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Viewing mobile learning from a pedagogical perspective

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Mobile learning is a relatively new phenomenon and the theoretical basis is currently under development. The paper presents a pedagogical perspective of mobile learning which highlights three central features of mobile learning: authenticity, collaboration and personalisation, embedded in the unique time-space contexts of mobile learning. A pedagogical framework was developed and tested through activities in two mobile learning projects located in teacher education communities: *Mobagogy*, a project in which faculty staff in an Australian university developed understanding of mobile learning; and *The Bird in the Hand Project*, which explored the use of smartphones by student teachers and their mentors in the United Kingdom. The framework is used to critique the pedagogy in a selection of reported mobile learning scenarios, enabling an assessment of mobile activities and pedagogical approaches, and consideration of their contributions to learning from a socio-cultural perspective.

Keywords: mobile learning; pedagogy; socio-cultural theory; framework; pedagogical features

1. Introduction

Portable, handheld devices have increasingly powerful multimedia, social networking, communication and geo-location (GPS) capabilities and consequently, mobile learning (m-learning) offers numerous opportunities as well as challenges in education. Despite the ubiquity and flexibility of these devices, there has been minimal use of m-learning approaches in some education sectors and developments have tended to be more about the design of the tools than of the ensuing learning. There is an ongoing need to examine the pedagogies that are suitable for m-learning, and to conceptualise m-learning from the perspective of learners' experiences rather than the affordances of the technology tools (Traxler 2007).

This paper investigates what a pedagogical framework for m-learning may look like from a socio-cultural perspective. This theoretical perspective suggests that learning is affected and modified by the tools used for learning, and that reciprocally the learning tools are modified by the ways that they are used for learning. Central to our position here is the notion that learning is a situated, social endeavour, facilitated and developed through social interactions and conversations between people (Vygotsky 1978), and mediated through tool use (Wertsch 1991).

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Identifying specific, current features of m-learning and m-teaching from a socio-cultural perspective provides a potentially useful lens for researchers' analyses of pedagogical approaches; helps teachers to critique and reflect on their teaching activities and offers critical insights into the design of m-learning materials. Our framework offers an examination of m-learning which foregrounds pedagogy rather than technology; a perspective in which the pedagogy is central and the technology is under investigation only for what may be distinctive about the learning afforded by that technology. Although sophisticated theoretical models have been developed (Laurillard 2007; Pachler, Bachmair, and Cook 2009; Sharples, Taylor, and Vavoula 2007), locating distinctive features of learning with mobile devices is an evolving process as devices and associated technologies mature.

Accordingly, informed both by current m-learning theory and by socio-cultural theory, this paper identifies three distinctive features of m-learning through our framework. The features are authenticity, collaboration and personalisation. The pedagogical framework was developed and extensively tested through a range of activities in two m-learning projects located in teacher education communities. *Mobagogy* was a professional learning community of eight academics in an Australian university, formed to investigate how to use mobile technologies in their own learning and teaching (Schuck et al. 2010). The community met regularly over a period of 18 months to discuss emerging relevant teaching issues and applications. *The Bird in the Hand Project* was a UK sponsored initiative supported by the Teacher Development Agency and examined the experiences of a group of trainee and newly qualified teachers who were provided with smartphones (iPhones) to use in their placement and first teaching schools. It explored how a group of eight trainee teachers and their mentors used smartphones to support and enhance their professional practice. Extensive descriptions of activities within both these projects are available elsewhere (Kearney, Schuck, and Burden 2010).

2. Background

M-learning is described in numerous ways, but these descriptions all consider the nexus between working with mobile devices and the occurrence of learning: the process of learning mediated by a mobile device. Numerous characteristics of m-learning have been identified in the literature. Koole's (2009) FRAME model sits well with socio-cultural views of learning, taking into consideration both technical characteristics of mobile devices as well as social and personal learning processes. She refers especially to enhanced collaboration, access to information and deeper contextualisation of learning. Our paper extends Koole's model, to include understandings of "mobile pedagogy" which draw on socio-cultural understandings presented in her model.

Danaher, Gururajan, and Hafeez-Baig (2009) propose a framework based on three key principles: engagement, presence and flexibility (see Figure 1). "Presence" refers to the "simultaneous awareness and locatedness of self and others ... encompassing the emotional element of being human" (26). They further breakdown "presence" into three sub-group "interaction types": cognitive (student-content), social (peer) and teaching (student-teacher). Inherent in this model is implicit discussion of pedagogy; the aim of our paper is to make this discussion central and explicit.

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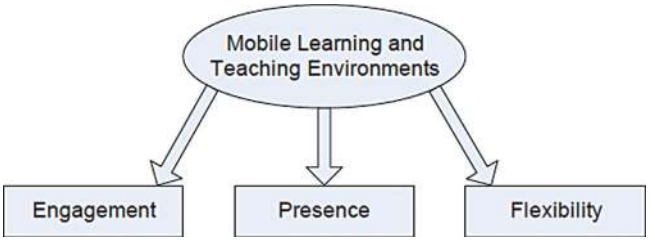

Figure 1. From Danaher, Gururajan, and Hafeez-Baig (2009, 23). Copyright: IGI Global Reprinted by permission of the publisher.

Other researchers have provided insights into different social aspects of m-learning. Traxler (2009, 30) described m-learning as "noisy" and problematic, featuring three essential elements: the personal, contextual and situated; while Klopfer, Squire, and Jenkins (2002) identified five features: portability, social interactivity, context sensitivity, connectivity and individuality. Pachler, Cook, and Bachmair (2010) analysed the interrelationship of learners with the structures, agency and cultural practices of what the authors call the "mobile complex" (1). The identification of these sets of characteristics and relationships established core features that we had to ensure were addressed in the development of our framework.

Larger-scale, more complex conceptual frameworks for m-learning design and evaluation have been proposed. Parsons, Ryu, and Cranshaw (2007) proposed a complex conceptual framework for m-learning with four perspectives: generic mobile environment issues, learning contexts, learning experiences and learning objectives. Vavoula and Sharples (2009) proposed a three-level framework for evaluating m-learning, comprising a micro-level concerned with usability, a meso level focusing on the learning experience (especially on communication in context) and a macro level dealing with integration within existing organisational contexts. Our framework aims to further interrogate this "meso level" of learners' experience.

Hence numerous frameworks have been proposed in the literature, ranging from complex multi-level models (e.g. Parsons, Ryu, and Cranshaw 2007) to smaller frameworks that often omit important socio-cultural characteristics of learning or of pedagogy. Common themes include portability of m-learning devices and mobility of learners; interactivity; control and communication. These descriptions acknowledge the prime importance of context, including spatial and temporal considerations, for analysing m-learning experiences. However, they typically attempt to merge affordances of mobile devices or characteristics of applications with features of the learners' experience. While acknowledging that the features identified in other frameworks are important in characterising technology-mediated learning by mobile users, we propose a succinct framework highlighting a unique combination of distinctive characteristics of current mobile pedagogy to bring socio-cultural insights to the literature on m-learning.

3. Time-space considerations

Formal learning is traditionally characterised by two constants or boundaries: *time and space*. learning places occupy fixed, physical spaces which are defined by relatively impermeable boundary objects such as walls, classrooms and school buildings. Similarly, traditional learning is situated in permanent temporal slots such

as teaching periods (timetables or semesters) which are relatively immutable (Traxler 2009). M-learning has the potential to transcend these spatial and temporal restrictions, overcoming "the need to tie particular activities to particular places or particular times" (Traxler 2009, 7).

With "space", m-learning offers a variety of alternatives including "virtual" or non-geographical spaces, such as virtual world environments created for mobile devices. In temporal terms, the requirement to learn in fixed, scheduled time spaces (which characterise current schooling) are also relaxed enabling the individual to be more flexible about when they learn. Previously fixed engagements or appointments can now be readily rescheduled and fixed notions of linear time are increasingly making way for a softer version of what some authors have termed "socially negotiated time" in which each party to an event is able to create and rearrange their schedules without excessive detrimental effect to either side (Ling and Donner 2009).

The implications of these two vectors in m-learning are beyond the scope of this particular paper but taken together they create what we term "malleable spatial-temporal contexts for learning". In blurring the physical and scheduled personality of institutional-based learning, time-space implications of m-learning open up opportunities for a wide variety of pedagogical patterns. Mobile technologies thus enable learning to occur in a multiplicity of more informal (physical and virtual) settings situated in the context about which the learning is occurring. These informal scenarios range from structured, teacher-mediated experiences in semi-formal places like museums and libraries, to more self-regulated experiences in learner-generated contexts such as coffee shops and public transport settings (Luckin 2010).

We are not attempting to identify specific causal links between the level of formality of "time-space" and m-learning experiences. However, to discuss distinctive features of mobile pedagogy, we must firstly acknowledge that the organisation of "time-space" in any learning environment profoundly affects m-learning experiences (Ling and Donner 2009). From a socio-cultural standpoint, insights into the organisation of "time-space" in a given learning environment is an essential part of understanding the nature of a m-learning experience, as depicted in Figure 2.

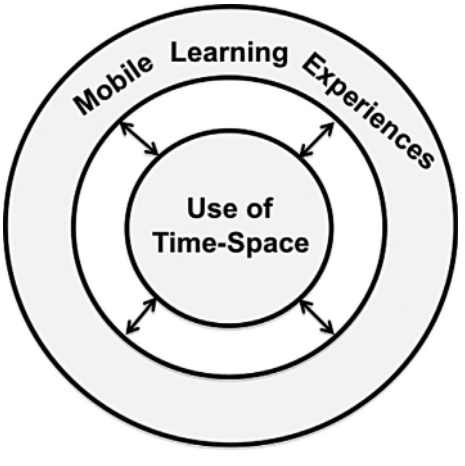

Figure 2. A two-way relationship between the organisation of Time-Space and m-learning experiences (socio-cultural perspective).

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4. Framework development and validation: locating distinctive mobile pedagogy features

The current framework was developed through an iterative design-test-analyse-refine cycle, akin to that suggested by Kemmis and McTaggart (1988), to address our key question: *what does a pedagogical framework for m-learning look like from the perspective of socio-cultural theory?* Activities in both projects fed into this cycle and leveraged numerous opportunities to test and refine the framework and its representation. Project activities contributing to the framework development included: exploring the socio-cultural characteristics underpinning m-learning; interrogating the literature on m-learning; investigating best practice approaches by interviewing global experts in the field; and initiating and testing selected m-learning pedagogies in the context of our own higher education subjects. A variety of strategies were used to promote collaborative critical reflection (Ghaye and Ghaye 1998) throughout the cycle, taking into account a range of perspectives from discipline, pedagogical and e-learning experts in our group.

The framework was validated through four methods. Firstly, inter-researcher validation was gained using feedback from m-learning researchers after presenting versions of the framework at four scholarly meetings: one internal teaching and learning university conference; a m-learning working group with scholars from around Australia and beyond; an internal Faculty presentation and an international m-learning conference (Kearney, Schuck, and Burden 2010). Secondly, intra-researcher validation was achieved through discussions amongst the designers of the framework. These discussions critiqued the framework from a pedagogical perspective and interrogated how well it aligned with the underlying socio-cultural theory. Thirdly, each iteration of the framework was tested by using it to analyse existing m-learning initiatives in both the *Mobagogy* and the *Bird in the Hand* projects, and also using it to guide the design of further m-learning experiences. Fourthly, a critical friend – an expert in pedagogy from within the group – was invited to critique final iterations of the framework and subsequently, to become a fourth author of this paper. His feedback contributed to the current framework presented here. These methods involving the users' perspective in the design process follow general design guidelines based on constructivist theory (Willis 2000).

Informed by these processes and mindful of our quest to use socio-cultural theory to capture central pedagogical features of m-learning environments, a framework prototype was designed using four dimensions: place, connection, immediacy and activity. This early version of the framework integrated temporal and spatial considerations. This version was "tested" by using it to critique our student teachers' use of mobile devices to vote on a controversial issue in a mass lecture (see upward thick arrows on each of the four scales in Figure 3).

In another example from our project trials, this version of the framework was used to critique the lack of interactivity in a group member's trial of student teachers' instructional use of podcasts. Similar trials took place in the United Kingdom where versions of the framework were used, for example, to gauge the extent to which trainee teachers could sustain a vibrant sense of community, which had characterised their face-to-face elements, whilst away from the university on their first teaching placements.

Further iterations of the framework emerged from our design and development cycle, as we tried to capture more succinctly the distinctive features of m-learners'

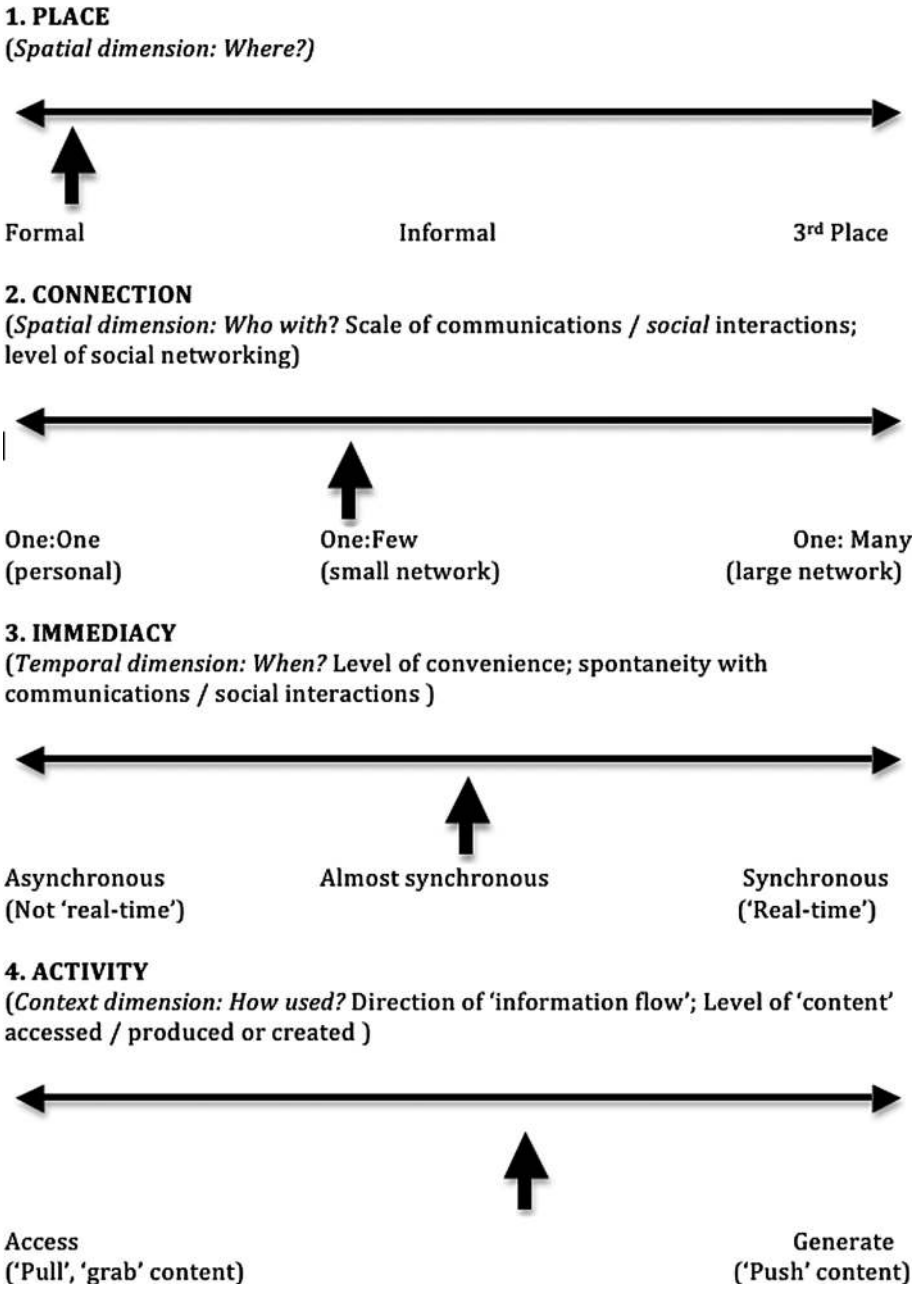

Figure 3. Use of a prototype framework to analyse one of our project teaching trials.

experiences. A well-developed framework incorporating five "scales" and numerous sub-scales was presented at our university teaching and learning conference (see Figure 4).

A more succinct, penultimate version of the framework (see Figure 5) was subsequently presented at mLearn2010 (Kearney, Schuck, and Burden 2010). Apart from a more succinct representation, a major development here was our treatment of "time-space" as a separate entity in the framework.

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Framework for examining m-Learning Scenarios

1. FLEXIBILITY

Where? When? **1.1** Setting *where learner is situated*; **1.2** Timing of schedule (**Scheduled** = 'just-in-case' timing; **Unscheduled** = 'just-in-time', on-the-fly' schedule; this scale may indicate an *incidental or spontaneous nature to the m-learning episode*); **1.3** Customisation: Level of customisation of activity

FORMAL setting		2nd PLACE		3rd PLACE	
Scheduled	Unscheduled	Scheduled	Unscheduled	Scheduled	Unscheduled

2. AUTONOMY

2.1 Goal-setting; **2.2** Task mediation; **2.3** Control over task pace

TEACHER SET GOALS		OTHER (eg. EXPERT / PEERS)		SELF-SET GOALS	
Teacher-mediated	Self	Teacher-mediated	Self	Teacher-mediated	Self

3. AUTHENTICITY

3.1 Task situatedness: Task 'fit' with context (setting, characters, tools etc.); **3.2** Task/Process Authenticity: is task (and associated practices) realistic and aligned with real practice? **3.3** Task supported by device's location (context)-aware functionalities

NO FIT		WEAK FIT (Simulated)		STRONG FIT	
Contrived	Realistic	Contrived	Realistic	Contrived	Realistic

4. CONVERSATION

Communication as experienced by learner AT or THROUGH the device. **4.1:** Scale of social networking (with whom?) **4.2:** Immediacy (**Asynch** = asynchronous (delayed); **Synch** = Synchronous (real-time) - influence ON *spontaneity* of dialogue) **4.3:** Modality

NONE	ONE:ONE		ONE: FEW		ONE:MANY	
	Asynch	Synch	Asynch	Synch	AsyncH	Synch

5. INFORMATION FLOW

How learner shares content using mobile device. **5.1** Scale: Level of networked sharing of information and resources; **5.2** Direction: of 'information / content flow' (**Access**: 'content' retrieved / acquired / 'pulled' (& processed) by learner; **Produce:** 'content' created / 'pushed' (& shared) by learner **Exchange**: Two-way 'push/pull' of 'content' … creation & retrieval by learner); **5.3** Content 'Currency'

PERSONAL		ONE:ONE		COMMUNITY			WEB (public)		
Stand-alone	Access	Produce	Exchange	Access	Produce	Exchange	Access	Produce	Exchange

Figure 4. Another prototype framework presented at a university teaching conference, 2009.

Further feedback from m-learning researchers at the conference, and from our critical friend, was valuable and informed refinement of the framework, in light of other data from the project activities. For example, one conference reviewer suggested we more closely examine critical features of games-based m-learning scenarios to help us further clarify the *Customisation* section of our framework. Descriptions of

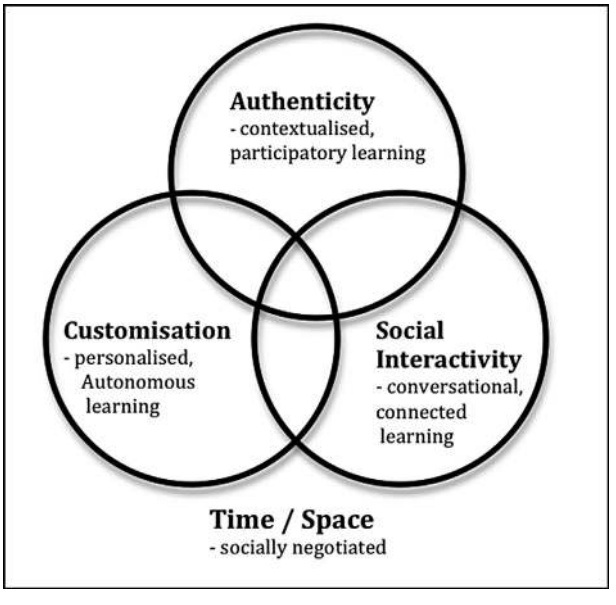

Figure 5. Penultimate framework presented at mLearn 2010 (Kearney, Schuck, and Burden 2010).

this scale and other sections of the framework were subsequently refined. Our critical friend critiqued our use of a "third space" theme (Kearney, Schuck, and Burden 2010) and suggested that this might be a distraction to the main focus of presenting the three pedagogical constructs. Also, two subsidiary sub-scales were developed for each section to more accurately pinpoint critical features of m-learning. As part of this final development, the *Customisation* scale was changed to *personalisation* in the current framework, with sub-scales of *Agency* and *Customisation*. Similarly, the *Social Interactivity* scale was changed to *Collaboration* with sub-scales of *Communication* and *Data Sharing* (see next section). Also, it became evident that the "three circles" representation (see Figure 5 above) caused confusion regarding "intersecting sections" and consequently, the three scales have been separated in the current visual representation (see Figure 6).

5. Current framework

In this section, we describe a rationale for including *personalisation, authenticity and collaboration* as the three distinctive features of m-learning forming the basis of our current framework, working within our previously discussed conception of "time and space". We also have formulated two sub-scales for each of these three constructs, as depicted in Figure 6 and described in the subsequent sub-sections. This current graphical representation now consists of circular layers, to show the close, connected relationship between the three constructs depicted in the inner "layer" and the six sub-scales in the outer layer. The bi-directional arrows in the representation depict the previously discussed symbiotic relationship between "Time-Space" and m-learning features.

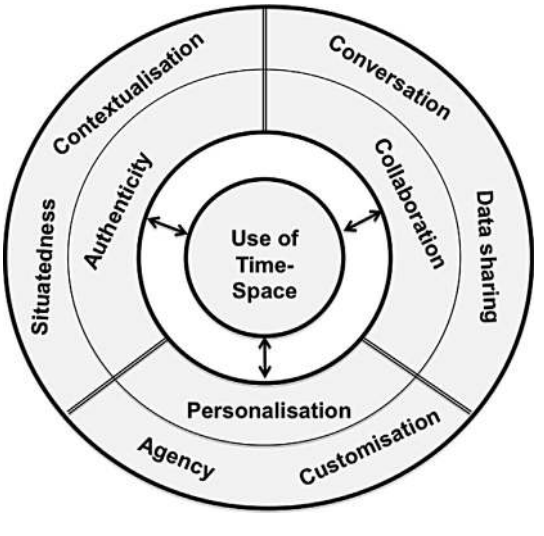

Figure 6. Current framework comprising three distinctive characteristics of m-learning experiences, with sub-scales.

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5.1 Personalisation

Personalisation, drawing on motivational theory (Pintrich and Schunk 1996) and socio-cultural theory (Vygotsky 1978), has become a corner stone of e-learning. Key features associated with personalisation include learner choice, agency and self-regulation as well as customisation (McLoughlin and Lee 2008). Learners can enjoy a high degree of agency in appropriately designed m-learning experiences (Pachler, Bachmair, and Cook 2009). They may have control over the place (physical or virtual), pace and time they learn, and can enjoy autonomy over their learning content. Goals are typically set by learners and their peers (e.g. some games). Furthermore, the "just enough, just-in-time, just-for-me" nature of some m-learning activities can create a personalised, tailored learning journey. M-learning experiences can be customised at both a tool and activity level. Users enjoy a sense of intimacy and convenience with their personal devices and the flexible, autonomous, often individually tailored activities lead to a strong sense of ownership of one's learning (Traxler 2007). In this sense, activities are customised for the learner to meet their different learning styles and approaches. Hence, we used two sub-scales (*agency* and *customisation*) in our analysis of personalisation, as shown in (Table 1).

Mobile users can use tools to record, organise and reflect on their customised m-learning experiences over time (Naismith et al. 2004). Emerging "context-aware capabilities" allow devices to acquire information about the user and their immediate environment (e.g. time, location, nearby people and objects), presenting unique opportunities to personalise learning experiences. Also, emerging "augmented reality" applications and customised interactions with "The Internet of Things" (Sundmaeker et al. 2010) offer promising ways for learners to select, manipulate and apply information to their own unique needs in a "pervasive learning environment" (Laine et al. 2009).

5.2 Authenticity

There is general agreement that authentic tasks provide real world relevance and personal meaning to the learner (Radinsky et al. 2001), although ultimately, authenticity "lies in the learner-perceived relations between the practices they are carrying out and the use value of these practices" (Barab, Squire, and Dueber 2000, 38). CTGV (1990) delineate *task, factual and process* levels of authenticity. Task authenticity refers to the extent to which tasks are realistic and offer problems encountered by real world practitioners. Factual authenticity refers to how particular details of a task (such as characters, instruments etc.) are similar to the real world, while a process level of authenticity refers to how learner practices are similar to those practices carried out in the community or "real-world" of practice. Radinsky

Table 1. Two sub-scales of the *Personalisation* construct used in our framework.

Scale	Sub-scale	Low activity is:	High activity is:
Personalisation	Agency (Pachler, Bachmair, and Cook 2009)	Externally controlled	Negotiated learning choices, for example, content, goals
	Customisation (McLoughlin and Lee 2008)	Uniformly structured, just-in-case	Tailored; just-enough, just-in-time, just-for-me

et al. (2001) espoused two models of authentic learning environments: a *simulation model and participation* model. Tasks that fit a simulation model of authenticity use the learning space (e.g. classroom) as a "practice field" (separate from the "real community") but still provide contexts where learners can practise the kind of activities they might encounter outside of formal learning settings. Alternatively, under a *participation* model of authenticity, students participate in the actual work of a professional community, engaging directly in the target community itself. Hence, we used two sub-scales (*contextualisation* and *situatedness*) in our analysis of *authenticity*, as shown in (Table 2).

M-learning episodes potentially involve high degrees of "task and process authenticity" as learners participate in rich, contextual tasks (setting, characters, tools), involving "real-life" practices. Learners can generate their own rich contexts (Pachler, Bachmair, and Cook 2009) with or through their mobile devices. The deeper contextualisation of tasks in these physical or virtual spaces can be supported by geo-location and data capture facilities (Brown 2010).

5.3 Collaboration

Collaboration in socio-cultural theory is often emphasised in terms of learning interactions with more capable peers or adults and there is a pedagogical emphasis on scaffolding (Trudge 1990). More broadly, social interaction, conversation and dialogue are fundamental to learning from a socio-cultural perspective as people engage in negotiating meaning (Vygotsky 1978). Recent pedagogical frameworks foreground the importance of these conversations in teaching and learning (e.g. Laurillard 2007; Sharples, Taylor, and Vavoula 2007), building on well-accepted Vygotskian theory. Shared conversational spaces mediated by mobile devices are conducive to timely, personally tailored feedback from instructors as well as rich peer interactions (e.g. multi-user mobile gaming environments).

M-learners can enjoy a high degree of *collaboration* by making rich connections to other people and resources mediated by a mobile device. This often-reported high level of networking creates shared, socially interactive environments so m-learners can readily communicate multi-modally with peers, teachers and other experts, and exchange information. Learners consume, produce and exchange an array of "content", sharing information and artefacts across time and place. Exchanged data files are often "just-in-existence", enhancing the immediacy of the m-learning experience. Indeed, the spontaneity of these communications and the currency of exchanged data are made possible by the accessibility and expectation of users being reachable at any time. We used two sub-scales (*Conversation* and *Data sharing*) in our analysis of *collaboration* as shown in (Table 3).

Table 2. Two sub-scales of the *Authenticity* construct used in our framework.

Scale	Sub-scale	Low activity is:	High activity is:
Authenticity	Contextualisation (e.g. CTGV 1990)	Contrived	Realistic/relevant to learner
	Situatedness (e.g. Radinsky et al. 2001)	Simulated	Participatory/embedded in real community of practice

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Table 3. Two sub-scales of the *Collaboration* construct used in our framework.

Scale	Sub-scale	Low activity is:	High activity is:
Collaboration	Conversation (e.g. Laurillard 2007; Sharple s, Taylor, and Vavoula 2007)	Unconnected/solitary	Rich/involves deep, dynamic dialogue
	Data sharing (e.g. Traxler 2010)	Isolated/emphasis on content acquisition & transmission	Networked/includes learner-generated content

6. Interrogating examples of m-learning

In this section, we use our current framework to critique a range of sample m-learning scenarios taken from recent, refereed literature in this field. The purpose of this analysis is to demonstrate how the framework can highlight important aspects of learning and pedagogy, as distinct from other analyses in the literature that typically focus on technical issues surrounding the affordances of mobile devices. We applied the framework to 30 scenarios chosen from recent m-learning conferences and other publications to capture the most innovative, contemporary activities flagged in the current literature. Activities were analysed using the six sub-scales to rate the critical features of these m-learning activities. When group members' ratings differed, differences were resolved through group consensus. From this analysis, we selected six examples (see Table 4). These examples illustrate the use of the framework in a range of contexts that exhibit different levels of the constructs. Informed by our time-space conceptions (see Section 3), we also describe our interpretation of the time-space organisation for each activity to provide additional insights into the m-learning context of each scenario.

The critical features of these m-learning activities were rated according to our framework using the scales and sub-scales described in Section 5. Hence, Table 5 (below) provides an indication of the extent to which features of our m-learning framework are exploited. (These ratings do not determine the qualities of the activities per se. Activities are designed for different purposes. Some features of m-learning may be appropriate in some circumstances but not others.).

Despite the rhetoric around m-learning virtually guaranteeing contextualised learning, very few of these scenarios rated highly in the scales for *authenticity*. Most activities involved either some form of contrived context (e.g. the high school Maths "apps" example) or activities that were merely providing a simulation of reality (such as the game – they were not participating in a real-life "governance" scenario). Interestingly, the Twitter example rated highly in authenticity, despite being in a formal professional learning setting. The activity was relevant (task, process etc.) to participants who chose to contribute to the Twitter feed. Delegates were certainly engaged directly in the professional community – including networking with colleagues who were not physically at the conference – and in this way, they were following a participation model of authenticity. Indeed, the process of Twittering has an increasing level of factual authenticity, as teachers begin to take up this activity as a normal everyday part of their professional networking practices. Similarly surprising were the generally low ratings in the *personalisation* scales. An exception was the game design scenario that allowed learners to enjoy high degrees of customisation and self-control over the learning process. In contrast, like most

Table 4. Brief description of examples of m-learning scenarios

	Source/scenario	Brief description
A	Ebner (2009). *Use of Twitter at a conference*	Delegates used a Twitter "back-channel" at a professional learning conference. During keynote presentations, delegates tweeted brief comments and questions in reaction to the speakers (or other tweeters). Twitter posts were projected in a cascading fashion on a screen behind the speaker. *From the perspective of the delegates in this formal conference venue (rather than the "lurkers" online), time was bounded by temporal parameters of the keynote speech. Use of Time-Space: fixed/scheduled/formal.*
B	Tangney et al. (2010). *Geometry in the field*	A second-level Maths class studying trigonometry who were working in teams of four students, using their smartphone's "angle tool" to measure the heights of three structures in their school grounds. Follow-up discussion of concepts occurred in the classroom.
C	Tangney et al. (2010). *Fractions Smartphone "apps"*	Maths students studying fractions use a Cuisenaire Rod "app" on their smartphone, allowing them to manipulate coloured cuisenaire-like rods on screen within a virtual "unit space". Small groups were organised by configuring the allocation of rods such that learners "trade" or "swap" with peers to solve problems. The teacher controls level of difficulty and to avoid students guessing, both time taken to complete various challenges and number of moves made are recorded by the applications. *Use of Time-Space (B and C above): These Maths learning activities take place "out-of-class" but nevertheless in a structured, teacher-mediated setting and are organised within fixed schedule of school temporal parameters. Use of Time-Space: fixed/scheduled/formal.*
D	Buhagiar, Montebello, and Camilleri (2010) *Augmented learning in an Art Museum*	Learners use an augmented reality application on their mobile devices that reacts to a user's location in the display area of an Art gallery. Students' augmented view consists of virtual information on their device screens, superimposed over the "real" object they are focused on. *This learning activity takes place in an informal, albeit bounded setting but organised to a relatively unfixed schedule and pacing. Use of Time-Space: "In Between" fixed/scheduled/formal* and *malleable/negotiated/informal.*
E	Gwee, Chee, and Tan (2010) *Games-based m-learning*	Year 9 social studies students studying governorship using the game *Statecraft X* on their iPhones. In this multi-layer strategy game, students and teachers get involved in multiple role-play scenarios that "move" from the real world to the game world. Other integral activities included online forums, reflective blogs, debates and whole-class discussions. *This learning activity takes place in a hybrid of formal (school) and informal settings and is organised to a relatively unfixed schedule and pacing. Use of Time-Space: malleable/negotiated/informal.*
F	Ng'ambi et al. (2010) *Podcasts of lectures*	Recording device was used for lecture casting to an existing institutional LMS. Students download resources, including podcasts to low cost playback devices (MP3 players and/or mobile phones). Queries that arose from listening to podcasts were sent as SMS to an anonymous Q&A tool within the LMS. *This learning activity takes place in an informal setting to a relatively unfixed schedule and pacing. Use of Time-Space: malleable/negotiated/informal.*

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Table 5. Ratings for each of the sample m-learning scenarios (described above in Table 4).

	Scenarios					
Scales Sub-scales	A *Use of Twitter at a conference*	B *Geometry in the field*	C *Fractions phone "apps"*	D *Augmented learning in an Art Museum*	E *Games-based m-learning*	F *Podcasts of lectures*
Personalisation						
Agency	Low	Low	Low	Low	High	Low
Customisation	Medium	Low	Low	Medium	High	Low
Authenticity						
Contextualisation	High	Low	Low	Medium	Medium	Low
Situatedness	High	Low	Low	Medium	Low	Low
Collaboration						
Conversation	High	Medium	Medium	Low	High	Low
Data sharing	High	Medium	Medium	Low	High	Medium

school-based tasks restrained by curriculum and learning space constraints, the podcast and Maths examples lacked agency and customisation.

The analysis highlighted a marked difference in the nature of *collaboration* in these scenarios. Scenarios such as the augmented reality application in the museum and the podcast activity were solitary activities that lacked social interactivity. Only the Twitter and Games scenarios (A and E) rated highly on these scales, due to the large network involved in the conference "Twitterverse" (including "lurker" colleagues in cyberspace) and the multi-player nature of the game. These two m-learning experiences also elicited in-depth conversations in supplementary activities. Given the text constraints of Twitter, the face-to-face and virtual conversations elicited from the Twitter display became a crucial part of the experience, at least from the perspective of the delegates present "live" at the conference. The face-to-face and virtual group activities structured by the social studies teachers enhanced collaboration for students during and after the game scenario (e.g. blogs, classroom-based discussions and role-plays). Indeed, a point of interest is the way that teachers used hybrid, integrated approaches (Dillenbourg 2006) to enhance pedagogically "weaker aspects" of these m-learning scenarios. For example, the supplementary, post-activity face-to-face class discussions used by teachers in the Maths and games examples elicits further learning conversations.

Use of the framework to interrogate m-learning scenarios identified a potential problem with collaboration and authenticity in augmented reality scenarios in informal settings such as museums and science centres. Cook (2010) addresses the problem of collaboration in a similar location-based, augmented learning museum activity by supplementing this experience with students working in pairs. Students were also asked to create a collaborative video blog emerging from their discussions in the museum. These activities initiated further collaboration through both the collaborative nature of the video blog production and also the stimulus it provided for further verbal and blog-based conversation. Laine et al. (2009) describe a similar system called *LieksaMyst* that enhances the authenticity of the museum experience by creating a role-play scenario whereby users interact with the museum artefacts (focused on Finland's history and culture). Authentic, albeit fictional, characters are

introduced through the system through a "story-based, role-play game" and users interact with these characters through the device. Although this is done through the technology in this example, role-play could be introduced as a face-to-face teaching strategy to enhance the authenticity of these museum-based m-learning scenarios.

In summary, the framework provides a renewed focus on important aspects of socio-cultural theory for educators and researchers working in and examining m-learning contexts. Use of our current framework as a lens to analyse more than 30 scenarios from recent m-learning literature suggested to us that it was finally scalable for examining and critiquing the pedagogical impact of a wide range of m-learning contexts. Some scenarios typically promoted in a positive light in this recent literature base did not necessarily rate highly in our three scales. For example, while listening to instructional podcasts on public transport may sound novel in terms of the informal context and control of task pacing, under closer inspection it mimics a transmission pedagogy with its roots in didactic teaching traditions of formal learning settings. A second use of the framework is as a guide for practitioners to interrogate their own m-learning designs. We recently examined our students' use of hand-held devices to complete class-based polls. Although the task elicited rich learning conversations and involved some networking activity, it was a relatively contrived, structured task with minimal flexibility. The insights gained from the use of the framework contributed to development and enhancement of our practice. These contributions arise from using the framework to make the relationships among elements of the learning explicit. In this way, the framework also serves as a developmental tool by focusing on the essential constructs of learning from a socio-cultural perspective. Importantly, the framework itself will continue to be revised and refined to enable it to represent the many varied manifestations of m-learning.

7. Conclusion

A succinct framework highlighting distinctive, current socio-cultural features of mobile pedagogy has emerged from our design and development procedures, leveraged by our project activities. Three constructs characterising the pedagogy of m-learning have emerged: *authenticity, collaboration and personalisation*. The authenticity feature highlights opportunities for contextualised, participatory, situated learning; the collaboration feature captures the often-reported conversational, connected aspects of m-learning while the personalisation feature has strong implications for ownership, agency and autonomous learning. How learners ultimately experience these distinctive characteristics is strongly influenced by the organisation of spatial and temporal aspects of the m-learning environment, including face-to-face and virtual teaching strategies. The framework discussed in this paper is by no means prescriptive – while such a pedagogical framework provides a spotlight to illuminate and examine m-learning experiences, account still needs to be taken of learners' specific characteristics and needs, the environments in which the learning could potentially take place and the preferences and characteristics of teachers, including their epistemological beliefs. Teacher roles and the learning task design are further crucial factors.

This paper did not set out to examine causal links between the use of "time-space" and m-learning experiences. However, we do advocate a need for researchers to explore in more detail the time-space continuum and how it might be organised to optimise learning mediated by mobile technologies. Central to the idea of m-learning is that learning contexts can be generated by students; occurring in different places

and at different times and not confined to formal learning settings in institutions. Informal learning environments characterised by fluid geographical boundaries and malleable, socially negotiated time frames need further investigation with these goals in mind. A framework specifying critical attributes of m-learning experiences provides a useful lens for this research agenda. As mobile technologies develop, our challenge as educational researchers is to probe new pedagogical opportunities that honour principles of authentic, collaborative, personalised learning, drawing on well-researched socio-cultural tenets. The framework presented in this paper will also assist practitioners' understanding and analysis of unique teaching challenges in emerging m-learning environments and facilitate critical insights supporting their design of m-learning experiences and resources.

References

Barab, S. A., Squire, K. D. & Dueber, W. (2000) 'A co-evolutionary model for supporting the emergence of authenticity', *Educational Technology Research and Development*, vol. 48, no. 2, pp. 37–62.

Brown, E. (2010) 'Introduction to location-based mobile learning', in *Education in the wild: contextual and location-based mobile learning in action*, ed. E. Brown, Learning Sciences Research Institute, University of Nottingham, UK, pp. 7–9.

Buhagiar, A., Montebello, M. & Camilleri, V. (2010) 'Mobile augmented reality in an arts museum', in *Proceedings of mlearn2010: 10th world conference on mobile and contextual learning*, eds M. Montebello, V. Camilleri & A. Dingli, University of Malta, Valetta, pp. 395–397.

Cook, J. (2010) 'Mobile phones as mediating tools within augmented contexts for development', in *Education in the wild: contextual and location-based mobile learning in action*, ed. E. Brown, Learning Sciences Research Institute, University of Nottingham, UK, pp. 23–26.

CTGV (Cognition and Technology Group at Vanderbilt). (1990) 'Technology and the design of generative learning environments', *Educational Technology,* vol. 31, no. 5, pp. 34–40.

Danaher, P., Gururajan, R. & Hafeez-Baig, A. (2009) 'Transforming the practice of mobile learning: promoting pedagogical innovation through educational principles and strategies that work', in *Innovative mobile learning: Techniques and technologies*, eds H. Ryu & D. Parsons, IGI Global, Hershey, pp. 21–46.

Dillenbourg, P. (2006) 'Orchestrating integrated learning scenarios', in *Proceedings of the 23rd annual conference of the Australasian society for computers in learning in tertiary education: who's learning? whose technology?* eds L. Markauskaite, P. Goodyear & P. Reimann, Sydney University Press, Sydney, pp. 955.

Ebner, M. (2009) 'Introducing live microblogging: how single presentations can be enhanced by the mass', *Journal of Research in Innovative Teaching*, vol. 2, no. 1, pp. 91–100.

Ghaye, A. & Ghaye, K. (1998) *Teaching and learning through critically reflective practice*. David Fulton, London.

Gwee, S., Chee, Y. & Tan, E. (2010) 'Game play time and learning outcomes of boys and girls in a social studies mobile game-based learning curriculum', in *Proceedings of mlearn2010: 10th world conference on mobile and contextual learning,* eds M. Montebello, V. Camilleri & A. Dingli, MaltUniversity of Malta, Valetta, pp. 16–23.

Kearney, M., Schuck, S. & Burden, K. (2010) 'Locating mobile learning in the third space', in *Proceedings of mlearn2010: 10th world conference on mobile and contextual learning,* eds M. Montebello, V. Camilleri & A. Dingli, University of Malta, Valetta, pp. 108–115.

Kemmis, S. & McTaggart, R. (1988) *The action research planner*. Deakin University Press, Victoria.

Klopfer, E., Squire, K. & Jenkins, H. (2002) 'Environmental detectives: PDAs as a window into a virtual simulated world', in *Proceedings of IEEE international workshop on wireless and mobile technologies in education,* IEEE Computer Society, Vaxjo, Sweden: pp. 95–98.

Koole, M. L. (2009) 'A model for framing mobile learning', in *Empowering learners and educators with mobile learning*, ed M. Ally, Athabasca University Press, Athabasca, Canada, pp. 25–47.

Laurillard, D. (2007) 'Pedagogical forms of mobile learning: framing research questions', in *Mobile learning: Towards a research agenda,* ed N. Pachler, WLE Centre, Institute of Education, London, 153–176.

Laine, T., et al. (2009) 'Characteristics of pervasive learning environments in museum contexts', in *Proceedings of 8th world conference on mobile and contextual learning,* eds D. Metcalf, A. Hamilton & C. Graffeo, University of Central Florida, Orlando, pp. 26–34.

Ling, R. & Donner, J. (2009) *Mobile communications.* Polity, London.

Luckin, R. (2010) *Re-designing learning contexts.* Routledge, London.

McLoughlin, C. & Lee, M. (2008) 'The 3 P's of pedagogy for the networked society: personalization, participation, and productivity', *International Journal of Teaching and Learning in Higher Education*, vol. 20, no. 1, pp. 10–27.

Naismith, L., et al. (2004) 'Report 11: literature review of mobile technologies in Learning', *Futurelab series*, [online] Available at: http://archive.futurelab.org.uk/resources/publications-reports-articles/literature-reviews?custom:filteryear=2004

Ng'ambi, D., et al. (2010) 'Podcasting for mobile learners: using ubiquitous technologies to enhance learning in large classes', in *Proceedings of mlearn2010: 10th world conference on mobile and contextual learning*, eds M. Montebello, V. Camilleri & A. Dingli, University of Malta, Valetta, pp. 256–262.

Pachler, N., Cook, J. & Bachmair, B. (2010) 'Appropriation of mobile cultural resources for learning', *International Journal of Mobile and Blended Learning*, vol. 2, no. 1, pp. 1–21.

Pachler, N., Bachmair, B. & Cook, J. (2009) *Mobile learning: structures, agency, practices.* Springer, New York.

Parsons, D., Ryu, H. & Cranshaw, M. (2007) 'A design requirements framework for mobile learning environments', *Journal of Computers*, vol. 2, no. 4, pp. 1–8.

Pintrich, P. & Schunk, D. (1996) *Motivation in education: theory, research, and application*. Merrill, Upper Saddle River, NJ.

Radinsky, J. et al. (2001) 'Mutual benefit partnership: a curricular design for authenticity', *Journal of Curriculum Studies*, vol. 33, no. 4, pp. 405–430.

Schuck, S., et al. (2010) 'Mobagogy: mobile learning for a higher education community', in *Proceedings of the IADIS mobile learning, 2010 conference,* eds I. Sánchez & P. Isaías, IADIS Press, Porto, Portugal, pp. 69–76.

Sharples, M., Taylor, J. & Vavoula, G. (2007) 'A theory of learning for the mobile age', in *The SAGE handbook of e-learning research,* eds R. Andrews & C. Haythornthwaite, Sage, London, pp. 221–224.

Sundmaeker, H., et al. (2010) *Vision and challenges for realising the Internet of Things.* CERP-IoT, European Commission, Luxembourg.

Tangney, B., et al. (2010) 'MobiMaths: an approach to utilising smartphones in teaching mathematics', in *Proceedings of mlearn2010: 10th world conference on mobile and contextual learning,* eds M. Montebello, V. Camilleri & A. Dingli, University of Malta, Valetta, pp. 9–15.

Traxler, J. (2007) 'Current state of mobile learning', *International Review on Research in Open and Distance learning*, vol. 8, no. 2, pp. 1–10.

Traxler, J. (2009) 'Learning in a mobile age', *International Journal of Mobile and Blended Learning*, vol. 1, no. 1, pp. 1–12.

Traxler, J. (2010) 'The 'learner experience' of mobiles, mobility and connectedness', *Background paper to presentation ELESIG Symposium*: *Digital Futures,* 21 Jan iLab, Innovation Works, University of Reading, [online] Available at: http://cloudworks.ac.uk/cloud/view/3472

Trudge, J. (1990) 'Vygotsky, the zone of proximal development and peer collaboration: implications for classroom practice', in *Vygotsky and education: Instructional implications and applications of sociohistorical psychology,* ed. L. Moll. London: Cambridge University Press, New York, pp. 155–172.

Vavoula, G. & Sharples, M. (2009) 'Meeting the challenges in evaluating mobile learning: a 3-level evaluation framework', *International Journal of Mobile and Blended Learning*, vol. 1, no. 2, pp. 54–75.

Vygotsky, L. S. (1978) *Mind in society.* MIT Press, Cambridge, MA

Wertsch, J. V. (1991) *Voices of the mind: a socio-cultural approach to mediated action*. Harvard University Press, Cambridge, MA.

Willis, J. (2000) 'The maturing of constructivist instructional design: some basic principles that can guide practice', *Educational Technology*, vol. 40, no. 1, pp. 5–16.