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COLUMN: RETHINKING CREATIVITY AND TECHNOLOGY IN EDUCATION

From Crayons to AI: Widening the Lens on Educational Technology and Creativity

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Progress, far from consisting in change, depends on retentiveness. When change is absolute there remains no being to improve and no direction is set for possible improvement: and when experience is not retained… infancy is perpetual. Those who cannot remember the past are condemned to repeat it.

-George Santayana

You can't connect the dots looking forward, you can only connect them looking backwards.
-Steve Jobs

Ten years ago, we, The Deep Play Research Group,[1] were invited to write a regular series of articles for this journal exploring the relationship between technology, creativity and learning. To celebrate this anniversary, we decided to write two summary/synthesis articles, looking across these 56 pieces that we have published so far. In the first synthesis article (Keenan-Lechel et al., 2023), published in the last issue, we took a somewhat personal stance, having current members of the group describe a few of their favorite conversations with creativity researchers who we have interviewed for the series. We used these descriptions to point to both the diversity of ideas we have explored over the years and also to locate deeper themes and ideas that hold this series together. In this, the second of our ten-year celebratory pieces, we take a somewhat different approach, that of looking back on this series, to identify lessons learned, possible opportunities missed, and use that knowledge to look ahead to the future of the series.

Let's Start at the Very Beginning…A Very Good Place to Start

In our first article, titled *Crayons are the Future* (Mishra & The Deep-Play Research Group, 2012), we made a somewhat tongue-in-cheek commentary on the chrono-centric nature of most conceptions about technology and teaching, where the focus is inordinately on the newest, shiniest piece of technology as being *the* tool to transform education. This reflects a naïve but persistent way of thinking about technological change (or social change in general), where we assume that the times we live in as being the most significant. We unpacked this view of technology by creating a table where we listed some technological innovations that happened in the first 12 years of the 20th century (in parallel to the first 12 years of the 21st—when our series first began). See the table from Mishra and The Deep-Play Research Group (2012) below (Table 1):

In introducing this table, we wrote:

There are many examples in this table that we could point to, but we will draw attention to the year 1903—which saw the invention of the crayon. The crayon is a

[1] The Deep Play Research Group is an informal group of doctoral students and faculty members from across institutions. The membership of the group has shifted over the past decade but each individual has contributed, in their own unique manner, to this series. The past and present members of the group are listed below in alphabetical order by last name (with the names of currently active members in *italics*). They are: Liz Boltz, William Cain, Carolina Torrejón Capurro, Michael DeSchryver, Kristin DeBruler, Kristin Elwood, Matthew Evans, Chris Fahnoe, Jon Good, *Natalie Gruber*, *Danah Henriksen,* David Hicks, Megan Hoelting, Elizabeth Jungkind, *Sarah Keenan-Lechel,* Matthew Koehler, John Lee, *Rohit Mehta,* Daniel Memmert, *Punya Mishra, Carmen Richardson,* Sandra Sawaya, Shagun Singha, Colin Terry, Laura Terry, *Melissa Warr*, and Aman Yadav.

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Table 1 Technological innovation in the first 12 years of the 20th century

Year	Technological Innovation
1901	Radio, vacuum cleaner
1902	Air conditioner, neon light, teddy bear
1903	Crayons, first flight, tungsten for bulbs
1904	Teabags, vacuum diode
1905	Theory of relativity
1906	Cornflakes, sonar, triode
1907	Synthetic plastic (Bakelite), color photo, helicopter
1908	Cellophane, Geiger counter
1909	Instant coffee
1910	Talking motion picture
1911	Electrical ignition system for cars
1912	Motorized movie cameras, life savers candy, tank

> wonderful educational tool—of value from elementary school onward. However, to think of the crayon (or any of the other tools mentioned in the list) as being of foundational significance to 20th century education is clearly naïve. Heavy emphasis on the tools and technologies of the early 21st century (twitter and wikis as being two examples) as the basis of education in this century is just as misguided. Do we really think that technological innovation is going to stop as of 2012? Do we really believe that our approaches to teaching with technology revolve around what we think of as new or cool today? (p. 13)

This broader point is still relevant today, ten years later. The tools and technologies that we may regard as being innovative or "cool" may or may not stand the test of time, and may or may not have the impact on education that we expected them to have.

For example, consider Edison's invention of the moving talking picture in 1910, which prompted educational scholar Devereaux to write:

> The introduction of the use of the talking picture into education may prove to be an event as epochal as the application of the principle of the wheel to transportation or the application of steam power to the industrial age" (Devereux, 1933, p.101).

Looking back, it may seem clear that did not happen, despite significant changes and innovations in this area—from film projectors to YouTube; from grainy black-and-white film to TikTok and Instagram videos; from heavy, cumbersome cameras to powerful 1080p videos on our cell phones—the methods, of creating, viewing and sharing moving images have transformed dramatically. Despite these amazing transformations, any direct obvious impact of the "moving picture" on educational systems and practices has been minimal. Thus, we would argue that our original point still stands. We should be skeptical about the transformative powers of new technologies and their impact on the educational system and student learning.

In addition, we argued that the field's views on technology are often narrow and assumed to be limited to the digital. Per our original notion of chrono-centrism, we tend to think that our own era is the most important one, or the one that matters the most (Van der Vleuten, 2020). But the etymology of the word *technology*, stemming from the ancient Greeks, is much more related to broader notion of *tools* and *craft* (and thus, perhaps, to creativity). Therefore, our series has from the start sought to spotlight creativity as a conceptual frame that is tied to technology, and to learning in general. Looking across the years of this column and its diverse threads might give the impression that we have been dabbling, somewhat idiosyncratically, across topics. And indeed, we like to dabble. But there has also been a method to the madness. The threads tying our work together always addressed the fundamentals of creativity with a broad conception of technology—consistently connecting back to what this means for learning and for applications of education. This is the connective tissue of our series, and we take this opportunity to look back across what we have covered, before looking ahead to the future.

Moving Ahead from the First Column

In our initial column pieces after that inaugural article, we covered a variety of topics related to this triad of concepts: creativity, technology, and learning. Our approach has always been interdisciplinary, and often transdisciplinary, considering different disciplines, the connections between them, and how disciplinary lenses can come together to support creativity and creative learning. Early columns took up specific disciplinary lenses to focus on different connections to creativity, technology and learning in the sciences, mathematics, engineering, architecture, the arts and more. In exploring these ideas, we argued that the way that schools organize content by disciplines works directly against the ways that artists, scientists, and scholars engage in real-world creative thinking and work. In preparing learners for the future and the real world, ideas are connected and interconnected, and intense work within a discipline requires using creative and critical thinking skills in a transdisciplinary way (Mishra, et al., 2012).

Moving forward from specific disciplinary applications or examinations of creativity, our next few articles focused on the concept of creativity itself, and what it looks like in the world more broadly, and in education. We argued for the importance of defining creativity in order to understand,

support, and evaluate it; and we proposed a NEW approach for doing this in which creativity products/processes can be distinguished by three characteristics, i.e., creative artifacts are *Novel, Effective, and Whole* (Mishra et al., 2013). A creative product/process has an element of *novelty* or uniqueness. It also must be *effective* (appropriate, valuable) in its given context. And finally, a creative artifact is *whole*, which speaks to the style, make, or crafting of the process/product, and its "fit" within a specific context. While there will always be an element of subjectivity when discussing or evaluating creative work, a framework like this offers some structure and common ground, and provides a foundation for shared understanding.

Considering the meaning of creativity also means looking at the misconceptions surrounding it; thus, our series has also taken on many of the myths that surround creativity, especially in the way that people think about who is and is not creative, and where creative ideas come from. For instance, contrary to some popular belief, we argued that people are not simply born with creative ability, or the lack thereof. Nor is creativity a result of a spark (the classic "Eureka" moment) that comes from nowhere. All creativity builds upon ideas and objects that already exist and thus an important element of creativity is not just deep background knowledge of a domain and our previous experiences with it, but also diverse experiences and knowledge of other domains that enrich our understanding of the core area, providing new and unique connections as the basis of creative (novel, effective, and whole) ideas. Thus, the ability to be creative relies on having "diverse mental resources to build on. These resources may include personal knowledge bases, interests, and experiences, which allow creative people to manipulate existing works and knowledge to create something new" (Henriksen et al., 2014, p. 17).

We expanded on this theme through a series of articles that build on the work of Michele and Robert Root-Bernstein on transdisciplinary creative thinking skills. In 2014–2016, we focused on each of the seven skills—Perceiving, Patterning, Abstracting, Embodied Thinking/Empathy, Modeling, Play, and Synthesis. This series of articles on transdisciplinary skills was structured to be applicable to educators, artists, and scholars seeking to embed creativity supporting practices in their work. In each piece, we pulled in practical suggestions and examples of the creativity that flows within and through disciplines, often drawing on pedagogical examples from teachers who were part of a graduate educational technology program we worked within. Finally, over the past few years our series has focused on interviews with some of the most interesting and creative researchers in the field, bringing their expertise and experience to bear on these topics (covered in greater detail in Keenan-Lechel et al., 2023).

Essentially, our series has argued that technologies have a reciprocal relationship with creativity, where they are both driven by human creativity, and they also drive it, through tools that afford opportunities to create, explore, and share ideas or artifacts in fundamentally different ways than ever before (Glăveanu et al., 2020). How we learn affects this, and is also affected by it, as are the practices and systems of formal and informal education. Technologies provide people with the functionality to extend our minds and thinking skills or capacities out into the world (Sternberg & Preiss, 2005). They offer tools that mediate creativity by extending the capabilities of our minds outside of ourselves, allowing us to do more than we could with just our minds alone (Coeckelbergh, 2017). In a larger sense, technologies are not just digital; they involve any artifact or tool that extends human capacity for thinking, making, or creating beyond our innate mental capacities. Thus, we found it valuable to begin this series with the notion of "technologies" of 100 years ago, like crayons, which, in today's age of digitally networked magic, might not be thought of as technology, and yet is a tool that provide some extension of human skill, thought and expression.

From Crayons to AI: Back to the Future

In hindsight, however, there may be something we missed or under-emphasized in our work over the first few years of this series. By focusing on the crayon (or the moving picture) and the potential impact on education we may have overlooked potentially more transformative inventions that happened in the first decade or so of the 20th century. As we review the original table (from 1901 to 1912) and see the impact of some of these technologies on the world at large, their indirect impact on the educational system cannot be denied. The impact, however, may not have been directly within the classroom—rather these technologies have changed the broader world dramatically, which has often influenced how we think (or how we need to think) about education and learning for the next generation. In other words, certain technologies may not have had a direct or obvious impact on classroom practice, but technological change has irrevocably changed the world which education is situated in, affecting its meaning and purpose.

For instance, even if we acknowledge that Devereaux's vision of the impact of cinema on classrooms was off-base by many orders of magnitude, it would also be shortsighted of us to ignore the impact of cinema on the world at large. From *Birth of a Nation* to Leni Reifensthal's propaganda films, to the rise of the Hollywood blockbuster, to the spread of popular cinema across the world, the technology of the motion picture has changed the world at large, a world within which education functions. It has changed the

social/cultural context, the broader socio-political knowledge ecology within which schools exist and where learning and teaching happen.

Similarly, the invention of the diode in 1904 and the triode in 1906 may not impacted education directly within their immediate years (or even decades). However, we cannot ignore that the diode and the triode set the stage for the electronic revolution to come. The diode and triode were replaced over time by transistors and then chips (with thousands and now millions of transistors), all of which are foundational to the digitally networked world we live in today.

The very notion of digitality has entirely transformed the educational landscape that we find ourselves in today, from kindergarten to graduate school, in comparison to what it looked like 100 years ago (or even 10 years ago). Beyond notions of formal or information education, the digital nature of our world has fundamentally shifted the knowledge landscape we are in and the information diet that many people consume. The very nature of knowledge or learning, and our assumptions about them, or about the computational formulation of the human mind, are dramatically different today than they were 100 years ago, largely due to those inventions back in the early 1900's. From space travel, to entertainment, from cell phones to cloud computing, so much traces back to the invention of the diode and the triode.

What this means is that creativity, learning and technology all exist within the complex tapestry of human life, culture and society. So does the phenomenon of education, which, as an innately human and designed system, is interconnected to the rest of human activity and society. This is a broader sociocultural view of creativity, learning, and technology, and their effects on education, recognizing that whether or not certain technologies are used in the classroom they still influence education, by changing the "ground rules" of the broader context for education.

To be fair, these ideas—the immense impact of technology on society, the creative process, or the production of creative artifacts—were never completely missing in our series so far. For instance, we have written about the way in which social media has transformed the creative process by blasting open the doors for creative products to be disseminated (Henriksen & Hoelting, 2016). New tools make it easier for anyone to explore, create and share. New access to creative products means that the "gatekeepers" of the past, who could approve or deny the sharing of creative products, can now be bypassed. Similarly, many of the scholars we interviewed directly addressed these ecological themes, recognizing that creativity, like learning, technology, and education in general, does not happen in a vacuum. They are all embedded in systems of culture and human activity, and best understood through these interconnections.

As we pause, a decade into this series, to look at our present moment, one thing is clear—the pace of technological change is only speeding up. In this decade we have seen the establishment and growth of Wikipedia as a powerful source of information created almost entirely through a non-centralized distributed process. We have seen the iPhone (and other smart devices) take over the world, connecting people in ways never imagined. We have observed how social media tools can lead to social and political unrest through the spread of misinformation and fake news, and extended use of social media can have negative effects on individuals, health outcomes, and society (Akram & Kumar, 2017).

So maybe the question we have been asking about the role of creativity and technologies in learning is too narrow. Perhaps the questions should be: What technologies from recent decades are changing the very ground rules by which our world functions? What is changing the ecology within which education functions? Thus, we offer up a new table, in parallel to the earlier one above, but for a century later. It aims to look at technologies that emerged between 2001 and 2012 (the year we first started this series) that have the potential to be truly transformational and significantly change the world in which we live.

Year	Technological Innovation
2001	First space tourist, Wikipedia is launched, iPod
2002	iRobot releases Roomba
2003	Human genome completed, Skype is released
2004	Facebook is released
2005	YouTube and Google Maps are released
2006	Twitter comes alive
2007	iPhone is introduced and the FitBit is released
2008	Nakamoto publishes Blockchain/ Bitcoin whitepaper, AirBnB and the rise of the gig economy
2009	Uber, Bitcoin (first digital currency) is launched
2010	Netflix goes full streaming, Instagram is released, iPad is launched, IBM's Watson wins Jeopardy
2011	Snapchat, Minecraft are launched; Social media fueled protest movements (Arab Spring and Occupy Wall Street)
2012	CRISPR is developed, Tesla introduces electric car Model S; Google introduces first self-driving car, Tinder/Hinge usher in online dating, Oculus introduces VR headset; Kodak files for bankruptcy, First Raspberry Pi goes on sale.

In our first column article, we mentioned the iPhone, Facebook, and Twitter—but Bitcoin and CRISPR, transformational technologies in their own right, were not yet on our radar, and thus received no attention. Neither was the rise of the gig economy, which in many ways is transforming the nature of work, and thus will force changes in education. Similarly, the self-driving car portends the rise of AI, which may be the most transformational technology our world has seen, for work, life, and the broader economy and society.

In all this, we need to remember what has been dubbed "Amara's Law," named after Roy Amara (American scientist, futurist, and President of the Institute of the Future). He famously coined the adage that, "We tend to overestimate the effect of a technology in the short run and underestimate the effect in the long run" (The Virtulab, n.d.). This adage refers to how, with new technologies, people quickly get excited about the potential or the changes in their lives, which often causes tunnel vision around the tool in question. We either become enthusiastic and see only what a tool can do for us, how innovative or creative it is, and how efficiently it will change our lives and our businesses. Or, alternatively, we see in it the destruction of all that that we have currently. But eventually, the novelty wears off and both utopian and dystopian visions seem overwrought. Yet even as the immediate excitement dissipates, we often fail to recognize some of the longer-term and unexpected changes or effects of new tools upon human life and society, for better and worse. As Neil Postman argued, technological change is not additive; it is ecological, which means that the advent of a new technology changes everything once it is infused into the system, and this can be hard to predict. As he wrote:

> A new medium does not add something; it changes everything. In the year 1500, after the printing press was invented, you did not have old Europe plus the printing press. You had a different Europe. After television, America was not America plus television. Television gave a new coloration to every political campaign, to every home, to every school, to every church, to every industry, and so on (Postman, 1998).

One can make similar arguments for the Internet, social media and more. At the start of the pandemic, Zoom suddenly became ubiquitous and initially seemed novel and impactful to many people. But as the novelty wore off, people started to trickle back to (and even long for) more face-to-face interactions. Yet, the long-term effects settled into place and remained, often greater than expected. The ubiquity of remote work/meetings was established via Zoom and this will likely continue to be a commonplace fixture of work, more so than it ever was pre-pandemic. But we could not predict how the world would also experience a mass decline in mental health as a direct result of so much time online, with endless virtual meetings (now termed "Zoom fatigue") and a loss of tangible interactions. These kinds of unexpected long-term effects of technologies happen with all kinds of new tools. Users cannot help but experience initial excitement in assuming how tools will transform their lives; and creators rarely understand or appropriately gauge how something will interact with and have long-term effects upon the real world until it is actually situated there.

As we look ahead to the continuation of this series, we are proud of what we have achieved in the past decade. We have aimed to capture a set of key ideas and themes, with thought-pieces, explorations, and conversations with some of the greatest scholars and thinkers in this area. That said—this is still not enough. We must recognize that there are broader and deeper trends that impact education, beyond the classroom and existing educational systems.

Moving forward, this series must keep a dual focus. It is critical to recognize that the only constant is change, and it can be difficult to understand and assess the most pervasive and systemic effects of the tools we have in hand today. The impact of some of these technologies may not be *directly* within the classroom but happen to society broadly, and thus will *indirectly* but still powerfully affect education. The issues we discuss in this series will continue to evolve and our goal is to maintain a sense of perspective about the effects (both positive and negative). When it comes to future-thinking, the goal should always be to imagine broadly, to cast a wider net and expand our lenses, to try to stick our necks out a bit more—thinking more expansively, and critically, about the culture, values and sociology of technology, creativity and learning. In it in this way, that this series, and the work that we do as educators and researchers will continue to be relevant ten years into the future.

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