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Artificial intelligence as a tool for creativity

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A R T I C L E I N F O

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A B S T R A C T

The release of ChatGPT has sparked quite a bit of interest about creativity in the context of artificial intelligence (AI), with theorizing and empirical research asking questions about the nature of creativity (both human and artificially-produced) and the valuing of work produced by humans and artificial means. In this article, we discuss one specific scenario identified in the creativity research community – co-creation, or use of AI as a tool that could augment human creativity. We present emerging research relevant to how AI can be used on a continuum of four levels of creativity, from mini-c/creativity in learning to little-c/everyday creativity to Pro-C/professional creativity and Big-C/eminent creativity. In this discussion, AI is defined broadly, not to include only large language models (e.g., ChatGPT) which might approach general AI, but also other computer programs that perform tasks typically understood as requiring human intelligence. We conclude by considering future directions for research on AI as a tool for creativity across the four c's.

Introduction

Artificial intelligence (AI) technology has become a major topic of interest to creativity scholars, especially since the release of ChapGPT in November 2022. New research questions emerged, from examining creativity of ideas produced by generative AI and comparing them to those produced by human participants (Cropley, 2023; Koivisto & Grassini, 2023) to examining audience perceptions of AI-generated vs. human-made art (Chamberlain et al., 2018; Hong & Curran, 2019; Ragot et al., 2020) to ethical and humanistic implications of AI for creativity (Lee, 2022). Runco (2023) suggested a term parallel to artificial intelligence – artificial creativity – to describe machine-based generative outputs. Cropley et al. (2023) examined the attributes of artificial creativity and compared them to human creativity.

Taking a different approach, a collaborative of creativity scholars discussed four major scenarios how AI systems can influence creativity (Vinchon et al., 2023): (1) human-AI co-creation, where AI becomes a tool (or one of the tools) for human creativity and has a potential to augment it; (2) human only creativity becoming a hallmark of 'true' creativity, similar to the handmade effect in consumer product evaluations (Fuchs et al., 2015) or the authenticity effect in judgements of art (Locher et al., 2015; Newman & Bloom, 2012); (3) plagiarism concerns; (4) AI diminishing human creativity in some individuals by weakening motivation and self-concept of creativity. Each of these scenarios is likely to spur their own lines of research. For instance, creativity researchers might conduct studies to examine who would be likely to get discouraged and who would be inspired by AI systems. Similar to the creative mortification effect (Beghetto, 2014), we can hypothesize that those who end up being negatively affected by the presence of generative AI are individuals who do not have high creative self-efficacy, value of creativity, and the ability to regulate emotions, such as anxiety and frustration, during the creative process.

In this article, we focus on the scenario of co-creation or the use of AI as a tool for creativity. We consider a broad view of AI as including any computer programs that perform tasks that are typically understood as requiring human intelligence. AI technologies include narrow (or weak) intelligence that are specialized for specific kinds of tasks (e.g., self-driving cars) and broad or general intelligence (which is still theoretical, but tools like ChatGPT might be approaching it; Bubeck et al., 2023; Wang & Siau, 2019).

When we discuss AI as a tool for creativity, we draw an analogy with other technologies that have been used to augment human creativity. Invention of photographic technology created a new artform (Hertzmann, 2018), although with some initial resistance. The advent of

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computers enabled development of innovative statistical methods and their widespread application in scientific research. For example, although factor analysis was first used by Spearman (1904) and formally defined by Thurstone (1935), increases of computational power made it possible to apply these techniques more broadly and spurred development of new methods (e.g., structural equation modelling, latent curve models; Cudeck & MacCallum, 2007). These methods were in turn applied broadly in scientific research, such as identification of five broad factors of personality (Wiggins & Trapnell, 1997). Although history is a good teacher, and can inform by analogy, it is important to examine how emerging AI technologies specifically can be used in the service of human creativity.

In the following sections, we examine potential uses of AI technologies across the four levels of creativity, from mini-c to little-c to Pro-c, and Big-C (Kaufman & Beghetto, 2009), followed by discussion of future research directions. We apply the Four C's framework as a convenient guide and acknowledge that it presents a simplified view of creativity. Most importantly, the four levels are not discrete and mutually exclusive categories. Rather, they are best understood as a continuum that provides a useful model for theory and research on different manifestations of creativity. For example, little-c creativity (or everyday creativity) can often become Pro-c/professional creativity when a casual activity inspires expertise acquisition and grows into a professional endeavor.

AI as a tool across the 4c's

Mini-c creativity. Mini-c creativity is a form of creativity that happens in the learning process (Beghetto & Kaufman, 2007). Mini-c creativity can be described as original only to the individual, often without being shared with others, and its quality is best described in terms of personal meaningfulness. For instance, mini-c can manifest as insights that contribute to new understandings, or personally meaningful connections between one's experiences and new knowledge being acquired.

The study of AI in the context of education is examining applications of AI technologies in traditional academic subjects (e.g., supporting learning toward mastery of reading and writing, Passonneau et al., 2017), as well as investigating how these technologies might be applied toward learning skills beyond traditional academic competencies (Grassini, 2023; Tuomi, 2023). Implications of AI for mini-c creativity remain largely unexamined. We could hypothesize that because of the potential for personalization of learning using AI technology, the likelihood of personally meaningful insights and associations that is the highlight of this kind of creativity could be higher than with traditional instruction.

Beghetto and Karwowski (2019) have proposed micro-longitudinal design to study the dynamic nature of the creative process in learning. In contrast to traditional longitudinal designs which include multiple assessments across days (e.g., in the case of experience sampling methods), months, or years, micro-longitudinal designs involve measurements in a short time period – from seconds to minutes. These designs could be useful in the study of mini-c creativity in interactions with AIs, with data about the nature of the interaction recorded in the AI environment and supplemented by think aloud and survey methods. A similar approach has been employed by Kangasharju et al. (2022) to observe how secondary school students use the AI tool Poetry Machine to learn poetry writing and what kinds of poems they generate using this tool.

Little-c/everyday creativity. Little-c creativity refers to original and appropriate ideas or products in the context of everyday life and interactions (e.g., leisure activities, daily challenges in relationships or work). Typical measures of creative thinking, such as divergent thinking tests or problem solving tasks, are best understood as measuring little-c creativity. As these measures continue being widely used in creativity research, and they are easy and quick to administer, it is not surprising that this is where research on AI and creativity has started.

Cropley (2023) compared responses to a divergent association task produced by human participants and by ChatGPT (versions 3 and 4). The task asked respondents to generate 10 words that are as different from each other as possible, with responses scored based on semantic distance. ChatGPT generated more original responses than humans, although the differences were small. Koivisto and Grassini (2023) collected responses from human participants, ChatGPT (versions 3.5 and 4), and Copy.Ai on the alternate uses test and found higher mean originality for AI responses, measured both in terms of semantic distance and human ratings. AI did not generate commonplace responses, but it also did not consistently produce more original ideas than the best performing humans. These results suggest that AI as an idea generation tool might be especially helpful to those who tend to generate ideas low on originality.

A study of storytelling provided a direct test of the effects of humans using AI as a tool. Participants were asked to write an 8-sentence story about an adventure on open sea. Comparing those who had no AI access, participants who were introduced to ChatGPT-4 as a tool for idea generation wrote more novel and useful stories (defined as appropriate, feasible, publishable) (Doshi & Hauser, 2023). Moreover, being able to solicit multiple ideas from the AI further increased novelty and usefulness compared to getting a single idea, as well as resulted in stories rated as better-written, more enjoyable, having a surprising twist, and having changed people's expectations of future stories they read. The downside of access to AI was that stories were more similar to each other for those who worked with ChatGPT than for the human-only condition. Of note, story originality and usefulness were enhanced only for participants with low creative thinking ability (measured by the divergent association task), suggesting that benefits of using AI might be restricted to those with low creative potential.

Pro-c/professional creativity. Kaufman and Beghetto (2009) define Pro-c or professional creativity as a form of creativity that requires expertise and is socially recognized (e.g., published writing, exhibited artwork, significant creative contribution at work, founding of businesses or organizations). This form of creativity tends to be defined by domain-relevant education and often by use of distinct methods or tools (e.g., programming languages for software engineers, architectural design tools).

AI applications have extensive use in business, such as for customer service chatbots, virtual concierge, recommendation systems, fraud detection in financial institutions, and sales. Although AI applications could potentially contribute to greater creativity of an organization overall, in themselves many are not tools used for co-creation with humans. However, other examples of co-creation with AI raise to the level of Pro-c creativity. For example, artist Refik Anadol created a piece entitled Unsupervised that was exhibited at the Museum of Modern Art in New York in 2022–2023 that trained AI on publicly available data from the Museum collection. The piece reinterpreted history of modern art and combined it with information from the lobby where it was presented – changes in light and sound, visitor movement, outside weather data (Diehl, 2022). The AI enabled a work devised and developed by a human artist that previously would not have been possible.

Dell'Acqua et al. (2023) conducted a study in a sample of management consultants in which the control (human-only) group was compared with the experimental groups having access to ChatGPT-4 (AI tool only and AI tool plus prompt engineering materials groups). The dependent tasks were designed to realistically reflect consultant work (e.g., developing a concept for a niche footwear product from generating ideas, to developing prototype description, to market analysis, and product launch). Human raters judged quality of each of 18 subtasks, including: (1) tasks directly relevant to the creative process, such as generating product ideas, evaluating and selecting the best idea, coming up with potential names for their product, describing a prototype, coming up with a marketing slogan; and (2) communication about the creative product (e.g., writing an inspirational memo to company employees, describing the product development process in a Harvard Business Review style article).

Results showed that participants in both AI conditions performed better than those in the control condition, even when controlling for performance on a similar baseline task, with the ChatGPT + training group doing better than the ChatGPT only group. Similar to other studies, those who had low scores on the baseline task benefited more than those who had high scores, and using AI reduced variability of ideas.

Furthermore, the study compared performance on a task within the capability of the AI tool and a task designed so that AI would produce incorrect output without extensive guidance. Although participants with access to ChatGPT were rated as producing higher quality output than those without AI help, they were also more likely to make mistakes. In other words, participants over-relied on the AI.

Big-C/eminent Creativity. Contributions that change a domain and have an enduring influence on a field, or even culture at large, constitute Big-C or eminent creativity (Kaufman & Beghetto, 2009). At this time, there are no studies of Big-C creativity enabled or facilitated by AI systems. However, developments in AI, such as the AlphaFold, which was designed to predict 3D structure of proteins based on their genetic sequence, have sparked interest of scientists in biomedical fields (Callaway, 2022). At a minimum, AlphaFold can be used to save time on a long process of understanding the structure of proteins that could be employed in developing new treatments for challenging diseases and potentially lead to revolutionary innovations. In a year after AlphaFold database was publicly released, more than 250 publications across biomedical sciences referred to it, suggesting quick adoption and application in research (Varadi & Velankar, 2023). It would not be far-fetched to imagine Nobel Prize winners in physiology or medicine employing this tool or a similar AI tool in the years to come.

Future directions: Or, what do we need to know

Research on AI systems as tools for human creativity is in its infancy, although the broader research on human-computer interaction and specifically creativity support tools has a long history (e.g., Frich et al. 2018, Remy et al. 2020, Schneiderman 2007). Studies reviewed above open new questions, others can be derived from previous work examining the use of new technologies on the creative process, and some can be based on theoretical approaches to the study of creativity. Furthermore, research should include exploratory descriptive studies of how people apply AI tools for different tasks, as well as how these tools can be purposefully employed to augment human creativity and innovation.

AI tools will differ in their application to either a specific kind of creativity or across the continuum of creativity. Narrow tools can be designed to support a particular kind of creativity. For example, tools designed for uses in education could be considered having everyday/little-c creativity in mind (such as the Poetry Machine, created to teach poetry writing to secondary school students; Kangasharju et al., 2022). Other narrow tools are specifically designed with professional creativity in mind (e.g., AlphaFold, Callaway, 2022; Varadi & Velankar, 2022). AI tools that are more general in nature (e.g., ChatGPT) can be potentially applied at different levels of creativity.

Research will have to examine the effects of these tools in different contexts (e.g., education vs. workplace) and when different levels of creativity are expected (e.g., creativity in learning vs. professional creativity). Effectiveness of AI tools could be tested using existing instruments, but will also require development of new tools. For instance, Cherry and Latulipe (2014) have developed the Creativity Support Index, a self-report measure aimed at evaluating the extent to which tools designed to assist creativity meet six criteria: easing collaboration, enjoying using the tool, facilitating exploration, allowing expressiveness, immersion, and satisfaction with outcomes. This measure has been widely used in the research of creativity support tools (e.g., Chan et al. 2022, Gero et al. 2022, Koch et al. 2019) and is valid in assessing the subjective experience of tool use. This subjective experience is crucial – without ease of use and perceived value, people are unlikely to adopt creativity support tools. However, this instrument is not sufficient to evaluate the more objective effects of creativity support tools, including AI tools, across the creativity continuum. For creativity support tools to have effect on creativity in learning, we need to assess learning outcomes and subjective evaluation of meaningfulness. For everyday creativity, relevant evaluation criteria might include frequency of daily creative activities. For professional creativity, in addition to subjective reports, it would be important to evaluate objective criteria for both effectiveness in reaching specific goals and originality in doing so.

Observational and think aloud studies will be valuable in examining mini-c creativity in interactions with AI technology. Mini-c creativity can emerge in the process of learning about AI tools themselves (e.g., exploring new ways of using the technology and gaining new insights about it), as well as when AI tools are used as part of the instructional process. If the instructional process is personalized with the use of AI, we can ask whether creative learning is more likely than in group-based instruction. Furthermore, interaction between human instruction and the AI will be relevant. Students, whether children or adults in professional settings, might be less likely to rely only on the ideas provided by the AI if they learn about how these technologies generate ideas (i.e., based on co-occurrences of concepts in a body of training data) and the nature of the creative process before interacting with the AI (e.g., that first ideas tend not to be the most creative; Lucas & Nordgren, 2020).

The first frontier in the study of little-c/everyday creativity in the context of AI has been addressing idea generation. Existing research found that AI on average produced more original responses to divergent thinking tasks than humans (e.g., Cropley 2023, Koivisto and Grassini 2023). However, groups that used AI tools to generate ideas had ideas more similar to each other than groups that did not employ AI tools (Dell'Acqua et al., 2023; Doshi & Hauser, 2023). If the goal is to generate the most creative ideas, the question becomes how to scaffold the use of AI tools to reach this goal.

As important as divergent thinking is for the creative process, convergent thinking is necessary too. To date, the use of AI as a tool in these processes has not received much attention. Even in the broader study of creativity supporting tools (of which AI is a subset), Rodrigues et al. (2023) found an emphasis on divergent, rather than convergent processes. Case studies by Cropley et al. (2023) suggest that evaluation and verification remain in the human domain. Future research should examine performance on both divergent and convergent creative tasks, such as those incorporating multiple constraints or having to integrate different pieces of information. Some existing research assumes that AI is at this time not a very useful tool for tasks that can be broadly considered part of the verification aspect of the creative process (e.g., Dell'Acqua et al. 2023), but this area of research is still to be developed.

Another direction of research with implications for a range of manifestations of creativity, from everyday/little-c to professional creativity, concerns using AI tools to support processes of creative metacognition (Lebuda & Benedek, 2023) and self-regulation of creative action (Ivcevic & Nusbaum, 2017). These processes are the know how that helps transform creative potential into creative achievement and emerging research showed that interventions prompting people to consider different regulation strategies when working on creative tasks and projects increased their creativity (Zielinska et al., 2022). Use of AI tools can make such prompting specific to individual profiles of expectations and available strategies, as well as specific stages of their work. Such application of AI tools can augment human creativity not by providing ideas, but strengthening the process by which human ideas are developed and built into tangible outcomes.

Anthony et al. (2023) discussed the role of AI in the future of work and distinguished two kinds of applications: AI as a medium and AI as a tool. The study of professional creativity employing AI can be considered a subset of this broader approach. Studies from the perspective of AI as a tool examine how these technologies support performance by addressing ways in which people interpret and interact with the AI. The first step in this direction was a qualitative study by Dell'Acqua et al. (2023), which examined how those who successfully used AI without propagating its mistakes approached their tasks. They identified two distinct approaches and named them after hybrid creatures in myth and fiction: Centaurs and Cyborgs. By analogy to their mythical half-human and half-horse namesakes, Centaurs divide tasks into those for which humans have an advantage and those for which the AI has an advantage. For example, they might observe the strength of AI in writing and assign it that task while they take the task of generating recommendations based on human understanding and integration of information from different sources, such as interviews and spreadsheets with quantitative data. Interactions with AI described as Cyborg behavior involve integration of human and AI action, analogous to beings in science fiction which integrate cybernetic implants into their biological systems. In this approach, instead of assigning tasks to a human or AI, each task is accomplished jointly. For instance, a human might start a sentence and ask AI to complete it or edit drafts generated by the AI. In this way, working with an AI accomplishes the function of revising and is similar to the strategy of adjusting approach in the study of self-regulation of creative action (Ivcevic & Nusbaum, 2017; Zielinska et al., 2022). Future research will have to address to what extent Centaur and Cyborg behavior identified in observations of performance on realistic management consultant tasks generalizes across domains, such as design, art, science, or engineering.

Studies of professional creativity in the context of AI will concern understanding of ways in which people coordinate and collaborate to achieve joint tasks and projects. This line of work will be especially relevant for understanding creativity in teams. It could be the case that even if maximal individual creativity is not enhanced by the use of AI tools, team or organizational creativity could be increased because of savings in time achieved and because of reducing the gap between high and low performers.

To understand the use of AI in team creativity, future research should examine how individual performance translates to group performance depending on the nature of tasks (Steiner, 1972). For additive tasks, group performance is defined by the sum of individual team members' contributions. Brainstorming is a good example of this kind of task; highest group outcome is based on the sum of ideas independently generated by individuals in the group (Brown & Paulus, 2002). Because using AI tends to increase the average originality of ideas, it might be helpful for team performance on additive idea generation tasks. For disjunctive tasks, group success is based on the best individual performance. To what extent AI tools help group performance on these kinds of tasks will depend on the manner in which group members use the tools. Studies might address to what extent members can discern which subtasks are most suited for humans vs. AI, as well as how to resist overreliance on AI. For conjunctive tasks, group outcome is determined by the weakest group member. Existing research suggests that AI tools are especially helpful in diminishing the gap between lowest and highest performers, making it likely to augment team performance on these tasks. Because the creative process from idea generation to evaluation to the daily work of development and finally product completion includes many subtasks, the question becomes how to apply AI and when to maximize individual and team performance.

Across the continuum of creativity, it will be important to investigate individual and situational factors that facilitate the use of AI technologies to augment human creativity. On the individual level, we can hypothesize that openness to experience can predispose individuals to be more receptive to adopting AI tools and that narrower traits, such as curiosity, can facilitate exploration aimed at developing strategies for how to optimally use the technology. Situational factors can involve both training in strategies of AI use and team processes that can facilitate problem finding and verification tasks.

To understand AI as a tool for creativity, we will need to both compare generative processes by AI and humans (Cropley et al., 2023) and compare features of narrow and general AI tools with other technologies that have previously been used in the service of creativity. The latter research will provide a ready pool of questions. For instance, the implications of computer assisted design for the profession of architecture has been well studied, from the process of adoption of these tools in education and practice (Andia, 2002; Pelman, 2022) to their effects on organizations (Loukissas, 2012). Cicero said that history is the teacher of life. New technologies introduce new variables and often qualitative changes in the way we live and work. Yet, comparisons with previous tools and technologies are likely to continue being relevant.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this article.

References

Andia, A. (2002). Reconstructing the effects of computers on practice and education during the past three decades. *Journal of Architectural Education, 56*(2), 7–13. https://doi.org/10.1162/10464880260472512

Anthony, C., Bechky, B. A., & Fayard, A. L. (2023). Collaborating" with AI: Taking a system view to explore the future of work. *Organization Science, 34*(5), 1651–1996. https://doi.org/10.1287/orsc.2022.1651

Beghetto, R. A. (2014). Creative mortification: An initial exploration. *Psychology of Aesthetics, Creativity, and the Arts, 8*(3), 266–276. https://doi.org/10.1037/a0036618

Beghetto, R. A., & Karwowski, M. (2019). Unfreezing creativity: A dynamic micro-longitudinal approach. R. A. Beghetto & G. Corazza (Eds.). *Dynamic perspectives on creativity* (pp. 7–25). Springer. https://doi.org/10.1007/978-3-319-99163-4_2.

Beghetto, R. A., & Kaufman, J. C. (2007). Toward a broader conception of creativity: A case for "mini-c" creativity. *Psychology of Aesthetics, Creativity, and the Arts, 1*(2), 73–79. https://doi.org/10.1037/1931-3896.1.2.73

Brown, V. R., & Paulus, P. B. (2002). Making group brainstorming more effective: Recommendations from an associative memory perspective. *Current Directions in Psychological Science, 11*(6), 208–212. https://doi.org/10.1111/1467-8721.00202

Bubeck, S., Chandrasekaran, V., Eldan, R., Gehrke, J., Horvitz, E., Kamar, E., … Zhang, Y. (2023). Sparks of artifiial general intelligence: Early experiments with GPT-4. *arXiv: 2023.12712v5*. https://doi.org/10.48550/arXiv.2023.12712

Callaway, E. (2022). What's next for the AI protein-folding revolution. *Nature, 604*, 234–238. Downloaded from https://www.nature.com/articles/d41586-022-00997-5.

Chamberlain, R., Mullin, C., Scheerlinck, B., & Wagemans, J. (2018). Putting the art in artificial: Aesthetic responses to computer-generated art. *Psychology of Aesthetics, Creativity, and the Arts, 12*(2), 177–192. https://doi.org/10.1037/aca0000136

Chan, L., Liao, Y. C., Mo, G. B., Dudley, J. J., Cheng, C. L., Kristensson, P. O., et al. (2022). Investigating positive and negative qualities of human-in-the-loop optimization for designing interaction techniques. In *Proceedings of the 2022 CHI conference on human factors in computing systems* (pp. 1–14). https://doi.org/10.1145/3491102.3501850

Cherry, E., & Latulipe, C. (2014). Quantifying the creativity support of digital tools through the creativity support index. *ACM Transactions on Computer-Human Interaction (TOCHI), 21*(4), 1–25. https://doi.org/10.1145/2617588

Cropley, D. (2023). Is artificial intelligence more creative than humans?: ChatGPT and the divergent association task. *Learning Letters, 2*. https://doi.org/10.59453/ll.v2.13, 13-13.

Cropley, D. H., Medeiros, K. E., & Damadzic, A. (2023). The intersection of human and artificial creativity. D. Henriksen, P. Mishra (Eds.). *Creative provocations: Speculations on the future of creativity, technology & learning* (pp. 19–34). Springer International Publishing. https://doi.org/10.1007/978-3-031-14549-0_2.

Cudeck, R., & MacCallum, R. C. (2007). *Factor analysis at 100: Historical developments and future directions*. Lawrence Erlbaum Associates Publishers.

Dell'Acqua, F., McFowland, E., Mollick, E. R., Lifshitz-Assaf, H., Kellogg, K., Rajendran, S., et al. (2023). *Navigating the jagged technological frontier: Field experimental evidence of the effects of AI on knowledge worker productivity and quality*. Harvard Business School Technology & Operations Mgt. . Unit Working Paper No. 24-013Available at SSRN https://ssrn.com/abstract=4573321.

Diehl, T. (2022, December 15). MoMA's daydream of progress. https://www.nytimes.com/2022/12/15/arts/design/refik-anadol-unsupervised-moma-review.html.

Doshi, A.R., & Hauser, O. (2023). Generative artificial intelligence enhances creativity but reduces the diversity of novel content. Available at SSRN: https://ssrn.com/abstract=4535536 or DOI: 10.2139/ssrn.4535536.

Frich, J., Mose Biskjaer, M., & Dalsgaard, P (2018). Twenty years of creativity research in human-computer interaction: Current state and future directions. In *Proceedings of the 2018 designing interactive systems conference* (pp. 1235–1257). https://doi.org/10.1145/3196709.3196732

Fuchs, C., Schreier, M., & van Osselaer, S. M. J. (2015). The handmade effect: What's love got to do with it? *Journal of Marketing, 79*(2), 98–110. https://doi.org/10.1509/jm.14.0018

Gero, K. I., Liu, V., & Chilton, L. (2022). Sparks: Inspiration for science writing using language models. In *Proceedings of the designing interactive systems conference* (pp. 1002–1019). https://doi.org/10.1145/3532106.3533533

Grassini, S. (2023). Shaping the future of education: Exploring the potential and consequences of AI and ChatGPT in educational settings. *Education Sciences, 13*(7), 692. https://doi.org/10.3390/educsci13070692

Hertzmann, A. (2018). Can computers create art? *Arts, 7*(2), 18. https://doi.org/10.3390/arts7020018

Hong, J. W., & Curran, N. M. (2019). Artificial intelligence, artists, and art: Attitudes toward artwork produced by humans vs. artificial intelligence. *ACM Transactions on Multimedia Computing, Communications, and Applications (TOMM), 15*, 1–16. https://doi.org/10.1145/3326337 (2s).

Ivcevic, Z., & Nusbaum, E. C. (2017). From having an idea to doing something with it: Self-regulation for creativity. M. Karwowski & J. C. Kaufman (Eds.). *The creative self: How our beliefs, self-efficacy, mindset, and identity impact our creativity* (pp. 343–365). Academic Press.

Kangasharju, A., Ilomäki, L., Lakkala, M., & Toom, A. (2022). Lower secondary students' poetry writing with the AI-based poetry machine. *Computers and education: Artificial intelligence, 3*, Article 100048. https://doi.org/10.1016/j.caeai.2022.100048

Kaufman, J. C., & Beghetto, R. A. (2009). Beyond big and little: The four c model of creativity. *Review of General Psychology, 13*(1), 1–12. https://doi.org/10.1037/a0013688

Koch, J., Lucero, A., Hegemann, L., & Oulasvirta, A. (2019). May AI? Design ideation with cooperative contextual bandits. In *Proceedings of the 2019 CHI conference on human factors in computing systems* (pp. 1–12). https://doi.org/10.1145/3290605.3300863

Koivisto, M., & Grassini, S. (2023). Best humans still outperform artificial intelligence in a creative divergent thinking task. *Scientific Reports, 13*(1), 13601. https://doi.org/10.1038/s41598-023-40858-3

Lee, H. K. (2022). Rethinking creativity: Creative industries, AI and everyday creativity. *Media, Culture & Society, 44*(3), 601–612. https://doi.org/10.1177/01634437221077

Lebuda, I., & Benedek, M. (2023). A systematic framework of creative metacognition. *Physics of Life Reviews*. https://doi.org/10.1016/j.plrev.2023.07.002

Locher, P., Krupinski, E., & Schaefer, A. (2015). Art and authenticity: Behavioral and eye-movement analyses. *Psychology of Aesthetics, Creativity, and the Arts, 9*(4), 356–367. https://doi.org/10.1037/aca0000026

Loukissas, Y. (2012). *Co-designers: Cultures of computer simulation in architecture*. Routledge.

Lucas, B. J., & Nordgren, L. F. (2020). The creative cliff illusion. *PNAS Proceedings of the National Academy of Sciences of the United States of America, 117*(33), 19830–19836. https://doi.org/10.1073/pnas.2005620117

Newman, G. E., & Bloom, P. (2012). Art and authenticity: The importance of originals in judgments of value. *Journal of Experimental Psychology: General, 141*(3), 558–569. https://doi.org/10.1037/a0026035

Passonneau, R. J., McNamara, D., Muresan, S., & Perin, D. (2017). Preface: Special issue on multidisciplinary approaches to AI and education for reading and writing. *International Journal of Artificial Intelligence in Education, 27*, 665–670. https://doi.org/10.1007/s40593-017-0158-8

Pelman, B. (2022). Architectural Prototyping in Architectural Education: How design knowledge is constructed within physical-digital hybrid environments. *The Design Journal, 25*(3), 481–489. https://doi.org/10.1080/14606925.2022.2053421

Ragot, M., Martin, N., & Cojean, S. (2020). Ai-generated vs. human artworks. a perception bias towards artificial intelligence?. In *Proceedings of the extended abstracts of the 2020 CHI conference on human factors in computing systems* (pp. 1–10). https://doi.org/10.1145/3334480.3382892

Remy, C., MacDonald Vermeulen, L., Frich, J., Biskjaer, M. M., & Dalsgaard, P. (2020). Evaluating creativity support tools in HCI research. In *Proceedings of the 2020 ACM designing interactive systems conference* (pp. 457–476). https://doi.org/10.1145/3357236.3395474

Rodrigues, A., Cabral, D., & Campos, P. F. (2023). Creativity support tools and convergent thinking: A preliminary review on idea evaluation and selection. In *Proceedings of the 15th conference on creativity and cognition* (pp. 305–311). https://doi.org/10.1145/3591196.3596821

Runco, M. A. (2023). AI can only produce artificial creativity. *Journal of Creativity, 33*(3), Article 100063. https://doi.org/10.1016/j.yjoc.2023.100063

Schneiderman, B. (2007). Creativity support tools: Accelerating discovery and innovation. *Communications of the ACM, 50*(12), 20–32. https://doi.org/10.1145/1323688.1323689

Spearman, C. (1904). General intelligence,' objectively determined and measured. *The American Journal of Psychology, 15*(2), 201–293. https://doi.org/10.2307/1412107

Steiner, I. D. (1972). *Group processes and productivity*. Academic Press.

Thurstone, L. L. (1935). *The vectors of mind. multiple-factor analysis for the isolation of primary traits*. University of Chicago Press.

Tuomi, I. (2023). Beyond Mastery: Toward a Broader Understanding of AI in Education. *International Journal of Artificial Intelligence in Education*, 1–12. https://doi.org/10.1007/s40593-023-00343-4

Varadi, M., & Velankar, S. (2023). The impact of AlphaFold Protein Structure Database on the fields of life sciences. *Proteomics, 23*(17), Article 2200128. https://doi.org/10.1002/pmic.202200128

Vinchon, F., Lubart, T., Bartolotta, S., Gironnay, V., Botella, M., Bourgeois-Bougrine, S., et al. (2023). Artificial Intelligence & creativity: A manifesto for collaboration. *The Journal of Creative Behavior*. https://doi.org/10.1002/jocb.597

Wang, W., & Siau, K. (2019). Artificial intelligence, machine learning, automation, robotics, future of work and future of humanity: A review and research agenda. *Journal of Database Management, 30*(1), 61–79. https://doi.org/10.4018/JDM.2019010104

Wiggins, J. S., & Trapnell, P. D. (1997). Personality structure: The return of the Big Five. *Handbook of personality psychology* (pp. 737–765). Academic Press.

Zielińska, A., Lebuda, I., & Karwowski, M. (2022). Simple yet wise? Students' creative engagement benefits from a daily intervention. *Translational Issues in Psychological Science, 8*(1), 6–23. https://doi.org/10.1037/tps0000289