Reconceptualizing Design Research in the Age of Mobile Learning

Brenda Bannan
George Mason University
Division of Learning Technologies
College of Education and Human Development
George Mason University
Fairfax, VA
bbannan@gmu.edu

John Cook
Education Department
University of the West of England
Frenchay Campus
Bristol, UK
John2.cook@uwe.ac.uk

Norbert Pachler
UCL Institute of Education, University College London
Culture, Communication and Media
Institute of Education
University of London
20 Bedford Way
London WC1H 0AL
n.pachler@ioe.ac.uk

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Abstract

The purpose of this paper is to begin to examine how the intersection of mobile learning and design research prompts the reconceptualization of research and design individually as well as their integration appropriate for current, complex learning environments. To fully conceptualize and reconceptualize design research in mobile learning, the authors address and unpack the unique affordances of mobile learning and implications for design research as well as the design process that has impact on both. Asserting a socio-cultural view of learning, investigating mobile devices as cultural transformational tools is proposed to potentially expand perceptions and access to resources in how we view teaching and learning (as a form of social capital), but also how we design for it and conduct research in complex settings.

Keywords: Mobile Learning, Mobile Learning Research, Design Research

Introduction

A challenge for education and educational research is to embrace design research as a form of inquiry into how individuals and groups use digital resources to support educational and other forms of cultural/social processes; and to produce model approaches that orchestrate instructional contexts that take full account of cultural, social and geographical differences. A re-examination of emergent models, the connection between research approaches/methods and design processes are necessary given the dramatic shifts in our society, educationally and economically related to technology-enhanced learning (TEL), and particularly given the pervasiveness of mobile technologies. Mobile technologies may be viewed as transformative cultural resources that permeate our daily lives. We argue design research provides an emerging, rigorous yet flexible research approach subsuming different paradigms that embrace these complex environments to uncover new insights about learning. This complexity introduces methodological and design challenges. As Tom Reeves (2013) asserted in his keynote address at the American Educational Research Association Design Based Research Conference in September, 2013 "In the era of iPhone, we want frictionless solutions, but people and institutions can feel messy, they introduce uncontrolled variability". Below we argue that advocating for a design research approach allows us to 'systematically' seek out 'never-seen before possibilities' to inform learning and research in these messy, mobile learning contexts that lend themselves to 'uncontrolled' variability (Reeves, 2013) and fuzzy generlisations (see Bassey, 1998). Mobile technology-enhanced learning, in our view, requires an increased sensitivity to context, cultural resources, social-cultural features of formal and informal learning environments and the reconceptualization of research approaches that align with these important and unique factors for mobile design and research. This paper will attempt only to begin to address and unpack these complex issues and the bridging of social capital (with mobile devices and services functioning as cultural resources) related to design research processes that may better address the learning with mobile devices in TEL.

Mobile learning, we argue, provides a unique context for both evaluation (making judgments about the efficacy of interventions) and research (systematic investigation for the purpose of discovering new knowledge, insights or questions). Sharples (2009) states that mobile learning presents significant challenges for evaluation as the content may not be fixed and the activity can cut across formal and informal settings. This transference across content, location and activity in mobile learning emphasizes that: "…there is no fixed point to locate an observer, the learning may spread across locations and times, there may be no prescribed curriculum or lesson plan, the learning activity may involve a variety of personal, institutional and public technologies, it may be interleaved with other activities, and there may be ethical issues concerned with monitoring activity outside the classroom" (Sharples, 2009, p. 17). In addition, the complexity of conducting research in mobile learning as distinct from evaluation is addressed by Pierroux (2009). He points out that empirical research about mobile learning raises important issues that remain to be addressed including: 1) a need for improved methods and longitudinal studies; 2) addressing our networked society that increasingly includes mobile, social and ubiquitous technologies; 3) tracing learning through tracking pattern of use across different devices in different settings; 4) a need for new theoretical models and design approaches that address the unique characteristics of mobile technologies and 5) addressing appropriate methods of data collection and analysis in empirical research.

Despite these concerns, in recent years, mobile learning has become a recognized sub-domain of technology-enhanced learning and mobile learning research is increasingly finding inclusion in specialist journals in the field. However, there continues to be a distinct lack of definitional clarity about mobile learning – conceptualizations vary greatly but research designs tend to focus on attempts to measure the efficacy of mobile device-based interventions in terms of attainment or achievement gains. Other work frequently foregrounds technological features or is often rooted in a transmission-based approach around the metaphor of learning as 'delivery'. From our perspective, whilst we clearly recognize the importance of understanding the affordances and potential of, as well as the value added by mobile devices, we question the performativity paradigm underpinning such a restricted view of the role of mobile devices in education. Following Kalantzis and Cope's (2004, pp. 45) perspective on learning, we are particularly interested in the contribution of mobile devices and attendant services in meeting the two learning conditions of 'belonging' and 'transformation'. That is, our perspective on efficacy, guided by Kalantzis and Cope, looks for the extent to which mobile devices and services engage learners' identity and take them on a journey into new and unfamiliar territory within a zone of intelligibility and safety (p. 46). Consequently, we are interested in the extent to which mobile devices and services foster inter- and intra-personal conversation-based processes of coming to know and being able to operate in, and across, new and ever changing contexts and learning spaces at the interface of formal education and everyday lifeworlds (Pachler, Bachmair & Cook, 2010). Such a view of learning and definition of mobile learning has a number of implications for researching (mobile) learning and asks questions of appropriacy of research and design paradigms and methods. From a research perspective, we support a view of an exploratory as opposed to a positivist paradigm, one that recognises the complexity and dynamic nature of the social and cultural world with an attendant methodological pluralism and is content with

'fuzzy generalisations" rather than a statistical calculation. Fuzzy generalizations "replace the certainty of a scientific generalisation ('it is true that…) by the uncertainty, or fuzziness, of statements that contain qualifiers ('it is *sometimes* true that…')" which stand in contrast to statistical generalization of quantitative empirical research (see Bassey, 1998). The practice of design and design research, we argue, inherently acknowledges and includes a 'lack of certainty' within the nature of the process of design and stands in contrast to former polarized definitions of what types of research outcomes are generalizable elaborated below.

To fully conceptualize and reconceptualize design research in mobile learning, one must address and understand, individually, the unique affordances of mobile learning and implications for research as well as the design processes that impact on both. Design research differs from design-based learning where students design and build systems in science or engineering as part of a project-based learning approach (Apedoe & Schun, 2013) and learning design which relates to teacher-practitioner pedagogical patterns (Laurillard & Ljubojevic, 2011). Design research is distinct from these approaches by integrating rigorous, long-term cycles of applied and empirical research as part of a complex, evolving design process. The design process attempts to positively influence and effect change in a learning context through the building of an intervention through which we uncover pedagogical principles that may be applicable and researchable in similar situations. This is often conducted through identifying and investigating a learning problem, the design and development of an educational innovation and its trial and iteration in multiple contexts over time. Determining a particular phenomenon to focus on in design research is often based on an identified need and the selective perception of the researcher who becomes intimately familiar with the learning context and activity as he or she closely examines and analyzes real-world practices and settings for purposes of design (or re-design) of an educational innovation.

The increasing number of publications on the design, use and investigation of mobile technology in formal and informal learning environments in recent years speaks to the increasing need for a strong theoretical basis for conducting mobile research. Kukulska-Hulme et al. (2011) argue that the theoretical basis for understanding mobile learning is lacking. However, theoretical frameworks have begun to emerge. For example, (Pachler, Bachmair & Cook, 2010) have put forth a theoretical framework conceptualizing mobile devices as cultural resources across informal and formal learning contexts. This socio-cultural stance has the potential to expand our understanding and analysis of mobile learning through a conceptualization of teaching and learning, and where it takes place, without compartmentalizing learning solely to the classroom. Aligned with this perspective, we elect to view mobile devices as cultural transformational tools worthy of expanding our perception and access to resources, creating an important shift not only in how we view teaching and learning, but also how we design for it and investigate it in complex settings. Mobile devices and services functioning as cultural resources links to our view of social capital aligned with Bourdieu and Wacquant (1992): "Social capital is the sum of the resources, actual or virtual that accrue to an individual or a group by virtue of possessing a durable network of more or less institutionalized relationships of mutual acquaintance and recognition (p.119).

The design process of conceptualizing and creating mobile learning applications and experiences as a form of social capital can generate, discover, expand and/or confirm theoretical propositions about mobile learning. Given that there is no single, generally accepted mobile design approach, a systematic approach involving inductive and deductive cycles of analysis, design and development typically occurs in mobile learning design research. These processes progressively zero-in on a design "particular" or an idea selected from the problem landscape and sometimes through the generation or morphing of multiple ideas (Nelson & Stolterman, 2012). Carrying out analysis, design and development as well as aligning research activity in mobile learning with a socio-cultural frame may uncover new insights into contextual factors or seek out never-before considered variables (or combination of variables) in learning environments. To attempt to fully embrace the unique features, complexity, authenticity and un-structuredness of the mobile design and research context provokes an alignment with a rich investigation of a socio-cultural view of the mobile devices contexts of our lives. In doing so, we take the position that learning is not necessarily a purely cognitive process but also a social phenomenon, and does not only take place in one location but across communities, locations, time, social contexts and sites of practice or what Pachler et al. (2010) refer to as "life-worlds," socio-cultural milieus and structures. To fully consider and conceptualize this more comprehensive view of learning with mobile devices and the impact on the practice of design research is the challenge we attempt to address in the following discussion.

The Need for Reconsideration of Design Research and Design Process for Mobile Learning

Design research for mobile learning subsumes the full complexity of the act of design or design processes but also attempts to further our understanding of the informal and formal contexts where learning might occur, and investigate *how* we think learning might occur in these complex settings. Assuming a socio-cultural view of mobile learning contexts for analysis, design and research provides a rich lens for generating and investigating learning principles, in situ, as we seek out and select a design problem and attempt to orchestrate a pedagogical approach exploring the impact and results of the intervention.

The progressive, dynamic nature of design research may uncover new insights into the context, learners, and learning goals as well as determine if the innovation may or may not work in realistic mobile learning settings. A deep dive or investigation into the mobile context(s), participants and activity sensitizes us to specific cultural practices and instantiation of targeted phenomena. Observing the particulars of the situation and then prototyping an intervention to address a particular aspect of the learning setting may uncover unforeseen insights about teaching, learning or design in a process that has been referred to by David Kelley of the product design firm IDEO as "building to think". A four phase integrated design research process such as the Integrated Learning Design Framework (see Figure 1) has been leveraged for mobile learning design research contexts (Bannan, 2013; Bannan, Martinez & Peters, 2010) but may not go far enough in

fully embracing Pachler et al.'s (2010) socio-cultural perspective on mobile learning. Other representations and descriptions of design research may be too simplistic as well to incorporate the nuances inherent in a socio-culturally sensitive approach (McKenney & Reeves, 2012).

Insert Figure 1 about here (see end)

To intersect these theories and processes is to bring the creative (e.g. the design seeking activity of the research team) and analytic together in a systematic but flexible manner. The analytic is brought to bear through the reductionist, rational selective perception and identification of a learning need or problem in a design research situation possessing multiple objectives (e.g. design, development and research), crossing multiple contexts (e.g. formal and informal) and multi-layered interaction (e.g. teacher-student, student-to-student, peer-to-peer, etc.). The creative occurs within the generative activity of mobile design itself, with attempts to engineer or co-create a mobile intervention or solution in a democratic, interdisciplinary team setting. Therein lies one of the core challenges of the intersection of design and research, balancing the potential polar opposites of deductive acts of analysis and inductive creativity and the un-structured cycles of design, particularly given the unique affordances of mobile learning. To begin to fully embrace the complexity of mobile design research, we start by closely examining the ecology, affordances and complexity of mobile learning, then address the current state of design research, design processes and finally, offer some insights into their intersection.

Mobile Learning Ecologies and the Mobile Complex

The affordances of learning ecologies that are being explored by mobile learning researchers present unique facets that are just beginning to be addressed in connected cycles of design and research. For example, Carmean, Franfort & Salim (2013) point out that a 'features' orientated perspective on affordances of mobile devices is not enough to characterize mobile learning. They propose that we need to examine the deeper affordances of mobile devices, particularly the immediacy and the connection natively built into such devices. Indeed, they go further saying that if we are to understand the potential for new learning experiences and support that new mobile devices afford, then we need to examine mobility *plus* design. Specifically, for them, this involves "…understanding new learning and support possibilities when designing for mobile technology in new learning uses, designing with mobility and designing to leverage mobility as a unique feature for the learning experience". This notion of allowing for 'never-seen before possibilities' links to the concept of design seeking (see below) and is a key reason for taking a design research approach

Striving towards the design and investigation of deeper affordances of mobile learning may be represented by Pachler et al.'s (2010) theoretical framework describing "the mobile complex", i.e. the triangular structuration model of mobile learning comprising the structures that govern users' being in the world, agency (the user's capacity to act on the world) and cultural practices (the routines users engage in), as well as their interplay

(see Pachler et al., 2010); it comprises a number of features with significant implications also for mobile learning and design research. Structural changes, for example, in particular the transferal of responsibility for risk-taking and meaning making from the state to the individual framed as a consumer of services available in a market environment have consequences for research. The increasing segmentation of society into social milieus with differentiated dispositions towards risk-taking, consumption and learning is another such feature. Yet others include the changes in the nature, production and use of cultural resources linked to mobile devices and services typologised by Ito et al. (2008) as 'hanging out', 'messing around' and 'geeking out' or by Gee (2011) as 'passionate affinity based learning' (see http://www.jamespaulgee.com/node/50), around shared endeavours or interests following rather different organizational patterns to those traditionally covered by educational research. A further important central feature is the emergence of a new habitus of learning within the mobile complex which is characterized by device users as learners constantly viewing their life-world with expectancy and contingency and as a potential resource for learning (see also Kress and Pachler, 2007). In this work, we are attempting to determine what is the most appropriate way of capturing these transformations and processes in a design research approach.

Affordances:

Another important driver for examining fitness-for-purpose of research methods is linked to perpetual improvements in technology. In the literature various attempts at defining the affordances of digital technologies, a notion already introduced above, exist (see e.g. Conole and Dyke, 2004 or Oliver, 2005). For a detailed discussion of the notion of affordance in relation to the mobile complex and the triangular structuration model, see Bachmair and Pachler, (forthcoming). Due to lack of space we can only explore affordances briefly here. Pachler et al. (2014, p. 141) distinguish the following affordances:

· collaborative and communicative potential;

· interactivity and non-linearity;

· distributed knowledge construction;

· multimodal knowledge representation;

· authentic/contextualized/situated material, interaction, tasks and settings;

· multifunctionality and convergence;

· portability, ubiquity, personal ownership; and

· user-generated content and contexts.

Let us look briefly at two of the above by way of exemplification here. Convergence refers to two related dimensions: on the one hand the bringing together of different technological functions that previously required separate tools in one device, such as telephony, voice recording, camera, clock etc.; on the other hand it refers to the connectivity to internet-based services, tools, resources and networks. It is an important pre-requisite for the other affordance we briefly want to discuss here, user-generated contexts. Mobile devices and services afford users opportunities to leverage access to knowledge distributed across people, communities, locations, time, social contexts, sites of practice etc. to assemble and re-assemble their own contextual frames for learning. The above affordances pose a number of challenges not only in terms of the design of pedagogical interventions in and across formal and informal contexts as well as systematically inquiring into them.

Orchestration:

One important piece of contextualization for the purposes of our current discussion is the recent debate in the specialist literature around the notion of 'orchestration' of learning. According to Roschelle, Dimitriadis and Hoppe (2013), this discussion is evidence of a reflection on the relationship between research and practice by members of the European technology-enhanced learning community. The discussion is said to oscillate between a 'laboratory' view (transfer from an idealized setting to the classroom) and a 'field' view (complex, highly variable and unpredictable settings) (see also Chan, 2013). The former, they point out, lends itself better to doing what they call "scientific" research, the latter to educational 'problem-solving' and more easily allows the measuring of impact.

Dillenbourg (2013, p. 485) defines orchestration as "how a teacher manages, in real time, multi-layered activities in a multi-constraints context" – not all commentators responding to Dillenbourg's position paper agree with this definition. From what he calls an 'evolutionary hypothesis', i.e. that technologies could incrementally improve school efficiency (without defining what he means by efficiency), Dillenbourg goes on to wonder what its role might be in relation to the under-exploitation of technologies in schools and how it differs from instructional design. Furthermore, Roschelle et al., in their commentary, interpret this as a desire to increase the potential of TEL-research to be meaningful and make a difference (p.524). In our present discussion we also seek to make a contribution to the debate about how best to contribute to the efficacy of technology use in teaching and learning through research.

To more fully represent this contribution, we examine the current state of design-based research, the historical as well as current conceptualizations of inherent design processes within design research and combine these with the above stated affordances and theoretical positions related to mobile learning to provoke progression toward reconceptualizing the future of mobile learning design research.

Design-based Research

Design research has gained traction over the last ten years appearing as a core topic in special issues of academic journals, in multiple book publications and in academic practice related to technology-enhanced learning environments (Plomp & Nieveen, 2013; McKenney & Reeves, 2012; Andersen & Shattuck, 2012; Kelly, Lesh & Baek, 2008). An integrated research and development approach in education, design research (sometimes referred to as educational design research or design-based research) has been leveraged to investigate emerging pedagogical and technological learning technology contexts and is comprised of connected cycles of learning technology design, development and research. One possible aim of design research is to identify and model technology-mediated, social learning and behaviors in order to design tools that support, promote and study the practices under investigation. Rather than postulating whether a certain approach and outcome is better than another, researchers have embraced design research as a form of inquiry that will best position them to generate theory or learning principles as well as to produce and test a designed solution for a complex problem in context for which no clear guidelines or solutions are available (Kelly, 2004; McKenney & Reeves, 2012; Plomp, & Nieveen, 2009).

Sandoval (2013) defined design research as: 1) pursuing joint goals of improving practice and refining theory; 2) occurring through iterated cycles of design, enactment and analysis; 3) employing methods that link processes of enactment to outcomes; 4) involving sustained engagement with stakeholders; and 5) striving to produce usable knowledge (p. 389). Reimann (2013) states that design-based research "brings a qualitative change in the relation between design and research" in that the research is "fully integrated as a key component of an ongoing design process and from engaging in long-term collaborations with researchers and practitioners (p.45)" This research orientation is different from traditional approaches that attempt to contain, control or observe a particular phenomenon of interest over shorter periods rather than engage in long-term, contextual, interventionist and engineering stance to introduce change through an innovation that design research assumes. Different phases of design research may warrant particular research methods at various points of the integrated research, design and development process, therefore a broader menu of research methodologies – both applied and empirical – at given points is important to consider as part of the design research process (Bannan-Ritland, 2003; Bannan, 2009; 2013). The dynamic, flexible and open-ended nature of the practice of design research integrating multiple research methods seems to well-align with intersection of design processes and mobile learning landscape described below (Bannan, 2010).

In addition, the reconsideration of design research in the landscape of mobile learning raises tensions between the creation of what Nelson et al. (2012) would refer to as the "design particular" or a unique mobile design problem with the effort to generalize related research-based assertions to other situations. Design research, similar to case study methodology, assumes a stance of generating assertions about how learning might occur, attempting to uncover the salient features of a design research case that may have analytic generalizability that Bassey (1998) calls "fuzzy generalizations." This type of generalization assumes "unmeasured uncertainty" while also acknowledging the potential of analytic generalizations about patterns of behavior in complex learning settings stating

that "… in [design research] cases similar to the [design research] cases studied, it *may* be found that x leads to y" (Bassey, 1998). Our position on the potential of design research in mobile learning is that it is an approach uniquely qualified to assume an exploratory stance as opposed to a positivist paradigm, one that recognises the complexity and dynamic nature of the social and cultural world with an attendant methodological pluralism and is content with 'fuzzy generalizations." Design research with a socio-cultural frame provides a way to 'systematically' seek out 'never-seen before possibilities' or produce analytic generalizations in the complex learning situations of today embracing the messiness and authenticity of mobile learners' life-worlds. In this view of design research, the generated salient learning features of a novel solution or a "design particular" may be potentially applied to different contexts. Simmons, (1996) eloquently states this issue as:

> The tension between the study of the unique and the need to generalise is necessary to reveal both the *unique* and the *universal* and the *unity* of that understanding**.** To live with ambiguity, to challenge certainty, to creatively encounter, is to arrive, eventually, at 'seeing' anew (pp. 237-8).

Through our stance to consider and reconsider the full complexity of design research with mobile learning, we strive to position this form of research with all its implication as employing a socio-cultural lens in order to "see anew" as we implement design processes under a design research approach.

Design Processes in Educational Contexts

Applied to educational contexts, a design research approach is attractive in relation to the design of deliberate pedagogical choices (i.e. not just research about the production of artefacts and technological tools/apps but focus on the specific conceptualisation of pedagogical interventions with the purpose of maximising learning). These pedagogical choices are made within the act or process of design. Less emphasis has been placed on the fundamental and systematic design process subsumed in a design research approach in the literature. However, it is the act(s) of design, design decisions and pedagogical choices made through a chosen design path that may ultimately produce the educational innovation along with generating theoretical insights into learning.

Integrating complex cycles of design with research cycles is not an easy nor simple task. However, as Sandoval (2013) indicates, "it is critical to understand what design in design research means" as the design process in design research encompasses "any facet of a designed environment that researchers feel requires systematic study (p. 389)." How then do researchers select a facet or an area of study in the complexity of mobile learning space? This important question assumes and demands that researchers identify rich areas for integrated design and research cycles that can contribute both a useable innovation as well as having the potential to generate new knowledge for research. Accordingly, Cook, Bannan and Santos (2013) have begun to investigate the design seeking process or how researchers actually may identify and frame design and corresponding design research problems that may have the most traction for future scaling and diffusing in a social

system. Design seeking draws on a view of knowledge as being essentially problematical: it is not just a question of solving a problem, it is more a question of seeking out the nature of the problem and then devising an approach to solving it. A key problematic issue that Cook et al. (2013) have encountered when analyzing ethnographic research (conducted for a large European Commission-funded project that these researchers are a part of) is that there is a need to consider scaling of use from the outset when design seeking. For example, designing for scale (i.e. so that large numbers of users will take up mobile learning artifacts) needs to consider systemic pain points (e.g. problems in learning and work-based practice that recur over several contexts and which therefore present prime candidates for design research-based investigations). A key notion is that for technology to be adopted on a large-scale, it needs to seek empirically-based 'systemic pain points' that, if addressed, have the potential to attract significant take up by other groups of professionals who face the same problem providing a type of analytic generalization (Cook et al., 2013 provide examples taken from UK Health Sector). There is hence a clear need for advancements in design research if these 'never-seen before possibilities' are to be identified and designed for. Cook et al. (2013) describe several systemic pain points gathered from empirical research and co-design workshops, to create a mobile learning prototype for larger scale networked scaffolding and specifically aimed at enabling and encouraging the development of trusted networks among distributed groups of nurses in the Northeast of England. Framing this design seeking and scaling in a design research approach allows for scale and generalization aligned with Bassey's (1998) description. Enhanced understanding of the pragmatic implications as well as how we make pedagogical choices within the design process are subsumed in a design research approach. This approach also considers the unique affordances of mobile learning to provide clues for ultimately improving both the intervention and our methods to investigate it.

Design seeking and scaling illustrate only one aspect of the design and design research process. The overall act of design itself is not well understood and a complicated activity. In the 1960s Horst Rittle first referred to design problems as "wicked problems". As cited in Buchanan (1972, p.15):

> As described in the first published report of Rittel's idea, wicked problems are a "class of social system problems which are ill-formulated, where the information is confusing, where there are many clients and decision makers with conflicting values, and where the ramifications in the whole system are thoroughly confusing."

Any examination of design activity or process or research will reveal the true natural complexity of design as a "wicked problem" in an attempt to develop a new or novel solution and determine if it works in an un-structured, multi-layered effort with multiple stakeholders. The nature and influence of the actual, implemented design process that intersects with the deliberate pedagogical choices may greatly influence design research cycles as well as the resulting theoretical and pragmatic outcomes.

The actual implemented design process in any field or effort is far more complex than the more limited linear representations and descriptions of it that appears in in the literature. Design researchers need to be sensitive to the fact that the act of design, even for a specific pedagogical outcome, may constitute one of many possible paths and may even be unpredictable, containing many design moves or choices and sometimes resulting in unintended consequences. However, despite the inherent ambiguity and complexity of design, many applied and deceptively simplistic design processes have prompted the creation of incredibly innovative solutions to address technological and social problems – such as the increasingly popular process of design thinking.

First written about by Buchanan (1972), design thinking is currently experiencing a resurgence in the literature with recent popular publications aligning it with creativity, business management, service and the social problems and processes of our time (Brown, 2009; Dunne & Martin, 2006). Design thinking has many definitions in the literature but seems to have some characteristics and processes of design in common across descriptions such as: 1) empathetic investigation of the design context involving users, stakeholders, and designers; 2) framing and re-framing the design problem; 2) ideation of design concepts; 3) prototyping; and 4) testing through iterative cycles of design and improvement (Plattner, Meinel & Liefer, 2012). Design thinking is an applied problem solving construct that often involves investigative cycles such as applied ethnographic methods and structured observations in order to investigate a selected context for purposes of targeted design.

There is significant crossover in design, design thinking and design research processes – albeit for somewhat different aims. Buchanan (1992) speaks to this crossover in his description of the emergence of design thinking as "…a concern to connect and integrate useful knowledge from the arts and sciences alike, but in ways that are suited to the problem and the context (p.6)." Processes of design and design thinking as well as design research seem to strive to connect the creative, artistic and generative design process with the more rigorous, scientific and theoretical cycles of research that are contextually bound. As Buchanan (1992) goes on to state:

> Designers are exploring concrete integrations of knowledge that will combine theory with practice for new productive purposes, and this is the reason why we turn to design thinking for insight into the new liberal arts of technological culture (p.6).

How then can the design process and design thinking advance or bridge our social/cultural capital for technology-enhanced learning environments such as those represented by mobile learning? To begin, a broader conceptualization of the culture, context and spaces involved in mobile learning is required that values and integrates theory and practice with a full appreciation of the crossover of the multiple contexts in our lives in which we use, design for and study technology. Buchanan (1992) referred to this as the design of complex systems or environments that span contexts where we live, work, play and learn. He stated "This area is more and more concerned with exploring the role of design in sustaining, developing and integrating human beings into broader

ecological and cultural environments, shaping those environments when desirable and possible or adapting to them when necessary (p.10)." A broader view of the cultural resources, social/cultural capital that may be leveraged for TEL and an appreciation of the full complexity of the act of design within design research as a "wicked" problem may lead to and better address what Pachler et al., (2010) refer to as "the new habitus" of learning within the "mobile complex" described above.

Integrating Mobile Learning, Design Process and Design Research and Cultural Ecologies

How then, do we begin to investigate the true complexity of design process, design thinking and mobile learning across contexts of our lives and broaden our cultural and social understanding of teaching and learning with mobile devices? Theory as an analytical tool can reveal insights not previously considered and can be leveraged for improved analysis and research. Mobile learning, we argue, should be viewed as much more than merely the introduction of a device but as a cultural artefact that crosses over learners' life worlds of living, working, playing and learning (Pachler et al., 2010). To design for mobile learning and furthermore, to investigate mobile learning through design research reveals important insights into our culture and social system. Mobile devices are attractive to us from an educational design research perspective because of the affordances they provide for meaning making, for engagement with and for mediating the world around us as well as for communicating with it. These affordances may include, among other things, increasing portability, functionality, multimedia convergence, ubiquity, personal ownership, social interactivity, context sensitivity, location awareness, connectivity and personalization, converged device and ubiquity (Pachler et al., 2010, p. 7). Educational research and theory has just begun to intersect with these capabilities and affordances to gain insight into new methods of teaching, learning and training. Pachler, Bachmair and Cook (2010) have presented their socio-cultural pedagogical frame for mobile learning that describes the interrelationship between three components: agency, the user's capacity to act on the world, cultural practices, the routines users engage in their everyday lives, and the socio-cultural and technological structures that govern their being in the world viewed as an ecology which in turn manifests itself in the form of an emerging cultural transformation. This theory provides a useful analytical tool or frame through which to view and broaden our understanding of mobile learning, mobile design process and mobile design research.

In addition, how we view and, indeed, how we conduct research is vastly different from that of five years ago. This is true for the field of technology-enhanced learning research in general as it is for mobile learning research in particular; design research and mobile learning also present different challenges than five years ago. (see e.g. Bannan, 2012; Vavoula, Pachler & Kukulska-Hulme, 2009) Design research as an emerging approach to educational research facilitates the deep investigation into individual and organizational cultures as well as artifacts to improve our understanding of context for design and research purposes. The complexities inherent in mobile learning research in a global context, the natural ambiguity of the creative design process and the drive for rigour in research methods all manifest significant challenges for educational design

research. In combination, the challenges multiply but also provide opportunities to reconsider and reconceptualize technology-enhanced learning research with mobile devices.

Without fully considering the dynamic nature of the "wicked" design process with multiple possible paths and a shift toward a socio-cultural theoretical perspective, as in the mobile complex, in order to more fully embrace the cultural and social impact of mobile learning, it is difficult to fully represent the holistic impact of mobile learning in research. Exactly how emergent technological capabilities and social/cultural interactions cross contexts impact on the study and creation of mobile learning application is not well understood and may require a dramatic shift in what information we pay attention to for both design and research as well as what theoretical lens we elect to view learning through. In essence, as the capabilities of technology-enhanced learning environments and our full understanding of their impact shift and change, so might our research methodologies need to change in considering or reconsidering: 1) what counts as learning; 2) as evidence that learning occurred; 3) as data; and 4) how we observe and analyze it. Design research, particularly in combination with mobile learning, with the dynamic, evolving qualities over longer periods of time combined with the "wicked" act of design possesses and epitomizes this shift.

Mobile Design Research Example

In reconsidering design research in the age of mobile learning, we stated that it required an increased sensitivity to context, cultural resources, social-cultural features of formal and informal learning environments and the reconceptualization of research methodologies that align with these important unique factors. A case example, the Learning Layers Design Research project is presented here to briefly epitomize these issues and the intricate interplay between the acts of design and research within a socio-cultural framing of learning. This large-scale design research effort involved the design of a solution for building personal and professional learning networks using mobile and social media for workplace learning. The project involved integrated views and enactment of design and design research processes based on a socio-cultural frame of learning involving the evolution of locally trusted personal learning networks. Several design processes as well as integrated research methodologies were implemented including ethnographic and observational research, among others. There was no predictable path or simple solution in this identified "wicked problem" of addressing workplace learning using mobile technology and, therefore, an appropriate design research project.

The Learning Layers Design Research team's sensitivity to context and cultural resources was demonstrated most clearly in the team's approach to exploring the problem by grappling with the complex issue of identifying rich problems in context that would have the most traction for later diffusion or scaling of the innovation, as in this case, the mobile personal network to address identified problems in the healthcare and construction professions. Sensitivity to context was carried out through multiple design

research cycle investigations into the professional setting to guide design and generate theoretical insights as well as attention to cultural resources exemplified through an archival of living and practice, evolving documents and artifacts representing cultural artifacts (see Cook et al.'s (2013) notion of the Open Design Library: a repositiory of design ideas surrounded by a community engaged in conversations). The specific socio-cultural aspects of the healthcare and construction industries were considered in depth with representatives from these work environments as part of the design research team and cycles along with researchers, developers, funders and other stakeholders (Cook & Bannan, 2013). The participants' current use of mobile devices as well as other best practice case scenarios involving the unique socio-cultural affordances of mobile devices for informal learning were examined prior to design and in ongoing evaluative cycles during and after prototyping. As the team progressed through initial design cycles and empirical studies, the issue of fronting or identifying systemic 'pain points' in these professional contexts that may warrant rich points for design and research arose. These points or identified problems provide the most promise for diffusion and scaling of the intervention and processes uncovered by the design research cycles and resulted in the Design Seeking and Scaling Framework. This work is representative of the layered complexity of mobile design research and the multiple outcomes that are possible given a systematic, rigorous, socio-cultural approach and more expansive view of integrated perspectives involved in mobile learning, design process, scaling and design research.

Conclusion

Mobile design research, design and design thinking processes, we argue here, can yield meaningful insights into aspects of learning and practice taking account of cultural, geographical differences through systemic, rigorous investigation of context, a view of mobile technology as cultural resources and by more fully embracing the complexity of the learning setting through integrated cycles of design and research. In this paper, we questioned the performativity paradigm underpinning the prevailing restricted view of the role of mobile devices in education. As an antidote we asserted a socio-cultural view of learning whereby mobile devices and services foster inter- and intra-personal conversation-based processes of coming to know and being able to operate in, and across, new and ever changing contexts and learning spaces at the interface of formal education and everyday life-worlds. Aligned with this view, we proposed a view of mobile devices as cultural transformational tools worthy of expanding our perception and access to resources creating an important shift not only in how we view teaching and learning, but also how we design for it and investigate it in complex settings. A four phase Integrated Learning Design Framework is presented; whilst this has been applied as a systematic frame to mobile learning design research contexts, it may not go far enough in fully embracing a socio-cultural perspective on learning. For us, the challenge is to intersect these theories and processes and in so doing bring the creative (e.g. design seeking) and analytic together in a systematic but flexible manner having an impact on learning whilst feeding back into theory: an ambitious undertaking. The theoretical frame provided by the mobile complex has significant implications for mobile learning and design research. For example, structural changes in the transferal of responsibility for risk-taking and meaning making from the state to the individual framed as a consumer of services

available in a market environment have consequences for research and design research. Key questions that arise are as follows: What is the most appropriate way of capturing ongoing transformations and processes in a design research approach? How do researchers select a facet or an area of study in the complexity of mobile learning space? We argue that some applied and deceptively simplistic design processes have prompted the creation of incredibly innovative solutions to address technological and social problems – such as the increasingly popular process of design thinking, which can usefully be viewed as a concern to connect and integrate useful knowledge from the arts and sciences alike, but in ways that are suited to the problem and the context; indeed this is something that the Design Seeking and Scaling Framework has made an initial attempt at, but which will benefit in future work from an influx of ideas from the literature on design thinking and open innovation. Consequently, a key unanswered question is: how can the design process and design thinking advance or bridge our social/cultural capital for technology-enhanced learning environments such as those represented by mobile learning?

In our attempt to reconceptualize design research in the age of mobile learning reveals many important issues. The complexities inherent in mobile learning research in a global context, the natural ambiguity of the creative design process and the drive for rigour in research methods all manifest significant challenges for educational design research. In a socio-cultural perspective 'learning' and success in learning are rather different from and more complex than a simple attainment gain orientated paradigm characterizing much of recent mobile learning research. In response to these issues and questions work is presented that has begun to investigate the design seeking and scaling process or how researchers actually may identify and frame design and corresponding design research problems that may have the most traction for future scaling and diffusing in a social system. However, although addressing key issues, this work does not yet capture the parallel nature of design research and has not bottomed out what it is to design for 'wicked problems'. However, what design research demands is that we address such issues with theory as an analytical tool that can reveal insights not previously considered and that can be leveraged for improved analysis. Mobile design research, design and design thinking process can take account of cultural, geographical differences through systemic, rigorous investigation of context, view of mobile technology as cultural resource and embracing the complexity of the learning setting through integrated cycles of design and research. A participatory, democratic involvement by all stakeholders and constituents as evidenced in the complexity of mobile design research may better leverage cultural and social capital resources to improve teaching and learning compared with some top-down traditional research approaches as we progress toward the future of TEL and mobile learning design and research.

Future Work

In the context of addressing current 'crises' and envision possible responses for education (see Traxler and Lally, this issue), we begin to unpack and attempt to reframe the intersection of mobile learning and design research. Embracing a socio-cultural view of learning with mobile devices and services attempts to target the nexus of formal

education, design research and everyday life-worlds to potentially incorporate a more democratic, global perspective. Mobile devices viewed as transformational cultural tools expand our perception and access to resources and, as stated previously, demand a shift in how we view teaching and learning, how we design for it and how we investigate it in complex settings through design research. The ILDF provides a systematic model for design research as an inquiry process with four progressive phases positing guiding questions that respectfully investigate local and broader contexts and attempt to leverage appropriately aligned methods. These are not exhaustive but present a starting point to outline a systematic approach that may ultimately incorporate alternative methods and views of evidence including fuzzy, analytic generalizations to broaden and enhance our understanding of teaching and learning.

Fully addressing this view of cultural transformation with mobile devices as well as the interplay between learners' formal education and everyday life-worlds provokes the consideration (and re-consideration) of the complexity and design process of mobile learning spaces and related design research methods. Our future work will attempt to address the "second generation of learning" (see Traxler and Lally, this issue) to incorporate facets of user-driven, universal personal technologies and also consider some forms of knowledge as "now created locally, partially, contingently, for-me, for-now." We believe design research can provide more socio-cultural sensitivity to context and human activity to investigate these interactions across learners' life worlds. Design research can also be aligned with differing philosophical views of cognition such as activity theory, but ultimately attempts to provide a pragmatic and systematic approach that may integrate varying views of human cognition and activity to iteratively generate, build and investigate complex pedagogical phenomena. With a socio-cultural, transformative view of learning and research, people moving "into technological and social spaces" provide a context ripe for a design research approach. Articulating the democratic, sensitive, culturally-relevant aspects of integrated design and research processes for mobile learning will truly encompass a "wicked" endeavor, but a critical one, in addressing new perspectives on learning with transformative mobile devices. With this view, we hope to have contributed to the developmental trajectory of design research and mobile learning.

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Figure 1
Questions and Methods for Design Research by ILDF Phase

ILD	Informed Exploration	Enactment	Evaluation: Local Impact	Evaluation: Broader Impact
Guiding Questions for Research	Questions: What are identified gaps/problems in theory, practice, and/or the marketplace? What information can be gleaned from existing data or research? How can we characterize the problem or learner need? What are the systemic social, cultural, and organizational influences or constraints on design? What are characteristics of the audience?	Questions: What are the learning targets for innovation? What design principles or strategies may be applicable? How to identify and operationalize cognitive and performance processes in design? To what extent does the design embody the theoretical model?	Questions: Is the enacted design usable, valid and relevant? Is the design instance accessible and efficient in delivering instruction or supporting learning? What is the local impact or effectiveness of the design instance? How effective is the design solution in achieving learning targets at its highest fidelity in full context?	Questions: What factors influence diffusion, adoption and adaption of innovation? What are the pragmatic demands of the learning environment that influences adoption of design? What policies and cultures shape participants use of innovation?
Applicable Research Methods	Methods: Benchmarking Performance/needs analysis Interviews Survey of Experts Focus Groups Observations/Role Modeling Case Studies	Methods: Task Analysis Contextual Analysis Designer Logs Expert Review Audience Review	Methods: Usability Testing Expert Review Observation or Video records Interviews Formative Evaluation Pre-post Comparative Studies Quasi-experimental studies	Methods: Analysis of computer log files Multi-site Interviews, Surveys and Observations Data mining Correlational studies Quasi-experimental studies