Tipping the canoe: What can be learned from a postdigital analysis of augmented and virtual reality in networked learning?

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(NLC Abstract) Abstract

In this paper, the authors use a postdigital lens to examine augmented (AR) and virtual reality (VR) as potentially effective tools for networked learning. The postdigital perspective suggests that the 'digital' is so pervasive that it is no longer considered novel or noteworthy; rather, it is so embedded in our day-to-day lives that it now evades notice. This examination draws upon the concepts of analogue and digital to explore ontological and epistemological characteristics of AR and VR as well as how media and materials may shift on a continuum or manifest both characteristics concurrently. Two vignettes are used to create a shared context and atmosphere from which to consider the pedagogical use of these technologies. One vignette describes a VR app that invites the learners into a canoe where they are immersed into a lesson about Indigenous constellations; the second describes an AR app in which the learners direct their smartphones up at the sky also to learn about constellations. While the learning goals are similar, the experiences are differently nuanced. The paper offers a discussion of considerations that may be useful in designing learning experiences with these technologies. The authors discuss the analogue and digital characteristics as well as the freedoms and constraints relative to sites of learning, activities, learner configurations, and representations of learning. A postdigital analysis benefits from 'shifting work'; that is, much can be learned from shifting between analogue and digital. Such shifting may surface failures, depletion of resources, and the emergence of new entities. The value of examining the digital, analogue, ontology, and epistemology of AR and VR is that it helps to make the human-technology relationship more perceptible. In becoming more aware of the taken-for-granted aspects of learning technologies, it is possible to more effectively design for learning.

(NLC Abstract) Keywords

Augmented reality, virtual reality, postdigital, networked learning, analogue, digital

Introduction

There is little if any writing published on augmented reality (AR) and virtual reality (VR) in networked learning (NL). This may be the case because these technologies are often used by individuals in isolation or in face-to-face, classroom settings. Multiple individuals can gather within a VR environment; however, each needs to wear a headset and wield one or two hand-controller devices. AR, on the other hand, often involves the use of a hand-held device that will allow images, text, video, or audio to be displayed when the camera detects a "trigger" image. Although learners can gather around a hand-held device to experience AR together, it is difficult to collaborate in an AR environment by distance. In this paper we explore the characteristics of AR and VR from a postdigital perspective. To begin, we offer two vignettes written to establish an atmosphere and provide shared AR and VR contexts. Next, we outline our understanding of NL and the postdigital approach. Within a postdigital lens, we then discuss how AR and VR technologies manifest analogue and digital features. As postdigital phenomena, we shift to an examination of freedoms and constraints with regard to the ontological and epistemological characteristics of these technologies. Finally, we raise some considerations for designing learning experiences that integrate AR and VR tools. Our analysis intended to stimulate critical thought about pedagogical applications for AR and VR in networked learning environments. A postdigital analysis can provide valuable insights into human-technology-environmental entanglements and surface hidden features and

implications of these technologies. Such analysis is an important first step before attempting to integrate these technologies within networked learning environments.

Vignettes

Before engaging in our postdigital analysis, we offer two vignettes. The first vignette describes a VR application (app); the second proposes an adaptation of the application for AR. In both cases, the goals include learning the names of Indigenous constellations and building sensitivity to Indigenous worldviews.

Vignette 1 (VR)

Sprockety[1], a small upstart company operating out of a small office in the research park near the University of [withheld for review], developed a beautiful Indigenous storytelling VR app:

> *Once the learners are outfitted with headsets and hand controllers, the immersive VR experience begins. There is a canoe accompanied by the sound of a gentle breeze and waves crashing against the shore. As the learners gingerly step into the canoe and sit down, the stars appear in the twilight sky. Turning their heads, the learners can look all around towards the horizons. To the left is the nearest shoreline. To the right, the water reaches beyond the horizon. Having had some time to familiarize themselves with the virtual topography and the feel of the controllers, a light appears in the surrounding water. The canoe suddenly lists as the pair of learners lean over almost simultaneously to gaze into the water. They squeal with a mix of delight and disbelief while coordinating their actions to right the watercraft before carefully peering into the water again. "You lean over the right and I'll lean over the left," one says to the other. While the learners are trying to discern what is in the water below, a spirit appears in the form of an old man, an Elder. The man begins to speak. His gentle, wise voice mixes almost melodically with the sounds of the water. He begins to describe the constellations. He provides their Indigenous names and recounts stories of their origins.*

Vignette 2 (AR)

Although there is no canoe to tip over, an AR app can also teach learners about the constellations through storytelling:

> *The learners turn on their smartphones and navigate to the constellation app. After the app opens, it geolocates the phone using global positioning information. The app accesses date and time information to ensure correspondence to the correct season—after all, different stars are visible in different locations depending on the time of year. At the same time, it uses directional information and the accelerometer, so it can provide instructions to each learner such as telling them to turn left or right and up or down. Once the app is fully operational, the learners can hold their devices up to the sky. Viewing the night sky through the camera, the app guides them in locating the North Star, Venus, and other key astronomical bodies—each time asking the learners to tap the screen when located. This process of triangulation helps the app overlay the constellation map accurately. The learners move as directed by the smartphone to locate the first constellation. As each learner reaches a particular location on the constellation map, it triggers the display of a video of an Elder who recounts the name and story of the constellation. Once the video finishes playing, the learners shift their smartphones scanning for another trigger point. Each time they shift and reach a different constellation, they trigger a new video.*

The two vignettes offer similar learning content and learning goals; however, the use of the two technologies shapes a different learning space and mindset. As Pischetola and Dirckinck-Holmfeld (in Gourlay et al., 2021) write, technology is not neutral but "embedded with values [and it is important to] explore how interactions with technologies entail a different quality of value, material texture, information, aesthetics, conviviality, and environment to which we couple our bodies and brains in a relational designed NL practice" (p. 338).

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[1] Sprockety is no longer in operations and their VR application is currently inaccessible. We have taken some creative liberties with the vignettes in order to highlight potential aspects of VR and AR experiences.

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Networked learning and the postdigital

Last year, the Networked Learning Editorial Collective (NLEC, 2020) invited a redefinition of NL. Their article reviews the historical bases and early definitions arriving at the description of NL as "involving processes of collaborative, co-operative and collective inquiry, knowledge-creation and knowledgeable action, underpinned by trusting relationships, motivated by a sense of shared challenge and enabled by convivial technologies" (p. 319). In reconsidering the definition, the NLEC recognize the dangers of binary conceptions of information and communications technologies—a recognition they attribute to the "postdigital lens" (p. 318).

Having emerged from the field of art, music, and aesthetics (Andrews, 2000; Cascone, 2000; Metzinger, 2018), the postdigital refers to a philosophical perspective in which the 'digital' is so ubiquitous, it is passé; it has already happened (Cascone, 2000; Cramer, 2015). Through its pervasiveness, it becomes commonplace hardly drawing attention; it escapes the critical gaze. There is a not-so-subtle danger in its invisibility: "we risk the agency of machines (programmed through neoliberal values) creating the platforms by which we exist" (Jandrić & Hayes, 2020, p. 293). The postdigital lens helps us view the world as something in which the virtual is no longer separate from human-social existence (Jandrić et al., 2018). Previous dichotomies of are no longer viable conceptualizations of the world. From a postdigital perspective, the world is a *blend* of dichotomies such as old and new, digital and analogue, virtual and physical. The world shifts easily between these dichotomies or manifests such characteristics concurrently (a *multiplistic* view). What was considered 'old' technologies can be repurposed and reconceptualized. Technology, once considered 'other', is an inherent part of the human lifeworld and co-creates experience. The realization that the digital is but an imperfect representation of reality re-establishes the value of and openness to that which is analogue. For those wishing to design learning experiences in networked environments, the postdigital conceptions of analogue and digital ask designers to think more deeply about 'shifting' between them and what pedagogical benefits can emerge.

Analogue and digital

A common misconception is that computers and electronics are digital. Etymologically, the word 'digital' referred to the digits on one's hand: fingers. Fingers can be counted because they are discretely identifiable objects. According to the Oxford English Dictionary (2010), digital came to refer to "signals or information represented by discrete values of a physical quantity such as voltage". A clock that displays the time using discrete numbers is an example of a digital technology. Analogue, on the other hand, refers to phenomena characterized by continuous variability. A clock that displays time using hour- and minute-hands is analogue. The Oxford English Dictionary (2010) defines analogue as "relating to signals or information represented by a continuously variable physical quantity". There are both analogue computers, which process continuous data such as a thermometer or barometer (measuring temperature or atmospheric pressure changes in real-time correspondence to the physical phenomenon), and digital computers, which process discrete data such as 0s and 1s (*Analog Computer: Features, Examples and Its Comparison with Digital Computer*, 2021). Beaumier and Koole (in press) outline the ontological and epistemological characteristics of analogue and digital phenomena (Table 1).

Table 1: Ontology and epistemology of analogue and digital (adapted from Beaumier and Koole, in press)

	Ontology	Epistemology	Example
Digital	Perfect (seemingly) representation and/or reproduction of a world.	Observed through discrete values such as numbers, bits, pieces.	A digital clock display, binary code (1s and 0s), a mosaic of tiles or pointillism.
Analogue	Correspondence to physical phenomenon/a.	Observed through continuity, continuous variability.	An analogue clock display, a thermometer, a barometer, a naturalistic painting.

Admittedly, the analogue-digital dichotomy is, in itself, problematic because it is binary—unless it can be conceptualized as phenomena that can occur simultaneously or on a continuum. To this point, there are difficulties in categorizing current technologies. An electronic watch can be set to an analogue display or a digital display. The different displays can confer not only a different aesthetic, but differently nuanced information. For example, compared to a digital watch, an analogue watch provides additional visual information such as time ranges and can assist with quick, visual approximations of time. Ontologically, then, is an electronic watch digital, analogue, or both? Other phenomena such as light, depending on the apparatus used to view it, can appear as a particle or a wave. Ontologically, is light digital, analogue, or both?

The vignettes of the AR and VR applications described above help to illustrate and problematize the digital and analogue analogy. Both VR and AR exhibit digital and analogue characteristics. Both are reliant upon underlying computational processes involving digital code (1s and 0s). The VR vignette illustrates a representation of a world—albeit one that does not exist within the physical reality (i.e., without the aid of the headset and hand controllers). Aspects of the VR experience can be considered highly analogue because the sounds and visuals appear seamless and continuous to the learner. The AR application described above blends analogue and digital: viewing the night sky is highly analogue (continuous) while the triggered messages (whether video, audio, or text) may be considered digital components.

AR and VR from a postdigital perspective

In common parlance, 'virtual' is viewed as something that is not real or almost real. It is commonly associated with computer-generated worlds. However, Metzinger (2018) argues that virtual reality is much closer to our everyday consciousness than one might expect: "the conscious experience produced by biological nervous systems *is* a virtual model of the world—a dynamic simulation" (p. 3). Virtual and augmented reality devices are, after all, designed to work with our sensory-motor capabilities which are interpreted by the human brain. The brain is constantly interpreting sensory data and constructing representations of the world. Metzinger (2018) suggests that regardless of whether our perceptions are derived from a physical world or a computer-generated world, our brains strive towards an "integrated ontology" (p. 4). Although some VR applications might be highly realistic while others are more dream-like or hallucinatory, it can become difficult to ascertain the difference between real life and virtual experiences as users can develop a sense of presence and embodiment. It, therefore, should not be surprising that the learners in the VR vignette above panicked when they sensed the canoe tipping over.

Chalmers (2017) defines virtual reality as "an immersive, interactive, computer-generated environment" (p. 132). "Immersion describes the involvement of a user in a virtual environment during which his or her awareness of time and the real world often becomes disconnected, thus providing a sense of 'being' in the task environment instead" (Radianti, Majchrzak, Fromm, & Wohlgenannt, 2020, p. 2). Chalmers (2017) offers five categories of VR: *immersive, non-immersive, interactive, non-interactive* and *non-computer generated*. *Immersive* environments are characterized by three-dimensional spaces in which a user can explore through the sense of vision, hearing, and sometimes touch. Radiante et al. (2020) define immersion as "the degree to which a user can modify the VR environment in real-time" (p. 3). Radiante et al. (2020) argue that people will perceive the level of immersion differently depending on 1) individual perceptions of isolation from the physical world in relation to 2) the type and quality of technology used.

Controllers, keyboards, mice, head-and-body tracking tools permit interaction. Interaction requires tools to support perception such as visual displays, speakers, and headsets. *Non-immersive* environments are often two-dimensional worlds displayed on computer screens. They may be referred to as virtual worlds such as SecondLife (https://secondlife.com/). Greenwald (2021) suggests that AR is related to this non-immersive category. *Interactive* refers to a type of environment in which a user's actions can affect objects or features within an environment. *Non-interactive* environments include passive simulations such as watching a linear video. While the VR vignette describes a somewhat passive storytelling experience, the sensory tools such as headsets, speakers, and visual displays are still necessary to experience the simulation; therefore, there is still some interaction in the canoe vignette. *Non-computer generated* refers to camera-generated environments. Metzinger (2018) writes that AR "adds an environmental layer that is invisible for others, superimposing a new and additional set of priors onto the conscious subject's model of reality" (p. 14).

Beaumier and Koole (in press) provide additional insights into the ontological and epistemological nature of AR and VR (Table 2) with regard to freedom and constraints in experience and learning with these technologies. While the VR experience in the vignette is ultimately constrained by the underlying programming (software) and the need for a headset and handset (hardware), perceptually it offers potentially unlimited freedom to explore within a world from multiple angles, inside and outside. The learner may defy normal physical limitations because space is virtual. AR, meanwhile, remains much more tethered to the physical world; objects on screen may appear to defy laws of physics, but the human learner remains bound by them. For these reasons, the two technologies may be viewed on a continuum between freedom and constraint. Other non-immersive, virtual worlds also fit on this continuum. For example, in SecondLife, the user remains bound by physical laws, but their 2D avatar does not.

Table 2: Ontological and epistemological characteristics of AR and VR (modified from Beaumier and Koole, in press)

	Ontological characteristics	Epistemological Characteristics
VR	Activities occur within digitally rendered environments. *Freedom* to alter the environment. (Example: the user can fly.) Space and locale are virtual.	Virtual features can be superimposed and added to the environment. *Freedom* to alter perception of the environment (neither tethered to a physical environment nor laws of physics).
AR	Activities overlaid upon and *constrained* by physical environments and objects. (Example: the user cannot fly; avatars can.) Physical space and locale play an important role (Klopfer & Squire, 2008).	Virtual features can be superimposed upon the physical. Freedom to alter one's perception of the screen environment (yet experience remains tethered to a physical environment).

In re-examining the VR and AR vignettes at the beginning of this paper, there are certain freedom and constraints associated with each that render one more conducive to NL than the other. In VR, learners may participate together even though they are physically separated from each other. It is possible, for example, that with the right equipment, two learners from different geographic locations can sit in the VR canoe together and experience the learning activity. Co-experiencing a phenomenon can increase the learners' sense of co-presence. *Presence* within the context of VR may be defined as "the subjective experience of being in one place or environment, even when one is physically situated in another" (Witmer & Singer, 1998, p. 225). AR, however, is tightly connected to the physical environment. Learners from different continents will see a different configuration of constellations at a given time. Furthermore, when it is night-time for one learner, it might be afternoon for another. Therefore, collaboration between physically remote learners will require additional strategies; however, experiencing the same AR activity at the same time is difficult and the sense of co-presence will be differently nuanced.

Design for learning

Understanding analogue and digital characteristics of technologies as well as the freedoms and constraints of such technologies can inform practitioners about learning environments and help designing for learning. It is helpful to consider the sites of learning, activities, configurations of learning groups, and representation of learning (Table 3).

Sites of learning

The spatial-temporal location in which individuals engage can impact how learning is experienced qualitatively. In comparing the VR and AR vignettes above, the learners in each case likely experience a different sense of embodiment and presence. In one case, the learners sense being seated in a canoe as the sights and sounds surround them; in the other, the learners are standing, looking up at the stars and following the directions in coordination with their smartphones. The VR app creates a sense of precariousness because the learners' movements can overturn the canoe with any sudden movements. The AR app, on the other hand, allows the learner to remain firmly standing on the ground fully aware of both the 'real' physical world around them and the screen space. The VR experience can be shared simultaneously by two people who might be separated by great physical distance. The learners using the AR app might coordinate their experience by telephone or physical co-presence.

In both vignettes, the learning experience is co-created by the people, technologies, and networks. By understanding the constraints and freedoms of different configurations of these elements, instructors can think about how they wish to orchestrate collaboration and sharing. Learners may be asked to broadcast their activities to other individuals synchronously or asynchronously. Learners from disparate physical locations may be asked to gather into one virtual site. Many of these decisions are related to the learning goals and technologies accessible to the learners.

Activities

In both vignettes, the learning goal is to gain a better understanding of the culture's worldview through knowledge of cosmology. The VR app was designed to immerse the learner into a different world and, thereby, foster and openness to new ideas and sensitivities. The app offers a somewhat passive experience in which the

learner acquires knowledge by listening to stories along with some ability to choose which stories are narrated and when. Although the AR app has the same goal, there is less of an immersive experience. Once the AR app teaches the learner how to navigate and trigger narratives, the learner has greater control over which stories are triggered.

When using particular technologies, analysis of the technologies can become an additional learning goal. For example, learners can be asked to analyse the analogue and digital characteristics of the activities to create greater awareness of how they are engaging with each other, the environment, and the technology. Learners can be asked to analyse the applications with regard to social justice and environmental impacts. By reflecting upon their use and struggles with the technology, discussions may reveal that the technology is too costly for many people because it requires specialized equipment and a computer with great processing power. VR also requires a large amount of space in order for learners to move freely. Some learners might be prone to dizziness from the visual equipment. Availability of VR and AR apps in language other than English can be challenging. In addition, learners may wish to investigate the use of energy and resources in the production and use of electronic technologies. Similarly, for the AR app, learners might also discuss cost, the need for higher quality personal devices with sufficient capacity to fully operate the application. In other words, are these technologies inclusive for learners of all socio-economic-cultural backgrounds?

Learner configurations

Instructors might also consider how learners can exploit technologies for collaboration, which is an important aspect of NL. They might find ways to organize learners into analogue (i.e., unified groups) or digital configurations (smaller groups or separate individuals). It is also important to consider constraints of learner configurations in terms of social, physical, and political rules; for example, a class may need to establish rules of netiquette and turn taking. Furthermore, how might organization of learning offer freedom for meaning-making, negotiation, and sharing? The instructor might then plan how and when these learner configurations and rules of interaction can shift and blend. Learners may be asked to shift between working with others and working individually. They can reflect upon the value of cooperation, collective action, and relationships in the learning process—all of which reflect key values in NL.

Representations of learning

In traditional, classroom-based learning and even many forms of online and blended learning, learners are often expected to demonstrate what they have learned through exams, essays, presentations, portfolios, and artefacts. An interesting possibility is to ask learners to consider creating digital and analogue representations—or blends thereof. For example, having access the VR or AR app as described in the vignettes, learners could be asked to depict what they have learned. They could choose analogue modalities such drawing. They could shift their drawings from analogue to digital by collecting drawings from multiple learners and creating a mosaic on a wall (physical or virtual) or a video mosaic in which each drawing is presented along with narration. Learners may be asked to reflect upon how they experience the digital, analogue, and blended representations differently, which representations appeal to them, which representations they feel will help them remember the constellations or the better understand the culture's worldview. And, finally, learners can consider how their representations can become depleted through repeated use (such as when a .jpg image is repeatedly resampled and resaved, losing information each time.) Cascone (2000) argues that it is important to consider "concepts such as 'detritus,' 'by-product,' and 'background'. . . when visual artists first shifted their focus from foreground to background (for instance, from portraiture to landscape painting), it helped to expand their perceptual boundaries, enabling them to capture the background's enigmatic character" (p.13). When technologies fail, perform in unexpected ways, or co-create unusual experiences, that which is normally imperceptible or unnoteworthy is raised to awareness.

Table 3: Designing for learning

	Analogue / Digital	Freedoms/constraints	Shifting
Sites of learning	What are the qualitatively similar or different nuances of 1) different sites of learning networked together (a mosaic of site) vs. 2) individuals converging into one virtual learning space.	What might constrain these convergences? How might these convergences expand freedoms?	Learners may be asked to broadcast their activities to other individuals synchronously or asynchronously. Learners from disparate physical locations may be asked to converge into one virtual site.

Activities	Which aspects of the activity are analogue/digital?	What are the goals that guide the activity?	Critical analysis as a learning objective/goal: Learner can be asked to analyse the analogue digital characteristics of the activities to create greater awareness of how they are engaging with each other, the environment, and the technology.
Structure / organization	How might the class be organized in a way that is analogue (a unified group)? How might the class be organized to be digital (smaller groups or individual work)? How and when can the organization shift from one to the other?	What are the constraints within the structure of the learning organization? Are there social, physical, or political rules? How might organization of learning offer freedom for meaning-making, negotiation, and sharing?	Learners may be asked to shift between working with others and working individually. They can reflect upon the value of cooperation, collective action, and relationships in the learning process.
Representation of learning	What is a digital/analogue form(s) that conveys what the individual(s) has(ve) learned? Can the learners shift between analogue, digital, or both?	Does the nature, aesthetic, or experience of the activity change when shifting? Do those changes constrain how the learning activity can shift? What might constrain or free learners to create or share their representations?	Learners can be asked to shift between coding, decoding, recoding, repurposing, and reconfiguring representations. They may be asked to reflect upon how materials may become depleted with repeated use (lossy formats being repeatedly sampled down, paper breaking down, etc.) and/or how new forms emerge through shifting. What can be learned from failures or detritus?

Conclusion

Using a postdigital lens to explore teaching and learning technology, at first, may seem to be an esoteric endeavour. However, we argue that the value of examining the ontological and epistemological, digital and analogue characteristics of AR and VR is that it helps to make the human-technology relationship more perceptible. The above discussion of designing for learning offers various levels in which an analogue-digital metaphorical analysis can yield interesting and valuable questions and observations. One can examine how humans and non-humans are organized, ways to represent understanding, places and space for learning. In each case, one can ask if there is an analogue view or a digital view. One can reflect upon whether there is value to such views and for whom/what. One can ask who or what is included or excluded as one shifts configurations. Knox (2019) writes, an "interpretation of the postdigital relates to a growing interest in surfacing the often-hidden material dimensions of the digital, such as the human labour required to produce and sustain technology, and the infrastructures and substances required to produce it" (p. 365). In a learning situation, whether face-to-face or networked, 'shifting work' can offer tangible benefits; that is, much can be learned from shifting between analogue and digital. Such shifting may surface failures, depletion of resources, and the emergence of new entities. Not only will an electronic photograph lose information and become blurry through repeated sampling and saving, so will a paper photograph as it is replicated repeatedly using a photocopier or pencil and paper tracing. What is important is noticing and questioning. Metaphorically, it is important to tip the canoe to see what sensitivities emerge.

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