Mobile VLE vs. Mobile PLE: How Informal is Mobile Learning?

Wen Pin Chen, David E. Millard, Gary B. Wills
Learning Societies Lab, School of Electronics and Computer Science,
University of Southampton, Southampton, UK
{wpc07r,dem,gbw}@ecs.soton.ac.uk

ABSTRACT
Mobile Learning Systems are often described as supporting informal learning; as such they are a good fit to the idea of Personal Learning Environments (PLEs), software systems that users choose and tailor to fit their own learning preferences. This paper explores the question of whether existing m-learning research is more in the spirit of PLEs or Virtual Learning Environments (VLEs). To do this we survey the mobile learning systems presented at M-Learn 2007 in order to see if they might be regarded as informal or formal learning. In order to categorise the systems we present a four dimensional framework of formality, based on Learning Objective, Learning Environment, Learning Activity and Learning Tools. We use the framework to show that mobile systems tend to be informal in terms of their environment, but ignore the other factors. Thus we can conclude that despite the claims of m-learning systems to better support informal and personal learning, today's m-learning research is actually more in the spirit of a VLE than a PLE, and that there remains a great deal of unexplored ground in the area of Mobile PLE systems.

Author Keywords

Informal Learning, Personal Learning Environments, Virtual Learning Environments

INTRODUCTION

In e-learning we are used to talking about systems that manage the teaching/learning experience, for example, Intelligent Tutoring Systems (ITS) that modify or personalize that experience (Graesser and van Lehn et al. 2001) , and Virtual Learning Environments (VLEs) that act as common space for teachers and their students to share resources and communicate with one another. For example, Moodle and Blackboard are VLEs that provide educators with online learning resources structured into courses and activities, teachers can interact with the learners through tools such as discussion forums and email, and set simple online assessments and tasks[1].

Since 2000 we have also seen the emergence of Personal Learning Environments (PLEs). These are an alternative to the VLE approach where students are given back the control of their learning space (van Harmelen 2006), in a PLE the student can manage their own learning experience, for example by managing their time, helping to organise learning goals and activities, and collating reference material. For example, PLEX - a software system that provides a learning space where the learner can organize their learning activity and monitor their learning processes towards desired learning outcomes by revising their learning plans as needed.

A few differences between VLEs and PLEs have been argued. The main difference is that in a VLE the learning resources and learning objectives are more in the control of the institutions rather than the learner themselves (PLEs). We would argue that a VLE is more like an administration or management environment rather than a learning environment. In PLEs students have more flexibility on the control of their learning experience.

In the last few years a debate has started about which of these approaches suites a new generation of tech savvy teenagers (sometimes called Generation Y, or Millennials), this new generation has been stereotyped as Digital Natives (Prensky, 2001) – people who are at home online and come to an educational institution with their own set of digital tools already in place (for example, email, social groups and web presence). More recent reports have suggested that the change is less extreme than this and more balanced across the population as a whole (Rowlands, Nicholas et al. 2008) but nevertheless it seems that modern Web 2.0 style tools and applications have changed students' expectations of what their learning environments should provide.

This should be good news for m-learning systems, which are often described as supporting informal learning (Sharples 2002). This is because mobile systems seem to be in the control of the student rather than the teacher, for example they may be accessed and used at a time of the student's choosing, and may even run on the student's personal device (such as

[1] Moodle (www.moodle.org) and Blackboard (www.blackboard.com)

a mobile phone, or digital music player). On the surface then, m-learning systems are more like a PLE than a VLE, and therefore will be more appealing to the changing needs of new students.

However the term informal learning can be used in a variety of ways, with subtle differences in meaning, and it is unclear to what extent we might describe m-learning systems and applications as supporting informal learning.

In this paper we analyse the mobile systems that were amongst the presentations from M-Learn 2007 (a total of 17 systems from 40 papers) in order to give a clear picture of whether most mobile systems really do support informal learning, and thus whether they are in the spirit of PLEs or VLEs. To do this we have had to create a model of informal e-learning that is detailed enough to differentiate between different types of formality. Our goal is to assess to what extent m-learning systems have embraced the PLE ideal, and to give a framework within which future advances might be evaluated.

The paper is structured as follows: *Background* describes related work on informal and formal learning and places this within the m-learning domain. *The 4D Model of Formal Learning* presents our framework, explains the dimensions we use to assess a given system and gives some examples. The *Review of M-Learn 2007 Systems* places each of the 17 systems presented at last years M-Learn conference into our model in order to assess how formal or informal they are. *Analysis and Discussion* presents an analysis of the results in order to reveal trends within the review, and finally *Conclusion and Future Work* summarises our findings and suggests future directions.

BACKGROUND

With the swift advance of Information technology, learning is no longer confined in a specific location, it could be *'beyond the classroom'* (Bentley 1998) and *'informal and incidental learning in the workplace'* (Marsick and Watkins 1990) and (Dale and Bell 1999). Mobile devices have the potential to make learning more diverse and interesting (Sharples 2002). Learning theory is an attempt to understand the processes and factors involved in learning, four different orientations of learning have been identified: behaviour, cognitive, humanistic and the social/situational (Smith 1999; Merriam and Caffarella 1991). In general, learning includes formal learning, non-formal learning, informal learning, in terms of their characteristics of learning environment and context (Jeffs and Smith 1990).

Knowles (1975) identified informal learning with self-directed learning, he included five steps: 'To diagnose their learning needs, formulate learning goals, identify resources for learning, select and carry out learning strategies, and estimate learning outcomes'.

Others believe that the self-direction extends to the learners environment, McGivney states that informal learning is learning outside a dedicated learning system, non-curriculum-based learning activities and planned and structured learning (McGivney 1999). '*In intentional formal learning, the goals and the process of learning are explicitly defined by a teacher or by an institution. In intentional, informal learning, the goals and the process are explicitly defined by the learner*' (Vavoula 2004).

Other views that have been expressed include Dale and Bell (1999) who claim that informal learning depends on the work context, and emerges from the experiences of the learner, for example by practicing skills, and Eraut (2000) who links formal learning to accreditation and qualifications.

The difficulty with these existing models of formal and informal learning is that each comes from a different perspective, where they value certain types of informality more than others, for example learning direction over learning location. Thus what is informal to one model could be formal to another.

What is needed is a framework for understanding how these perspectives relate to one another, to help solve this problem we present a 4D Model of Formal Learning, which explicitly considers a number of different dimensions.

4D MODEL OF FORMAL LEARNING

We have based our dimensions on typical "who, what, when, where, why, how" questions; as such we are considering the learning experience as a whole, rather than looking solely at the system. For example, this means that the same system can be more or less informal depending on *how* and *when* it is being used. Figure 1 shows how these six questions form four dimensions (and also how they are sometimes grouped together into higher-level terms such as *context).*

We have simplified the six questions down to four dimensions by considering Environment (Where and When) and Activity (What and Who) as two rather than four criteria. We have done this for two reasons: firstly, this is the level at which they are commonly described in the literature where *environment* and *activity* are well understood terms; secondly it simplifies the classification and enables effective presentation of the results and thus making it easier to analyse.

Our four dimensions are as follows:

- Learning Objective (the goal of the activity - *Why* is the student doing this activity?)
- Learning Environment (the place and time of the activity - *Where* is the learning activity happening and *When* is it happening?)
- Learning Activity (the activity itself - *What* is it that the student is going to actually do, and *Who* are they doing it with?)

- Learning Tools (the tools used to do the activity - *How* are they going to undertake the activity?)

<table>
<tr><th>Question</th><th>Dimension</th><th>Higher level</th></tr>
<tr><td>Where</td><td rowspan="2">Learning Environment</td><td rowspan="4">Context</td></tr>
<tr><td>When</td></tr>
<tr><td>What</td><td rowspan="2">Learning Activity</td></tr>
<tr><td>Who</td></tr>
<tr><td>How</td><td>Learning Tools</td><td rowspan="2"></td></tr>
<tr><td>Why</td><td>Learning Objective</td></tr>
</table>

Figure 1: Relationship of *Key Questions* to *Dimensions* to *Higher-Level Terms*.

When placing a given m-learning experience in the framework we say that for each dimension a system is either *student-led, teacher-led,* or *negotiated* (meaning that both student and teacher had some say). This gives us three classifications on each of the four dimension, and thus allows is to potentially distinguish between 81 different types of formality and informality. We capture this in shorthand using S, N or T for each dimension in turn (Student, Negotiated, Teacher). So for example we might say that an experience in which all four dimensions are controlled by the teacher is TTTT, but one in which the Learning Environment is controlled by the student is TSTT.

The 4D Model allows us to step back slightly from disagreements about what constitutes formal learning, it shows that one's opinion of formal learning will change according to which of the four dimensions one holds most valuable. This is how different commentators can draw different conclusions about the formality of the same learning experience.

Example: A School Nature Fieldtrip

To demonstrate our 4D model consider the following scenario:

> *"Clare is using a PDA to record observations that she is making on a school nature fieldtrip. Clare's teacher has asked her to write descriptions of the wildlife that she sees in order to understand more about the food chain. The teacher has asked Clare to use a special journal application on her PDA to write her observations, which then synchronises to a central server so that Clare can access them at a later time."*

Using our 4D model we would classify this m-learning experience as TNTT:

- **Learning Objective** – Set by Teacher (to understand more about the food chain)
- **Learning Environment** – Negotiated (fieldtrip is at a set time and place, but Clare is free to move about within the area as she likes)
- **Learning Activity** – Set by Teacher (to record observations in a journal)
- **Learning Tools** – Set by Teacher (Clare must use the special journal application on the PDA)

We can imagine that small changes could affect the formality of this scenario in different ways, for example the teacher could have let Clare choose the way in which she records observations (informal tools), or could have asked her to come up with her own way of exploring the food chain (informal activity). Another possibility is that Clare could have been asked to come to this type of environment in her own time, in order to undertake the project as a piece of homework (informal environment). If all these changes were made it would radically change the scenario from TNTT to TSSS.

REVIEW OF M-LEARN 2007 SYSTEMS

We went through the proceedings of M-Learn 2007 and placed each of the systems we found into our 4D model of formality. There were forty papers accepted to the conference, but only 17 mobile experiences described (as many of the papers referred to theory, or were themselves reviews or analyses). We do not claim that these 17 systems are representative of mobile learning as a whole, as they describe novel systems, often deployed in experiments or trails (rather than an extended deployment in a real environment). However they are representative of the efforts of the m-learning research community, and indicate the extent of research interest in formal or informal m-learning systems.

The Systems

These systems and experiences are categorized in terms of their general type (e.g. fieldtrip support, or assessment). Several of the systems come from the same paper.

Collaborative learning environment

MOULE system (Arrigo, Giuseppe et al. 2007), *Mobile Jigsaw project* (Thompson and Stewart 2007), *Theory and practice of mobile learning in school project* (Hartnell-Young 2007), *MyArtSpaces system* (Sharples, Lonsdale et al. 2007), *Mobile Blogging* (Cochrane 2007), *StudentPartner system* (Hwang, Hsu et al. 2007), *Mobile Group Blog to support Cultural Learning* (Shao, Crook et al. 2007). All of these aimed to provide students with an interactive learning environment by means of use of social software and mobile functionality such as GPS.

Remote control environment

Remote Laboratory system (Mittal and Gupta 2007) and *Mobile Engineering Laboratory Application* (Mittal, Pande et al. 2007). These systems use a mobile device to control and supervise a remote laboratory.

Language Training

ESL system (Ally, Schafer et al. 2007) and *Mobile phones for language learning project* (Cooney and Keogh 2007) both aim to help the people improve their language ability. The former focused on English grammar and the latter concentrated on listening, speaking, reading and writing of the Irish language.

Assessment

Examination system (So 2007) aimed to assess learners using mobile devices, *MOBI system* (Matthee and Liebenberg 2007) enables formative assessment for Maths on mobile device, and *15/16 Game system* (So 2007) was to test students by means of interaction with other people.

Lifelong learning

Adapt-VLE system (Elson, Reynold et al. 2007) is used to train learners about changes of medical information, and *Museum visiting* (Bressler and Kahr-Hojland 2007) was a spontaneous visiting application (without the requirement of a structured fieldtrip).

Feedback

Voting system was devised (So 2007) to allow students to use their mobile devices to vote on a topic or subject.

Catagorising the Systems according to the 4D Model

System / project	Context				
	LO	**Env'**	**Act**	**Tool**	**Grp**
Voting system (So 2007)	T	T	T	T	**1**
15/16 Game system (So 2007)	T	T	T	T	
MOULE system (Arrigo, Giuseppe et al. 2007)	T	N	T	T	**2**
Mobile phone for language learning (Cooney and Keogh 2007)	T	N	T	T	
Theory and practice of mobile learning in school (Hartnell-Young 2007)	T	N	T	T	
Examination system (So 2007)	T	N	T	T	
Mobile Group Blog to support Cultural Learning (Shao, Crook et al. 2007)	T	S	T	T	**3**
Mobile Jigsaw project (Thompson and Stewart 2007)	T	S	T	T	
Remote Laboratory system (Mittal and Gupta 2007)	T	S	T	T	
ADAPT-VLE system (Elson, Reynold et al. 2007)	T	S	T	T	
Mobile Engineering Laboratory Application (Mittal, Pande et al. 2007)	T	S	T	T	
MOBI system (Matthee and Liebenberg 2007)	T	S	S	T	**4**
Student partner system (Hwang, Hsu et al. 2007)	T	S	S	T	
MyArtSpace system (Sharples, Lonsdale et al. 2007)	T	S	S	T	
ESL project (Ally, Schafer et al. 2007)	S	S	T	T	**5**
Museum visiting (Bressler and Kahr-Hojland 2007)	S	S	S	S	**6**
Mobile Blogging (Cochrane 2007)	S	S	S	S	

Table 1.Systems/projects within the mlearn2007 conference papers

We have used our 4D model to categorise these 17 systems. The results are shown in Table 1 above. We have grouped systems which have the same 4D profile. There are six groups covering the whole table, and we have arranged them so that the most formal group is at the top and the least formal is at the bottom. Student led values are shown in light grey.

Examples of a System in Each Group

Due to space limitations, rather than explain the categorization of all 17 systems, we have chosen instead to describe one system from each group. In each description we have indicated the places the description matches the 4D Model using the simple notion of LO/Env/Act/Tool followed by T/N/S. So for example, we might say "The student uses their PDA on a fieldtrip (**Env:N**)" to indicate that because it is a fieldtrip the *Environment* dimension is *Negotiated*.

Group 1 (TTTT)

15/16 Game System - Students are asked to use a WAP browser on their mobile phones (**Tool:T**) in the classroom (**Env:T**), to participate in a class game called 15/16. The teacher asks a question (**LO:T**) and the students can choose from a multiple choice answer (**Act:T**), the teacher (or another student) then tries to convince the students to change their minds, by giving a plausible explanation for one of the answers (whether it is right or wrong). The Mobile phones send the students answers and any changes to a server, and the teacher can show this to the class to show the number of students who got it right, and those that changed their minds.

Group 2 (TNTT)

MOULE – is a system that allows students to collaborate through a Moodle-type portal in order to communicate and share resources. For example, a lecturer wishes to teach her students about the architecture in a particular square (**LO:T**), she sets up an activity in Moodle that asks students to make notes about particular points of interest (poi) (**Act:T**). A student visits the square and is free to explore the space, and find the poi that have been described (**Env:N**). Once the poi has been found, the student can take a photo using the built in MOULE toolkit (**Tool:T**). One interested twist with this system is that students back in class (**Env:T**) can collaborate with the the students in the field (**Env:N**). Thus MOULE can be used (at least partially) in an informal way (TNTT), but for the student in the classroom it is a more formal experience (TTTT).

Group 3 (TSTT)

Mobile Jigsaw Project – used mobile devices as an enabler for group work. Teachers chose an issue in the children's local area (**LO:T**), and created small groups of children who were given a number of devices with preloaded software, such as digital cameras, and a tablet PC (**Tool:T**). The children then plan their own fieldtrip (**Env:S**), and visit the environment where they work as a team to gather evidence in order to ask science-based questions back at the classroom (**Act:T**).

Group 4 (TSST)

MOBI System – Students use a bespoke MOBI client (**Tool:T**) on their PDAs to access a wide variety of Activities concerned with Maths (**LO:T**). Students can choose which activities they feel might be useful to them (**Act:S**), and undertake those activities whenever and wherever they like (**Env:S**).

Group 5 (SSTT)

ESL Project – uploaded a wide range of grammar exercises to a student's mobile device. At a time or place of their choosing (**Env:S**), the student could choose to test or expand any part of their knowledge of grammar (**LO:S**). They would then take an appropriate pre-loaded exercise (**Act:T**) using a browser on their mobile device (**Tools:T**).

Group 6 (SSSS)

Mobile Blogging – gave an overview of how blogs might be accessed, written and used on a mobile device. In the given scenario a student accesses the blog throughout their day (**Env:S**) on whatever device they have available using a variety of browsers (**Tool:S**), the blog offers them general functionality, allowing them to explore items of interest with their friends (**LO:S**), and supports a wide range of activities such as journaling, mircoblogging, discussion, comments, etc. (**Act: S**).

ANALYSIS AND DISCUSSION

We undertook this study expecting to see that Mobile Devices support informal learning across the 4D Model, however it is clear from our analysis that while the majority of mobile applications have an informal environment (ether where or when the student can use the tool), relatively few are informal in other ways.

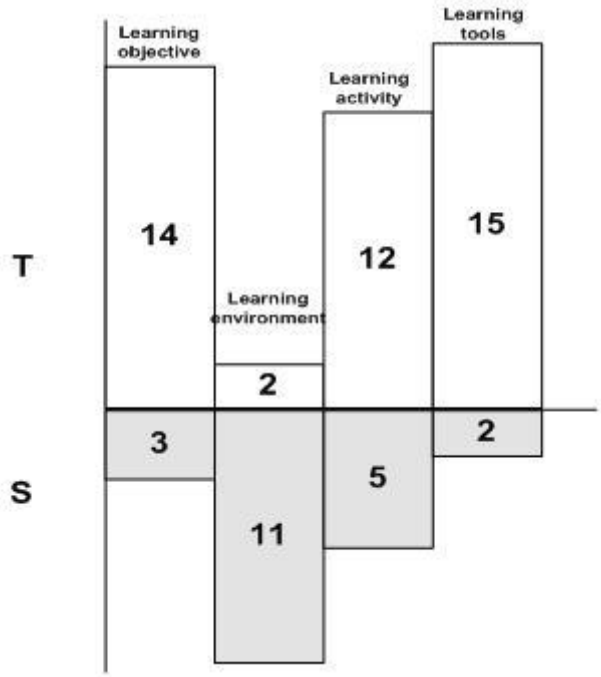

Figure 2. The ratio of T and S for each Dimension

Figure 2 shows the ratio of Teacher-Led to Student-Led in each of the four dimensions (negotiated is not shown in the figure). It clearly shows that Informal Environments are far more frequently supported than Informal Objectives, Activities or Tools.

Partly this may be because our sample was from research papers, where authors are often describing trials of particular tools (so for example, we would expect to see fewer choices for participants regarding which tool they could use). However, it could also be argued that while the data reflects the methods of experiments, it is still valid in that it tells us that there are few mobile experiments being conducted where users *do* have a choice of tools. In effect, while mobile learning claims to be conducive to informal learning – only a very restricted type of informality is currently being explored by the research community.

Figure 3 compiles the data from Table 1 into a matrix that shows the four dimensions (a 3x3 grid of 3x3 grids). We have shaded each cell of the matrix to reflect the overall level of informality of that cell, the darker the cell the more informal it is (so TTTT is white, SSSS is almost black, and TTSS and SSTT are the same shade of grey. The number of systems in a given cell is shown in a white circle over that cell. In effect this diagram shows a map of informality in the surveyed systems. From this diagram it is clear that whole areas of possibility are not being explored, in particular *Negotiated Learning Objectives* (such as placement study), *and Informal Learning Objectives* in *Formal Settings* (such as project work in school).

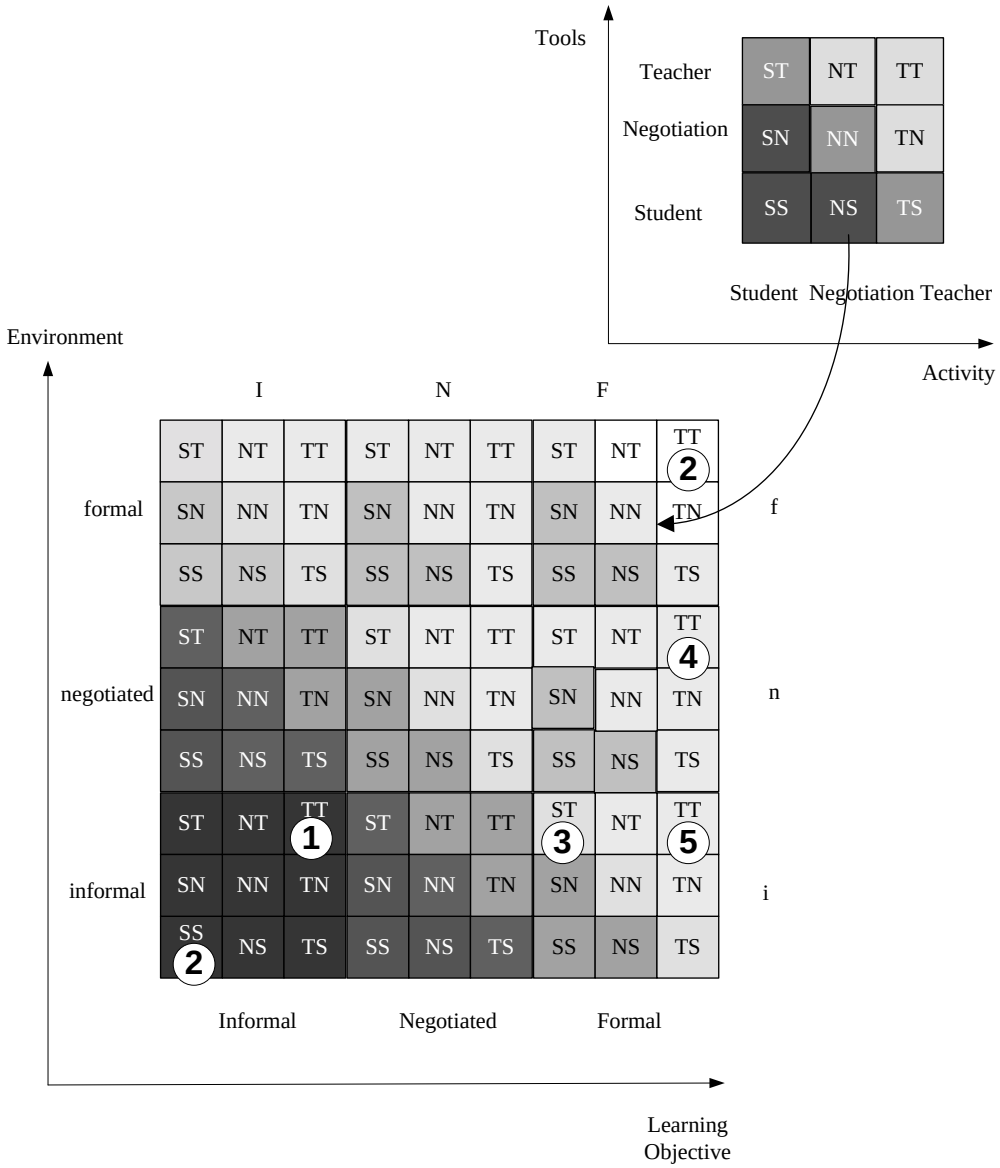

Figure 3: The Landscape of Informality in Our Study

As a whole, our study shows that in mobile learning research systems, teachers are more likely to take control of learning objectives, activities and tools but less likely to control the student's environment. This seems to be because mobile learning research focuses on the geographic mobility of devices (rather than their ubiquity, or any sense of student ownership and thus potential control).

CONCLUSION

In this paper, we set out to explore whether m-learning systems and applications tended to be in the style of Virtual Learning Environments (VLEs) or Personal Learning Environments (PLEs). We concluded that the major factor was the formality of the learning, as PLEs support a range of informal activities, but VLEs tend to support more traditional formal activities.

To undertake an analysis of systems presented at m-learn 2007, we first had to come up with a framework for formal and informal learning, which would allow us to distinguish between the different types of formality. We have thus presented the *4D model of formal learning*, which looks at four factors within an experience to see if they are student or teacher led (Learning Objective, Learning Environment, Learning Activity and Learning Tools).

We characterised each of the 17 systems presented in m-learn 2007 using our framework and have discovered that while most are informal in terms of their environment (where and when they can be used), most are formal in all the other terms – so for example, students rarely get to choose their own learning objectives or the methods that they will use to achieve them.

It therefore seems that although m-learning applications seem well placed to become part of a student's PLE, little research is being undertaken to understand how they could be used in this way. In essence m-learning researchers are reinventing the VLE on the mobile device, rather than looking at how we could use them to support more subtle aspects of informal learning, and thus the increasingly important PLE area.

REFERENCES

Ally, M., Schafer, S., et al. (2007). Use of Mobile Learing Technology to Train ESL Adults. Melbourne Australia.

Arrigo, M., Giuseppe, O.D., et al. (2007). A COLLABORATIVE MLEARNING ENVIRONMENT. the 6th international conference on mobile Learning. Melbourne Australia.

Bentley, T. (1998) *Learning beyond the Classroom: Education for a changing world*, London: Routledge.

Bressler, D. and Kahr-Hojland, A. (2007). Learning Informal Science with the Aid of Mobile Phones: A Comparison of Two Case Studies. the 6th international conference on mobile Learning. Melbourne Australia.

Cochrane, T. (2007). Mobile Blogging: A Guide for Educators. the 6th international conference on mobile Learning. Melbourne Australia.

Cooney, G. and Keogh, K. A. (2007). Use of Mobile Phones for Language Learning and Assessment for Learning, a Pilot Project. the 6th international conference on mobile Learning. Melbourne Australia.

Dale, M. and Bell, J. (1999) Informal Learning in the Workplace. DfEE Research Report 134, London: Department for Education and Employment.

Graesser, A. C., van Lehn, K., et al. (2001). Intelligent Tutoring Systems with Conversational Dialogue, AI Magazine, 22(4):39-51

Elson, B., Reynold, P., et al. (2007). Bluprint for an Adaptive Training - Virtual Learning Environment (ADAPT-VLE) for the Training of Dentists. the 6th international conference on mobile Learning. Melbourne Australia.

Eraut, M. (2000) 'Non-formal learning, implicit learning and tacit knowledge in professional work' in F. Coffield The Necessity of Informal Learning, Bristol: The Policy Press.

Hartnell-Young, E. (2007). Making the Connections: Theory and Practice of Mobile Learning in Schools. the 6th international conference on mobile Learning. Melbourne Australia.

Hwang, W. Y., Hsu, J. L., et al. (2007). A Study on Ubiquitous Computer Supported Collaborative Learning with Hybrid Mobile Discussion Forum. the 6th international conference on mobile Learning. Melbourne Australia.

Jeffs, T. and Smith, M. (1990) (eds.) Using Informal Education, Buckingham: Open University Press.

Knowles, M. Self-Directed Learning: A Guide for Learners and Teachers. New York: Association Press, 1975.

Marsick, V. J. and Watkins, K. E. (1991) Informal and Incidental Learning in the Workplace, London: Routledge.

Matthee, M. and Liebenberg, J. (2007). Mathematics on the Move : Supporting Mathematics Learners through Mobile Technology in South Africa. the 6th international conference on mobile Learning. Melbourne Australia.

Merriam, S. and Caffarella. (1991, 1998) *Learning in Adulthood. A comprehensive guide*, San Francisco: Jossey-Bass.

Mittal, A. and Gupta, C. (2007). A Novel Remote Laboratory Control and Evaluation Framework. the 6th international conference on mobile Learning. Melbourne Australia.

Mittal, A., Pande, A., et al. (2007). Content-based Network Resource Allocation for Mobile Engineering Laboratory Applications. the 6th international conference on mobile Learning. Melbourne Australia.

McGiveney, V. (1999) Informal Learning in the Community. A trigger for change and development,Leicester: NIACE. 99 + xii pages.

Ng, W. and Nicholas, H. (2007). UBIQUITOUS LEARNING WITH HANDHELD COMPUTERS IN SCHOOLS. the 6th international conference on mobile Learning. Melbourne Australia.

Prensky, M. (2001). "Digital Natives, Digital Immigrants". In *On the Horizon, October 2001, 9*(5)NCB University Press.

Rowlands, I., Nicholas, D., et al. (2008) The information behaviour of the researcher of the future

Shao, Y. J., Crook, C., et al. (2007). Designing a Mobile Group Blog to Support Cultural Learning. the 6th international conference on mobile Learning. Melbourne Australia.

Sharples, M. (2002). Disruptive devices: mobile technology for conversational learning.International Journal of Continuing Engineering Education and Life Long Learning,12(5/6), 504-520.

Sharples, M., Lonsdale, P., et al. (2007). An Evaluation of MyArtSpace: a Mobile Learning Service for School Museum Trips. the 6th international conference on mobile Learning. Melbourne Australia.

Smith, M. K. (1999) 'Learning theory', the encyclopedia of informal education, Available on www.infed.org/biblio/b-learn.htm

So, S. (2007). A Study on the Acceptance of mobile Phones For Teaching and Learning with Pre-service Teachers. the 6th international conference on mobile Learning. Melbourne Australia.

Thompson, K. and Stewart, K. (2007). The mobile jigsaw - a collaborative learning strategy for mlearning about the environment. the 6th international conference on mobile Learning. Melbourne Australia.

van Harmelen, M. (2006). Personal Learning Environments. Proceedings of the 6th International Conference on Advanced Learning Technologies (ICALT'06), IEEE.

Vavoula, G. (2004). KLeOS: A knowledge and learning organisation system in support of lifelong learning. PhD Thesis. University of Birmingham, UK.