



Digital

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INTRODUCTION

“Digitalization has revolutionized the way we live, work, and interact with each other. From online shopping to social media, technology has changed the world as we know it, and perhaps one of the most significant impacts of digitalization is on human creativity. With the advent of digital tools and platforms, people from all walks of life have been able to unleash their inner artist, writer, musician, and designer like never before. Digitalization has made it possible to explore new creative realms, collaborate with others on a global scale, and share our creations with the world at the touch of a button. In short, digitalization has given us unprecedented power to create and innovate, and the results have been nothing short of extraordinary.”

When prompted to “Write a catchy introduction about how digitalization has influenced human creativity,” the much-debated artificial intelligence (AI) chatbot, ChatGPT, launched in November 2022 by the

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American research lab, OpenAI, proposes the text above. Although the catchiness lies in the eyes of the reader, it is compelling to argue that the text is both *effective* (or appropriate) by serving the desired purpose and, maybe more debatable, *original* (or novel) by conveying its content in a manner that is if not surprising, then at least not quite as one might have expected, e.g., hyperbolic terms like ‘revolutionized’ and ‘extraordinary.’ The text therefore arguably meets the criteria of the standard definition of creativity (Runco & Jaeger, 2012). With AI as the pioneering example, the past three decades, in particular, have seen an upsurge in new digital technologies and tools to support human creativity (Frich et al., 2018b; Frich et al., 2019b). This has given rise to several pressing questions and concerns. No longer seen as the pinnacle of a uniquely human ability, creativity itself is now undergoing a transformation, suggesting that previous conceptualizations may no longer suffice. The ubiquity of digitalization has ushered in not just a novel landscape of opportunities but also a great complexity in how we understand creativity in our humanistic approach to production, education, collaboration, inspiration, ideation, experimentation, and expression of creativity. Although it could be tempting to wipe the slate clean and build a whole new framework to support an understanding of creativity directly based on digitalization, we find it more rewarding to return to the first analytical model of creativity, *the four-P model*, to explore through examples the impact of digitalization on creativity today, six decades later. Rather than championing a particular ism, our work is interdisciplinary and mainly draws upon Human-Computer Interaction (HCI) and digital design research. Our position is situated and pragmatic, influenced by Donald A. Schön’s (1992) notion of ‘designing as reflective conversation with the materials of a design situation’ as presented in his eponymous paper. In other words, we subscribe to the idea often attributed to American author and playwright, Arthur Miller, namely that “man must shape his tools lest they shape him.” The number and sophistication of these tools for creativity have grown dramatically with digitalization, and this calls for further investigation into and reflection on the concept of creativity itself in the digital age.

REVISITING THE CLASSIC FOUR-P MODEL OF CREATIVITY

In his seminal short paper, Mel Rhodes (1961) aimed to take “some of the fuzz off the concept of creativity” (p. 305). Following Joy P. Guilford’s (1950) influential presidential address to the APA (American Psychological

Association) a few years earlier, an event often considered the beginning of modern empirical creativity research, Rhodes' model became a cornerstone in the first wave of creativity research (Sawyer, 2012). After spending five years pursuing definitions of creativity, which yielded forty (!) propositions, Rhodes realized that these definitions were not mutually exclusive. Rather, they seemed to “overlap and intertwine” (p. 307), indicating four distinct strands. These four strands of creativity were (1) *person*, (2) *process*, (3) *press*, and (4) *product*. In sum, they are known as *the four-P model of creativity*. Since Rhodes introduced his model, the creativity research community has proposed more refined conceptualizations of creativity insofar as the four P's may not fully capture creativity in its complexity (Runco, 2007). Key contributions include Glăveanu's (2012) five A's framework (actor, action, artifact, audience, and affordances), Lubart's (2017) seven C's of creativity (creators, creating, collaborations, contexts, creations, consumption, and curricula), inspired by a 1967 paper by Guilford (1967), and recently Sternberg and Karami's (2022) eight-P theoretical framework that incorporates the themes of wisdom and intelligence (purpose, person, press, problem, process, product, propulsion, and public). While these contributions have an even more nuanced perspective on creativity than what Rhodes originally presented, we wish to embrace ahistorical perspective by exploring how far digitalization has pushed our understanding of creativity since the four-P model's inception as the first clear, analytical perspective on creativity.

Person

Rhodes' first strand in the four-P model is *Person*. By this, he addresses the individual who engages in the creative process and is shaped by a range of factors that are believed to influence the individual's creative output. Among these factors are personality traits, cognitive abilities, and motivational tendencies. Rhodes suggests that individuals who exhibit creativity often possess specific personality traits that set them apart from others, such as a tendency toward openness to new experiences, curiosity, persistence, and a willingness to take risks. In addition to personality traits, cognitive abilities, e.g., the capacity for divergent and convergent thinking, play a role in determining the creative potential of an individual. Motivational factors also affect the understanding of the personal aspects of creativity (Amabile, 1983).

The increased accessibility and exposure to a diverse range of creativity-related content and perspectives online, which will be unfolded under *Press*, may help facilitate the development or transformation of these traits in individuals. The use of various digital tools may further enhance certain cognitive skills, such as the ability to generate ideas and solutions quickly and efficiently. Young generations grow up with access to a continuously evolving set of digital tools to support creative exploration and expression, such as cameras integrated into mobile phones, programmable toys such as LEGO Mindstorms®, and easily accessible programming environments such as Scratch®, among others (Papert, 2020). Proficiency in using such tools can accelerate the development of creative potential, which Runco (2003) emphasized be included as an additional P in an updated model of creativity.

The flipside of such opportunities, however, is that digital tools may also impede cognitive abilities critical to the creative process, including the ability to concentrate and engage in sustained creative thinking. Just as the young generation today grows up with access to an unprecedented range of tools for creative expression, they are also exposed to ever more content designed for passive consumption rather than active engagement. Digitalization may therefore also impact motivational factors associated with creativity. While the increased accessibility of digital tools and platforms may offer individuals new opportunities for self-expression and creative exploration, the same range of opportunities can also create new types of pressure and expectation around productivity and output (Amabile et al., 2002). This can negatively affect intrinsic task motivation and creativity, as individuals feel pressured to produce content at a rapid pace.

As illustrated by the text in this chapter's introduction, written by the AI chatbot, ChatGPT, one of the most fundamental changes and indeed challenges to Rhodes' initial notion of Person is that of who or what we consider to be a creative agent (du Sautoy, 2019). While we have traditionally used digital technologies to automate routine tasks, a new generation of generative AI systems display an uncharted capacity for creating text, visuals, and code that mimic—and are often hard to distinguish from—the output of human creators. This clashes with fundamental assumptions about creativity as a quintessential human ability, and it prompts us to reconsider how we define creativity. The capabilities of AI tools are rapidly evolving, and we speculate that many creative practices will increasingly revolve around forms of human-AI interactions, shifting the role of digital tools from instruments to something more akin to

creative collaborators. This ultimately begs the complex questions of who the actor is, what it means to be human or a human actor, and whether the ‘actor’ of creativity has not always been an interactive and evolving system of person and tools, mind, and culture; a point emphasized by Glăveanu (2020), (see also the entry on “Things”).

Process

The second strand in Rhodes’ four-P model is *Process*, which captures cognitive aspects such as perception, learning, and the stages of the thinking process. Of relevance for understanding the creative design process are also the tools and materials facilitating the process. Digitalization has presented vast new opportunities for creative expression based on the development of new kinds of creativity support tools (CSTs) for easy integration into creative processes. Designing such tools to be truly useful has been called a ‘grand challenge’ for HCI researchers (Shneiderman, 2009). One of the domains of creative practice now revolutionized by CSTs is architecture. The use of classic floor plans, façade, and cutting planes have for centuries been the fundamental approach to visualization in architectural design, but 3D Computer-Aided Design (CAD) has completely transformed the way architects design buildings. The use of CAD-based tools not only offers a much more detailed and accurate representation of a building than ever before but also enables the exploration of complex organic forms of buildings. A groundbreaking example of architectural design that seems unfeasible without advanced CAD-based tools is the Guggenheim Museum Bilbao designed by Frank Gehry and inaugurated in 1997. This means that the CSTs have shaped not only the creative product (the museum) but indeed the creative design process itself. Another example of a novel approach to creating unique and innovative structures in architecture and design is a parametric design that uses algorithms to create multiple variants of complex shapes that can be explored and changed. Attempting to generate the same number of variants with such tools would no doubt have led to a very different and much more time-consuming process.

A more generic item that has become near-synonymous with the creative process, not least in design, is the small, but versatile sticky note. Since their inception more than fifty years ago, sticky notes have become the most widely-used design material and are now integral to many creativity techniques such as brainstorming and affinity diagramming (see,

e.g., Harboe & Huang, 2015). Like many other materials used in creative processes, sticky notes have been digitalized, enabling change of color, resizing, and easy copying (Dalsgaard et al., 2020). Digital sticky notes offer an infinite digital canvas in contrast to the whiteboard as the standard sticky note workspace. The digitalization of sticky notes affords several benefits, such as remote collaboration in real-time, storage and distribution of the canvas, etc. Still, digital does not simply mean easier, faster, or better compared to paper (see, e.g., Umejima et al., 2021), and the drawbacks of going digital cannot be ignored (Christensen et al., 2020). The digital sticky note stays in the computer and unlike its analog counterpart, it cannot be glued to almost all physical objects and surfaces, including even the human body (Vermeulen & Biskjaer, 2020), as a way to get an easy overview of a complex creative process. As a case in point, the comparison of analog and digital sticky notes demonstrates that different tools embody different affordances and constraints, which in turn can shape the creative process.

With reference to Wallas' (1926) classic book, *The Art of Thought*, Rhodes (1961) argued that seeking inspiration is one of the key stages of creative thought processes. Fashion designers, for instance, take inspiration from other designers' works as well as nature, fine art, etc. Previously, such inspirational sources were mainly found in printed books, by visiting museums, or by traveling to remote places. Today, digitalization, not least the Internet, provides an immense and easily accessible resource. One of the most well-known sites is the image-sharing and social media service, Pinterest, founded in 2009, which is said to currently have several hundred million active users. Indeed, it seems that digitalization has changed our conception of the very first part of a creative process. Jane Darke (1979) coined the notion of a 'primary generator' to describe the creative decision-making that as a catalyst sets the creative process in motion; an idea that has since been influential in design (Biskjaer & Christensen, 2021). With the development of generative AI as a resource in creative processes, overcoming the problem of writer's block (see, e.g., Rose, 2009) might have become a little bit easier. This again points to the big question of how digital technologies impact creativity: To what extent does the adoption of digital technologies lead to different modes and practices of creation? With the Internet and, likely soon AI, being a fundamental part of today's global culture both individually and collectively, such shifts in our approach to creativity are undeniable as we are witnessing fundamental changes in "the very processes that define culture such as

communication, meaning-making and institutionalisation” (Lierat & Glăveanu, 2016, p. 331). A promising approach to this complexity might be to begin by posing some of the basic, but difficult questions, such as who, when, where, how, and why (ibid.). Concretely, we subscribe to Lierat and Glăveanu’s (2018) idea of analyzing the distributed nature of online creativity through three key dimensions: social, material, and temporal, (for the importance of the temporal aspect, see also Kaufman & Beghetto, 2022).

Press

According to Rhodes (1961), *Press* pertains to “the relationship of human beings and their environment” (p. 308). This environment comprises various factors that can either support or constrain the creative process indirectly by affecting variables related to the creative process or person. These factors occupy multiple scales, from the macro-level socio-cultural context in which creativity unfolds over the meso-level of organizational culture and infrastructures and to the micro-level of creative practitioners’ resources and workflows. In the broader perspective of *Press*, we see digitalization not as an event, but rather as a continuously evolving fundamental condition for many aspects of human creativity. As society has become increasingly digitalized, this has caused a profound transformation of *Press* factors that shape or influence creative processes, bringing about both opportunities and challenges.

One of the most significant benefits of digitalization is the increased accessibility and sharing of information via global infrastructures and platforms, which can expand the range of resources and perspectives available to creative individuals (Shneiderman, 2007). As a case in point, a graphic designer can search for design inspiration on platforms like Behance® or Dribbble® where thousands of designers share their work and creative processes. This can expose the designer to a broader range of styles and approaches, helping them to develop their own unique aesthetic (Bruckman, 2008). Similarly, a writer can access a wealth of research and data on virtually any topic through online databases and academic journals, providing them with a more comprehensive understanding of their subject matter and serving as a resource for cognitive offloading (e.g., Dror & Harnad, 2008, see also the entry on “Memory”). Still, having access to such an abundance of inspirational material presents another

challenge: How to capture, store, and recollect the materials for later creative use (Dalsgaard et al., 2023).

Digitalization has also enabled new forms of collaboration that transcend physical and geographical barriers. Online communities and forums allow creatives to connect with like-minded individuals from around the world, sharing ideas and providing feedback on each other's work (Poetz & Schreier, 2012). This can promote the exchange of diverse perspectives and the development of new, innovative solutions to creative challenges. An example of this are platforms such as Splice® or BandLab® where musicians can collaborate on songwriting projects, sharing ideas and tracks remotely. This can allow for a more diverse range of sounds and styles, as musical collaborators, literally, bring different influences and types of expertise into the mix (Biasutti, 2018). Similarly, photographers can share and critique each other's work on social media platforms like Instagram, allowing for a more interactive and collaborative creative process (see also Literat & Glăveanu, 2016, 2018).

For good and bad, digitalization has also led to an acceleration in the pace of work, creating pressure to produce quickly and frequently. In some instances, an increased speed of production can lead to a greater quantity of work and the ability to meet tighter deadlines. This can be beneficial for creatives who work in fast-paced industries such as advertising or social media marketing. On the other hand, the pressure to produce quickly and frequently may impede creative processes. Creativity often requires a certain amount of time and space for ideation, experimentation, and refinement, and the importance of incubation is well-established (see, e.g., Tsenn et al., 2014; Gilhooly, 2016). The expected pace of creative production may cause writers and journalists to feel compelled to generate a high volume of content quickly, resulting in lower-quality work or burn-out. Similarly, designers or artists may struggle to produce their best work under the pressure of tight deadlines. The demand for rapid production can also lead to a reliance on templates or pre-designed solutions, rather than allowing for individualized and original creative approaches. This can result in a decrease in the overall quality, originality, and uniqueness of the work produced.

Product

The final strand in Rhodes' four-P model is *Product*. Rhodes (1961) underlines that Products be differentiated from ideas, which are construed

as “a thought which has been communicated through other people in the form of words, paint, clay, metal, stone, fabric, or other material” (p. 309). ‘Product,’ on the other hand, means an “idea embodied into tangible form” (ibid.). From an ontological perspective, this distinction is a bit puzzling since it seems to imply a dichotomy between a material and its tangible form. Even so, Rhodes’ focus on a necessary perceptibility of a creative product has been influential and brought to the fore in one of the most-cited definitions of creativity, according to which: “creativity is the interaction among *aptitude, process, and environment* by which an individual or group produces a *perceptible product* that is both *novel and useful* as defined within a *social context*” (Plucker et al., 2004, p. 90, original emphasis).

Despite the advanced affordances of digital tools, some artists still prefer analog technologies. One example is American author, Paul Auster (b. 1947), who famously insists on writing in hand before switching to his Olympia SM-9 De Luxe (early version) typewriter, thereby avoiding digital word processors such as Microsoft Word altogether (Auster & Messer, 2002; Biskjaer & Dalsgaard, [forthcoming](#), see also the discussion of the predilection for analog photography in the entry, “Rules,” as an example of a ‘self-imposed creativity constraint,’ Biskjaer, 2013). Such examples of opting-out strategies, however, are the exception. Most artists have embraced digital technologies even though their creative expertise mainly lies within analog media. One example is British visual artist, David Hockney (b. 1937) who has embraced the iPad®. Using the app, Brushes®, Hockney humorously remarked that one of the benefits of creating a digital artifact is that “there is no cleaning up needed even if you have drawn all day,” and that using a backlit iPad meant that he could turn off all the lights in his house to paint the moonlight while still seeing his (digital) canvas clearly (Hockney, 2020).

Many types of creative products today often emerge through networking processes (Chung et al., 2022) that would be hard to imagine without digital technologies, and several creative professions now rely entirely on digital technologies while working on a creative product, e.g., journalists (Franks et al., 2021), musicians (Folkestad, 2012), and designers in various disciplines (Frich et al., 2019a), to name but a few. In other creative domains, the creative product itself can be seen as a hybrid between a traditional analog artifact and a given digital technology that serves to augment or add to the former. Such examples include so-called smart textiles or e-textiles in which sensors are added to the clothing material (see

e.g., Stoppa & Chiolerio, 2014) or media architecture installations where advanced interactive lighting is designed for and then projected onto a unique building façade (see, e.g., Dalsgaard & Halskov, 2010).

At first glance, such examples point toward the benefits of digitalization for creative products regardless of domain. Still, several challenges remain. Some of these are easy to resolve, such as when David Hockney (2020) adds a thin film to the surface of his iPads to add friction to emulate the feel of a pen on paper. Others are very complex. The advanced affordances of CSTs entail that a creative individual can feel trapped in a loop of never-ending, non-destructive editing of a short story, or making version after version of an almost-identical track to get it ‘just right.’ Such unconstrained possibilities might be detrimental to creativity, as the creative digital product may never appear to be finished. Other challenges revolve around social media and legal issues, not least the risk of copyright infringement. Given how easy it often is to duplicate a creative product, it is near-impossible to control what happens to one’s creative products once uploaded to a social media platform. The professional quality of these CSTs also means that any outcome will often sound or look professional, and with ubiquitous access to videos, tracks, photos, and texts, etc. online, the risk of high-quality creative products being ‘drowned out’ amidst all these creative offerings is an ongoing concern. Interestingly, the emergence of NFTs (non-fungible tokens), i.e., a unique digital identifier that through blockchain technology can certify ownership and authenticity, has already had a significant effect on digital art. In 2021, the NFT-fitted work entitled *Merge* by artist Pak even reached a record-breaking auction price of US\$91.8 M. This suggests that NFTs as a state-of-the-art example of a digitalized creative product, paradoxically, marks a return to the theme of German philosopher Walter Benjamin’s (1892–1940) seminal essay written more than eighty years ago, *The Work of Art in the Age of Mechanical Reproduction* (1936), in which he argues that mechanical reproduction devalues the aura (‘uniqueness’) of a creative product (Benjamin, 1969). As digital products become increasingly recognized as ‘sites of creativity,’ it becomes equally relevant to discuss Rhodes’ (1961) conventional distinction between Product and Press, which is more challenging to uphold in a digital context (see also the entry on “Space”).

TOWARD A SOCIOTECHNICAL UNDERSTANDING OF CREATIVITY

As shown by the above interpretation of digitalization through Rhodes' (1961) four-P analytical model, the four strands are difficult to segregate. Rhodes himself was aware of this and noted that although “[e]ach strand has unique identity [...] only in unity do the four strands operate functionally” (p. 307). The role and complexity of creativity in society have changed significantly since Rhodes presented his four Ps, and this development suggests that a more nuanced perspective may be required. As mentioned, other more fine-grained analytical frameworks and models have been proposed, and the research community’s call for developing a new sociocultural perspective on contemporary creativity seems a relevant and promising avenue for future work (Glăveanu et al., 2019). As argued elsewhere, however, we believe that such an endeavor within creativity research, given its strong roots in psychology, must also embrace a more technology-inclusive approach toward creativity in response to the growing impact of digitalization on sociocultural practices (e.g., Frich et al., 2018b). Here, a helpful first step would be to recognize the importance of a transparent nomenclature, which is critical in creativity (see also the entry on “Language”). Ideally, such future creativity research should be built on close interdisciplinary collaboration between the APA and the HCI research communities (Frich et al., 2018a). Here, it would be relevant to examine how to create more clarity about how digital technology, such as ChatGPT and other AI-powered resources, are not merely additions to or tools for human creativity but indeed an integral part of the very phenomenon itself. Some scholars are already working in that direction, among them Pegah Karimi et al. (2018) who have proposed a basic distinction between *creativity support tools* (the development of digital tools to support users’ creativity); *computational creativity* (fully autonomous systems where algorithms generate creative artifacts); and *computational co-creativity* (co-creative systems where computers and users interact to make creative artifacts). A focal point that is attracting increasing interest is *prompt engineering*, that is, what a user types into an AI-driven system to achieve a desired (creative) result, (see, e.g., Oppenlaender et al., 2023; Gero et al., 2023; Liu & Chilton, 2022). Although any simplified taxonomy can be challenged, and although the number of P’s that future analytical models of creativity should consist of is an open question, we hope

that this ‘Digital’ entry can inspire others to pursue a sociotechnical understanding of creativity.

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