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Fostering Creative Thinking in a Digital World

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Article abstract

We are now moving rapidly into a new world, one shaped by the Fourth 'Industrial' Revolution. This world is one in which digital technologies in various forms will shape work, play and everyday life. Such technologies, unlike the relatively passive ones of the past, are adaptive, able to learn and make decisions and changes using their artificial intelligence (AI). AI, however, has its limits, and productive thought continues to need fostering in the classroom. As a consequence, education systems around the world must respond in what has been called the Fourth Education Revolution. This article explores the potential relationship between AI, creative thinking and education, and the fostering and development of human creative thinking supported by AI. Some significant omissions in current notions of AI support for creative thinking are presented, and some cautionary thoughts offered. The article concludes with recommendations for a more structured and comprehensive provision of AI support.

Fostering Creative Thinking in a Digital World

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Abstract
We are now moving rapidly into a new world, one shaped by the Fourth 'Industrial' Revolution. This world is one in which digital technologies in various forms will shape work, play and everyday life. Such technologies, unlike the relatively passive ones of the past, are adaptive, able to learn and make decisions and changes using their artificial intelligence (AI). AI, however, has its limits, and productive thought continues to need fostering in the classroom. As a consequence, education systems around the world must respond in what has been called the Fourth Education Revolution. This article explores the potential relationship between AI, creative thinking and education, and the fostering and development of human creative thinking supported by AI. Some significant omissions in current notions of AI support for creative thinking are presented, and some cautionary thoughts offered. The article concludes with recommendations for a more structured and comprehensive provision of AI support.

Keywords: Human creativity; computational creativity; AI; Fourth Industrial Revolution; human-computer educational collaboration.

Introduction

AI and the fourth 'industrial' revolution

We are moving rapidly into a new world, a world shaped by the Fourth 'Industrial' Revolution in which digital technology, in the form of genomics, robotics, information and nanotechnology will change lives (O'Hara, 2007; Prisecaru, 2016). Unlike earlier, somewhat 'passive' technology, this will be adaptive, able to 'learn' from experience, make decisions, and act on them using their artificial intelligence (AI). Artificial intelligence may be defined as 'technology with the ability to perform tasks that would otherwise require human intelligence' (SCAI, 2018), or 'a system that analyses the environment and hence takes actions with some autonomy to achieve a particular goal' (Krafft et al., 2020). Both definitions are justifiable but they direct thought in different directions. The first ties AI to human thought and behaviour and can bring with it connotations of the non-human life of fiction and films. It is important to put these undertones aside. Today's AI falls short of the world of fiction and should not be confused with it. For at least the present, it can be more helpful to see AI through the eyes of the second definition, with its emphasis on technical functionality.

Nevertheless, while AI has its limitations, it is a very powerful tool which can carry out many routines unattended. Given that significant parts of some people's work are often routine, and that people's wages are a major cost for businesses, AI-enabled devices could do the work of people more cheaply, tirelessly, productively, and with fewer errors. In the EU, there is a strong belief that AI will take work away from people (Dignum, 2017). For instance, at least one large European Bank is reported as expecting to cut its workforce by almost 50 000 (Pistrul, 2018). Bakshi, Frey and Osborne (2015) estimated that as many as half of the jobs in the USA and one-third of those in the UK are at risk. Some believe the impact will be less than this (Arntz, Gregory & Zierahn, 2016), while others, looking back in history at earlier industrial revolutions, believe that some occupations will disappear and be replaced by others (Ramge, 2019; Clark, 2020): robots, for example, will need to be maintained (at least in the foreseeable future). There is, however, a consensus that work will change. Bakshi et al. (2015) see the change for people as a move away from routines to what is more difficult to turn into an algorithm, namely, thinking that is hard to define, such as that which is creative. Bregman (2018) makes the point that this includes knowing when and why we need to be creative, and which problems are worth thought and need solutions. In an AI-shaped world, this will

put problem noticing, problem appraising, decision making, planning and creative thinking at a premium (e.g., Pistrul, 2018).

AI and the fourth education revolution

Education will need to respond to this in what Seldon (2018) has described as The Fourth Education Revolution. In his book, Aoun (2017) asks how higher education institutions can prepare students for their professional lives in such a climate. He suggests a framework for a new discipline, humanics, which prepares students to be inventive and creative discoverers who can meet the needs of our societies in ways that even sophisticated AI cannot do. He sees the workplace as one in which smart machines and human professionals work side by side, with the latter having skills in data, and technological and human literacies. The policies of national governments concerned with maintaining economic advantage, and pressures from 'the knowledge industries' which want a supply of workers to meet their needs, have all led to proposals that education at all levels should embrace the information age by producing more digitally competent people. In particular, education should:

1. Equip students with knowledge and skills which could, at the least, be a foundation for further study in the domain of digital technology (e.g., Lourie, 2018).
2. Make all students 'digitally literate' so that they can become 'responsible, competent, and creative users' of digital technology (e.g., HMSO, 2018).
3. Develop 'Twenty-first Century Competences' which reflect the needs of a digital world, such as creative thinking, problem solving and being innovative, critical thinking, decision making, and metacognition (e.g., Voogt & Roblin, 2012).
4. Be taught by AI-enabled technology as an efficient and effective means of providing an education (e.g., Hans & Crasta, 2019).
5. Recognise that what it means to be a teacher will change in this digital world (e.g., McCluskey, 2012).

Putting aside an education that is about more than the narrow needs of the workplace, seeing schools as a ripe market for digital technology, and teaching being somehow 'fixed ' by that technology-- all assumptions capable of prompting hesitation (see e.g., Mehta et al., 2020; Seethal & Menaka, 2019; Selwyn, 2016)-- item 3 is of particular interest in this context. Proposals of this kind are not, of course, new, although tying it closely to the narrower needs of the digital world is (Howard, 2018). The competences have wider application than in the workplace, as when they empower the individual by, for instance, fostering learning, preventing exploitation, enabling problem solving in everyday life, and even by being an antidote to the demands of the workplace, digital or otherwise. This is not to say that attempts to foster such competences have been universal, or always successful, but that does not detract from their potential value in life more widely.

Holford (2019) has directed attention to the way that organisations are seeking to replace as much of human thought and action as they can by robots and AI, and this includes automating the creative process. This would make such human competences in the workplace redundant. For instance, some may point to automated journalism which uses software to convert data into publishable news stories, story generation, game construction, and art production (e.g., Carlson, 2015). For instance, Nikolay Ironov is an artificial neural network and decision making device in the Lebedev Design Studio. It is reported as being able to generate new logos and brand identities for businesses (Art Lebedev, 2020), and it is said that clients believe the designs come from a person. But, as Raczinski and Everitt (2016, 275) put it, 'just because a computer program appears to produce a creative output, this does not mean that its code is inherently creative – it just follows the rules that produce the output from a human creation in an automated manner ... computers do not consciously create as do humans ...'. Cohen, himself the creator (in the human sense) of software which generates art-like images, did not regard what his software did as creative (Cohen, 1999). Because of the illusion of human-like creativity, Cohen preferred to avoid the word 'create' in connection with 'computational creativity', and, instead, described it as 'Behaviour X'. Using human intelligence (HI) as an analogy for artificial intelligence (AI), and transferring terms without qualification, can mislead: analogies have limits.

According to Acer et al.'s (2017) distillation of definitions of human creativity, it is the process of producing something new, novel or original, appropriate or fit for purpose, and, preferably, in some way surprising or satisfying. (The precise meaning and weight of these terms may change with context.) The process is often unconscious, 'intuitive', and emotional. It draws on tacit knowledge and heuristics, and can involve social agency (Newton, 2016; Herzmann, 2018) while that of AI is one of routines, templates, algorithms, rules, and lacks the benefit of tacit knowledge (Leppänen at el., 2017). One consequence is that the products are likely to be different, and those of successful human creators could be more relevant, surprising, and better suited to the context in which they will appear (Holford, 2019; Trausan-Matu et al., 2010). As Raczinski and Everitt (2016, 271) point out, 'taking theories on human creativity and directly applying them to machines seems logical but may be the wrong (anthropomorphic) approach'. For example, Hertzmann (2018) points out that computer art is not human art. No doubt, the products of computational creativity (what Holford (2019) calls 'pseudo-creativity') may be adequate for some organisations' needs, but the process of human ideation is not confined to routines and rules; at times, it may fail, but it can notice needs and problems, can improvise when a machine cannot (Sarathy & Scheutz, 2018), it can draw on emotional connections, and, as Boden (1998) pointed out, can evaluate potential products. Fostering a competence such as this is worthwhile, both for students themselves, and for their workplace. This is not to say that such thought must be entirely outside the world of digital technology. We increasingly live in a hybrid world of AI and HI (human intelligence), and aspects of human creativity and machine creativity may be made mutually supportive (e.g., Galanter, 2016). Wilson & Daugherty (2018) list areas of potential 'collaboration', presented and supplemented here (with some paraphrasing) in Figure 1.

HI-AI collaboration for enhanced performance

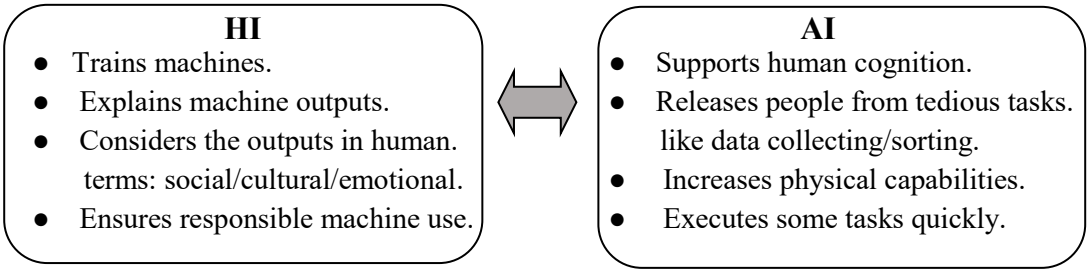

Figure 1: Some potential areas of collaboration between people and digital devices (HI: human intelligence; AI: artificial intelligence).

Fostering human creative thought in a hybrid world

In the workplace

There are some informative and diverse instances of human creative processes with digital augmentation in the workplace. For instance, journalists are expected to produce new stories or, at least, original angles on old news. The process can be slow, but there is software to help, such as INJECT which uses a web crawler to mine news, generate possible associations between items, and present them for the journalist to evaluate and serve as the basis of a story. Maiden et al. (2020) found that using INJECT led to more novel stories (although not necessarily 'more valuable' stories). Designers often sketch ideas as they develop them, but can become trapped by 'fixation' when they cannot break away from an existing idea. Karimi et al. (2020), led by the notion of 'design by analogy' produced the Creative Sketching Partner to help designers progress. The designer offers a sketch and the tool provides another from a different category, that shares some but not all features (hence 'design by analogy'). This is intended to prompt further ideation and iteration to refine an idea. More specific is software by Dubey et al. (2020) used to support the design of clothes. Based on past commercial successes, this identifies marketable aspects of items of clothing and allows them to be merged and varied by the designer. Interest in a movie is often generated by a trailer. Smith et al. (2017) used software to

select known structures in a film commonly understood by audiences and used by film makers to convey emotive concepts in events. The human partner edited and arranged these to produce the trailer. In the workplace, health and safety matters can be a concern, but suggestions for solutions can be vague or evasive. Maiden et al. (2017) describe a tool which takes the report of the problem and offers existing, potentially relevant, generic approaches to solving it. These are to stimulate creative thinking and the production of a specific solution.

These examples serve to show that digital support can be elicited for quite diverse creative endeavours. Where there is a need for creative thinking, it seems likely that some form of digital support could be constructed. The second point is that the support can take some of the tedium out of parts of the process. Edison is reported as saying that invention is 99% perspiration and 1% inspiration. It seems that some of the perspiration may be reduced by using AI. The third point is that support can be used to overcome significant obstacles to productive thought, such as idea fixation. Garcia (2015) described how the musician and composer, David Cope, turned to computers to help him overcome 'composer's block'. The human creative process is not formulaic and can be susceptible to disruptions of this nature.

(ii) In the classroom

Unsurprisingly, digital support for creative thinking in the workplace is designed for adult use. While Luckin et al. (2016) are ardent advocates of the use of AI in education, they remain vague about its role in supporting creative thinking. Creative thinkersfor the classroom would at least need to reflect the different ages and abilities of the students and the different disciplines or subjects taught. If it is also a tool to foster the development of human creative thinking, then it may need to be different in its composition, because the primary goal is one of human learning. Some aspects of creative thinking it could support are, for example:

- need, opportunity, and problem finding or noticing,
- need, opportunity, and problem exploration, clarification and formulation,
- the process of ideation, idea selection, and development,
- reviewing and completing, and
- helping to overcome obstacles in each of these, such as fixation.

Early digital technology of a somewhat passive nature has been routinely used to support creative writing by, for instance, enabling drafts and revisions of children's stories, and providing a ready access to information, story templates and story boards. For older students, more sophisticated programs offered structures and plot-building frameworks for book-length writing. In technology and art, readily available draw and paint tools made experimentation easier and errors of less consequence. (To set against that, the internet also provides ready-made pictures for reproduction, taking away the need to practise creative activity.) Working with young adults learning English, Fageeh (2010) had them produce web-based publications in the form of blogs in English. He found that the activity was motivating and enhanced linguistic proficiency and creative expression. Majid et al (2003) described a study in which they compared the use of two tools (the internet and a non-technological tool, SCAMPER) to facilitate creative writing with primary school children in Singapore,to see how each facilitated creative writing. The children who used the internet showed greater improvement in their creative writing's fluency and elaboration.

As far as a more active AI is concerned, Park Woolf et al. (2013) found that few such learning systems were consistently used in classrooms, and support for creative thinking and creative competence development by this means seems to have attracted less attention. This can be justified on educational grounds: we could want students, particularly young students, to exercise their creative processes directly, not confused with the capabilities of digital devices, in order for them to grasp the nature of those processes before they hand some over to AI. There is, however, a tendency in education to think in terms of the 'creative arts' as though all else could not be creative (Newton, 2012, 2013; Rees & Newton, 2020). Faced with such beliefs, the notion of fostering or supporting creative thinking in history, or mathematics, or the sciences would seem incongruous.

The fostering of creativity more broadly, regardless of subject, has attracted some

attention. For instance, in a study of Korean elementary school teachers' perceptions of AI and education, Ryu and Han (2018) noted that teachers with experience in leading schools recognized that AI education would help to improve creativity. Safinah Ali has described a project of the Robots Group at MIT. The expansion of AI into children's lives is significant, but she points to a lack of evidence of efforts to educate school age pupils in AI, and its wide use and misuse. MIT is currently developing a curriculum for middle school pupils based on student-machine partnerships in creative expression in art, music, and poetry (Ali, 2020). Ali et al. (2019) aimed to develop a 'creative mindset' in young children (between 6 and 10 years of age) using the Droodle Creativity Game. A Droodle is a simple, abstract drawing in need of a title. A social robot, serving as a model for creative behaviour, gives it a title. The child then has a turn inventing a title for the next drawing, and so it goes on. Ali et al. found that the children playing the game with the robot produced significantly more and a greater variety of titles than those without the robot. While this was seen as a development of a general creative mindset, it could, of course, reflect the development of creative title construction, something much narrower. It remains to be seen if this 'mindset' generalises usefully to other areas of classroom activity. Also relating to a general capacity for creativity, videogame playing has been found to 'predict' some measures of it, at least with 12 year-olds in the USA (Jackson et al., 2011). But, as is often said, correlation is not causation, so it remains to be seen if providing videogames raises creative competence, or increases it in specific classroom domains.

Nevertheless, aspects of subjects seen as being creative, like story writing in language skill development, have attracted some attention. For instance, for children of 5-6 years of age, Cooper and Brna (2001) developed an application they called, 'T'rrific Tales' to enable a co-construction of a multi-frame, cartoon-illustrated story. Young children writing stories often need a lot of teacher time, but this software provided a person on the screen who supplied affirmation and prompts to keep the construction going and to give it a story-like structure. Amongst other support, there were word and phrase banks, pictures to modify for the tale, and speech and thought bubbles. Although the stories were shorter than those produced conventionally, they were richer and more complex, and produced more enjoyment. The value of a tool for supporting story telling amongst older students (16 to 17 years old) has also been demonstrated: WebGIS (the Web-based Geographic Information System) is a package which enables the purposeful inclusion of maps in stories, alongside other forms of communication, to enhance their effect (Giannakou & Klonari, 2019).

It can make some educational sense to deny children access to collaborative AI while they develop an understanding of their own creative potential, but there can be a place for that which keeps a creative disposition alive. If this, however, does no more than have children model themselves on the computer, then it risks equating human creativity with computational creativity and limits understandingto what the software does. There also seems to be a belief in a generalisability of creative dispositions and mindsets which needs to be tested. For instance, do the habits of mind produced by the Droodle Creativity Game extend to creative thinking in, say, learning history or science? Creative thought in the various areas of human endeavour may have a family resemblance but there are significant differences in more than detail (Kaufman et al, 2017). AI aimed directly at developing human creative processes in particular domains could be helpful. Boden (1998) has indicated that creative thinking is not a unitary notion. There are kinds of creative thinking centred on idea combination, the potential of conceptual spaces, and productive transformation which could be systematically exercised. Does the mindset apply to all these? As understanding and competence develop, students could benefit from learning how to work with AI to increase the success and quality of their creative efforts.

Although not the focus of this study, it should be mentioned that digital technology may also be used with particular groups of students to overcome 'disadvantage and disaffection' by supporting various kinds of thinking to enhance skills and the acquisition of knowledge (Bradbrook et al., 2008). In this more general and broader use, digital support for creative thinking may not be the only or main concern.

Some cautionary thoughts about the design of AI creativity tools and learning aids

This suggests that AI tools could make a contribution to the development of student's creative competences, and to their experience of working with an AI tool to enhance the product of their creative thinking. Some cautionary thoughts regarding the further development of such tools may be helpful.

Human creativity is not the same as computational creativity

Holford (2019) makes a sharp attack on the notion of computational creativity as a substitute for human creativity. He points to the difference between symbols and signs, the former has multiple levels of meaning, while the latter has only one meaning. He argues that the reduction of symbols to signs in computational creativity reflects a belief that all knowledge can be made explicit and is a flawed epistemology. Human creativity, relying on heuristics and symbolic transformations, is a richer kind of thinking which notices relevance in places where AI is blind. Through working with AI, the danger is that human creative thinking will be reduced to what AI can do when HI could go beyond it. In other words, the distinction between computational and human creativity and the potential of the latter, would be lost. Of course, this may also arise if the user is uncritically enamoured with AI, or its use encourages an indolence or apathy which delegates thinking to the machine. Such outcomes would benefit neither the workplace nor the person's daily life, and the use of personal creativity as an antidote would be lost.

Educational misalignment

The thrust of the proposals is strongly towards an education which services the needs of the digital industries. But an education should be wider than that. While we would want students to be competent and confident in a digital world, we should not forget that there could be more to life than that. Ironically for the proponents of a narrower, work-focused education, it would also narrow the potential of human creativity to make remote connections between disparate mental entities. But there is another kind of educational misalignment. AI software is complex and can be costly to produce. It is likely to come from large and distant corporations and to bring with it a hidden cultural curriculum from elsewhere which may not be universally acceptable. There is the danger that, as Creely and Henriksen (2019) have put it, the values of the digital specialists who constructed the software will be privileged.

Omissions

Being imaginative and having good ideas is not all there is to creative thought. The human mind must also concern itself with noticing problems and opportunities, discriminating between those that are trivial or inconsequential and those that are pressing or worthwhile, and making the latter a priority. We have evolved to function in a social world; cooperation and the impact of new ideas and products on others have to be considered. This calls for wise thinking and decision making which takes itself beyond the immediate and narrow context. Technology has given enormous power to people, but how to choose whether how, and when to use it tend to have been neglected. There can be a dark side to creativity: if it leads to continual change, it can be unsettling for those subject to it. Moreover, institutions that initiate change often also have the power to coerce people to accept it by removing what went before.

Living in a hybrid world

We live in an increasingly hybrid world, one that we share with digital devices. But we are not like them: we have a capacity for reasoning, but are also guided by emotions. Being human is a condition we cannot shed but must recognise and manage by, for example, making the interaction of reason and emotion productive. Children will spend more and more time with digital devices which augment their thinking and learning, so it is important that they distinguish between HI and AI, and continue to learn what it means to be human in a given cultural context (Newton & Newton, 2019).

We put children in an artificial world; it is our responsibility to ensure that they know it is not all there is, and they should have time and space to think for and about themselves.

Practicalities

One obvious practicality is the availability of digital devices, and often, access to the internet. There are parts of the world where these are not readily accessible. Where there could be digital devices, many classrooms were not designed for a way of teaching that draws heavily on their use (e.g., Darmody, Smyth & Doherty, 2010). This can make the notion of using AI as a tool less of a routine behaviour, and it is this which is to be encouraged in what is supposedly a digital world for students. This practicality is mentioned here, but school design is commonly outside the control of the teacher.

Teacher identity

Given a burgeoning role of AI in education, it will affect what teaching means. Intelligent tutoring systems could take on aspects of what is now the teacher's role. This does not mean that the teacher must be redundant, but he or she will need management and orchestration skills to maximise learning, and check that it is of a quality and of a kind that is appropriate. But, the use of AI in education also calls for an understanding of the broader aims of education, and of the strengths, weaknesses, benefits and dangers of AI in order to appraise what is offered, to judge the promises, and decide on whether it is to be used, and if so, how it is to be used (Newton & Newton, 2019).

Conclusion: Towards working with computational creativity

It is not a matter of rejecting digital support. We all must live in a hybrid world, so it does no good for the next generation, or ourselves, if we avoid it, and cling tenaciously to past ways of working. Instead, we need to consider how we might take the best of what digital support offers, or improve what is on offer, and blend it with other good practices. This needs thought, and the specific answers will vary from place to place and context to context. Regarding AI support for human creative thinking in the classroom, it would benefit from a widening of provision both across all phases of education and across disciplines. The diversity in what is possible is seen in what is available for the workplace, and it is an indication that this is not an impossible task. The construction of these tools needs to be strongly influenced by educators familiar with teaching the targeted students and with the nature of creativity in the given domain. To this end, we recommend that four aspects of an educational context are considered when designing AI support:

1. the characteristics of the child or student, such as, age, stage, ability, experience;
2. the domain/discipline/subject in which human creative thinking is to be supported/developed;
3. the nature of the anticipated creative thought (e.g., idea combination, concept potential, productive transformation); and,
4. the part(s) of the process to be supported (e.g., problem noticing, exploration, formulation, ideation, potential solution appraisal, obstacle reduction, insofar as these are relevant to the particular nature of the creative thought).

We also suggest that there are some concerns which should enter into this influence. In particular, educators need to ensure that there is a clear distinction between human and computational creativity in students' minds; that what the tool does or supports is in alignment with their educational goals and the cultural context;that omissions or deficiencies are made good in the classroom, and that life in a hybrid world does not mean an entire life in the digital world, particularly for the younger child. Learning to be human may have been a routine matter in the past, but it now may need more explicit attention. In addition, there are the practicalities of integrating AI tools in the classroom and ensuring that they work seamlessly together – often a difficult task.

Historically, the human mind-computer processor analogy has been a useful way of explaining how the latter functions, but all analogies have their limits, and if taken literally, anthropomorphising digital technology can begin to impede understanding. Human creativity and

computational creativity are not the same: the former, at its least, takes into account relevance to the human situation, and at its best, may produce world-view-changing paradigms, although AI could usefully augment or support such creative activity. A careful distinction between human creativity and computational creativity may help students and their teachers understand the potential roles of the latter. Without that distinction, there is the danger than human creativity could be reduced to what only the tool can do, that is, Cohen's Behaviour X. Maybe the time has come to break from the analogy, and avoid the word 'creativity' in computational contexts, instead using some alternative with as few connotations as 'X'. In the meantime, teachers need an awareness of such matters, an ability to appraise particular tools which promise augmentation, and develop some sensitivity to unwanted effects.

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