Educational metasystemology perspective in management of Artificial Intelligence paradigm within teacher training

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Abstract: *This study, focused on understanding how to manage the artificial intelligence paradigms and diversity of pedagogical design frameworks in education, aims to contribute to the study of whether and how nowadays teachers design feasible learning environments. The emergence of the new idea of artificial intelligence, its impact on the real-virtual ecosystem of learning and communication, and its advancement in open science are explained in detail. Particularly, this study intends to explore teachers' opinions regarding how to develop successful learning strategies in the minds of their students as the integrity of cognitive, affective, metacognitive, and social life-long learning strategies. The web-based questionnaire created in Google Forms was used as a reference case. Its results completed by pre-university teachers (N= 64) who attended a teaching training program are presented. The conclusion indicates that teachers do believe that artificial intelligence replaced linear approach and systematic instructional design in favor of metasystems learning design. However, the opinions of teachers regarding the impact of artificial intelligence in digital assessment are not in line with the finding of researchers concerned with the issue of pedagogical design in the diversity of learning environments.*

Keywords: Artificial Intelligence, Metacognition, Ecosystem of learning and communication, Pedagogical design, Learning Strategies, E-assessment.

1. Introduction

Artificial Intelligence (AI) is a common term used to define things or processes generated by 'intelligent behavior with minimal human interventions' (Hamet & Tremblay, 2017). Even if until now, AI has mostly remained conducted among stakeholders in higher education, we have also begun to observe that its practice has seeped into theory and practice of e-assessment. Nevertheless, we lack a global perspective of what has been done in pedagogical design and its results. In response, this study offers some insights from the perspective of educational metasystemology – a new line of research studying the context, content, and

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methodology of education at the intersection of pedagogy and management, taking into account the rapid diversification of research and learning environments.

1.1 Lesson study

The origin of AI is connected to Ancient Greek, and Egyptian Myths, and other ideas related to the incredible power of a Mechanical man. In science, the term was coined in 1956 by John McCarthy (Andresen, 2002). Then, for a couple of decades, it was two competing paradigms, defined as *symbolism* and *connectionism*. Symbolism, dominated by the end of the 1980s, following the hypothesis of Newell and Simon et al. that intelligent human behavior is the arbitrary set of symbols and rules that manipulate the symbols, the manipulators are syntactic, and the syntax has a systematic semantic interpretation. Symbolism adopts an assumption that human thought consists of manipulating words according to rules of reasoning and rules of conjecture. In sum, symbolism, known also as a knowledge-driven paradigm, was based on a linear mode of thinking of the human mind, using predefined knowledge, algorithms, and computing power (Zhang, Zhu & Su, 2023).

Connectionism, dominated by 2015, was based on the idea that AI is a system of intelligent networks of artificial elements and the human mind. The perceptron, a prototype of an artificial neural network, developed by Rosenblatt in 1958, is the first model of connectionism, which unified biophysics and psychology in the form of learning curves and neurological variables (Rosenblatt, 1958). In education, connectionism was applied mostly in intelligent textbooks, which 'are a new form of digital textbooks that provides students with intelligent learning services, such as automatic question answering, adaptive navigation support, automatic linking, and personalized recommendation' (Jiang, Gu & Du, 2023).

One can observe the emergence of the third generation of AI. This generation is *generative* because of its proven capacity to generate text, sound, code, or other facilities of the human mind. However, in the opinion of Zhang, Zhu & Su (2023) for more intelligent AI we need robust and explainable AI theories versus safe, reliable, and extensible technology, which will integrate knowledge-driven and data-driven methods by 'simultaneously using the four elements of knowledge, data, algorithms, and computing power'. Such epistemology should integrate the psychological and pedagogical aspects of learning and communication.

How to manage the emergent generation and other technologies of AI? *How to identify the best practices of AI and implement them in pedagogical design*? With these ideas in mind, it was developed the theoretical framework, developed questionary, and was conducted online survey in the Republic of Moldova, where the interest in using AI in education, especially in the programming and use of robots in elementary education is high. This article aims to renew the debate about the affordability of artificial intelligence design frameworks and challenges for education, including the dynamicity of AI solutions and their impact on learning

design approaches. Initially, we present a brief review of representative research concerning the role of AI in education and the increased number of articles related to this area and it is presented the results of an online survey.

The theoretical background that helped to identify the questions for the questionary is covered in the first section. We started by looking for research regarding AI in education, and SMART opportunities of AI for education. The second section focuses on the dynamic nature of research on linear, systems, and metasystem models of thinking. The last part of this investigation concerns the opinions of in-service teachers in supporting digital assessment in the pedagogical design of teacher-centered and/or learner-centered learning environments.

2. Theoretical background

Nature of the AI and its impact on education was investigated by Chassignol, et al. (2018). These authors find that the impact of AI in education needs to be investigated taking into account the norms and experience for the design of content, use of innovative methods for teaching, learning, and evaluation, norms for technology-enhanced assessment, and rules for learning and communication,

2.1 The expanding amount of research on AI in education

The application of AI in education was gaining increased interest in the last few decades. There are at least five lines of research that integrate the theory and technology of AI:

- *programmed instruction* (Berchin, 1981; Daniel & Murdoch, 1968; Fincher & Fillmer, 1965; Kulik, Cohen & Ebeling, 1980; Wood, 1964);
- *intelligent tutoring systems* (Nwana, 1990) and practical application in the form of educational software, intelligent digital textbooks, etc., including the design of innovative *learning environments* (Lawler & Yazdani, 1987);
- *agent-based learning environments* (Baylor, 2002; Harrer, 2001) including chatbot conversational systems (Jia, 2004);
- *interactive humanoid robot* (Ishiguro, 2001);
- *social artificial intelligence*, including but not limited to the Internet of Things, machine learning, neural networks, smart learning, deep learning, smart assistants (Ghosh, Chakraborty & Law, 2018; Hwang & Chien, 2022; Yang, 2022), and intelligent social interventions.

This idea can be proven using the Books Ngram Viewer. Figure 1 shows the growing number of studies concerned with the subject of ‘artificial intelligence in education’.

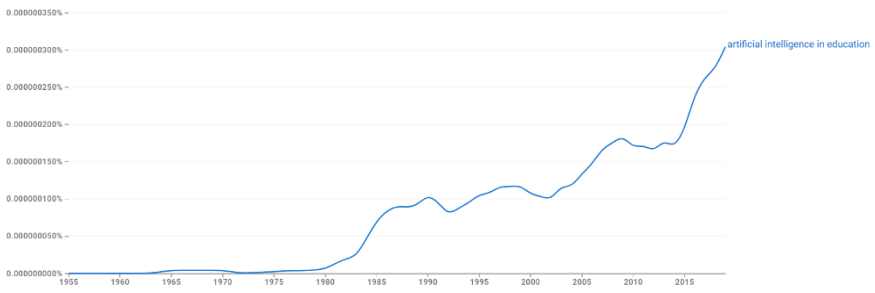

Figure 1. The increased number of research on AI in education

These five lines of research investigate the impact of AI in education through the newest educational technologies and environments. Nowadays, the most researched term is *AI literacy*, which refers to the competencies of life-long learners to enable understanding of the management of artificial intelligence programs, the scope of instructional design frameworks, and the essence of pedagogical design. According to Yang (2022), 'AI literacy is an organic part of digital literacy for all citizens in an increasingly intelligent society'. But, how to achieve this?

Programmed instruction is related to the linear thinking paradigm. Students are introduced to new material in an artificially designed instructional environment through a graded progression of 'intelligent' supervised steps. This system offers rich feedback or individualized learning through 'branching programs' (Crowder, 1959) or 'adaptive systems' (Werbos, 1987) – a branch of 'generative systems' (Wexler, 1970) able to generate and solve problems in the limit of programmed instruction. The 'intelligence' of these programs is related to step-by-step instruction, intelligent analysis of student's answers, and immediate feedback on what was previously programmed.

Intelligent tutoring systems (ITSs) use AI in two ways: (a) direct instruction (e.g., students gain knowledge from presented didactical material) and (b) indirect instruction (e.g., LOGO - students learn by programming). With the increased use of ITSs in business, the labor market, and education it was developed three main types of machine learning were: supervised, reinforcement, and unsupervised learning. However, the majority of ITSs models were based on system thinking as 'an attempt to produce in a computer behavior which, if performed by a human, would be described as 'good teaching'' (Nwana, 1990). Such 'intelligent' tutors were integrated into Intelligent Computer Aided Instruction and Intelligent Assessment Technologies. Moreover, the alternative ways to teach students are learning environments – a space to exercise creativity through innovative ideas.

The development of agent-based learning environments was grown on the 'agent metaphor' used to identify the system mode of thinking. As was noted by Baylor (2002), the agent-based learning environments approach is a way to operationalize and simulate the 'human' aspect of instruction in a more ecological

way than other controlled computer-based methods. Agents use learning objects and, therefore, allow more flexible modes to generate the instructional content and analyze students' answers. However, with the emergence of chatbot conversational systems, the models of agent-based learning environments become more flexible. It was observed a big potential to use conversational interfaces to facilitate learning.

The interactive humanoid robot was designed to assist humans with 'tasks that are physically demanding, unsafe, unpleasant, or boring' (DiSalvo et al., 2002). Even the emergence of the interactive humanoid robot was guided by the idea to develop more efficient models of learning and communication, soon was observed that human-robot interaction is an important question for a learning and communication ecosystem. For instance, in '*Homo Deus: A Brief History of Tomorrow'*, Yuval Noah Harari notes that people try to create an artificial life using famine, plague, and war as manageable challenges. After it was observed that more people pass away from eating too much 'safe and nutritious food' than from infectious diseases or from suicide or self-harm than from terrorists and criminals.

Nevertheless, the improved artificial models of interactivity and flexibility common in designing interactive humanoid robots opened a door for novel models of social artificial intelligence. On the one hand, social artificial intelligence arises the problem of how humans will control the humanoid robots, firstly because of the unexpected digital ecosystem and secondly, because control is the primary function of management, therefore, such a problem should be solved at the intersection of the educational and management sciences. On the other hand, AI uses advances in Virtual Reality or/and Augmented Reality to create more innovative products for educational purposes, mostly in digital media (Gong, 2021). Moreover, AI cannot compete with human intelligence that includes material, economic, emotional, spatial, and spiritual forms of intelligence among others.

One more thing is related to *generative artificial intelligence*. This term refers to technology that (a) can generate all kinds of data (e.g., images, 3D objects, texts), (b) perform all kinds of data transformation (e.g., domain transfer, style transfer), and (c) enrich datasets and improve machine learning. Baidoo-Anu and Owusu Ansah (2023) observed that GAI took the world by surprise that artificial intelligence can perform complex tasks in the field of education, including but not limited to (a)promotion of personalized and interactive learning environments, (b)providing ongoing feedback to inform teaching and learning and (c) generating prompts for formative assessment. In sum, the management of artificial intelligence paradigms and pedagogical design frameworks is a huge issue, identified at the intersection of education and managerial sciences.

2.2 SMART opportunities of /for AI in education

While this is still a lively debate in the frontier area of education and management regarding whether and to what extent AI is useful in design for more successful teaching, learning, and assessment activities, the research community

seems to agree on several features that should characterize an innovative pedagogical design framework with AI. To understand this, we will look at SMART opportunities of/for AI in education (Table 2).

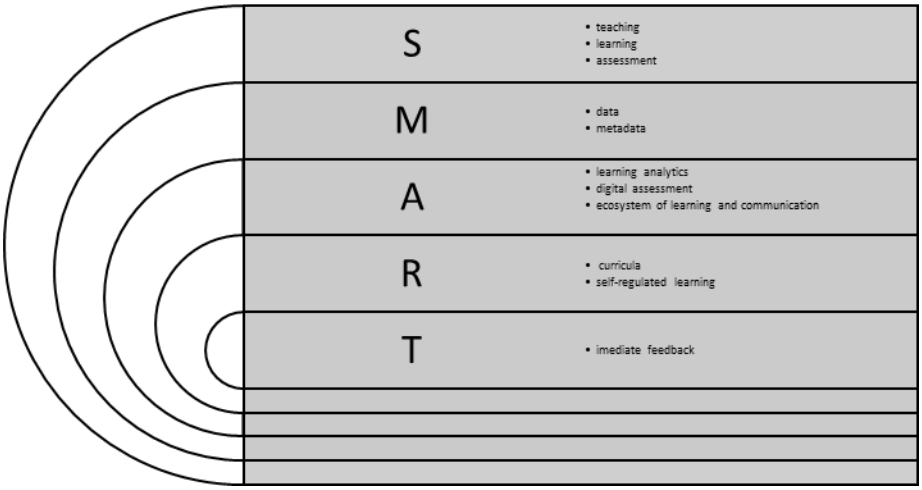

Figure 2. SMART opportunities of /for AI in education

'Connection' between AI in education and SMART opportunities allow us to understand the essence of AI. In the opinion of Ahmad et al. (2021) AI applications in education refer to Intelligent Tutoring Systems (ITS), social robots, and smart learning devices. ITS is an intelligent system tutoring students based on detailed input by presenting information in an interactive form and providing an interactive test of a student's knowledge at the end. Social robots are intelligent machines following social behavior and are used in education for teaching and tutoring instead of human teachers. Smart learning devices and other personal means and tools used for learning are mobile technologies addressing students' education-related issues (e.g., locations, and schedules).

The new generation of AI can help both teacher and student to generate the first draft of an essay, identify the most relevant literature, assist in composing a research methodology, edit and format the paper, and summarize the entered text to compose a suitable abstract or/and a conclusion, etc., and all these activities save the time of researcher because they are time-consuming. The potential application of AI for education is to summarize research data in affordable figures, tables, and other visual elements. However, nowadays more than ever it is important to critically analyze this paper and effectively manage the theory and technology of education. An important issue is ethical concerns (Salvagno, Taccone & Gerli, 2023).

The opportunities of AI for teaching, learning, and assessment were described. Bhbosale, Pujari & Multani (2020), for example, note that robots like Ozobot and Cubelets teach and help learners to learn. However, as was noted by Alam (2021) 'AI is an area of research in which computers, robots, and other technologies are programmed to exhibit human-like intelligence, as characterized

by cognitive skills such as learning and adaptation, as well as decision-making capabilities '. Even, in theory, capabilities are associated with metacognition, in practice the impact of AI in education need to be related to creativity and 'human' forms of intelligence (e.g., material, emotional, and spiritual).

The disadvantages of AI are more related to patterns of thinking. Even if AI can increase the performance of teacher to monitor students' learning through learning analytics, diversification of learning environments create in students' minds a collapse of reality. AI in education is unable to compete with human soft skills like curiosity, critical thinking, problem-solving, and innovation based on insight. Intelligent people will always be able to communicate, experiment with new ideas, evaluate feedback critically, observe and solve problems 'outside the box,' and apply creative solutions to pressing issues.

3. Method

3.1 Data collection

In the endeavor to find answers to the above RQ, it was decided to use the qualitative method of questionary and collect the data through an online survey tool consisting of questions 'extracted' from the theoretical background of this paper and purposedly built to investigate the above RQs. The questionnaire 'Teachers' and students' perceptions of the impact of AI on learning outcomes' was designed and developed by the author of this research and was implemented in the form of an online survey using Google Forms. It comprised a total of 16 questions designed for collecting qualitative data from teachers and students.

The opportunity to respond to an online survey was promoted in several training activities for in-service teachers organized in 2023. These had been established in response to the urgent need to provide in-service teachers with specific teacher training on approaches, strategies, and methods regarding how to deal with innovative technologies, specifically with AI technology in education (e.g., educational robots, and digital assessment). 64 participants responded to the call to complete the online survey. Most of the participants are students (68,2%) and teachers (15.6%). Regarding age, our sample population was composed as follows: 21-30 years = 50 (78,1%), under 20 = 12(18,1%), and 31-40 years = 2(3.1%). School level is presented, as follows: high school = 31(48,4%), university level = 20(31.3%), college = 8(12.5%), and other = 5(7.8%). In terms of learning activity, most of our respondents were from town = 61(95.3%).

3.2 Results

The majority of our respondents responded that the best learning strategies are (a) problem-solving in real school settings = 26 (40.6%), (b) interactive discussion with peers = 15 (23.4%), (c) teacher's lecture = 26 (40.6%), and (d) comprehensive reading = 6 (9.4%). However, to achieve this result is important to

develop soft skills. The term ‘soft skills’ refers to ‘personality traits, goals, motivations, and preferences’ (Heckman & Kautz, 2012). Therefore, the best learning strategies for a contemporary student are problem-solving.

In the opinion of our respondents, the most comprehensive category of methods refers to (a) methods of exploring reality (based on direct or indirect contact with reality) = 30 (40.9%), (b) methods of acquiring and transmitting knowledge = 19 (29.7%), (c) action-based methods (role play, project, etc.) = 10 (15.6%). This outcome supports the findings of our earlier research, which indicated that the majority of actual students consider themselves to be world travelers rather than individuals looking to influence the world in any way.

Our respondents state that the most important method for them is (a) practical work = 30 (46.9%), (b) description of what was observed and investigated = 13 (20.3%), (c) storytelling = 6 (9.4%). Regarding what digital resources are used to convey teaching message, participants respond, as follows, (a) video/audio files = 23 (35.9%), (b) simulations with educational software = 20 (31.3%), (c) photos/videos made personally = 10 (15.6%), (d) images from the Internet = 8 (12.5%). These findings suggest that students 'come' to university for practical skills out of curiosity and a desire to develop their curiosity, creativity, problem-solving, and decision-making skills to deal with ambiguous situations.

It was a surprise for us to observe that most of our respondents report that the students’ activity is evaluated mostly by (a) oral communication = 28 (43.8%), (b) tests on paper photographed and transmitted online = 20 (31.3%), and (c) computer interactive tests = 13 (20.3%). Respondents selected the following statements for the actual situation, in which we are living: (a) assessment measures the quality of the teaching process = 28 (43.8%); (b) assessment measures learning outcomes / educational goals = 19 (29.7%), and (c) assessment is a unique opportunity to develop learning competence = 17 (26.6%). Moreover, in the opinion of our respondents, digital assessment is more (a) correct (i.e., sensitive to the psycho-pedagogical and cultural characteristics of groups of students) = 30 (46.9%); (b) accurate (i.e., the measurement error of competencies is minimized) = 18 (28.1%), and (c) reliable (i.e., obtains and provides the same results for all situations) = 16 (25 %) in comparison with traditional forms of assessment (e.g., paper-and-pencil). E-assessment tools are balanced if the pedagogical design is based on principles of coherence, comprehensiveness, and continuity – state 27 (42,2 %) of participants.

4. Conclusion

Nowadays, AI generates text, images, voices, movies, etc. Traditionally, pedagogy and learning theories have a special role in supporting the applicability of educational technologies in various learning settings. Less explored tasks are

psychological aspects of learning and assessment with AI. Learning occurs in a variety of learning environments, both physical and virtual.

This article presents the findings of a theoretical-practical investigation of AI in education. Overall, findings show that the term 'AI' is used to describe things or processes produced by intelligent behavior. In the context of digital education, AI takes the form of (a) supervised learning, where each data point has features and a corresponding label, (b) unsupervised learning, where a certain kind of algorithm learns patterns from untagged data, and (c) semi-supervised learning, where a combination of labeled and unlabeled data is used to train models. However, AI cannot compete with human skills such as curiosity, critical thinking, problem-solving, and insight-driven innovation even can generate text, music, and pictures. Thus, AI may increase the performance of lifelong students if is adequately applied.

5. Limitations of the study and future research

Nowadays, pedagogical resources and learning tools integrate a variety of AI solutions in the form of adaptive interactive environments and AI-generated guidance aims to support learning through hyperlinks, glossaries, multimodal communication, and various immediate feedback strategies. However, none of these solutions address the question of how to 'learn more effectively with self-paced environments' and instead focus on cognitive load and motivation (Koc-Januchta, Schonborn, Tibell, Chaudhri & Heller, 2020). For learning with digital tools, developing AI literacy is, therefore, essential.

Recent developments in learning and assessment with AI emphasize affective, social, and metacognitive strategies. However, effective strategies are more related to emotional AI (Ho, Mantello & Ho, 2023; Zainol, Keikhosrokiani, Asl & Anuar, 2023; Chen, Cheng, Zou, Zhong & Xie, 2023; Geetha et al., 2023) and not to the natural stimulation of students' emotions, feelings, attitudes, creativity, and motivation to learn in various kinds of learning environments, both physical and virtual. Regarding metacognition, AI methods focus on 'real-time assessment of a learner's verbatim transcript' (Wang & Lin, 2023), 'meta-learning' (Drigas, Mitsea & Skianis, 2023), meta-awareness, etc., which could include (meta)cognitive strategies of self-regulated learning.

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