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Imagining the affordances of mobile devices as a mechanism in teaching and learning

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ABSTRACT

This paper reports on two experiments in mapping the affordances of mobile devices in supporting teaching and learning. The first argues for personally imagined rather than fixed affordances of educational technologies – what a technology "affords" is not static but is rather how an individual imagines a technology's use and how this is enacted. The second melds affordance theory with the structure of realist evaluation and positions affordances as mechanisms in selected educational settings. The paper's findings are drawn from observation and a review of literature.

Introduction

The affordances of educational technology are the qualities we notice and purposefully exploit to enhance what our students can do in terms of the amplification of human capacities. Affordances are what, consciously or otherwise, lead us to select one technology over another to fulfil a particular role in teaching and learning.

This paper will contend that affordances are not static or fixed within a technology but are rather how an individual imagines a technology's use and how this is enacted in differing settings. One person may not see the affordances noticed or exploited by another. There is an idiosyncracy to the identification and use of the affordances of a technology particularly in educational settings.

The paper will present its contentions, drawn from observation and a review of the literature. It will begin with a brief discussion of the theoretical background, that is, of affordances and realist evaluation. It will then define what is meant by the descriptor, "mobile devices" and, to represent the first experiment described in this paper, will offer a mapping of their imagined affordances. This enacts the notion of affordances being "in the eye of the beholder" and offered by the author as a personal and idiosyncratic view. The second experiment will position the imagined affordances of mobile devices as a mechanism whose outcome changes between contexts. It will do this by positioning affordance theory into the cascading structure of realist evaluation, that is, Context+Mechanism=Outcome (Pawson & Tilley, 1979).

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Background

There are two distinct theoretical frameworks underpinning the experiments presented in this paper: affordance theory and realist evaluation. This section introduces these frameworks and provides a brief overview of each in turn.

Affordance theory

A critical seminal understanding in affordance theory is that "perceived affordances … determine usability" (Norman, 1988, p. 123) and that an affordance is "bestowed upon an object by a need of an observer and … [his/her] act of perceiving it" (Gibson, 1979, p. 139). The emphasis is on individual perception. The affordances of educational technologies thus seem, like beauty, to be in the eye of the beholder. The consensus is that if an affordance is not noticed or appreciated, it does not exist (Gibson, 1979; Norman, 1988; Salomon, 1993).

A recent reconstruction of affordance theory speaks of imagined affordances (Nagy & Neff, 2015) where affordances are "in large part imagined by users" (p. 1). The emphasis here expands from perception to imagination, where personal creative and critical insights are brought to the task of identifying affordances including those perhaps not envisaged or encoded by the original designers (Shaw, 2017). This paper pursues the notion of individual interpretation of affordances as being imagined and purposefully exploited rather than as fixed within the technology and objectively observed.

There are a number of published lists of affordances (see, for example, Bower, 2008; Conole & Dyke, 2004). This paper does not compete with or aim to refute these lists. It will, rather, encompass their understandings. The existence of these lists serves, in some measure, to support the contention of affordances as "imagined," that is, open to individual interpretation.

Realist evaluation

Realist evaluation is a systematic strategy based on the deceptively simple question, what works for whom in what circumstances (Pawson & Tilley, 1997). Jolly and Jolly (2014) described realist evaluation as being "based on the premise that aspects of context trigger particular mechanisms … which result in observable outcomes" (p. 28). A realist evaluation approach is often expressed as an equation, namely, Context plus Mechanism equals Outcome (C+M=O). Of particular interest to the discussion of affordances in this paper is that realist evaluation accepts that:

> *… real life programs are rarely entirely successful or entirely unsuccessful, but have patches of success and failure. … a program judged to have worked well in one place [may] fail in another or in subsequent years. Realist Evaluation (RE) not only focusses on underlying factors behind outcomes but the various ways in which they can combine and recombine to cause outcomes.*
>
> (Jolly & Jolly, 2014, p. 29)

The elements of realist evaluation may be interpreted in this discussion as follows:

- *Context* refers to the "spatial and institutional locations of social situations together, crucially, with the norms, values and interrelationships found in them" (Pawson & Tilley, 1997, p. 216). This accepts that a range of conditions, often sociocultural, will affect the outcomes of any program. In this paper, contexts are described as (and reduced into) different educational sectors embedding connotations of relationships between students and their teachers and in their overarching purposes.
- *Mechanisms* are causal processes sensitive to variations in context (Pawson & Tilley, 2004). Critically, mechanisms cannot be directly observed as they are "not usually visible" (Westhorp, 2014, p. 5). An argument for affordances as mechanisms is implied in Pawson's (2002) observation that "subjects are persuaded to accept, install, maintain and act upon it [affordances]" (p. 344).
- *Outcomes* are the observable products of the mechanism adopted in a specific context. Pawson and Manzano-Santaella (2012) explained that: *We know there will be a complex footprint of outcomes; the trick is to explain it. Why are the winners winners and why are the losers losers? Why does a programme work in Wigan on a wet Wednesday and why does it then fail in Truro on a thunderous Thursday?* (p. 178, emphases added)

In this paper, outcomes noted in specific contexts are reported from a review of the literature. Outcomes are here thus regarded as dependent on context and in how affordances have been imagined or interpreted.

Mobile Devices

Mobile devices are often erroneously thought to have been inspired by science fiction such as Star Trek's communicators and Dick Tracy's wristwatch. The inspiration for digital mobile devices can more sensibly be said to have emerged in the late 1960s when Alan Kay proposed the Dynabook, a computer the size and shape of a slate designed for children. Kay and Goldberg (1977/2003) explained the *Dynabook* as "a dynamic medium for creative thought" and asked:

> *Imagine having your own self-contained knowledge manipulator in a portable package the size and shape of an ordinary notebook. Suppose it had enough power to outrace your senses of sight and hearing, enough capacity to store for later retrieval thousands of page-equivalents of reference materials, poems, letters, recipes, records, drawings, animations, musical scores, waveforms, dynamic simulations, and anything else you would like to remember and change. We envision a device as small and portable as possible which could both take in and give out information in quantities approaching that of human sensory systems. (p. 394)*

Contemporary mobile devices encapsulate this ambitious vision. This is evident in Shaw's (2017) description of emerging technologies as "a constellation of technologies that are networked, computerized, social, mobile, and interactive. It covers a wide array of channels, platforms, technologies, and media" (p. 594, emphases added). In this paper, mobile devices include laptop computers, personal digital assistants (PDAs), smart phones and an assortment of tablets including those referred to as "post PC tablets such as iPads, Android tablets, Blackberry Playbook, and HP Touchpads" (Godsk, 2013, p. 1) and the "2-in-1 device category … [which includes] Microsoft's Surface Pro Tablet – with a full-featured Windows operating system – and Apple's iPad Pro, with a 12.9-inch screen (Stevenson & Hedberg, 2017, p. 128).

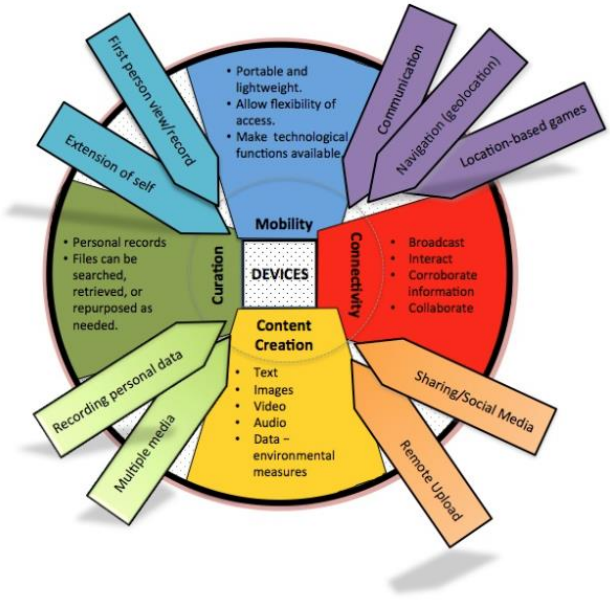

Figure 1. Mapping the imagined affordances of mobile devices

Further to this, Pegrum, Oakley and Faulkner (2013) added "handheld" devices to their description of mobile devices and made a distinction between these and "portable" devices such as laptops which "although they can be transported to different locations, lack the convenience and flexibility of smaller handheld devices" (p. 66). Delić, Domančić, Vujević, Drljević, and Botički, (2012) explained that mobile phones "can [now] be compared to desktop computers" because they are "equipped with high speed processors, graphics hardware, a number of sensors including GPS, gyroscope, compass etc. combined with high resolution displays and cameras" (p. 289).

The increasing technical capacity and ubiquity of mobile devices has engendered the rise of e-learning and m-learning environments (see Al-Emran, Elsherif, & Shaalan, 2016; Berger, Mohr, Nösekabel & Schäfer, 2003). The human and cognitive capacity of mobile devices, as envisaged by Alan Kay, has similarly supported the rise of the Theory of Mobile Learning (TML) based on constructivism and proposing that learning is continuous and extends outside the classroom (Sharples, Arnedillo-Sánchez, Milrad, & Vavoula, 2009).

Mapping the imagined affordances of mobile devices

The first experiment described in this paper was an individual mapping of the affordances of mobile devices. This began with brainstorming the qualities the author "imagined" to be common to all mobile devices that, in turn, led to the selection of four discrete but interdependent affordances being identified. These are: mobility; connectivity; content creation; and, curation. They were chosen from personal observation and experience and are offered as idiosyncratic rather than a final, fixed or comprehensive list. They are as the author imagined them at this point in time and are intended as generic rather than specific to education.

The selected affordances are positioned in the centre of the diagram in Figure 1. The order is also idiosyncratic with the affordances placed in a clockwise direction moving from those which derive their potential from their technology to those which are driven and controlled by human agency and intention. For example, the "mobility" of mobile devices is made possible through advances in engineering and miniaturisation of computer components while "curation," irrespective of which technology is used, is based on a human need to organise and categorise physical and digital items.

The circular clockwise form of Figure 1 also allows for an overlapping of affordances that is indicative of actual and potential use of the devices in question, typically in educational settings. These hybrid affordances are not fixed within the devices nor in how others might interpret them. Similarly, their positioning around the circle is as imagined and personal as is the selection of the discrete affordances. Where they are located creates differing overlaps and, in turn, different hybrid affordances.

The following introduces each of the four imagined affordances shown in Figure 1. Four overlapping or hybrid affordances are also described: mobility-connectivity; connectivity-content creation; content creation-curation; and curation-mobility.

Mobility

It is self-evident that mobility is central to any mapping of the affordances of mobile devices (Klopfer, Squire & Jenkins, 2002). Figure 1 annotates three characteristics of the affordance of mobility: (i) that devices are portable and lightweight; (ii) that devices enable flexibility of access "any time, anywhere"; and, (iii) that devices allow the use of inbuilt technological functions for communication, recording (particularly audio), capturing still and video images, and the sensors and GPS (Delić et al., 2012). The third characteristic obliquely references the potential to download and use of "apps" making a wide range of additional functions available (see Stevenson & Hedberg, 2017).

However, if mobility is considered simply as the physical dimensions of mobile devices, then note should be made that this is curiously a major determinant of the use of mobile devices in primary schools and early childhood settings. For example, Keane, Lang and Pilgrim (2013) reported on a school in Melbourne (Australia) which chose iPads because they were "small enough for Year 7 boys to carry around all day" (p. 30). Mobile devices are of an appropriate size and weight for younger children to use and, where necessary, to be taken outside of the classroom or travel home with students. They can be stored and replaced more efficiently than desktop computers.

It seems, however, impossible to isolate the affordance of mobility from other technological capacities. A Victorian Department of Education and Early Childhood report on the use of the iPod Touch (DEECD, 2008) included children's perceptions, including:

- *I like to think that iPods are little computers that can fit in your pocket.*
- *You get to take it everywhere you go; it loads anywhere, does anything you want and it's like your imagination in your pocket.*

These comments from children concatenate portability (size and weight) with connectivity, processing, human intention and learning outcomes. Similarly, a white paper from Apple on the iPod in education offered that they offer "an entirely different model of 'learning on the go.' Its 'fit-in-your-pocket' portability helps promote independent learning [and] support collaboration among learners" (Pasnik, 2007, p. 6).

While mobility is made possible solely through advances in engineering and a re-imagining of technological capacity, its exploitation as an affordance is dependent on its application to meet educational and social purposes and its being enmeshed with other affordances, particularly connectivity and curation. Mobility is a necessary affordance but is not of utility in and of itself. Mobility, synonymous with portability and flexibility, is, intertwined with personal ownership and user-agency. Despite this, it cannot be seen as independent of other affordances. Sharples et al. (2009) "usefully unpacked" mobility into five categories which have also been observed in later studies. They are:

i. *Mobility in physical space*: people on the move trying to cram learning into the gaps of daily life or to use those gaps to reflect on what life has taught them. The location may be relevant to the learning, or merely a backdrop. Some of the university students in Henderson, Selwyn and Aston's (2017) study interpreted the affordance of mobility in "prosaic" ways referring, for example, to making a bag lighter and removing the need to come to campus.
ii. *Mobility of technology*: portable tools and resources can be carried around as they are conveniently packed into a single lightweight device. It is possible to transfer attention across devices, moving from the laptop to the mobile phone, to the notepad. The keyword in the previously cited description of an iPod by a child as "your imagination in your pocket" (DEECD, 2008) is "your," the personal possessive pronoun which corroborates the notion of affordances as utility identified (or imagined) by an individual.
iii. *Mobility in conceptual space*: learning topics and themes compete for a person's shifting attention.
iv. *Mobility in social space*: learners perform within various social groups, including encounters in the family, office or classroom context.
v. *Learning dispersed over time*: learning is a cumulative process involving connections and reinforcement amongst a variety of learning experiences across formal and informal learning contexts. This is implicit in Wang and Karlström's (2012) finding that portability/mobility allowed learning to take place "semi-informally, and out of the school context" (p. 4).

Mobile-Connectivity

Naismith and Corlett (2006) included wireless or mobile phone connectivity as a critical success factor in mobile learning projects. Connectivity allows unrestrained access to learning resources, links people across contexts and allows students to capture material that can be sent to a personal media space and then shared or presented. The term *connectivity* is shorthand for the *accessibility* that Bower (2008) referred to as a temporal affordance allowing access "anytime anywhere" and *synchronicity* that determines if connections are in real time or delayed.

The majority of mobile devices have or have the potential to connect to the Internet. "Smart" phones have inbuilt 3G/4G cellular connectivity while tablets and laptops can be connected to a wifi network (through a local area network, 'hot spotting' or Ethernet cable). Mobile devices can "situate and connect

learners by supporting authentic, context-specific, immediate learning" (Zimmerman & Howard, 2013, p. 2). Figure 1 suggests that being "connected" means that the mobile device can be used, for example:

- *to broadcast*, for example, report on what is happening in the user's current location through a variety of platforms and a variety of media, perhaps posting a tweet or an entry to a blog;
- *to interact*, for example, conduct a synchronous conversation by phone or *Facetime/Skype* with someone in another location;
- *to corroborate information*, for example, use spoken language to activate an "intelligent assistant" such as *Siri* or *Google Assistant* to check on whereabouts or other context-sensitive information. Further, it is possible for students to use mobile devices "to access to multiple information sources and shift from an authority based learning environment to more flexible learning structure" (Yorganci, 2017, p. 181); and,
- *to collaborate*, for example, working remotely with others to share or compare data either synchronously or asynchronously.

These actions are made possible by two more of the "affordances" described by Bower (2008). These are:

- *Access-control* – the capacity to allow or deny who can read/edit/upload/download/ broadcast/view/administer ("permission-ability"), capacity to support one–one/ one–many/many–many contributions and collaborations ("share-ability"); and,
- *Technical* – the capacity to be used on various platforms with minimal/ubiquitous underlying technologies, ability to adapt to bandwidth of connection, speed & efficiency of tool/s.

The following looks to the overlapping or hybrid affordance of mobility-connectivity noted in Figure 1. This combination of affordances enables Sharples et al.'s (2009) mobilities in conceptual and social spaces.

Mobility – Connectivity

Elwell (2014) noted that:

> *Mobile devices are making constant wireless Internet connectivity a reality; meanwhile, the arrival of ubiquitous computing is folding the material world itself into an expansive "Internet of things." As a result, the line between life online and life off-line has become blurred in an existential equivalence of the digital and the analog. (p. 233)*

Mobility-connectivity allows communication (see Figure 1) regarded elsewhere as a standalone affordance of new technologies (Shaw, 2017). For example, Conole and Dyke (2004) argued that "the communication and collaborative abilities of technology present another key affordance that offers the potential for learning enriched by engagement with the "other." New technologies have opened up the possibility of new forms of dialogue and communication" (p. 117). The simplest example of this is the use of mobile phones that allow communication irrespective of location. Portability (synonymous with mobility) was included by Schrock (2015) as one of the communicative affordances of mobile media.

Combining mobility and connectivity introduces context sensitivity (Wang & Karlström, 2012; Yorganci, 2017). While an automatic technological function, it enables the use of geolocation-based augmented reality applications which have been described as "a direct or indirect view of real world scenes in which physical objects are annotated with, or overlaid with computer generated digital information" (Delić et al., 2012, p. 289). It also allows engagement in location-based games which can be "delivered as a mobile app. … they integrate storytelling, augmented reality and rich media with GPS, maps and gamification methodologies. Their benefits … include their potential to enhance and extend the way students interact with locations, mobile content and communicate with each other" (Edmonds & Smith, 2016, p. 350).

A further, perhaps unexpected, outcome of the mobility-connectivity hybrid affordance is the philosophical notion of a mobile device as an extension of self. Schleck, Palmer, Penn and O'Neill (2011) conjectured that:

> *… technologically mediated identity is perhaps most salient in relation to mobile technology. The mobile phone, in particular, has become intrinsically linked to our everyday lives, both physically and sociofunctionally. It has taken a step beyond enabling the " presence of absence" by providing a reminder of another person; rather it enables the relatively novel possibility of being reachable almost anywhere by anyone at any time. This pervasiveness is possible because of the mobility of such devices, but they are not just portable; they are personal. We no longer contact the location; instead we contact the person. In this sense, the device is an extension of its owner and serves as a reminder of the individual's connectedness, reinforcing a sense of social identity. (pp. 299-300)*

It is of incidental importance to note that, in July 2017, some iPod models were discontinued. Gibbs (2017) explained that "Apple has killed off the last remaining app-free music players in its roster, the iPod Nano and iPod Shuffle, leaving nothing but multi-use, connected devices in the brave new world of streaming, apps and games" (para. 1). The iPod Touch with its wifi connectivity remains in production highlighting the importance of connectivity as an affordance of mobile devices.

Content creation

Schäfer (2011) defined user-generated content (UGC) or user-created content (UCC) as "directly refer[ring] to the phenomenon of users producing media texts and describes … texts (either written text, photos, videos, or audio files) stored on websites" (p. 237). Content creation is voluntary, participatory and

frequently collaborative. Individuals create, edit and manage content in networked environments (Rainie & Wellman, 2012). Content creation differs in intent from the mobility and connectivity affordances in that it is a singularly human endeavour as opposed to what is essentially technological in nature.

Online content creation has been possible since the emergence of Web 2.0 leading to the redefinition of Internet users as "active participants and creators, developing content, designing personal websites, and launching their own online enterprises" (Montgomery, Gottlieb-Robles & Larson, 2004, p. 1). This affordance has engendered its own neologisms. Content creators became known as Generation C (Trendwatching.com, 2004–2005) and "produsers" (Bruns, 2005). Livingstone (2008) suggested that content creation allows "new opportunities for self-expression, sociability, community engagement, creativity and new literacies. … [and] will counter the traditional dominance of consumers by producers and facilitate an innovative peer culture among young people locally and globally" (p. 4). Similarly, "produsage demonstrates the changed content production value chain model in collaborative online environments: in these environments, a strict producer/consumer dichotomy no longer applies" (Bruns, 2007, p. 4).

Content can be created on mobile devices exploiting available technical functionality and making use of firsthand experience. Dev and Lau (2015) explained that:

> *Compared with traditional desktop-based platforms for content creation, a typical mobile computing system's unique input and output modalities permit a more direct and natural interaction experience and thus motivate deeper levels of engagement. ... the development of techniques for creating content on handheld devices with inbuilt sensors, such as camera flashes and accelerometers, has the potential to extend computer graphics technologies to millions of mobile device users. (p. 84)*

"Produsers" create original content using text, images, video, and audio. The process of content creation happens through what Bower (2008) described as the micro-level flexible collaborative/productive interactions of media affordances. These, more specifically, are write-ability, draw-ability, speak-ability, and video-produce ability. Critical to the affordance of content creation using mobile devices is the hybrid affordance of Connectivity - Content Creation.

Connectivity - Content Creation

Content created on connected mobile devices can be shared in real time through social media or 'cloud' repositories. Rainie and Wellman (2012) noted that social media can be used to document personal memories, learn about and explore things, advertise oneself and form friendships. Mobile technologies allow immediate creation and sharing of personal experiences in digital format from a simple capturing of holiday photographs to the writing of a personal blog.

The Pew Internet and American Life Project found that the sharing of "self-created content online like photos, videos, artwork or stories" has remained constant for teenagers and has increased for adults (Lenhart, Purcell, Smith, & Zickuhr, 2010). Mobile applications include live video streaming. For example, a recently developed app, *Periscope*, is automatically linked with *Twitter* ensuring its immediate (and occasionally unwitting) distribution to a wider audience.

Curation

Curation has traditionally been the work of galleries, museums and libraries. It is concerned with collecting and exhibiting or cataloguing materials so that they can be found easily and thus accessed/used as efficiently as possible. The term curation embeds understandings of care and preservation as well as of organisation. Digital curation moves these processes online and is commonly used to describe searchable relational databases. Curation through mobile technologies makes use of cloud storage technology simplifying and extending access.

Curation is evident in Facebook's Timeline that became standard in January 2012. Elwell (2014) explained that "the public relations logline for the new [Timeline] platform is 'Tell your life story.' Through photos, videos, and status updates, users are invited to narrate the story of their lives; to re-present their 'real' off-line lives through an online self-identity narrative" (p. 236). Digital curation creates a collection that can be searched and protected, that is, restricted to a delimited audience. In this, it calls on and embeds Bower's (2008) navigation and access-control affordances.

Curation - Content creation

The intersection of curation and content creation allows for the storing of personal experiences in multiple media formats. Personal webpages and blogs replace family photograph albums or professional portfolios while travelers record their journeys through *WordPress or Facebook* posts. The created albums can be shared in real time rather than after the event or to a closed audience. This affordance aligns with Bower's (2008) temporal affordances, particularly "record-ability" (ability to be recorded) and "playback-ability" (capacity to be played back).

Curation – Mobility

Where curation and mobility intersect, a particularly 21st Century experience emerges. This is where we all become reporters of our world. What we record and keep (curate) is autobiographical, first-person and personal (Hein, O'Donohoe, & Ryan, 2011). While this has a potentially historical and political affordance, it could be argued that it is an extension of self (see Schleck et al., 2011).

Waugh (2017) went further and argued that mobile devices "contain so many aspects of a person's identity that they … are an extension of that person" (p. 237). This is corroborated in an interview with the American composer, musician, and sound artist, Holly Herndon, where she admitted that "my laptop is an extension of my memory and self, it is a conduit to the people I care about and in many ways retains more knowledge about me in one moment than I can muster" (Waugh, 2017, p. 238).

This concludes the personal "imagined" mapping of four discrete interdependent and a further four hybrid or overlapping affordances of mobile devices. As noted, they are not offered as a comprehensive or fixed model. It is, rather, an experiment that is revelatory of what an individual knows and understands. The following section presents the second experiment described in this paper.

Mapping affordances as mechanisms in teaching and learning

The 2013 NMC Horizon Report (K-12) contended that mobiles devices have become:

> *… too capable, too ubiquitous, and too useful to ignore, and their distribution defies traditional patterns of adoption, both by consumers, where even economically disadvantaged families find ways to … use … mobile technology, and in schools, where the tide of opinion has dramatically shifted when it comes to mobiles in schools.*
>
> (Johnson et al., 2013b, p. 16)

This observation underpins Male and Burden's (2014 study that likened limiting the use of mobile devices in teaching and learning as trying to hold back the sea. This "tidal" metaphor extends to parallel changes in pedagogy and in the disposition to use technologies in teaching and learning. This section is about the use, agency and actual application of mobile devices in differing teaching and learning contexts, in terms of perceived or imagined affordances.

This second experiment thus shifts the imagined mapping (in Figure 1) into the role of mechanism in a realist evaluation of digital mobile devices in educational settings (Figure 2). Figure 2 outlines the Context + Mechanism=Outcome structure of this experiment. The "mechanism," or causal process, is the personal mapping of the affordances of mobile devices presented in Figure 1.

The broad "context" for the second experiment is, as noted, teaching and learning as defined in formal levels of schooling: primary, secondary, and higher education (see Figure 2). Six settings, drawn from published case studies, are presented as specific numbered contexts (C1 - C6). They represent examples of the variance possible through differing personal interpretations of affordances as a mechanism. They have been chosen because of the salient differences they represent in outcome and also, in how, in each instance, the affordances of the mobile devices selected for use in each setting have been interpreted as a "mechanism."

The "outcomes" of the examples presented are also variable and typically aligned with learning goals inherent in the contexts. In more abstract terms, the reported outcomes of using mobile devices in educational settings include: enhanced learner motivation and engagement, personalisation of learning and heightened self-direction and independence (Cornelius & Shanks, 2017).

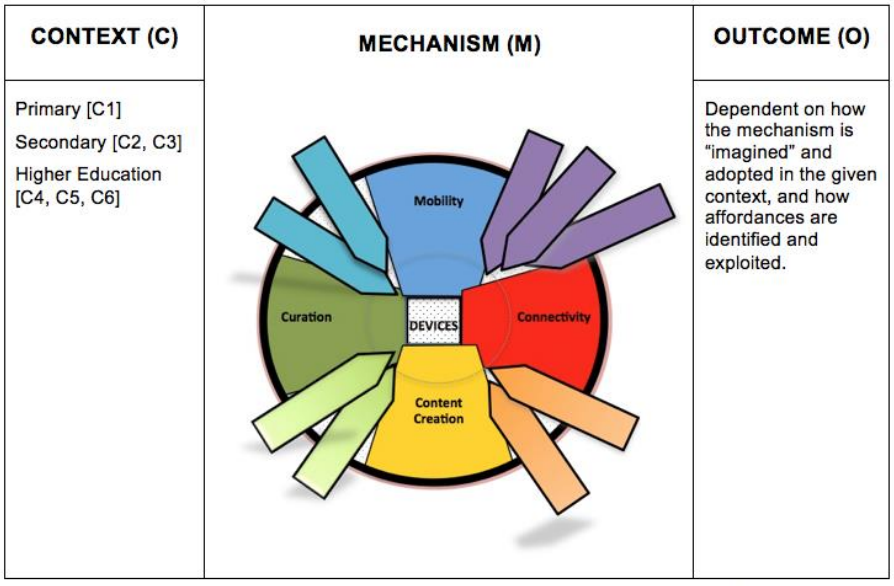

Figure 2. Affordances of mobile devices in education represented as Context+Mechanism=Outcome (Pawson & Tilley, 1997)

The following positions affordances as mechanisms in relation to the context in which the mobile device(s) selected in each instance is/are used.

Primary Education [C1]

Cornelius and Shanks (2017) investigated the use of iPod Touch devices in a small primary school in regional Scotland [C1]. Younger students were observed using the clock functions while older students used the calculator and dictionary often "at their own volition" (p. 24). The affordances of content creation and curation were impeded, that is, restrained by the technical capacity of the device being used. Some students preferred "using the iPod [note taking app] as they regarded their own handwriting as slow or untidy" (p. 24). Others, however, were frustrated by not having a camera and the small screen restricted drawing and writing. Further, the "opportunity for crossing boundaries between formal (school) and informal (home) learning was clearly under-exploited" (p. 28). This finding, while perhaps explained by the young age and relative dependence of the students on teachers and parents, is an indication that the potential hybrid affordance of mobility-connectivity was not imagined or exploited in this context.

Table 1 summarises the perceptions of C1's teachers of the use of iPods in their classrooms. Intriguingly, the findings from this one Scottish primary school are transferable to other teaching and learning settings including the other contexts described in this paper.

Table 1

Teacher perceptions of mobile devices in a primary school setting (after Cornelius & Shanks, 2017, pp. 23, 26)

Teacher experience	Realised Benefits	Ongoing Challenges	Resolved Challenges
All teachers	• Access to resources • Interactive learning • Extending learning	• Finding meaningful ways to use the devices • Pressure to keep apps up to date • Technical issues (e.g. synching, installing apps) • Connecting to the Internet	• Devices distracting pupils in class
Most teachers	• Development of teacher skills • Getting lessons started • Practice activities • Class management strategies • Supporting pupil autonomy	• Pupil demands for apps/resources • Using devices to their potential	• Need for additional resources • Helping pupils get started • Behaviour issues
Some teachers	• Instant Internet research • Cutting paper use • Pupil contributions to lessons • Providing (teacher-created)	• Getting to grips with the technology • Lack of knowledge of devices	• Pupils know more than teachers • Responsibility on pupils • Monitoring web browsing

	resources to pupils • Individualised activities • Assessment • Showcasing pupil work		• Rushing work to get time on device • Being out of my comfort zone
Not realised by any teachers	• Sharing with peers and parents		

Secondary Education [C2, C3]

Hartnell-Young and Heym (2008) described a project in three secondary schools in Cambridgeshire, West Berkshire and Nottingham (UK) [C2] where students and teachers were encouraged to find novel ways to use mobile phones to help their learning. A selection of the purposes identified by students included:

- Timing experiments with stopwatch function
- Photographing apparatus and results of experiments for reports
- Photographing development of design models for eportfolios
- Photographing texts/whiteboards for future review
- Bluetoothing project material between group members
- Receiving SMS and email reminders from teachers
- Synchronising calendar/timetable and setting reminders
- Connecting remotely to school learning platform
- Recording a teacher reading a poem for revision
- Accessing revision sites on the Internet
- Creating short narrative movies
- Downloading and listening to foreign language podcasts
- Logging into the school email system
- Using GPS to identify locations
- Transferring files between school and home.

These activities represent outcomes made possible by the mechanisms of mobility, connectivity, content creation and curation (see Figure 1). What they share is the centrality of technology to the action and to the cognitive engagement required, for example, the reviewing, collating and synthesising needed in recording science experiments. They further demonstrate that teachers and students, when given the opportunity to experiment or "imagine," can make meaningful use of devices both within and outside of formal learning settings.

Of particular interest is clear evidence of the hybrid content creation-curation affordance identified in the first experiment. One of the C2 teachers explained that the students' recording of plant growth equated to establishing an "historical record in science. … there was very clear value in taking a set of images over a period of time … [and] being able to look at that and see what's happened and the gradual biological change" (Hartnell-Young & Heym, 2008, p. 9). Content creation-curation affordance is seen here as a mechanism to scaffold scientific observation.

Keane et al. (2013) conducted a study of Netbook and iPad adoption in two secondary schools in Melbourne, Australia [C3]. As with C2, students at the C3 sites identified how the devices supported their learning particularly in English, LOTE (Languages Other Than English), History/Geography and Religious Education. Some were less than enthusiastic with one reporting that "I normally use the Netbook to simply type up my information - it does not benefit … [me] in any way. (It just makes my work look a lot neater)" while another offered that "I use it to 'write up' my essays, apart from that it does not seem to have many uses in the subject of English" (Keane et al., 2013, p. 33). Some of the Scottish primary students [C1] similarly recorded "neatness" as an "imagined" affordance, which, while related to content creation- curation, arguably belongs to a narrower view of technologies as a productivity tool.

It would seem, however, that use of digital devices in secondary classrooms was directly proportionate to teacher enthusiasm and the encouragement that students were given. At the heart of this observation is the reported comment of a school Principal in Keane et al.'s (2013) study that an iPad is "a device that by necessity requires teachers to change pedagogy" (p. 30).

Higher Education [C4, C5, C6]

Through the affordance of connectivity, mobile devices have been transformative in higher education. Higher education's adoption of BYOD (bring your own device) (see Van Wingerden, Lidz, Barse, DeMark, & Hamiter, 2016) has led to a "rethinking [of] the need for computer labs or even personal laptops. A student's choice of apps for his or her tablet makes it easy to build a personalized learning environment, with all the resources, tools, and other

materials they need on a single device, and with most tablets, the Internet is woven into almost every aspect of it" (Johnson et al., 2013a, p. 16). Devices tend to be viewed as the means to achieve learning outcomes and provide flexibility of access for all students.

An exception to the trend of welcoming personal devices to higher education is the Copenhagen Business School [C4] that has banned all mobile technologies from lectures. Sørensen, (2017) explained that the devices distracted students and frustrated academics "angered by the blue Facebook light, those ubiquitous and shiny white apples and the comatose students dominating the lecture hall" (para. 12). The teachers at the C1 primary school had also noted the potential for distraction (see Table 1) but had resolved this challenge by finding meaningful uses for the devices (Cornelius & Shanks, 2017).

More positively, Chen, Seilhamer, Bennett and Bauer (2015), in a large study of The University of Central Florida [C5] undergraduate students, found that they agreed or strongly agreed that using mobile devices:

- made it easier to access coursework (72 per cent);
- increased communication with other students (65 per cent);
- increased communication with instructors (60 per cent);
- increased personal knowledge in field of study (48 per cent);
- improved quality of work (43 per cent); and,
- increased motivation to complete coursework (42 per cent).

These outcomes are made possible through connectivity and the hybrid mobility-connectivity affordance, particularly in regard to communication (Figure 1). There is an implied attendance to the hybrid affordance of Content Creation - Curation in the reference to "personal knowledge" and the affective factor of motivation.

Discussion and conclusion

For this paper, these affordances of mobile devices were identified as: mobility; connectivity; content creation; and, curation. Where these affordances overlapped, a second set of hybrid affordances were created. These were: mobility-connectivity; connectivity-content creation; content creation-curation; and curation-mobility. Of interest is that some affordances exist irrespective of context while others are evident across educational sectors. Mobility (in the hybrid form of mobility-connectivity) was a key agent in primary, secondary and higher educational settings but younger students made little or no use of remote connection. Content Creation was common to all settings but, as expected, was less directed and more open for older students. Further, there are similarities in intent between this list and that compiled by the C2 secondary school students despite the difference in specificity. References to communication, for example, could be aligned with secondary students "bluetoothing" project material between group members and receiving messages from teachers (see Table 1). Similarly, C4 students' reference to personal knowledge could be an outcome of C2 students' actions in timing and photographing science experiments (Hartnell-Young & Heym, 2008).

There are further similarities with the C4 list to the reasons cited for digital technology being useful to university studies in two Australian universities [C6] (Henderson et al., 2017). The ease of access to coursework was matched with the frequent use of technologies to organise and manage the "logistics of studying" while improving the quality of work could be matched to the Australian students' using technology to support "basic tasks" and making the writing of assignments "easier" [C3] and the Scottish students' focus on neatness [C1].

This paper has presented the findings of two related experiments in the mapping of affordances of educational technologies, particularly of mobile devices. The first represented a personally imagined rather than fixed set of affordances supporting the argument that what a technology "affords" is how an individual imagines a technology's use and how this is enacted.

The second experiment mapped the affordances in context. They located the imagined affordances in context because the use of mobile devices cannot be separated from the conditions under which it would be used. This fixes them as a critical but hitherto unacknowledged process of learning design. While some affordances were noted in multiple settings, they were not enacted in the same way or to the same effect. This brings a greater nuance to how educational technologies are selected and further shows their symbiosis with the context in which they are used.

The first experiment can be interpreted as "what I imagined" while the second is "what I imagined … in a given setting." Both are arguably worth repeating with colleagues as a means to unravelling what they know of the potential of educational technologies and to what, at a deeper level, they may understand of the role of technologies in teaching and learning.

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