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LEAPING FORWARD WITHOUT LOSING SIGHT OF THE PAST: A COLLECTIVE REFLECTION ON THE FUTURE OF MOBILE LEARNING

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ABSTRACT
This paper presents the viewpoints of six international scholars who reflect on how they see mobile learning (ML) becoming its future self by reflecting on its past. Each scholar reflects on ML learning into the future with an eye towards the evolving nature of ML theory, alternative philosophical perspectives, associated pedagogy and practice, design and research practices and methods in ML, and emerging technologies relevant to ML. Along the way, they explore the potential impact—both positive and negative of adoption or non-adoption of ML in education and lifelong learning settings.

Keywords: mobile learning; seamless learning; hybrid learning; collaborative writing

1. INTRODUCTION

Mobile learning (ML) research is a rapidly evolving field that explores how mobile devices can support learning anytime and anywhere, in an (more) efficient, effective, and enjoyable manner. ML has been influenced by various social, cultural, and technological changes over the past decades and by different theoretical and pedagogical perspectives. However, as ML becomes more widespread and diverse, it faces new challenges and opportunities requiring critical reflection and inquiry. In this paper, we aim to provide a productive space to reflect upon and question how ML is positioned more generally in the technology-enhanced learning (TEL) and (digital) education domain. Our main objective of this collective reflection is to explore the past, present, and future of ML from different angles and perspectives.

To write this collective paper, we used the collaborative writing technique, characterised by "openness, collaboration, co-creation and co-social innovation, and collegiality that becomes a praxis of self-reflection of the subjectivity of writing" (Peters et al., 2022). We are six international scholars involved in ML research and practice for several years. We wrote collectively online and held synchronous meetings to reflect on our writings collectively. As we wrote and met together, the discussions splintered and converged. The process resulted in the collection of a range of perspectives, philosophical approaches, and values.

The contributions are organised as follows: Parsons provides a historical overview of ML pedagogies and theories as they emerged in relation to changing social forces and technologies. While Parson's contribution is more retrospective, Koole dives into philosophical/theoretical areas that challenge current perspectives in educational technology: socio-materialism and the post digital. Rusman delves into mobile and seamless learning design, examining both process and outcome perspectives on learning design. MacCallum then discusses the concept of affordances in relation to recent innovations in ML and explores how new technologies offer new affordances and barriers that need to be overcome as we move towards a new vision for ML. Cristol's contribution shifts into the 'digital deserts' issue in Ohio, where limited connectivity is essential for providing people access to banking, education, medical systems, and other key social and economic services. Finally, Arnedillo-Sánchez discusses the potential implication of unfettered access to mobile technologies in children's motor, brain, and emotional development.

To conclude, the authors engage in a discussion that explores the commonalities, divergences, and, most intriguingly, the tensions among the various perspectives presented throughout this collective paper. By engaging with the past, embracing diverse theoretical frameworks, examining design implications, addressing societal challenges, and considering developmental aspects, this paper strives to provide a comprehensive and nuanced reflection on the future of ML.

2. THE EVOLVING NATURE OF MOBILE LEARNING PEDAGOGY AND THEORY (PARSONS)

For mobile technologies to be effectively used in education, a rationale is needed for selecting appropriate pedagogies and their underlying learning theories. Over the years, different aspects of ML have come to the fore as both the technology and its contexts of use have evolved. In the early days of using mobile devices for learning, from the late 1990s, the limited affordances of the available devices led to pedagogies based on having a device that could communicate (via calls or text messages) and could be carried into different learning spaces. Therefore, pedagogical practices based on theories such as self-directed learning and social constructivism were put forward as being relevant approaches to ML (Stone & Thames, 2004; Zurita & Nussbaum, 2004).

Ten years or so later, as mobile devices became more powerful, with fast Internet connections, application processing and multimedia capabilities, new types of learning became possible. Informal learning became a realistic prospect, while more constructionist learning activities could be undertaken on more powerful devices (Siemens, 2005), using the increasing number of apps and coding tools available that supported the creation of digital artefacts (Anohah et al., 2017). More effective types of experiential learning became possible with devices that could interact with environments both physical and virtual, for example through location awareness and an increasing range of sensors that enabled the gathering of data for inquiry-based learning. An increasing range of media types meant greater support for different modes of learning, both in terms of the learning materials provided and those created by the students with devices that could handle high-quality images, videos, and sound.

Perhaps the most important technological change to impact ML recently has been artificial intelligence tools. For example, given a latitude and a longitude from a mobile device, tools such as ChatGPT can provide contextualised, interactive information about a location, opening new possibilities for situated cognition and place-based learning. Other AI features, such as image recognition, can provide further contextual learning opportunities and, combined with the ability to translate, transcribe, and summarise spoken information, AI-driven ML tools can transform what is possible for learners moving within and between contexts. ML practitioners need to consider the potential of mobile devices to offer intelligence both for and about learners, spanning an increasing range of connected devices. Future ML will take place within an environment where mobile devices are the most likely channels for learners to interact with the Internet of Things (Kassab et al., 2019). Learning theories such as situated and distributed cognition can come into play strongly in situations where students have access to a range of smart devices that can be deployed across different environments that may embed various forms of machine intelligence.

Social forces were also important in the evolution of ML. The increasing accessibility and affordability of powerful mobile devices and communications networks globally have made it possible for Bring Your Own Device learning to be at least potentially equitable. The pandemic made it even more important that students have access to Internet-connected digital devices and many students relied on their mobile devices for learning during lockdowns and the closures of educational institutions. However, this may have been a double-edged sword, in that while students' mobile devices may in many cases have been their only link to their teachers during school closures, some schools have attempted to turn the clock back to pre-pandemic styles of teaching. There are now efforts to limit opportunities for ML, for example with recent bans on using phones in schools in Australian states (Selwyn & Aagaard, 2021) despite evidence that such moves may be over-simplistic and counter-productive (Magnusson et al., 2023). In the face of these challenges, it is important that ML theory can make a strong case for the value of learners using mobile devices.

From a social perspective, ML theory has been influenced by sociological work in mobilities. Although the concerns of mobilities research are very different to most ML research, concerned as they are with the movements of people and the underlying forces of those movements, and not necessarily technology or learning, the field nonetheless embraces concepts of communicative, imaginative, and virtual mobilities that link closely with contemporary ML spaces. Perhaps more important are the broad social issues that are addressed, such as mobility constraints, surveillance, and inequality (Sheller, 2017). Such theoretical concerns also find a place in the processes of decolonising learning and the idea that ML needs to find a role that is unique, universal, and outside the established paradigm (Traxler, 2021).

Given these technological innovations and the social forces at play around them, what does this mean for the theory and pedagogy of ML? Several new theories of learning have been proposed in the 21st century, including some discussion of what a theory of ML might include (Sharples et al., 2005). However, the 21st century learning theory that has gained the most traction is connectivism (Siemens, 2005). Although it has been criticised for a lack of rigour as a learning theory, it has found a role in informing curriculum design (Bell, 2011). In its early days, one criticism was that not everyone believed the connectivism principle that learning may reside in non-human appliances (Kop & Hill, 2008). With the recent spread of tools based on large language models, this seems to be far more self-evident than it was when the theory was first developed, and therefore it would be relevant to reinterpret connectivism as a theory and how it may apply to ML pedagogies going forward. The pedagogical challenge is to ensure that learners are still able to construct their own knowledge in a world of intelligent, connected, mobile machines. In addition, ML pedagogies must take a broader social view that embodies an understanding of the inequalities and ideologies that have driven past practice to bring us to where we are today and ensure that future ML is justifiable, equitable, decolonised, and more human than machine.

3. MOBILE LEARNING: NOT QUITE POSTDIGITAL (KOOLE)

Since the term 'mobile learning' (ML) was coined, multiple definitions have emerged suggesting differing primary foci such as technology, pedagogy, mobilities, disruption, or other areas deemed significant to researchers. In his critical review of ML, Traxler (2021) notes that definitions of ML generally suggest "learning mediated by personal connected mobile digital technologies" (p. 6). He argues that within the field, conceptions of learning remain "unchanged" (p. 6) and have not reflected societal change nor challenged the "epistemological foundations of our worlds and cultures" (p. 7). There is much value in Traxler's critique. To create space for growth in ML research, it may be helpful to consider ML from different ontological and epistemological perspectives such as socio-materialism and/or the post digital.

Traxler's comment above reveals the often-binary way of viewing ML in terms of a human-technology divide. Socio-materialism offers an ontological 'sensitivity' which can assist in understanding patterns and unpredictability in the surrounding world (Fenwick & Landri, 2012). Within this view, the human and non-human are part of assemblages whose very ontological nature mutates as components of the assemblage shift. Assemblages can be conceptualised in many ways through many metaphorical patterns such as fluids, networks, and regions (Koole, Clark, Hellsten-Bzovey et al., 2021). More importantly, a socio-materialist would suggest that ML involves learners, content/procedures-to-be-learned, and tools (devices, networks to permit access and interaction with content). All such elements within the assemblage are interconnected in sometimes messy and unexpected ways. If, for example, the device is a smartphone, the nature of learning is co-created by the smartphone; however, if instead uses a laptop, the nature of the learning activity may shift. Using a smartphone, the learner might quickly turn it on while waiting for a bus, turn it off while getting on the bus, then turn it on after taking a seat or finding a spot to stand. Using a laptop, the learner might find it too cumbersome to turn it on and off so frequently—especially if all the seats on the bus are taken.

Barad's (2007) concept of intra-action accounts for an "entangled state of agencies" within assemblages (p. 23) in which "distinct agencies do not precede, but rather emerge through, their intra-action" (p. 33). In considering the bus example above, the ability to access learning materials changes in accordance with the technology and its affordances, the nature of the learning content, and the preferences of the learners. At the same time, Barad's concept of intra-action challenges essentialist ideas of causality in which one entity acts upon another entity; rather, reality co-emerges or co-performs into existence. Within this view, learning is performative alongside the human, digital, and material which are co-present. The emergent performance is unique to that assemblage. This situation partly explains why educators can only design for learning (Laurillard, 2016) rather than designing actual, prescribed step-by-step learning trajectories along with specified outcomes (Parchoma et al., 2019). ML—along with every other type of learning—is contingent upon its assemblage.

The socio-material is complementary to the post digital perspective. However, the post digital focuses on continua between analog and digital, and between old and new. Unlike the use of 'post' (meaning 'after') in other theoretical perspectives, 'post' in post digital refers to a continuation of the digital but is also beyond the digital. It "neither recognises the distinction between 'old' and 'new' media, nor ideological affirmation of the one or the other. It merges 'old' and 'new'" (Anderson, Cox, & Papadopoulos, 2014, p. 5). For ML to be considered post digital, the digital would need to be so ubiquitous that it is unremarkable and passé (Cascone, 2000; Cramer, 2015)—noticed by its absence rather than its presence (Jandrič, Knox, Besley et al., 2018)—just as one is unconscious of the computer chips and digital goings on in one's car while driving. In the case of ML, learners may lack awareness of how the nature of their interactions might differ when they shift from, say, a smartphone to a laptop, but they remain aware of the actual tool used, suggesting that ML has not yet become post digital. Furthermore, the post digital perspective renders notions of causality (binary views) moot: technology does not 'cause' ML; however, ML cannot exist without technology as part of its assemblage.

The importance of considering alternative perspectives such as the post digital is to surface different realities that can inform the development and selection of learning theories, technologies, and pedagogically effective design. For example, if mobile devices are unremarkable (i.e., they are no longer noticed), then how designers present information/content and design of procedural lessons without learners being aware of learning modalities and platforms? If AI and seamless learning represent movements towards the post digital, and if information is always at hand, is there still a need for people to learn and remember information and procedures? What becomes the focus of pedagogy?

4. A DESIGN PERSPECTIVE ON MOBILE AND SEAMLESS LEARNING (RUSMAN)

The overall objective of mobile and seamless learning design is to influence the cognitive state and behaviour (activities) of learners to reach specific personal (learning) objectives in an environment or practice, through the design of learning scenarios that are leveraged and supported through the optimal combination of pedagogical insights, specific and unique affordances of (mobile) digital technology and an area of interest or domain.

The term ‘learning design’ can refer both to the design process itself as well as to an envisioned outcome or product of this design process, such as a specific learning scenario. Looking at the term from a process perspective, it is about systematically designing, developing, delivering, and evaluating (digital, physical or blended/physical) learning scenarios to support the acquisition of specific learning objectives by a (group of) learner(s). The design process consists broadly of determining the state, preferences and needs of the learner, defining the end goal of the learning process, and creating a grounded "intervention", based on learning and instruction theory, design frameworks and practice-based information, to assist in the transition (Wagner, 2011). To support the learning design process, different design methods and instruments might be adopted, for example rapid prototyping, design thinking, design research or ADDIE, with instruments such as card sorting, personas, canvases, use cases, scenarios or learner journeys, mock-ups, and ‘theoretical’ learning models. These design process models vary in the way in which they are prescriptive and deterministic (e.g., the system approach of instructional design by Romiszowski, 1993) compared to more open, cyclic, re-iterative models, in which various stakeholders and actors are part of the design process and the design process is ‘fuzzier’ (e.g., the design thinking approach, Curedale, 2019). Examples of learning theory used to guide design decisions are constructivist, behaviourist and connectivist or boundary crossing learning approaches. Examples of ‘theoretical’ instruments are generic frameworks for learning, such the ‘conversational framework’ (Laurillard, 2002), the Cultural History Activity Theory (CHAT)-framework (Engeström, 1987), as well as specific ‘holistic’ frameworks for ML, like Kearney’s (2012) and Koole’s (2005, 2009) frameworks, but also frameworks focusing on specific design factors, for example on the influence of the affective states of learners (Viberg, Kukulska-Holmes & Peeters, 2022) or their agency (Suarez et al., 2018). Looking from a technological perspective, models on specific affordances of mobile devices to support learning and personal development can be used, such as those defined by Sharples et al (2015) and Bannon, Cook & Pachler (2017, p.943). Affordances they mention are collaborative and communicative potential (“connectivity”); interactivity and non-linearity, distributed knowledge construction, multimodal knowledge presentation, authentic/contextualised/situated material, interaction, tasks and settings; multifunctionality and convergence (previously separated tools in one device and connectivity to internet based services, tools, resources and networks); portability (“always with you”), ubiquity, personal ownership and user-generated and created content and contexts (“sensor pack” to extend human senses, multimedia capture, data logging).

The resulting 'intervention' may be called a learning design too, only then from an outcome perspective. From this perspective, a learning design is a formal description of a learning scenario, that may also be expressed in a (re-usable) format. A learning scenario describes (roles of) actors participating in a learning process, the (order, sequence(s) and potential paths through) learning and support activities designed to achieve certain learning objectives in the most efficient, effective and engaging way and the environment (with actors, resources, instruments and services) to support individuals' activities. Actors may include learners, teachers, and experts. A learning design from an outcome or product perspective is a method enabling learners to attain certain learning objectives by performing a series of learning activities in a certain order in the context of a given learning environment (Tattersall et al., 2003). Examples of ML designs from an outcome perspective are e.g., more (inter)active learning scenarios, such as inquiry-based-, story-telling-and making, game-based and problem-based ML, but also more 'delivery' focused designs, such as micro-learning modules. Within these scenarios, design elements with specific designed affordances may be distinguished, such as for example triggers, nudges, and notifications (Rusman, 2019). These may be considered as 'building blocks' within a mobile (inter)active learning scenario.

Within each of these perspectives (process and product/outcome perspective) several layers can be distinguished in which informed and complex design decisions need to be made, dependent on the characteristics of the learners, the learning problem(s) and the environment(s) they are active in and the added value and affordances of mobile technology. The control on these design decisions can be with one or more of the following actors: researchers, designers, teachers, domain experts, students, but also be machine automated or supported.

Looking at existing research on learning design at various levels/layers and from different perspectives, it is noticeable that over the years the design methods to address ML design processes have been shifting from more prescriptive models towards more open and cyclic methods, with stakeholder involvement within the design process. However, as it is often argued that this kind of design approach fits the kind of complexity of the design problems best and can still contribute to theory development within the ML as well as the learning design domain, it is not clear on which aspect of the design process or of the design outcome this theory development can and should happen. It is rare that structural comparison of learning design solutions of comparable learning problems and the underlying rationales and considerations behind (chains of) design decisions during the learning design process are made. Notwithstanding, this could probably lead to the detection of most optimal design 'constellations' of design solutions to specific type of problem sets and design guidelines. Moreover, more insight into the design process itself could be gained, based on the analysis of the chains of design decisions at various layers that led to these constellations. These design decision chains may also be called the 'learning design pathways. However, currently little is known from a structural perspective about optimal design pathways to create the most effective, efficient, and enjoyable ML designs and the structural characteristics of these designed 'constellations' linked to specific learning problems in practice. Several learning theories and models are often used, based on the assumption that they are fitting and effective, however structural evidence remains absent. With reflection on the design methods used to structure the design process it is a similar case. Moreover, learning solutions are also often still linked to formal education only, for specific target groups (e.g., upper classes K-12 education), embedded in specific domains (e.g., language learning, mathematics (geometry) and (environmental) sciences) or focused on improving specific characteristics or steps in the learning process (e.g., improving reflection, supporting self-reflection, emotion-regulation, (peer)feedback or learners' agency). Yet did we generate 'overarching' (design) knowledge about the inherent characteristics of these contexts that make mobile and seamless learning designs especially feasible or effective there? And do we know more about (specific chains of design) decisions within the design processes that have led to these presumably optimal 'design constellations?

Therefore, looking at potential new alleys and perspectives for future research on mobile and seamless learning design, more structural and standardised expression and analysis of both design pathways (chains and layers of design decisions) and the design methods used as well as their relation to optimal 'constellations' of learning design solutions could provide further knowledge and insight in general principles, mechanisms and guidelines for the design of mobile and seamless learning solutions. As Buchanan (1992, p.6) stated 'designers are exploring concrete integrations of knowledge that will combine theory with practice for new productive purposes. However, as researchers, we should not forget to look for more generalisable knowledge that can potentially be derived and distracted when looking at the characteristics of collections of unique, 'one and only' design solutions. Potentially, design patterns could fulfil a role in expressing designs and uniting both practice-as well as theory-based perspectives when solving learning problems. "*Design patterns provide a structure for integrating the analysis and solution of a problem, in a way that is sensitive to context and informed by theory and evidence*" (p.3, E-LEN project). In a design pattern special attention is given to the forces which are acting on the problem and the rational for choosing a particular solution (p.2493, Baggetun, Rusman & Pozzi, 2004; Goodyear et al., 2004; Laurillard, 2012)". However, also other manners to elicit (pattens of) generalisable elements of both the mobile and seamless learning design process as well as the learning design outcome, in relation to structural characteristics of re-occurring problem situations, could be explored in future studies. Such as in the recent study of Cochrane et al. (2022), in which they used a combination of activity theory and the DTML-PAH matrix to express and analyse the characteristics of seven case studies. Potentially, recent AI development could play a role in detecting recurring patterns of design, both in terms of (chains of) design decisions as well as in terms of optimal 'design constellations' for specific problem types in educational practice.

5. THE AFFORDANCES OF NEW TECHNOLOGIES IN MOBILE LEARNING (MACCALLUM)

Much of the research into, and adoption of, ML has been driven by the unique affordances that mobile technology offers. Affordances can be either intended or unintended, and it is unlikely that the developers of mobile devices gave much thought to their learning potential, yet their learning affordances were quickly recognised. For example, some of the designed and therefore intended consequences of mobile devices are their portability and the ability to connect to networks and resources. From a ML perspective, an unintended consequence of these affordances is that learning can take place anywhere and anytime (Pimmer et al., 2016). In general, as mobile technology has evolved to offer more features, it has in turn enabled mobile learners to identify new affordances.

With ongoing research, many different ML affordances have been perceived in mobile technology. These include but are not limited to, the ability of mobile technology to support outdoor learning, engage in enhanced social communication, provide for the gathering of evidence and data, and support interaction with other learners' devices (Parsons, et al, 2016). These affordances provide an insight into the "possibilities for action" afforded by the technical design and features of mobile technology (Markus & Silver, 2008). However, as we consider the future of ML, new affordances will need to be identified and leveraged for ML to continue to make its mark in the education space.

As enhancements are made to current mobile technologies, this will in turn continue to promote new opportunities for ML. For example, innovations in mobile extended reality (XR), which includes both virtual reality (VR) and augmented reality (AR), have provided opportunities for more affordable access to sophisticated learning experiences that don't need specialist equipment to engage with, enabling student-created experiences (MacCallum, 2022). In addition, newer technologies like LiDAR have provided for more precise augmentation of physical objects within the digital space, therefore, opening richer and more precise context-aware AR learning (Lin, et al, 2022).

While new features on mobile devices may provide unique opportunities in themselves, the systems that these devices connect to may provide the most significant opportunities for new learning experiences. For example, learning analytics systems running in the cloud can support learners using mobile devices (Pappas et al., 2017), and the Internet of Things (IoT) supports person-to-machine interactions that enable IoT-based instruction in contexts such as the smart campus (Zeinab et al., 2022). Also, new AI technologies, coupled with mobile technology, may provide new learning opportunities. For example, through Generative AI, the creation of learning artefacts, such as videos, presentations, and even AR and VR experiences, can be sped up to remove the unnecessary repetitive work and allow for more focus on the creation of ideas and deeper understanding. This could include creating engaging learning opportunities that utilise both AI and mobile technology, such as those envisioned by Raptis, et al, (2021), where mobile technology and AI may be combined to support contextual and personalised information based on learner engagement with Art exhibits.

As we look to the future of ML, there is an opportunity to explore what new affordances are offered by mobile and its additive technologies, and how we can harness them to ensure that ML remains relevant in the future. However, this focus on affordance should not be mistaken as being simply techno centric. Rather, while technologies can suggest potential uses it is for the educator to evaluate the value of the tool in learning. Technology may provide new opportunities, but educators must judge if their use also brings worthwhile learning that is not impeded or inhibited because of the tool.

While exploring affordances, is important to acknowledge the challenges that ML brings. Their ubiquity means they are often seen as a classroom distraction, a negative affordance (Maier et al., 2009), and their use is often constrained by schools. Another challenge is the commodification of education, which has led to companies competing for attention and trying to sell the latest gadget promising to be the "silver bullet" to improve learning, often neglecting or undermining valid concerns related to privacy, data security, and the potential for intentional integration of addictive features embedded within these systems. Therefore, while we consider how new technologies may support new opportunities it is important to recognise the potential negative impacts that digital and mobile technology has on our learners (Cloete, 2017).

Taking an affordance lens to the exploration of ML must also include consideration of responsible and effective use of mobile technology in education, where learning takes precedence and where proactive measures must be taken. This entails implementing strategies to manage distractions, fostering a balance between digital and personal interactions, promoting critical thinking skills to combat misinformation, and working towards bridging the digital divide. It is crucial that we maintain a critical perspective regarding the role of technology in education, considering the interests and potential risks posed by its integration. As we progress towards the post digital era, mobile technology will play an even more decisive role, where its ubiquity and accessibility place powerful opportunities in the hands of learners. This power will come with strong caveats that we, as educators, need to explore alongside our students for the opportunities to be truly realised.

6. TURNING DIGITAL DESERTS INTO DIGITAL RAINFORESTS (CRISTOL)

Prior to the Covid-19 pandemic, the term digital divide was an often-used theoretical explanation for households lacking access to reliable broadband internet services (Gorski, P. 2005). Then Covid-19 took its grip on the global community, triggering the education of students at all academic levels, abruptly shifting from primarily face-to-face learning to remote learning. Immediately, students, parents, educators, and administrators in some communities around the world experienced unreliable or no broadband internet services consequently losing the ability to continue or limit formal learning (Dorn, et al, 2020). No longer was this a theoretical problem; this became a tangible educational-survival problem. The problem was like a desert lacking nourishment and water to sustain life; these communities became digital deserts lacking the technological nourishments to sustain learning outside of the classroom (Beaunoyer, 2020).

Digital deserts refer to areas or communities that lack access to reliable and affordable internet connectivity and digital technology (Levin & Downes, 2019). In educational digital deserts, students have difficulty completing their schoolwork or participating in online learning opportunities. This exacerbates existing inequalities and limits economic and social mobility for residents in these communities (Crock Bauerly et al, 2019). Many digital deserts are found in rural or urban communities which are economically disadvantaged and thus facing challenges to access education, job opportunities, critical information, and services available online. These deserts are not a Covid-19 phenomenon, some communities could have been labelled digital deserts prior to the pandemic. For example, in remote rural Bangladesh, communities faced many teaching and learning obstacles caused by lacking access to sustainable and reliable internet connectivity. Instead of experimenting with the current learning technology commonly found in developed countries, the primary experimentation in these communities was to find reliable electricity to function as a thriving community. Despite these circumstances, most parents viewed technology to help their children succeed in school and future jobs

(Cristol et al, 2019). For those residents living in developing countries' digital deserts, the notion of digital ubiquitousness is a foreign concept and unattainable, unless one argues their cars contain microchips, a measure of their participation in the digital sphere.

To nourish digital deserts into thriving digital communities, some political, business, and educational leaders are engaging multiple stakeholders. Some examples of these interactions include providing government subsidies for broadband internet infrastructure and regulatory reforms; community-based technology training programs and digital literacy programs; and partnerships between public and private organisations to expand access to digital services (Shakina, et al, 2021). These endeavours require a multifaceted approach involving investment, collaboration, and innovation across multiple sectors (Light, 2001).

In the United States, Ohio stakeholders are actively working to expand access to 5G and broadband internet across the state, particularly in rural and underserved areas. In 2019, these stakeholders created the Ohio Broadband Strategy (Ohio Broadband Strategy, 2023) to streamline the deployment of small cell wireless technology, which is necessary for the implementation of 5G and broadband internet. The belief is that the strategy will help neglected communities be on a more equal footing throughout the state, create jobs, boost the economy, and improve the quality of life for residents (Genetin, et al, 2022).

Recognising the urgency of the need, the immediate target is the training and education of the workforce with short turnaround times to be a workforce ready for sector-wide employment and advancement. The strategy uses a comprehensive and systematic process consisting of (1) professional awareness programs that aim to introduce 5G and broadband internet concepts and possibilities at middle- and high-schools (grades 6-12); (2) professional workforce development programs that develop an immediately employable workforce and (3) professional innovation programs to train the next generation of technical 5G and broadband internet leaders and executives. The Strategy operates through The Ohio State University (OSU), Broadband Internet & 5G Connectivity Center (Broadband internet & 5G Connectivity Center, 2023), a partnership between OSU and an industry intermediary. The Center houses, develops, disseminates, and administers the educational and workforce development programs. The industry intermediary leads the Sector Partnership, distilling industry needs, and, jointly with the Center, oversees planning and implementation.

While there are many challenges to overcome, there is hope that disenfranchised communities can eventually become equal participants in the larger digital learning community. Efforts, such as Ohio's, are undertaken to turn digital deserts into digital rainforests where all communities can ensure all students will have broadband internet access. By providing broadband internet access to these deserts, disenfranchised and underserved communities can address and challenge long-standing socioeconomic and learning barriers by using the technological offering in the global digital community.

Finally, partnerships such as Ohio's strategy between educational institutions, businesses, political entities, and community organisations provide resources and support for initiatives such as community technology centres, as well as scholarships and other financial assistance to help individuals access digital learning opportunities. While there is still work to be done to ensure that underserved communities are equal players in the digital learning world, these initiatives and efforts are making progress towards greater access and equity.

7. THE IMPACT OF MOBILE TECHNOLOGY ON CHILDHOOD DEVELOPMENT (ARNEDILLO-SÁNCHEZ)

Since its emergence, ML has exerted a disruptive effect on formal education, it has democratised access to learning opportunities and concerned societies regarding the impact technology may have on learning and learners. In recent years, there is growing concern on the negative effects ubiquitous access and endless exposure to screens may have on young children and their development (Wang, Qian, Li & Wu, 2023).

The affordances of mobile technologies: portability, connectivity, interactivity, location awareness, and data collection; have transformed learning paradigms, societies, and social interactions. Application areas where mobile technologies have created new learning opportunities include data collection, location awareness, and collaboration (Patten, Arnedillo-Sánchez, Tangney, 2006). To this end, ML has made learning opportunities more accessible than ever. It has decoupled learning from classrooms, bridged the gap between indoors and outdoors learning, enabled physical, virtual, and augmented learning and its contextualisation, and supported learners to become content creators and learning influencers. Constructivist learning approaches, focused on social interactions and creation of knowledge and artefacts, have championed ML implementations in these domains. However, behaviourist approaches, well suited for mobile devices as they support presenting stimuli, obtaining responses, and providing reinforcement, have prevailed with the upsurge of social media. The quasi-automatic response triggered by a ringing (or tweeting) mobile phone illustrates the stimulus-response bond which is a fundamental tenet of behaviourism (Jordan, Carlile, & Stack, 2008). The convergence of portable, connected mobile technologies, social constructivist practices and interactive/social tools, informed on behaviourist principles that incite constant reactions, interactions, or consumption of content, have brought unprecedented usage of mobile technologies.

In recent years, children's use of technology has become an acute concern. Screen time recommendations from the WHO, The American Academy of Paediatrics, and health ministries in various countries (Gottschalk, 2019) advise no screen exposure for children 0 to 36, 0 to 18 and 0 to 24 months respectively and less than1 hour per day for children 2 to 5 years old. However, a meta-review (36 papers from 15 countries across multiple geographical regions) examining the use of digital devices 49,126 pre-schoolers made, reveals an average 48.34% overuse and 26.83% problematic use (Wang, Qian, Li & Wu, 2023). Similarly, studies in Turkey (Kılıç, Sari, Yucel, Oğuz, Polat, Acoglu, Senel, 2019) on children 0 -5 years old and in the UK (Ofcom, 2021) on children 3-4 years old, report 75.6% and 82% exposure to mobile devices respectively. Children's first encounter with technology was reported to be as early as 6 months old and median age at the first-time use of a mobile device was 12 months (Kılıç, et al. 2019). Device ownership was 30.7% in Turkey and 52% in the UK. Tablets were the most owned device by children with a 68.4% ownership rate in Turkey (Kılıç, et al. 2019) and 48% in the UK (Ofcom, 2021). The use of mobile devices is reported to be predominantly unsupervised and the most frequent activity with mobile devices is watching videos. Extensive use of mobile devices by children happens when parents are undertaking daily tasks and require mechanisms for keeping children entertained and managing behaviour (Kılıç, et al. 2019; Wang, Qian, Li & Wu, 2023).

The evidence on children's use of mobile technologies paints a picture of frivolous unsupervised overexposure at very early stages of development. This evidence fuels concerns over the negative impact of screen-time on children's development and future learning potential. While the usage reported does not represent ML, researchers in the field should not ignore the development cascade risk this poses and the cumulative developmental consequences it may have for children (Masten & Cicchetti, 2010). For instance, screen-time in early years is associated with lower language skills, with difficulties in executive function and attention patterns (Ponti, 2023; Wang, Qian, Li & Wu, 2023). Moreover, screen-time can displace sensorimotor activities needed for motor development (Radesky, Schumacher, Zuckerman, 2015), which is correlated with language and mathematics learning (Bossavit, Arnedillo-Sánchez, 2022).

Against this background we call upon ML researchers to reflect on the consequences the continuous over exposure to mobile devices may have on children's development. We urge our community to engage with stakeholders to produce evidence-based literature, guidelines and policies that will support educators, parents, policy makers and technology corporations to make children-centred decisions based on their well-being and best interest.

8. DISCUSSION

This collective paper resulted in many conversations in which interesting patterns, convergences, and divergences in the issues surfaced. A significant area of tension arose in relation to the ongoing and increasing commodification of education. All agreed that we must maintain a critical perspective on technology and how it is used in education. The growth and interconnectedness of the global economy suggest the necessity for everyone to participate in (inter)national trade which, in turn, has led to a situation in which the acquisition of devices, use of apps, and access to content is the goal. Current devices such as mobile phones and wearables are designed to draw consumers' attention; they are the objects of desire, social status, and participation in society. In post digital terms, they are not yet invisible; rather, they remain highly visible, generating profits for large multinational companies' dependent upon consumers' purchasing patterns. Awareness of the devices and their marketing helps in protecting people. Curiously, the invisible bits and bytes transferred between visible devices via semi-hidden electronic networks support the commodification of people's personal, social, and economic data. As these transactions become increasingly invisible (post digital), powerful corporations can curate, buy, and sell these commodities with little attention or awareness of the end users.

Technology companies now vying for increased market share in education have vested interests in garnering attention, implementing persuasive techniques to control/guide user behaviours, and even foster addiction to their technological products. As technologies appear, they are not only absorbed into people's day-to-day lifestyles but also educational institutions, leading to a situation in which companies modify their marketing messages appealing to educators seeking the panacea to their pedagogical and learning design struggles. As Parsons notes, early ML was enacted with devices capable of text messaging or voice calls. Now, we can choose from a plethora of learning management systems, smartphone applications, wearables, and XR (to name a few), geared for online and face-to-face classrooms. The potential of mobile devices to offer intelligence both for and about learners may, indeed, enhance our ability to design for learning. While the affordances of such technologies are useful and appealing, there is agreement amongst the group that educators must remain aware of both opportunities and risks of technologies, old and new, analogue, and digital. Corporate and government collection of learners' data becomes all that much easier as networks underlying these systems fade into invisibility. As such, learning designers must attend to questions of how learners interact with data, what data they produce, what data they consume, and to what degree they are aware of and can protect their digital footprints.

Inequality of access and ethical use of technology emerged as a significant topic during group discussions of the issues presented in this collective paper. Cristol's contribution highlights the need for access to technology within our globalised economies. Without adequate access to robust technologies, entire communities can be hindered in their efforts to access essential services quickly and efficiently—potentially limiting their ability to participate in important economic and educational activities for achieving a reasonable quality of life. Cristol noted that for those living in digital deserts the notion of 'ubiquitous underlying connectivity' is both a foreign concept and unattainable (unless one argues rather frivolously that the cars they drive are loaded with microchips and therefore represents their participation in the digital sphere). Meanwhile, Arnedillo-Sánchez underscored the potential deleterious effects of unconstrained, overuse of technology in the normal, healthy development of children. While Cristol focused on ensuring access for disenfranchised communities in Ohio to create a 'digital rainforest', Arenedillo-Sanchez warns that access should be considered carefully depending on the people who could potentially be drowned by an ensuing flood.

Almost every author noted artificial intelligence (AI) as both a concern and an opportunity. Parsons suggested that there is a need to "keep ML more human than machine" yet noted that AI could offer contextualised learning for enhanced situated cognition and place-based learning. Rusman looked towards AI as a potential source of solutions for detecting recurring learning design patterns, decision chains, and offering optimal design constellations. MacCallum noted that generative AI could reduce unnecessary repetitive work and allow learners to focus on creativity, ideas, developing deeper understandings, and offer better support for in-situ learning. Meanwhile, Cristol's research suggests that AI remains out of scope for many communities around the world who lack adequate Internet access, and Arnedillo-Sanchez warns scholars to carefully consider how such technologies will impact child/human development. From a post digital perspective, Koole would ask how and to what degree AI will quietly and unnoticeably augment human learning.

9. CONCLUSION

In this paper, we have reflected on the past, present, and future of mobile learning (ML) from different angles and perspectives. We have explored how ML research has been influenced by various social, cultural, and technological changes over the past decades and by different theoretical and pedagogical perspectives. We have also discussed some challenges and opportunities ML faces in different contexts and domains.

Our main argument is that ML is a complex and dynamic phenomenon that requires ongoing reflection and dialogue as well as additional research collaborations among researchers, practitioners, learners, and other stakeholders. We have shown how our collaborative writing process enabled us to share diverse insights into ML and to identify commonalities, divergencies, and tensions among our group. We have also highlighted some areas of future research that could further advance the field of ML.

This collective reflection serves as an invitation for ongoing research and exploration in the realm of ML. We must continue to question, challenge, and refine our understanding through research, always seeking to improve and optimise the educational experiences facilitated by mobile technologies. By combining our efforts, embracing collaboration, and remaining open to diverse perspectives, we can shape a future for ML that is inclusive, innovative, and ethically grounded. As we embark on this journey, let the wisdom of the past guide us, the possibilities of the present, and the aspirations for a future where ML transcends boundaries, empowers learners, and enriches educational landscapes worldwide.

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