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Creative Peer System

An Experimental Design for Fostering Creativity with Artificial Intelligence in Multimodal and Sociocultural Learning Environments

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Abstract. To develop artificial intelligence (AI) that educators can adopt in general educational environments, we are examining the potential role of AI in the socio-cultural aspects of learning in human development. In this position paper, we propose an experimental design, Creative Peer System, where humans and machines learn from each other in a multimodal learning environment and develop original artifacts. The research is in the early stage, where we are actively developing new types of empirical studies. We will present the methodological and theoretical frameworks and a design proposal that can elicit constructive feedback toward further refinement and implementation of the experiment.

Keywords: Multimodal Intelligent Tutoring Systems · Multimodal Intelligent Tutoring Systemsd · Multimodal Intelligent Tutoring Systems · Multimodal Learner Modelling · Cultural-Historical Activity Theory · Zone of Proximal Development · Creativity · Early Childhood Education

1 Introduction

Creativity is considered an essential learning outcome for the 21st century that values problem solving and communication. Students need a broad range of knowledge, like understanding how things are made and accomplished [11]. Meta-cognitive skills such as critical thinking, creative thinking, reflection, self-regulation, and social and emotional skills such as empathy, self-efficacy, and collaboration are deemed critical. Traditionally, early childhood education is seen as the primary educational segment fostering creativity, while in later education, the focus is often more on academic knowledge acquisition. The high interest in academic knowledge has resulted in certain educational practices like testing that measure memorization.

Many types of research that examine artificial intelligence (AI) as an educational technology reflect on this interest in academic knowledge. AI and education research has many exciting developments that can increase personalization, reduce administrative labor, support assessments, and increase access to education [18, 6, 7]. Emerging research is investigating how AI can be integrated beyond the scope of academic knowledge acquisition and testing. There are concerns about AI integration in wider educational settings due to the limitations of current technology, like narrow cognitive capabilities, systematic biases, and lack of industry-wide norms and policies on data surveillance and privacy [19, 21, 20]. Along with these challenges, to develop AI that can be adopted in general educational environments, we believe there is a need to examine AI in the context of socio-cultural aspects of learning in human development. We see that a promising research domain is to study the role of AI in fostering creativity, especially in early childhood education. There is a long tradition of looking at methods to foster creativity as part of the child's overall development in early childhood education. In early childhood education, children's agency, play, and collaboration are seen as crucial [4]. Children are seen to grow in close interaction with their peers, caregivers, and educators. The objective is to learn life skills, social and emotional skills, and creativity — all simultaneously by playing with others in a socio-cultural environment of the child [17, 23, 2].

To explore the role of AI in creative capacity building, especially in early childhood education, we have set the following design research questions:

- How can AI be meaningfully incorporated into a socio-cultural learning environment?

To study the phenomenon, we focus on the following sub-research questions:

- How can AI enhance the creative capacity of the students?
- How can AI themselves be considered creative?

This article proposes an experimental design, Creative Peer System, where humans and machines learn from each other in a multimodal learning environment and develop original artifacts. The research is in the early stage of development, where we are considering various approaches and methods for new empirical studies. This article is more a position paper than a research paper presenting study results. In the following sections, we will briefly present the methodological and theoretical framework in consideration and an early design proposal that results from thought experiments carried out while studying the design context of AI in education. We conclude by discussing the potential impact for a wider researcher and educator communities by opening up the scope of AI in education toward new types of data sources, systems, and environments.

2 Methodologies and Frameworks

We rely on research-based design and design-based research methodologies interested in design artifacts and pedagogical interventions in educational settings and study their effects in a real educational context [14, 13, 3]. The idea is to design well-informed artifacts and practices that are expected to support certain pedagogical forms and models. Therefore, the design practice is an essential part of the research, and reporting the artifacts and the design process leading to them is vital as well. The designed artifacts form a part of the research argumentation [9, 8].

With the experiment, we aim to examine the role of AI critically in a learning context. As a theoretical framework, we use the cultural-historical activity theory [5]. We apply the activity theory and the idea of the zone of proximal development by rethinking the role and activity of the AI and the learner's interaction with the AI in a learning context.

Often AI as a learning technology is regarded as a tool within a learning environment [18, 6, 19]. The latest advancement in AI and anthropomorphic approach allows regarding AI as a creative peer [10, 12]. This experiment will aim to regard AI as a peer among the learners. In the experiment, subjects are humans and machines; objects are creating artifacts; communities are humans, machines, and evaluators; and tools and signs are making materials (Figure 1).

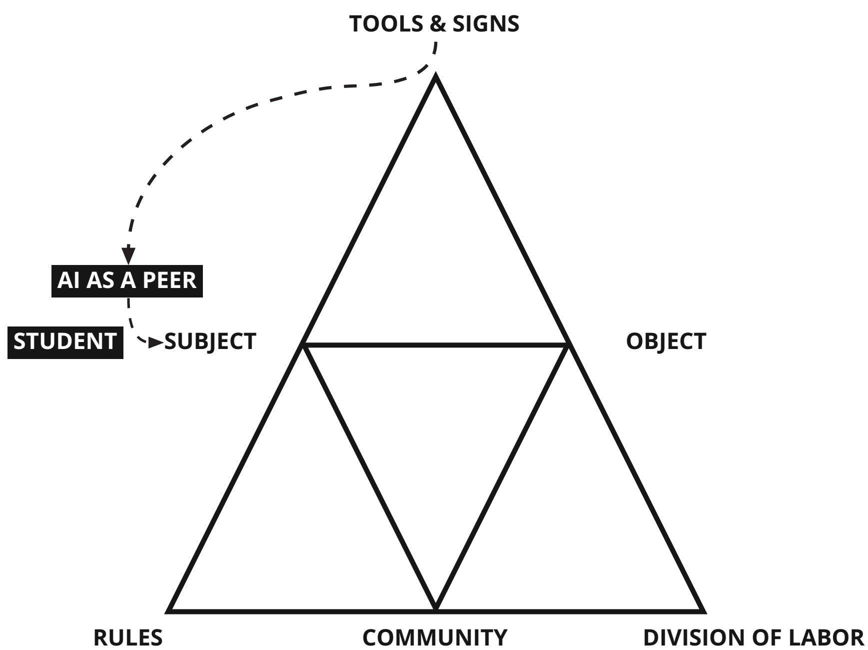

Fig. 1. Creative Peer System in Activity Theory Framework.

We assume that as a learner is expanding one's capacity in a learning context, AI may become a peer that grows with learners in the zone of proximal development as described by Vygotsky. The learner grows when interacting with a more knowledgeable or skillful peer [24]. This way, AI is not an intelligent tutor with a fixed knowledge domain but instead grows together with the learner as a peer (Figure 2).

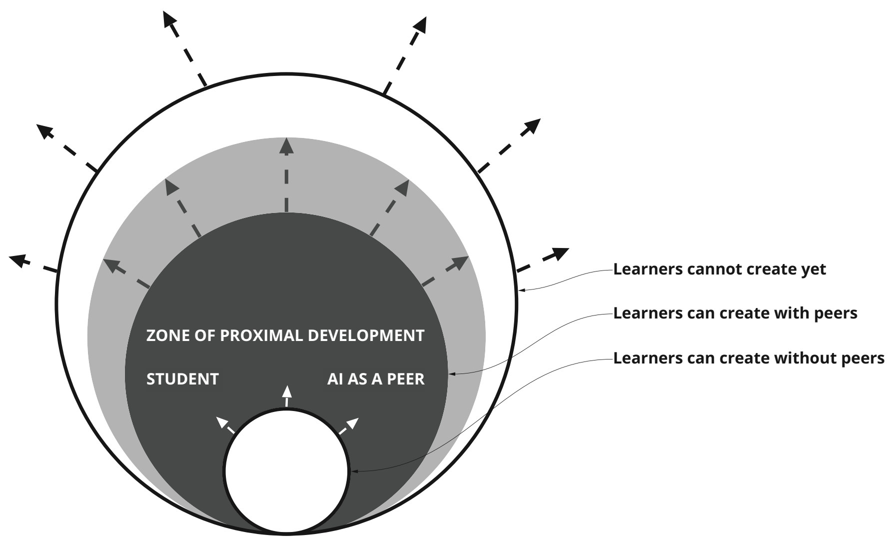

Fig. 2. Creative Peer System in the Zone of Proximal Development.

In assessing the creative capacity of the learners and machine, the experiment will have uninformed assessment criteria between human and machine learners. The experiment will develop assessment criteria developed in computational creativity: combinatorial creativity, evolutionary creativity, and transformative creativity [1].

In developing AI that exhibits creative behaviors, the experiment will use the generative adversarial network, reinforcement learning, and embodied learning through robotics and virtual simulation [10, 12, 15, 16, 22]. For AI to be engaging with human peers in a socio-cultural learning environment, it will be essential to engage in multimodal data sources and interaction techniques like computer vision, audio detection, automatic feedback, and artifact generation.

3 Design Proposal

The Creative Peer System is a socio-cultural learning environment where humans and machines learn from each other and produce a new form of creative artifacts. Below is an experimental design, a design concept, that can test the educational impact of the system in the context of early childhood education.

The experiment has three types of participants in the system.

- Students: five to ten kindergarten students at the age between four and seven.
- Teachers: one or two early childhood educators and at least one machine evaluator supervised by programmers.

– Machines: five to ten robots with learning and generative capacities (AI).

The system operates in a physical environment that enables peer-to-peer learning, making, and reflection to replicate the common practices of socio-cultural learning. The example system is a typical kindergarten art class in an open space that allows peer-to-peer observation and access to the same materials. The machines use multi-sensory techniques like camera vision and audio detection to observe their peers and assess the sense of presence in the environment.

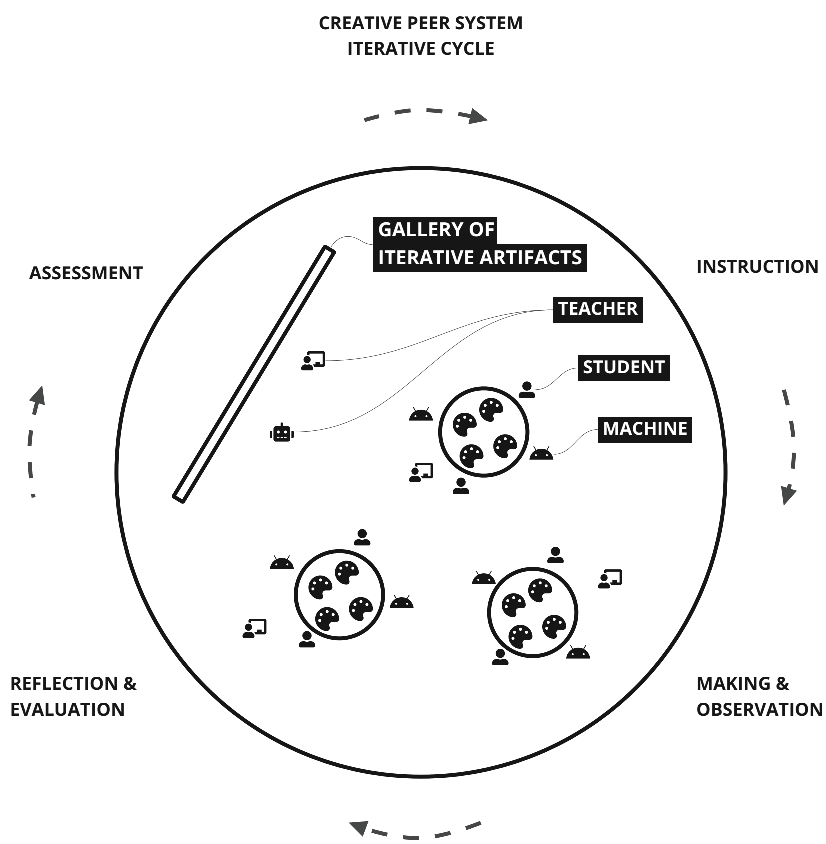

Fig. 3. Creative Peer System Environment and Iterative Cycle.

The system will have interactive cycles of activities involving the students, machines, and teachers. Each iteration cycle will go as follows:

- Instruction: Students and machines get situated side by side in an open space, receiving the same making materials and instructions.
- Making and Observation: Students and machines create their artifacts while observing others' progress freely.
- Reflection and Evaluation: Once the artifact creation is completed, the students and machine share their works in a shared space, observe, and reflect.
- Assessment: Teachers assess the artifacts considering three aspects of creativity (combinatory, exploratory, and transformative) using visual perception, interpretation, peer-to-peer discussion, and algorithmic categorization.

The system will repeat multiple iterations while documenting the interactions, artifacts, and assessments. After the series of iterations, the researcher can assess the creative capacity development of the group by tracking evolutionary behaviors such as stylistic transfers, diffusion, development of a new form of art, and new norm establishment.

In order to evaluate the educational impact of the system, comparable systems can be designed and tested with different groups of students. While the making activities and physical space stay the same, multiple variations can be tested, such as machines functioning in a different role, for example, tutor, tool, or absent, in a socio-cultural learning environment.

By evaluating the students' and machines' behavior and artifacts, the experiment can examine in what capacity AI can be incorporated into a socio-cultural learning environment. The experiment can reveal various ways AI influences the students' creative capacity and if AI itself can be considered creative by developing something original and transformative to its peers.

4 Discussion

Many topics need further consideration in this experimental design. While both human educators and machines will be used for evaluating the artifacts' creative development, there need to be systematic ways to measure both human creative capacity and artifacts' artistic evolution.

Many existing machine learning techniques require a high volume of data and numerous iterations to train and generate artifacts that are noticeably different from their previous outputs. Given these current technical constraints, there would need to be pre-training with data outside of the experiment, analogous to the students coming in with previous life experience. In addition, computational design and processing need to be up to the students' making and observation speed in real-time.

While the experiment seeks to address the machine's creative capacity in the socio-cultural learning context, it is debatable that this argument is limited only to the scope of the specific environment and learning activities. However, a Creative Peer System can be used to further experiment with the dynamics of creative capacity building in different environments, age groups, and objectives. These tests can contribute to a broader understanding of the machine and human creativity.

5 Conclusion

In this position paper, we propose that AI and learning science researchers look at the socio-cultural environment's role in human learning, especially in learning creativity. We propose an approach where AI is primarily considered a creative peer of the learners to develop its creativity and, in turn, help learners develop their creativity. We call this the Creative Peer System, a socio-cultural learning environment where humans and machines learn from each other and produce a new form of creative artifacts. As the research is still in its early stages, this paper can elicit constructive feedback toward further refinement and implementation of the experiment. We hope this work can positively contribute to expanding AI works as a multimodal educational technology in a general educational environment.

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