Mobile Learning: Impacts on Mathematics Education

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"Technology is essential in teaching and learning Mathematics; it influences the Mathematics that is taught and enhances students' learning."

(NCTM, 2002)

Abstract

New learning technologies have brought a series of additional challenges to teachers and educators. Whilst some Schools are moving towards implementing 1:1 technology initiatives and Bring Your Own Device (BYOD) programs, others are supporting classroom learning experiences through the purchase of mobile devices including iPads and tablets. Given the original game-based nature of mobile devices they have over time attracted interest from the educational community, and are used to engage learners in tasks that are quite often open-ended, and involve problem-solving. Through the use of mobile devices learning opportunities are becoming more interactive and can promote collaboration among learners in different ways. Cognitive and affective processes are enhanced through the interactive capacities of devices and applications. By using mobile devices as a tool in the Mathematics classroom, new experiences are provided for both the teacher and student. Technology is rapidly changing how we teach, and how we learn. Therefore, teachers need to be familiar and prepared to support traditional methods of teaching Mathematics with the integration of appropriate and effective uses of technology, which may include mobile devices and applications (Apps).

Mobile learning and associated technologies are being seen widely as becoming increasingly ubiquitous in society, particularly with youth. A body of literature exploring mobile technologies and learning in teacher education contexts is now emerging and being described by many as being "a fairly young area of research".

This paper has emerged from an interest in, and experience with, the use of technology in classrooms. The specific areas of focus to be addressed will centre on summarising developments and terminology; explore emerging practices for learning and teaching; consider possible challenges, limitations and implications for use of mobile learning in classrooms; and, identify possibilities for further research from gaps within the literature. Examples used will relate to the key learning area (KLA) of Mathematics.

1. Introduction

Mobile technologies are fast becoming a familiar part of the lives of many across the globe, and therefore, are forming an integral part of the fabric of society. [21] have identified that mobile devices, including for example cellular phones, smartphones, tablet computers; and, the affordances they allow have already changed the way people and society access and share information, conduct business, and connect with one another.

Researchers often describe mobile technology devices, and their use as being 'increasingly ubiquitous in society, particularly with youth' [7]. [38] states that mobile learning (or m-learning) refers to "any provision where the sole or dominant technology is a handheld or palmtop device". [2] identifies that "technology is of specific importance because it is transforming the very landscape of teaching and learning". No longer are mobile technologies and learning seen as being an isolated activity, but rather, one which is rich in nature, and needing to be explored in terms of the collaborative and collective experiences of individuals including teachers and students.

As described in a [39] working paper which examines the trends in m-learning, using mobile devices has:

> *… not yet had a massive impact on education, but as this Series signals, it is not likely to stay this way. Mobile devices – because of their ubiquity and portability – are positioned to influence teaching and learning in a way personal computers never did.* (p. 14)

Various perceptions related to the use of mobile technologies in learning include those by [19] who identify educators that employ mobile technologies as being "pioneers on a vast new educational frontier". They state that "we are at the forefront of a computing paradigm shift that will change how teachers and students interact with the world of educational connectivity, content, pedagogy and learning" (p. xiv).

2. Mobile Learning Developments related to Mathematics

[4] identifies that for over two decades the potential of digital technologies for Mathematics has been highlighted by stakeholders as having many possibilities. However, its integration into learning still confronts teachers, educators and researchers with many questions. This is supported by [8] who state that "the advent of mobile learning technologies into teaching and learning has brought both new possibilities and challenges to teachers". Researchers [20; 23] describe mobile learning as a technology which is "ubiquitous in nature, wireless, highly portable and endowed with multimedia capabilities bringing a new dimension to curriculum delivery". From two research studies into the integration of information and communication technology (ICT) in Mathematics education, [10] support these findings by identifying that "… digital technologies were becoming ever more ubiquitous and their influence touching most, if not all, education systems".

Whilst in its early stages, research on the use of mobile technology with a particular focus on Mathematics education is rapidly growing as an area of interest. This interest is developing as mobile devices and applications become more easily accessible and popular amongst students. [9] identify the examination of the effectiveness of mobile applications (Apps) as being another emerging area of research. To-date most of the research on Apps has been conducted by large media companies with a focus on marketing and the trial of devices. [17] states that "Applications (Apps) for hand-held devices, such as iPads and smartphones, are in great supply. Many of these focus on Mathematics. A recent search revealed more than 4000 apps for Mathematics education". However, there is limited research in Mathematics education outlining the use of Apps and accompanying pedagogies. With the increase of devices into classrooms and accompanying Apps, teachers and educators need to consider their effectiveness in supporting learning, particularly in relation to Mathematics. In its position statement, the U.S. National Council of Teachers of Mathematics (NCTM) claim that "Technology is an essential tool for learning Mathematics in the 21st century, and all schools must ensure that all their students have access to technology" [27]. According to the 2013 Horizon Report [11]:

> *Mobile devices and apps are increasingly valued as important learning tools in K-12. Apps in particular are the fastest growing dimension of the mobile space in the K-12 sector right now, with impacts on virtually every aspect of informal life, and increasingly, potential in almost every academic discipline.(p.4)*

Like other researchers, [17] has identified "Despite the rapid expansion of the use of apps in the educational domain, there is a lack of empirical studies as to their effectiveness in supporting learning,

particularly in relation to Mathematics". This lack of available research also extends to the uses of Apps by teacher educators in pre-service teacher education programs.

3. Terminology

[14] has identified various terms that are being used interchangeably in relation to the area of mobile learning and technology. As described by [13], this comparatively new terminology includes: mobile computing or mobile learning, which has also been called m-learning, m-teaching, or mobagogy. The terms relate to 'mobility of the technology', and 'increased mobility' in the application of the technology [6].

[25] states that mobile learning, or m-learning, "is part of a new learning landscape created by the availability of technologies" and supporting an education which is flexible, accessible, and personalised. She continues by stating that mobile learning can be viewed as a useful component of the flexible learning model, and where "the learner takes advantage of the learning opportunities offered by mobile technologies". [40] further supports this by stating that "Mobile learning is a part of a new learning landscape and offers the opportunity for a spontaneous, personal, informal, and situated learning. With the use of mobile technology in education, online learning communities can incorporate students from different backgrounds with vastly diverse learning styles into an educational setting".

As [40] describes a "Mobile phone – the recent and innovative technological device which represents a revolution in education gives the opportunity to learn "in motion", making the learning process more appealing, interesting and motivating". No generation is more at ease with online, collaborative technologies than today's young people – "digital natives", who have grown up in an immersive computing environment. Where a notebook and pen may have formed the toolkit of prior generations, today's students come to class armed with smart phones, laptops and iPods. Mobile learning needs to be seen as being an emerging and evolving area of teaching and learning practices. When examining mobile learning it is important to reflect on several questions including:

- What kind of technological devices are being referred to?
- What forms of learning can take place with these devices?

4. Emerging Practices for Learning and Teaching

[40] identifies that students today learn really and immediately, everywhere, in anytime, while they are walking, travelling, doing their routine actions, and above all in "in motion". Mobile technologies are the next step in the evolution of technology-mediated teaching and learning. These devices not only connect people in information, but are driving society, through the opportunities offered by spontaneous, personal, informal and situated learning. Mobile technologies have sparked the need for the strategies, applications, and resources necessary to support anywhere-anytime connections to formal and situational learning, as well as personal interest explorations [42].

[35] describe technology as having positive influences towards student learning, engagement, motivation and productivity. Mobile devices are seen to be no exception due to their numerous instructional features and ability to provide access anywhere to learning. [45] state that due to the increased ubiquity and instructional features of these [mobile] devices, mobile learning has become

"one of the key current trends of educational applications for new technologies". As a more connected, mobile society emerges with embedded technology, learning will no longer be restricted to classrooms. Rather, learning will extend more and more to the outside environment, providing opportunities for rich, diverse and encompassing experiences. [44] state that "No matter how sophisticated, elegant, or robust a specific technology is, it is only useful in educational settings if it improves educational processes and outcomes".

5. The Educator's Role in the Future of Mobile Learning in Mathematics

[33] consider teaching in distributed, personalised mobile environments as presenting certain challenges to educators. Whilst theorists of digital literacies have noted that mobile literacy, far from being a naturally acquired skillset, may require explicit development [32]. [33] state that "Students must learn to navigate, interpret information from, contribute information to, and communicate through the mobile web, mobile apps and the 'mixed reality' they engender, where the real and the virtual are interlinked [5]".

[12] discuss the work of [28] who has conducted research which has contributed to significant understanding about the "opportunities and challenges of integrating technology in Maths teacher education, particularly using the TPACK framework". [28] considers whether it is possible to "teach the important ideas embodied in the mathematical concepts in such a way that the technology places the concept in a form understood by the students". She identifies that "teacher educators need to be prepared to explore the learning possibilities of mobile devices in Maths education and 'need to develop a professional attitude of evaluation and reflection about tools for teaching – a thoughtful visioning that investigates and considers the impact of the tools for teaching Maths' (p. 199)".

6. Challenges and Limitations

Like any other instructional tool, mobile technology is not without its challenges [3]. [25] states that there are a multitude of challenges when introducing and implementing mobile technologies into the learning environment. This is further supported by [43] who state:

> … developments in technology and making the role of the teacher much more complex. In addition, teachers' beliefs about the value of technology for learning are important in their pedagogical reasoning, but there is evidence that teachers beliefs and practices do not change automatically as a result of classroom experience … enabling teachers to adapt their pedagogical reasoning and practices in response to learning opportunities provided by technology is likely to be a very difficult and complex process. (p.278)

[46] identify some of the challenges for teachers. These may include:

- When integrating technology into pedagogic practices, what processes do teachers undergo?
- Is teachers' pedagogy transformed? Or is it that the technologies slot into existing strategies without significantly changing the teaching style and learning processes?
- Does learning remain predicated on a information-transmission model [36], or social constructivist model of dialogic knowledge creation [41], or even a communal constructivist model [18]?

When considering limitations (or barriers) with the implementation of mobile technology, [24] refer to three categories: situational, institutional, and dispositional. They elaborate by identifying that *situational barriers* include lack of funding, time, and a lack of teacher knowledge of the technology as well as how to effectively integrate it into the school curricula.

[3] recognises that the lack of teacher knowledge and expertise is reported as a significant barrier frequently noted in the literature. This is further supported by the research by [31] who cited several issues with teachers' use of the technology. They found that teachers tended to use online tools as an electronic library and to retrieve information, rather than to communicate and collaborate. This has a flow on effect to the classroom when working with students, if a teacher is not confident and competent, in the effective use and modelling of the use of mobile devices and associated technology for learning and teaching situations. The second category effecting the implementation of mobile technology refers to *institutional barriers*. [29] noted that this barrier included lack of technology support professionals, insufficient funding, lack of adequate professional development, and continuing support to promote sustainability. However, the main *dispositional barrier* that has been noted in terms of implementing and using mobile devices, was seen to be teacher reluctance. The key to overcoming these challenges, as described by [3], lies in knowing that they exist and being proactive in addressing them. Further, [22], state that the "Successful infusion of technology in 21st Century schools will depend upon the training and experiences that pre-service teachers have prior to entering the classroom".

7. Implications

The literature identifies that the most common benefit of m-learning and the use of mobile devices by students was the level of motivation and engagement by individuals. Further, [22] identify that there are multiple advantages to the integration of mobile devices into learning. They also state that the implementation of mobile devices will "aid in the shift in pedagogy from a teacher-led classroom to a student-centred one". This is supported by the research of [37]. [1] discuss the provision that 24/7 mobile technology can provide, leading towards a flipped classroom concept and the ability to allow for learning to take place anywhere at any time.

As discussed by Pegrum et.al. (2013, p. 68), mobile learners will have to "operate successfully in, and across, new and ever changing contexts and learning spaces", which includes coming to understand "how to utilise our everyday life-worlds as learning spaces" [30]. In a sense, as they go on to point out, "the world has become the curriculum populated by mobile device users in a constant state of expectancy and contingency" [30], with reference to [16].

Researchers have found that when students learn with personal mobile devices embedded in their own contexts, that there is significant and greater scope for individualised learning and customisation [33].

8. Recommendations

In order for students to attain the benefits of mobile learning using associated devices and applications, they need to be exposed to opportunities where they can see and experience the potential of technology. The start needs to occur with pre-service educators being technologically proficient with the integration and infusion of technology in the learning and teaching processes, prior to taking up positions within schools [22]. Teacher education programs should provide models of technology enhanced learning environments, so that pre-service students can see and meet the challenges and expectations that they will themselves face within their classrooms. Research [22] has found that "Far too often effective models do not exist within teacher preparation programs".

[34] identified why effective models still do not exist:

> *In most classrooms, technology is merely grafted onto existing teaching practices, so what we get is educational practice that is technologically sophisticated but still fundamentally conventional: using PowerPoint instead of a blackboard or overhead projector for a classroom presentation, for example. Thus, in too many cases, technology reinforces rather than transforms educational practice (p.28).*

[22] identify that pre-service educators need to experience models of technological pedagogies which deal with problem solving and inquiry applications, so that they can become technologically proficient. This is supported by [15] who argue "that successful technology integration requires the relationships among and between three core components: content, pedagogy, and technology". Unless educators have skills and knowledge of technology − how it works, and what it can do − there is usually disconnect between the three core components.

9. Recommendations for Further Research

Mobile learning is seen to be an evolving area of teaching and learning practice. It has also been identified as being an area where there is an emerging body of literature being explored in terms of teacher education contexts, and the learning of students across curriculum areas. Specific recommendations for further research in this developing area relate to the use of mobile devices in classrooms, and with pre-service education students are required given the general nature of most reports that are currently available. The role that mobile learning has in being able to engage students within the [Mathematics] classroom through its effective implementation, and use of devices is also an area of significance for further study.

Other recommendations for further research could focus on examining mobile learning in light of the following important questions: 'What kind of technological devices are being referred to?' and, 'What forms of learning can take place with these devices?' A final area for consideration, as highlighted by [21], would be to consider conducting more empirical studies to substantiate whether mobile learning will enhance the learning and teaching of students within K to 12 schools, and individual curriculum areas like Mathematics. As [21] state "whilst there is evidence of the educational potential and enthusiasm for m-learning, … developing pedagogical approaches and perspectives connected to theories that enable the fuller m-learning capacity …" is an area for further research, review and discussion.

10. Conclusion

With the advances in technology changing processes in education, it needs to be recognised that mobile learning is part of a new landscape. Mobile learning provides many opportunities for personal, informal and spontaneous, situated learning. Through the use of mobile devices, students of all age levels and backgrounds will be able to collaborate, engage and learn in different ways.

Further, with the introduction of mobile learning and subsequent technology innovations into schools, opportunities are provided for major change and review in teaching practices. The engagement of students by educators, will enable the development of learning and teaching opportunities to fit emerging trends. For a young area of research, there is a lot of potential to transform classrooms with mobile devices, as well as individual subject areas like Mathematics.

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