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Artificial intelligence, creativity and education: finding a new perspective

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Abstract: *This review study aims to clarify the relationship between creativity development and artificial intelligence in education. Although this is a media-emphasised topic and individual technology projects (ChatGPT, Dalee-2, Midjourney) are part of educational activities, a more comprehensive analysis of the specific emphasis on creativity still needs to be provided. The study's novelty lies in synthesising current knowledge and forming recommendations about the relationship between creativity and AI in education. The study analyses 16 documents from the Web of Science database and, based on these, identifies six broad categories for critical reflection on the phenomenon of educational practice: the need to rethink the educational environment, goals and objectives, the emphasis on AI literacy, the focus on topics related to the future and its problems, the importance of developing theoretical conceptualisation of problems and abstract models in the curriculum, the connection with computational thinking, and the integration into the whole curriculum instead of isolated courses.*

Keywords: *artificial intelligence; creativity; review study; education; ChatGPT; AI; technology in education*

1. Introduction

Technology is fundamentally transforming education (Rodés Paragarino, V., & Gewerc, 2022; González-Pérez & Ramírez-Montoya, 2022). This is not just a matter of following trends (Pelletier et al., 2022) but of making more profound and systematic changes to the very nature of education (Treve, 2021). Technology is not external but a fundamental element transforming the environment (Zhang et al., 2023; Pelletier et al., 2022; Oliveira & Souza, 2022).

Generative artificial intelligence has become a significant technology trend between 2022 and 2023 and has begun to take hold in the form of user-friendly tools. In the field of artefact creation, the most visible projects are Dalle-2 (Kang et al., 2023; Hutson & Cotroneo, 2023), Midjourney (Borji, 2022; Byrne, 2023) and for language models, undeniably ChatGPT (Deng & Lin, 2022; Shahriar & Hayawi, 2023), for which there are already many studies focused on

education (Lo, 2023; Kasneci et al., 2023). These technologies will majorly impact the labour market (Zarifhonarvar, 2023; Pan & Froese, 2023).

For this reason, it is crucial to look at how ideas and models of education need to be transformed in the context of technological change (Cerny, 2022). Specifically, we want to focus on the relationship between artificial intelligence, creativity and education. It is creativity that has been associated with language models and other projects using generative AI (Jia et al., 2023; Creely, 2023), even as an educational challenge (Shidiq, 2023) or an issue of humanity (Haase & Hanel, 2023) and the development of typical human qualities and characteristics. The question of the relationship between the form of education and the use of AI to develop creativity will be a crucial focus of this study.

We know that the definition of the two key terms of our study is fluid and that each author may treat it differently. Artificial intelligence could be understood in the 1950s as a theory of human intelligence that machines can manifest, but it is not very easy to define in the current era (Bini, 2018). It can be seen as a superordinate concept of machine learning (Helm et al., 2020). Dobrev (2012, p. 2) boldly claims that "AI will be such a program which in an arbitrary world will cope no worse than a human". Turing's approach (Elkins & Chun, 2020) similarly reckons that an intelligent system is one that we cannot differentiate from a human in dialogue (Danziger, 2022; Alberts, 2022). In our study, we recognise the limitations of these definitions, which always work only with a specific facet of human activity, and we will understand artificial intelligence as a non-deterministic algorithm that uses machine learning to solve a particular set of problems.

Creativity can be a similarly complicated concept (Kampylis & Valtanen, 2010; Walia, 2019). Koestler (1981; 2014) suggests creativity occurs when two distinctly different frames of mind intersect. These are applied to a single phenomenon whose understanding differs from how we have understood it. Wallas (Sadler-Smith, 2015; Setiawani et al., 2019) links it to expertise that leads to a new idea being evaluated and succeeding in that evaluation. For this study, we can simplify creativity to a description derived from the Cambridge Dictionary: 'the ability to produce original and unusual ideas, or to make something new or imaginative', as the approaches of most of the studies we have analysed can be integrated into this definition. For a deeper analysis, we lean towards Feyerabend's (1984) understanding of creativity, which associates it with expertise, courage and originality. We will return to the meaning and structure of these simplifications and definitions at the end of this review.

There are currently (as will be shown in the Results section) a relatively large number of sub-studies that address the rise of creativity and AI in education. Still, there is a lack of a broader integrative view of the issue that can be examined from broader perspectives than just case studies or idea papers. In this study, therefore, we attempt to answer the question of the relationship between AI, creativity and education, specifically in formal education.

2. Methodology

The Web of Science (WoS) database, which collects documents from the most prestigious journals, proceedings and other sources, was used to obtain data for the review study. Thus, it provides the theoretically best quality and best-described results of current research among the databases. For the search itself, we used two selection steps. In the first step, we worked with the keywords "AI creativity education". The word education instead of learning was deliberate because the word learning occurs strongly in technology practice in the context of neural network learning or machine learning.

In this way, we obtained the first data set of 263 results. We exported keywords, fields of investigation, and abstracts in Voyant Tools for quantitative text document analysis to perform the first data analysis. This part of the research aims to provide a baseline for comparing the relevance of the results obtained for the second part of the review study. The dataset was finalised on 3 . August 2023.

To be able to go through the texts systematically, it was necessary to set additional rules for the selection of results. We, therefore, chose the following added criteria:

1. The language of the result must be English (reduction to 247 results)
2. Must be Open Access documents (reduction to 84 documents)
3. Document type - Article (reduction to 63)
4. Social Science Research Domain (reduced to 23)
5. Manual selection of irrelevant documents (reduction to 16)

Irrelevant results were applied in two sets of cases. Either the study was unrelated to the topic, even marginally, or (in the case of two studies) the articles needed to be of better quality. They were withdrawn from the journal by the publisher. They still appeared in the database. The fact that a relatively strongly selected dataset had 30% of results irrelevant shows that the topic we studied is, on the one hand, new and needs to be grasped.

On the other hand, extremely attractive in terms of keywords. At the same time, the original dataset with 263 results may have minimal relevance to the topic under study. The path of a qualitatively oriented review study is the only possible one in this context.

For the qualitative part of the review study, we looked at the research design and the focus of the study (whether it is theoretical, empirical or applied). For the critical question and findings, we did not follow the tone of the entire study but what was relevant to our research topic. Some of the studies addressed the phenomenon only marginally, so it was necessary to look at the details in the results. The original intention was also to observe the prevailing attitude of the study towards the AI phenomenon. This is not reported in the results, as it was positive or neutral in almost all studies. A completely different analytical method would have been needed for a more careful distillation.

In the table (Table 2) with the results, we list the countries, by which we mean the countries of the authors' institutions as listed in the WoS. The WoS also provides a summary of citation feedback, so the total citation feedback for some studies will be higher.

Three significant limitations of the study can be seen. 1) The too-small research sample analysed in the qualitative part reduces the possible diversity of conclusions and the plasticity of the issues reflected. 2) We only work with studies from WoS, which constitute a specific slice of reality; the study could be extended with studies from other databases (especially Scopus) or sources outside the academic environment that would be more relevant to practical issues and problems. 3) The studies are focused on only part of the world in their selection - we need studies from Africa, more documents from Europe or the Middle East and other areas. At the same time, their conception of creativity may differ from the studies in this review.

3. Results

In the first part of the results, we would like to offer a more comprehensive view of the whole issue through the lens of the two datasets mentioned above - one with 263 documents (Full) and the other with 16 selected ones (Selected). This first quantitative analysis aims to offer a basic description of the whole research set. Regarding the description of the datasets, the first Full with abstracts has approximately 54.3 thousand words and 6.2 thousand unique word forms; with keywords, we can talk about 4.5 thousand words and 1.2 thousand unique word forms. It is already clear from this overview that the thematic and content dispersion of the studies will be considerable.

Fig 1. Wordcloud of abstracts for the entire dataset.

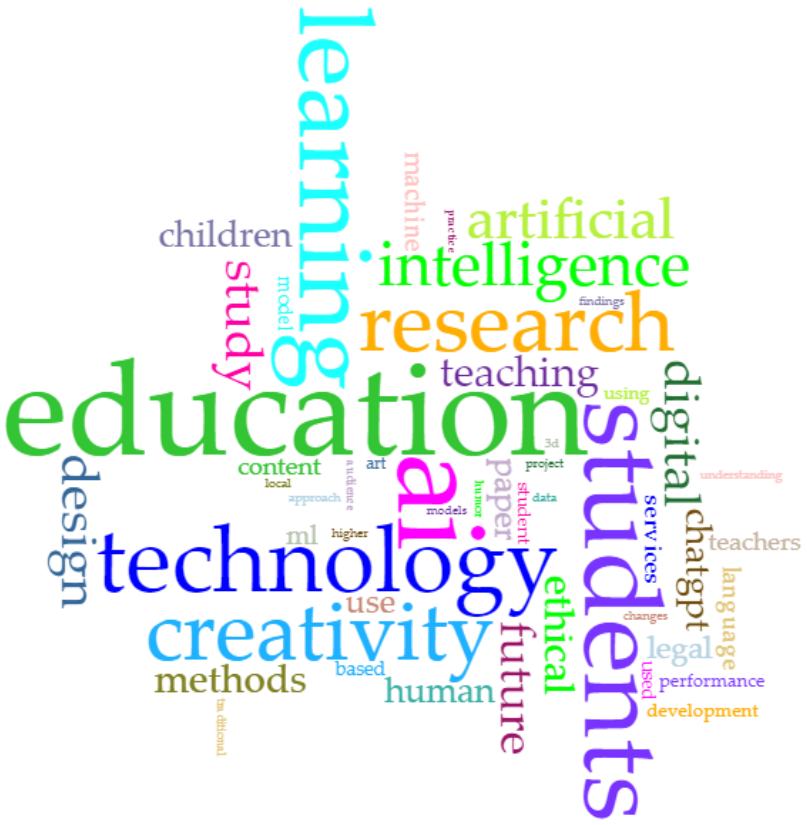

Fig 2. Wordcloud of abstracts for the sample dataset.

A comparison of Figure 1 and Figure 2 shows that the datasets are relatively similar in content (we are comparing abstracts, which already give a rather good indication of article casts).

However, compared to the former, our reduced dataset is more technical and less design-oriented, which should be considered when analysing the overall thematic focus of the studies. We also include a table (Table 1) with the most frequent keywords in the dataset analysed for a more profound overview of the research field.

Table 1. Captures data from the entire dataset from keywords with a frequency higher than 25.

Keyword - frequency	
Creativity - 111	Artificial - 44
Learning - 93	Innovation - 32
Education 93	Creative - 31
Design - 62	Thinking - 28
Intelligence - 57	Model - 28
AI - 47	Technology - 26

To illustrate the thematic landscape of the studies, we also include an analysis by discipline (Figures 3 and 4), as generated by the analytical tool integrated into the Web of Science. Their comparison shows that our selection for social sciences reduced primarily technical papers, which may not have sufficient relevance for the topic we studied. At the same time, the data show that our research is in a field at the boundary between educational sciences and computer sciences.

Fig. 3. Fields in the entire dataset.

Fig. 4. Fields in the sample dataset.

In the second part of the presentation of the results, we will work with the table (Table 2) that we obtained by carefully reading the individual studies in the sample (to which Figures 2 and 4 correspond).

Table 2. Overview of studies included in the qualitative part of the review study. The abbreviations for countries in the last column are KOR - Korea, USA - United States, CHN - China, ITA - Italy, THA - Thailand, DEU - Germany, UKR - Ukraine, GB - United Kingdom,

and AUS - Australia. The abbreviation Ref. denotes the number of citations (excluding self-citations) in WoS.

Authors	Question	Methodology	T/E/A	Interesting findings	Ref	State
Marrone, R; Taddeo, V and Hill, G	What is the relationship between AI and creativity?	Focus groups, interviews	E	Students with a better understanding of AI are less afraid and more able to implement it in their creative process. AI literacy is a crucial element for the future of education.	5	AUS
Kim, J and Lee, SS	Do we need to educate when we can use AI?	Experiment	E	The study shows that it is necessary to look for areas in which the use of AI makes sense and, at the same time, to connect work with AI systems with educational support. Then, better results can be achieved in creativity, at least in art.	0	KOR
Rong, QM; Lian, Q and Tang, TR	The combination of AI and VR and their educational effects.	Questionnaire	E	Students who work with VR and AI are more creative and immersed in learning. A fundamental limitation is the need for adequate teaching practices.	2	CHN
Ritchie, G	Can computers create humour?	Theoretical study	T	The study shows that computers can create jokes or perform humour, thanks to discoveries in the field of humour itself. Good knowledge of the phenomena to be generated is a prerequisite for their successful implementation.	10	GB
Treve, M	What impact has COVID-19 brought on the transformation of higher education?	Overview study	E	COVID-19 led to a transformation of teaching methods and forms. AI represents the next natural step enabled by the pandemic. AI systems can support differentiated and individualised instruction while reducing the burden on educators.	18	THA

Iskender, A	What opportunities or threats does ChatGPT bring to tourism education.	Experiment	E	The study says we do not know much yet, so we should work with this tool as much as possible. It cannot be banned or restricted, but that does not mean it is a one-size-fits-all answer. Regarding creativity development, the study emphasises the possibility of brainstorming or focusing on more cognitively demanding tasks.	6	USA
Tang, TR; Li, PF and Tang, QH	How can AI help students with design proposals?	Experiment	E	The study shows that if education is to lead to the creation of products, AI can help achieve higher quality and more complex outputs, leading to more efficient use of time and, thus, higher quality education.	0	CHN
Dwivedi, U; Gandhi, J; (...); Kacorri, H	How can ML education help creativity?	Experiment	E	The study shows that the design of ML algorithms incorporates concepts, such as the innovative cyclic approach, that are the same as those found in theories of creativity. Thus, learning to program ML algorithms stimulates creative competence.	1	USA
Viktorivna, KL; Oleksandrovych, VA; (...); Oleksandrivna, KN	How does AI affect foreign language learning?	Questionnaire	E	The study shows that working with AI systems can reduce spontaneity and, thus, creativity, as we often focus on personalised but closed tasks.	0	UKR
Henze, J; Schatz, C; (...); Bresges, A	How to connect AI and STEM?	Questionnaire, interviews	E	The study explored broader STEM topics but also explicitly works with AI. As a result, the emphasis on combining creativity and STEM makes much sense if we want students to be able to think innovatively and find new ways. STEM does not oppose creativity but positively influences each other when		DEU

				appropriately nurtured educationally. This study presents a concrete model of such interaction.		
Jia, ZX and Yang, YF	How can AI support decision-making processes?	Machine data analysis	A	The study deals with our topic only marginally. The critical point is that education significantly impacts the ability to use technology, including AI systems, and that AI-related creativity in the areas studied is gradually increasing. It can be said that we are learning to be creative using AI.	0	CHN
Gloor, P; Colladon, AF and Grippa, F	How can AI be used to classify ethical human behaviour?	Machine data analysis	E/T	Creative groups are more emotional. Multiple studies show a strong link between positive emotion and creativity. This fact leads to a discussion about creative groups' ethical standardisation and stability and the importance of educating them.	1	ITA & USA
Davis, AE	What areas of legal practice will be spared the impact of AI?	Theoretical study	T	According to the study, lawyers will provide four services AI cannot - decision-making, empathy, creativity and adaptability. These areas must be educationally targeted as they will be challenging to replace algorithmically.	1	USA
Chun, H	What impact does 3D printing have on the education process?	Theoretical study	T	The study addresses the topic peripherally but shows that technology (specifically 3D printing) positively impacts the development of creativity and creative thinking and that AI will fundamentally influence it. We need to look for ways to continue to engage with these themes while at the same time taking advantage of the opportunities that	0	CHN

				technological change realistically brings.		
Riekki, J and Mammela, A	How to help technology educate for an innovative and sustainable world?	Theoretical study	T	AI-enabled systems force us to think about long-standing social issues more complexly and systematically, not just analytically. The study highlights the educational pivot that needs to be made if technology is to be used significantly for the benefit of humanity and not for the pursuit of petty parochial goals.	5	FIN
Shafique, R; Aljedaani, W; (...); Choi, GS	What is the role of AI in online education?	Overview study	T	Despite its title, the study only marginally deals with the topic. It understands creativity in the search for the use of AI in different areas of online education, with the understanding that the context and possibilities of a given situation must always be carefully understood.	0	KOR & USA

If we were to comment on the results from Table 2 in general, most studies are from China (4), whose authors fail to link to the international setting. These are both lower quality and less cited studies than those coming from the Western cultural circle. On the other hand, the authors from the USA have three separate articles, but another two are produced by collaboration. An analysis of the cultural background of each study may also be relevant in that different educational systems and cultures place different emphasis on the importance and role of creativity in the educational process. Therefore, the analysis of texts should be approached with an awareness of the importance of cultural differences.

Empirical studies dominate, primarily based on testing a tool or procedure and then reflecting on it. The research designs in all analysed studies were relatively simple (except for the complex survey by Henze et al. (2022). However, review studies do appear, although the samples they work with are not (as in our case) particularly large or elaborate.

4. Analysis

The analysis of the studies is guided by an attempt to formulate some key themes that may be useful for further research on the relationship between education, artificial intelligence and creativity. This section follows a qualitative approach, so the key for us is not the number of occurrences but the themes each study offers.

Some studies show that the critical issue will be redesigning the educational environment and its practices. Tang et al. (2022) point out that artificial intelligence makes it possible to work with topics and projects that would be unattainable in standard class time or school assignments. Education through these technologies can be closer to practice and, at the same time, help with motivation. However, such a transformation expects a fundamental change in how educational lessons are designed. Victoriana et al. (2022) is our review's only negatively oriented study. This is not due to a negative attitude towards AI but because its inappropriate use in school education can lead to the creation of closed, uncreative tasks, which suppresses the meaning and educational usefulness of the whole technology. We need to change mindsets and frameworks to achieve good results. This is also confirmed by the study of Henze et al. (2022), who work with the development of a new educational framework and try to show that new technologies (specifically AI) allow for better work with imagination, creativity and discovery learning, and can lead to improvisation and quality learning if they are well used and logically implemented in the educational curriculum. If AI is to help creativity, new frameworks for its use, not minor applications in existing practice, must be sought.

The second important aspect of developing creativity about AI in education is the ability to work with AI tools and systems. The phenomenon sometimes referred to in the literature as AI literacy is a prerequisite for working creatively with these tools. Marrone et al. (2022) say that the better students know the tools, the less fearful they are of using them and the more creative their application can be. Similarly, Jia and Yang (2022) stress the importance of knowing the tools to make effective decisions and use them. Kim and Lee (2023) emphasise that knowledge of the tools allows one to look for areas in which AI makes sense and in which it does not. Good sub-tool knowledge is a prerequisite for developing creative thinking with AI, creating a sense of confidence and an experiential base essential for creativity.

Other studies touch on the theme of the future - creativity is oriented not to the present but to the space of the future, to the change of work positions, procedures, processes, and transformation of society. So, we can see the social aspects of these tools. Davis (2020) asks

about the legal profession's future and emphasises four 'new' areas that must be developed educationally - decision-making, empathy, creativity and adaptability. In all of these, the possibility of AI is evident, but simultaneously, the emphasis is on the presence of humans and their responsibility. Riekki and Mammela (2021) see the importance in that these tools and technologies will enable understanding of context in broader perspectives; education needs to focus on understanding context and contexts and the possibility of collaboration to solve complex and otherwise intractable problems and challenges. Iskender (2023) points out that we are still waiting to see the impact of these technologies. However, the way forward is to refrain from banning them but to engage in critical discussion and analysis, looking for ways to foster creativity through technology.

The advent of AI can mean something other than the loss of the need to understand theoretical concepts and problems. It is not about the end of classical education in which machines will replace humans but about the ability to use AI to apply and reflect on models. Ritchie (2013) shows that AI allows us to work with humour when we understand it sufficiently. Gloore et al. (2022) create models of ethical behaviour and then test them with AI. These technologies allow students to work more actively with their ideas if they understand well the world to which they relate, which is also the conclusion of Henze et al. (2022). Shafique et al. (2023) emphasise an excellent knowledge of the context and theories that constitute the fundamental prerequisite for AI systems' creative and meaningful use.

A specific perspective is offered by the study of Dwivedi et al. (2021), who points out that the ability to create one's machine learning models (i.e., to use artificial intelligence by having learners create or adapt the tools or algorithms themselves) is structurally identical to creative thinking. Programming AI for a specific task means understanding the context and having AI literacy. The authors believe that combining this with the ability to write code enables fundamental creative thinking.

It should also be remembered that AI does not form an isolated entity but often acts in the context of other tools and technologies; separating it from the rest of the tools and applications in research and school practice can have strong simplifying effects. Trewe (2021) points out that the whole phenomenon of AI must be seen in the particular educational and social field we find ourselves in since the COVID-19 pandemic. The latter has opened up a space for the transformation of education, and AI is entering this transformation as one of the factors. Above all, Trewe sees its future in the possibility of greater customisation of teaching, again a phenomenon that has opened up and is developing rapidly in the context of the pandemic. Rong

et al. (2022) see AI as a tool to better work with the positive educational aspects of virtual reality. Similarly, Chun (2021) links AI to the possibility of better use of 3D modelling and its positive impacts on the educational profile of students.

5. Discussion

Our analysis described six specific themes or aspects of the relationship between AI, creativity and education. Here we would like to put them in a broader context. The topic of teaching and AI has been described in the literature about education for a long time (Wong et al., 2020; Eaton et al., 2018; Zhai et al., 2021; Beck et al., 1996). What is new - and what emerges from our study - is that educational grasp is not easy and will require more than simply extending lessons, including new lessons or courses (Ouyang et al., 2022). We need some paradigm shift in education to be creative (Cerny, 2022).

Developing AI literacy (Ng et al., 2021; 2021a; Perchik et al., 2023) is essential for creativity education. If students cannot work with the tools, understand how they are shaped and the theoretical models and limits behind them, or lack ethical reflection on the phenomenon (Zhang et al., 2022), the positive impacts on creativity will be very limited. The development of new educational programmes and courses must not only be linked to informal education but should also gain sufficient space in both universities (Southworth et al., 2023) and lower levels of education (Olari & Romeike, 2021; Casal-Otero et al., 2023).

At the level of reconceptualising considerations of curriculum structure, there is also the theme of understanding the actual content or models that students could work with further or be used as theoretical underpinnings for working with AI, a theme related to looking to the future. In the literature, this theme can be seen well in the field of geography education (Burkholder, 2022; Davidson et al., 2023), where many studies focusing on the use of AI tools also appear (Chang & Kidman, 2023; Kim, 2023). From a broader perspective, we can see studies on the ability to solve large and complex problems through AI (Bao & Xie,2022; Zheng et al., 2022). These studies show that AI allows us to tackle many classical topics or problems from a completely different perspective and will force us to abandon the idea of a classical epistemically complete reality in favour of conceptual design (Floridi, 2019).

The development of computational thinking (Grover & Pea, 2013; Aho, 2012) has also been increasingly addressed in studies tracing its relationship to AI and machine learning (García et al., 2019; Tedre, 2022). It should be emphasised that we differentiate between programming, which increasingly in its primary forms can be done by AI systems (McNutt et al., 2023; Becker

et al., 2023), but the goal is to develop a particular way of thinking that is associated with creativity (Israel-Fishelson & Hershkovitz, 2022).

We see the temptation to reduce AI education to partially isolated courses as fundamental (DeNero & Klein, 2010; McGovern et al., 2011; Hu et al., 2023). Indeed, education in this area requires an integrative approach to lead to a closer relationship between AI and creativity. It is the specific applications (Eriksson et al., 2020; Mazzone & Elgammal, 2019; Miller, 2019) that lead to arguably the most exciting results, both directly in the domain being practised and in education (Ali et al., 2019; Zhai et al., 2021).

6. Conclusion

This is not the case. However unambiguous the media image of the phenomenon we have analysed might be. On the one hand, there is a large number of studies that address and reflect on the topic in some way; on the other hand, it can be said that - within all the studies analysed - there is more of a focus on the particulars than a systematic vision of the whole that works with a more demanding systematic theoretical approach. The remarks that can be found in the studies of Treve (2021) that there is and will be a transformation of educational reality that we do not yet see or understand, or Davis (2020), who asks what will change and seeks general reflections on humanity and its uniqueness, are so far the fundamental underpinnings of the whole discussion.

Our aim at the beginning of the study was to analyse the sub-themes that could be used as a basis for constructing a course focusing on the development of AI literacy about creativity. However, it turned out that not only was it impossible to respond adequately academically to such an assignment, but we needed a broader theoretical definition of the whole issue.

The relationship between the philosophy of education (Noddings, 2018) and the philosophy of information, as considered by Floridi (2019; 2014), needs to be considered, seeking a broader theoretical anchoring of the whole issue. Studies show that the need for more critical reflection on the phenomenon of creativity about technology is one of the significant barriers to further research. The studies understand creativity exclusively (at least in our selection) as an individual phenomenon, as an activity of an individual primarily detached from society. Even perhaps the most far-reaching study in this area, Tang et al. (2022), envisages a strongly individualised conception of creativity. Similarly, the vague definition of AI is not only a technical or conceptual problem but primarily a philosophical-pedagogical and didactic one; if we are not clear enough about what AI is and how we want to reflect it, then we cannot expect to implement

it in school subjects in a genuinely challenging way (Palouš, 2008), to change the way we think and solve problems (Riekki & Mammela, 2021).

Nevertheless, we believe that our study has provided some essential novelty points for further research and theoretical reflection on the whole phenomenon, which can be seen as necessary conditions for the development of the relationship between creativity and artificial intelligence in the context of education:

- AI literacy is a prerequisite for developing creativity. It is not possible to pit technology and creativity against each other. One is impossible without the other.
- Creativity presupposes the presence of abstract synthesising system models and the ability to think deeply and understand the world. This aspect should be emphasised as much as possible in education in place of factual or procedural knowledge and skills.
- Creativity about AI enables new problems and challenges students perceive as necessary and future-oriented.
- It is advisable to think about the development of computational thinking in school, not just algorithmisation and programming. Emphasis should be placed on general mental models and ways of solving problems.
- The topic of AI, if it is to be related to creativity, cannot be taught as an isolated stand-alone subject but must be integrated into various subjects in the curriculum.

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