogy and teaching [26]. Open-source tools and machine-learning packages are suggested to facilitate AI pedagogy and teaching [26], [32] Rules

In selected studies, rules are considered procedures, instruments, and theoretical frameworks that enable researchers and practitioners to examine the essence of AI pedagogy. In this respect, meta-design is used as a procedure to empower participants, allowing them to actively shape the processes of tool design to align with their specific local needs and evolving conceptions of fairness in use-time [13], [32]. On the other hand, semi-structured interview was used as an instrument to discuss the design implications of this work for their interprofessional learning game [13], [16]. [36] use Socio-Materialism and Cultural-

Historical Activity Theory to explore machine learning for rearranging and reorganizing the distributed basis of cognition in assistive assemblages [13], [16]. Assignments, e-textbooks, e-learning courses, a comprehensive human-AI collaborative instructional design model, review of existing research studies, drawing, and co-word analysis techniques are used as instruments to explore AI-assisted learning environments and instruction. The study of [35] use the change room to facilitate a promising direction to increase teachers' agency to change their practice and sustain that change. Social robots are used for learning activities. In addition to this, activity theory is used as a framework to imagine better inclusions of social and cultural components with AI.

4) Outcomes

Outcomes of studies provide insights into future directions to be considered in AI pedagogy. In this respect, it can be seen that interactive, personalized, and equitable teaching-learning experiences are essential to develop critical thinking, higher-order skills, improve engagement, communication, and expansive learning. In addition, awareness of the hybrid nature of adaptivity in real-world educational settings puts an emphasis on understanding the AI systems and human facilitators. In language learning, there is an important support of AI tools, and work-based learning experiences can be enriched by AI instruction. Change in teaching and collaboration foster AI practices for professional development.

I. Recommendations from CHAT Framework Analysis

1) Design policy

Human-centric education policy can be enriched by the design policy of AI pedagogy. As education relies on social, cognitive, and psychological dimensions to satisfy individual and society needs, design policy is important to underline human values in transferring new generations through the impact of technology. Therefore, it is crucial to acquire accessible, inclusive, and global educational activities. These activities can be achieved by a collaborative design policy. A win-win policy in designing educational activity for AI pedagogy fosters team teaching, student voices for the quality and outcomes in educational systems. It is recommended in future studies to conduct research to analyze the effects of design policies in AI pedagogy for effective practices. In addition, paying attention to collaboration culture, partnership, and voices of all stakeholders while designing educational activities is crucial.

2) Strategic planning policy in Schools

Strategic planning is a road map for educational actions by analyzing strengths, weaknesses, opportunities and threats. Opening up school culture to AI pedagogy with all parts of the school is needed. Putting this argument in an action plan of schools provides sustainable education and decreases inequalities for the quality of education. Therefore, it is recommended in future studies to analyze action plans of educational systems and schools by evaluating the readiness of school leaders and teachers about AI pedagogy.

3) Collaboration and team teaching

Collaboration in making cohort synergy in instruction is crucial. Establishing collaboration among students, teachers, and school leaders fosters the effectiveness of AI pedagogy, In this respect, communication plays a great role in making a bridge between AI tools and subjects. Making the models of team teaching and strategies, experiences related to team teaching (AI and teachers' collaboration) are highly needed to conduct further study.

4) Culture and background in the use of AI tools in instruction

Learners' differences and readiness to implement AI pedagogy are key factors. Understanding the culture and background of learners is important in the use of AI tools. In the instruction, it is suggested to evaluate the culture and background of both learners and teachers in the practice of AI pedagogy in order to achieve effectiveness and sustainable education.

5) Capacity building in ethics and skills in AI pedagogy

Quality of practices and sustainable educational activities rely on capacity building of knowledge and transformational learning. In these respects, AI pedagogy encompasses ethics and skills for a new way of teaching and learning as an art. Therefore, expanding the competences of teachers and developing their skills for both professional and personal development in new arts of teaching by AI pedagogy is highly needed. Value-driven education, inclusive education by touching the human values, is important in the global world to reach out in solidarity and achieve sustainable development goals. In this respect. Cultivating ethics in education, especially in AI education, is a crucial agenda for further studies..

VI. CONCLUSION

The mention of the AI-based education model and CHAT framework dates back to 2006. However, apart from a few publications in 2008 and 2012, there has been a serious lack of research until 2018, and only 3 publications in total have remained since their first mention. While 2018 and 2019 saw a promising increase in publications, the number of publications in the following years until 2023 shows that not enough attention has been paid to this issue. As of July 2024, only 3 documents have been published, suggesting that 2024 has the potential to be the year with the highest number of publications on record.

Of the 26 documents analyzed, 11 are categorized as articles and 10 as minutes, constituting approximately 80% of the total. The almost equal distribution between articles and papers indicates that the research is still in its infancy. The remaining documents consist of early access materials and review articles.

The most productive countries in this field are the USA and China. In total, only 16 countries contributed to the literature on the research topic. Following China on the productivity list, countries such as Australia and Canada appear 3 times, Spain and the UK 2 times, France and Germany 1 time.

The analysis of bibliometric matching (interaction between countries) revealed some points. The most productive country, the USA, received the most citations, while the second most productive country, China, received only one citation. Conversely, Germany was the second most cited country, despite being one of the least productive contributors. The top 5 most cited countries are South Africa, Australia, and Canada, respectively. The bibliometric aggregation map revealed 4 clusters. Countries such as China and the UK are in the most populous cluster, but their interaction both within their own cluster and in other clusters seems to be quite low. The USA, Germany, and Sweden are in the same cluster and have the strongest connections with each other. Similarly, Canada, France, Australia, Malaysia, and South Korea are in the same cluster and have strong interactions with each other. In addition, unlike the red cluster countries, it is observed that the USA and Canada have a very strong interaction. This kind of interaction is also observed between Australia, Canada, and France.

The theme analysis was conducted to illuminate and explore current research trends, needs and overlooked issues in the field. From the Niche Themes quadrant, the only term that appears in the top left is the theme "comprehensive learning". The Niche Themes quadrant shows themes that are not of high importance, giving an idea that extensive learning is not seen as an important point in the analyzed research. The Emerging or Declining Themes quadrant of the "machine learning" theme is located at the bottom left, showing how promising and emerging the topics related to machine learning

are, rather than at present, given the growing interest in this field. The Core Themes quadrant consists of "activity theory", "artificial intelligence", and "cultural historical activity theory" on the bottom-right. This leads to the interpretation that these themes are of great importance and should be investigated further. Finally, the Motor Themes quadrant gives an indication of the well-researched and well-established themes of "education", "teachers" and "mathematics education" in the upper left.

In order to help the insights obtained in the themes, another analysis of the research areas was also conducted. It can be seen that half of the analyzed research was conducted in the fields of "Education Educational Research" and "Computer Science". Two papers were recorded in the field of "Engineering" and only one paper per field was published in the remaining research areas.

In the analysis of the network map of the most frequently used author keyword analysis, it was determined that a total of ten different keywords were used by the authors. The most preferred keyword was activity theory, followed by artificial intelligence and education in the top three. Machine learning and teachers were used as keywords three times, while cultural history was used three times. The keywords activity theory, comprehensive learning, and mathematics education were used twice.

The main areas where studies are conducted are teaching, partnership, language education, learning, machine learning, human-centred approach, teaching, learning activities, deep learning, language, computer-mediated instruction, and ethics in AI. According to the CHAT framework analysis, the focal points of the studies concluded that AI-supported teaching is used to achieve objectives.

Analysis of studies based on CHAT frameworks, the subjects are teachers, peers, educational leaders, professors, mentors, children, students, and school leaders. This reveals how important cooperation and partnership between stakeholders is in the implementation of AI pedagogy for sustainable education.

Research considers all communities as stakeholders in implementing AI pedagogy and strengthening AI teaching. Teachers' intervention and structuring of AI-supported language learning in pedagogical design appear to play an important role in the effectiveness of learning.

The division of labour is based on the categories of roles and responsibilities in the implementation of AI pedagogy, as reflected by the selected studies. It is important to establish collaboration between educators, teachers, school leaders and educators as stakeholders in the design, implementation and teaching of AI pedagogy. For effective school reforms based on digital transformation, the importance of creating intermediaries to increase awareness and effectiveness in AI pedagogy for inclusive, accessible and sustainable education is identified.

In the field of AI pedagogy, tools play a crucial role in both designing and facilitating the learning and teaching process. Translation materials, drawing formats, text annotations, and teaching methods utilizing AI technologies have been developed. There is a demand for open-source security tools and machine learning packages that can effectively support the implementation of AI pedagogy and teaching practices.

The selected research studies view rules not only as procedures and tools, but also as theoretical frameworks that facilitate the exploration of AI pedagogy. In this framework, meta-design is used as a method to empower participants, giving them the ability to actively influence the design of tools to meet their unique local requirements and to enhance their perspectives on justice throughout their use. Assignments, e-textbooks, e-learning courses, a

comprehensive human-AI collaborative instructional design model, review of existing research studies, drawing, and collaborative word analysis techniques are used as tools for exploring AI-supported learning environments and teaching. The model of sustainable co-operation between universities and schools is used to conduct research applicable to school activities and to strengthen a school based on scientific foundations.

The research findings offer valuable insights into the potential pathways of AI pedagogy in the future. It turns out that fostering interactive, personalized and fair teaching-learning encounters is essential to enhance critical thinking, advanced skills, active engagement, effective communication and holistic learning. Moreover, the recognition of the hybrid adaptability required in real-life educational settings highlights the central role of AI systems and human facilitators. In particular, AI tools play a crucial role in enhancing language acquisition, while the incorporation of AI teaching methods enriches work-based learning experiences. Moreover, the integration of AI into teaching promotes professional development by encouraging exchange and collaboration.

AUTHOR CONTRIBUTIONS

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