A Historical Review on Learning With Technology:
From Computers to Smartphones

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INTRODUCTION

To harness technology in education has been a long-lasting endeavour by technology specialists, educators and also learners themselves (Facer, 2011; Somekh, 2007; Starkey, 2012). Among a variety of other terms in history, e-learning can be used as an umbrella term to cover their ongoing efforts. E-learning has been operating like a powerful lever that sparks a revolution in light of service of evaluation, institutional structure, relationships between the instructor and learner etc. (Horton & Horton, 2003). In a word, focus should be put on a cross-field content when it comes to e-learning. In the meantime, with mobile technology developing and spreading rapidly in recent years, 'mobile learning' or 'm-learning' has gained a solid foothold (Traxler, 2009a, 2009b, 2009c). With the increasing convergence of technology and education, the tool and medium to facilitate learning is shifting from stationary book pages to interactive digital screens. Digital technology has great potentials to breed a pedagogical transformation based on novel approaches and methods.

This chapter focuses on the broad contexts of e-learning and m-learning. By comparison, e-learning is not discussed that much due to its extremely wide coverage, while m-learning is elaborated despite its short history of development in recent decades.

E-LEARNING: EDUCATIONAL TECHNOLOGY ON THE COMPUTER MEDIUM

The umbrella term 'electronic learning', or 'e-learning' for short (also as 'E-Learning', 'e-Learning' or 'E-learning' in prior literature), is a broadly defined tool that may apply to any digital media in the course of learning and training, covering the overwhelming majority of, if not all, technologies in modern times. Although ICT (information and communication technologies) seems to be a more accurate term to include comprehensive digital technologies, e-learning seems to be more widely accepted and influential than 'ICT-based learning', which emerged at the turn of this century (Finger, Russell, Jamieson-Proctor, & Russell, 2007, p. 2).

In fact, the scope of e-learning varies across time and users. Generally speaking, e-learning includes computer-based learning, web-based learning, virtual classrooms and digital collaboration. In some conceptualisation, e-learning seems largely synonymous with the term "online learning" and overlaps with "distance learning" (Pachler & Daly, 2011, p. 11). In a narrow definition, e-learning is confined to

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"online access to learning resources, anywhere and anytime" (Holmes & Gardner, 2006, p. 14). Nevertheless, other researchers hold that, as fundamental terms, 'e-learning', 'online learning' and 'distance learning' are often used in a rather conflicting manner, and e-learning should not refer to web-based practice only (Moore, Dickson-Deane, & Galyen, 2011). In recent years, researchers on e-learning tend to prefer a more flexible boundary of the concept, adopting an open approach to define e-learning. In an inclusive definition, e-learning is described as learning assisted by almost any kind of technology (Daly & Pachler, 2010, p. 217):

[A] set of practices which enhance the potential of people to learn with others via technology-aided interaction, in contexts which can be 'free' of barriers of time and place. It involves the utilisation of a range of digital resources - visual, auditory and text-based - which enable learners to access, create and publish material which serves educational purposes.

The computer, increasingly sophisticated, versatile and integrative, always serves as the medium of e-learning. Researchers have long been using 'computer' to represent educational technology, with acronyms including but not limited to CAL (computer-assisted learning), CAI (computer-aided instruction), CML (computer-managed learning), CBE (computer-based education), and CmC (computer-mediated communication). The role of the computer in education might be slightly different. According to Higgins (1983), US researchers often used 'aided' and 'instruction' as in CAI, while their British counterparts favoured 'assisted' and 'learning' as in CAL. It seems that 'assist' may better describe the role of computers in education, while 'learning' can imply that the focus of this process is on the student's side.

E-LEARNING: FOR AND BY AUTONOMOUS LEARNERS

It is believed that e-learning may afford multiple pedagogical advantages in terms of, among others, availability, accessibility, and perhaps most importantly, learner autonomy (Ellis & Goodyear, 2010). At first, the richness of educational resources in e-learning settings significantly outperform those of traditional offline classrooms. Multimodal materials in various forms (e.g., spoken or written words, moving or stationary images, audios and videos) often abound in e-learning, offering different learning experiences (Domingo, 2014). Learners can also navigate to a wide range of expanded topics and related resources through hyperlinks, which is virtually impossible via physical textbooks. Shifting from pages to screens has made a huge difference.

In addition, it is apparent that live and/or prepared materials on e-learning platforms can reach a larger group of targeted learners simultaneously than those confined to an offline classroom. The MOOC project, for example, with its access to open learning resources, provides learners with unprecedented forms of courses beyond spatial-temporal limits. Teaching practitioners are enabled to offer equal opportunities for those who are disadvantaged by physical, geographical and social-cultural issues, without making special trips and visits to approach them. In this case, a crippled student living afar with slightly inferior academic performance can receive online courses as well, not being left behind by the peers. This indiscriminate and effective learning model may foster more potential advantages.

Furthermore, e-learning may help foster a higher level of learner autonomy. Researchers generally believe that e-learning features and enhances learner-centredness instead of traditional teacher-centredness (Doyle, 2008; Duffy & Kirkley, 2008; Luckin, 2010). In the meantime, e-learning is strongly associated with constructivism, both cognitive and social (Felix, 2005b; Koohang, Riley, & Smith, 2009; Rennie

& Morrison, 2012). In e-learning settings where students become central, the learning process is often problem-based rather than instruction-based. Problem-based learning, designed to adapt to the e-learning environment, is a teaching method that encourages students to seek solutions to practical problems (Pierce & Jones, 1998). Amidst the affordances of e-learning, learners are believed to learn by doing (Aldrich, 2005) independently or with peers. During the process, e-learning can help create a sense of user community, with which participants feel free to experiment, test and cooperate. Unsurprisingly, more collaboration and interaction with peers and instructors enable them to be more influential to others, which is a practical way to boost their sense of happiness and belonging through learning. Additionally, the benefits may go beyond national borders with Online International Learning (CIL). This new e-learning practice involves co-development of a set of online tasks and/or a course module by two or more academic staff from different countries, where students from different parts of the world learn together on a shared focus (Villar-Onrubia & Rajpal, 2015). By working with peers from different social and cultural backgrounds, students are invited to a wider range of knowledge through cross-cultural interaction, sharing personal experiences, and addressing cross-national issues in the e-learning context. This gives students opportunities to gain intercultural experience and extend professional reach.

In short, e-learning, often set in a student-centred leaning environment, allows students to construct knowledge through collaboration and interaction. In recent years, more attention has been paid to how much teamwork, resilience, critical thinking, computer literacy, time management etc. can be boosted through engaging students in collaborative e-learning communities (Moallem, Hung, & Dabbagh, 2019).

All these features of student-centred and constructivist learning are believed to grant students more autonomy. Learner autonomy, at the cost of over-simplification, means learners can take responsibility for their own learning (Little, 2001; Scharle & Szabo, 2000). As learners can be in almost full charge of most factors in their learning process, they have a dominant say in 'what to learn' and 'how to learn', including but not limited to the selection of learning material, learning methods and pace of study. By doing so, e-learners are empowered and enabled to make adjustments according to their individual needs in ways they feel comfortable with, potentially anytime and anywhere. Consequently, they tend to learn more actively and proactively, seeking a high level of responsibility for pursuing their goals. This kind of autonomy can also add to their motivation, satisfaction and confidence, in addition to the effects of developing learning skills and communicative competence. In summary, e-learning can promote the development of greater learner autonomy than the traditional teacher-centred classroom would have. This is a desirable scenario for e-learning, because learner autonomy is a matter of how technology can facilitate the evolution of a whole set of pedagogical philosophies, principles and practices, rather than merely using some new technical features to aid conventional activities.

One thing to note is that learner autonomy is not an expected outcome of e-learning but also a prerequisite. That is, while autonomous learners are fostered and enhanced by e-learning, e-learning entails learners' motivation, self-discipline and self-direction. Reinders and Hubbard (2013, p. 359) give a detailed description of the preconditions:

Technology has the potential to provide teachers and learners with the necessary support in this process but also in itself produces a number of challenges, especially as the successful use of technology often requires precisely those self-directed learning skills, it is intended to help develop as well as presupposing an adequate level of technological proficiency.

Thus, e-learning is for and by autonomous learners. It can be more successful provided that a certain degree of learner autonomy has been achieved, entering into a benign and mutually supportive cycle to maximise its pedagogical benefits.

DIFFICULTY IN EFFICACY EVALUATION

Despite the fact that learner autonomy is one highlighted benefit of e-learning, it also poses a great challenge to the evaluation of e-learning efficacy. In fact, it is widely accepted that assessment is an integral part of any teaching/learning process, and there is a significant body of knowledge related to production and use of assessment (van Aalst & Chan, 2007). It is a natural task to measure students' progress and improve arrangements from teachers' standpoint. However, in the e-learning context, in which autonomous learners take control of most of the learning process, instructors may find it difficult to employ conventional assessment tools, such as classroom observation and pre-/post-tests. Behind the screen, it is less likely to check whether a student is paying full attention to courses or really making effort to work out an answer. What's worse, many more varying factors that may influence learning outcomes should be taken into consideration: motivation, active learning, collaboration, interaction (with teachers and with peers), learner control, technological constrains (e.g. computer performance) and so on. Among them, motivation is an essential yet elusive variable that differs from prior knowledge and experience. In an online environment where individual students are physically separated, they may prefer collaborative interaction with teachers and peers to gain sense of participation and to enhance learning. It is no doubt that some reticent students in the offline classroom may become brisk learners with instant feedback and proactive comments on e-learning platforms. In this regard, motivation to learn is shared and strengthened through e-learning tools. However, motivation may also shrink when young learners get distracted and lost amidst tons of entertaining information online. Other factors tend to resemble the variance from person to person.

Computer Assisted Language Learning (CALL), if deemed as the derivative of e-learning in the context of language learning, may partly reflect the plight. CALL faces the long-standing concern of efficacy evaluation, "[b]ecause the computer potentially interacts with all the key variables - teachers, learners, methods, materials, and environments" (Hubbard, 2003, pp. 141-142). Long time ago, researchers like Dunkel (1991) raised the question whether CALL could be more effective than traditional classroom learning. During the past three decades there has been much discussion particularly on how to conduct evaluative research of CALL effectiveness. Chapelle and Jamieson (1991) explained the factors related to internal validity (whether the research results can be attributed to the studied factors) and external validity (whether the results can be generalised) of CALL evaluation research: to be internally valid, the measure of language improvement needs to be free from the influence of unaccounted for variables, which are not easy to clearly identify and exclude; to ensure external validity, a sufficient amount of demographic and procedural information needs be provided in the report. In Chapelle's book on computer applications in applied linguistics (2001), a separate chapter was used to explain and demonstrate in detail how to conduct judgmental and empirical evaluation of CALL, with a set of 12 broad research questions across six categories to be addressed. Despite the early awareness and continuous effort, to date there has been no one rubric or set of concrete guidelines available to provide CALL educators with a fair, complete, and consistent model of evaluation (Leakey, 2011).

Over the decades, meta-analyses of evaluative research on CALL efficacy fail to provide satisfactory empirical results (Felix, 2005a, 2005b, 2005c, 2008; Grgurović, Chapelle, & Shelley, 2013; Zhao,

2003). Only tentative conclusions can be drawn that e-learning can help produce slightly better learning outcomes and is accepted by learners in general; the results are not yet universal and widely recognised. Thus, evaluation of CALL efficacy remains a major challenge for further dissemination (Levy, Hubbard, Stockwell, & Colpaert, 2015). Although self-assessment, questionnaires, interviews, portfolios and so on may shed light on learners' achievements, those largely subjective data may not be able to help draw robust conclusions.

Partly due to the evaluation problem, CALL is not yet fully integrated into language learning. Warschauer (1998) notes that there are no CALL-like terms, such as 'BALL' (book-assisted language learning), 'PALL' (pencil-assisted language learning), or 'LALL' (library-assisted language learning). Those powerful tools are being used in a natural way by all, while computers are still highly noticeable and promoted by part of education practitioners. Likewise, e-learning has not reached the phase of 'normalisation', when we all take e-learning for granted, without consciously aware of its role in education (Bax, 2011; Chambers & Bax, 2006). The penetration of e-learning is being furthered by mobile learning ('m-learning' for short), which has inherited and exacerbated the assessment difficulty. The detailed discussion on m-learning is set out below.

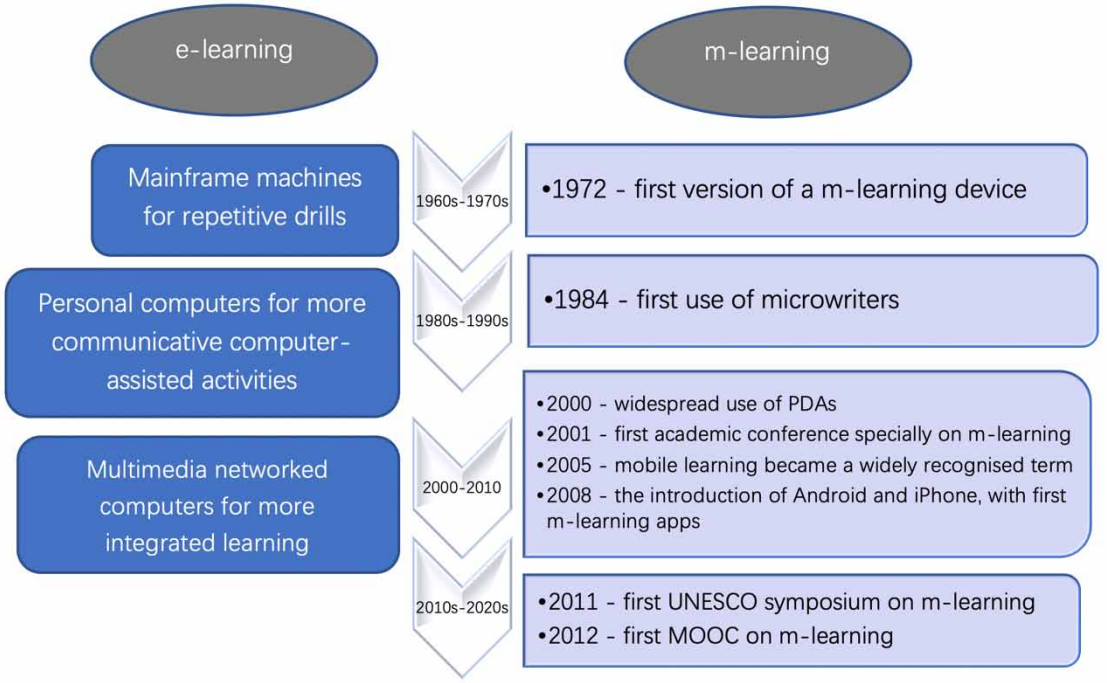
M-LEARNING ON THE SMARTPHONE MEDIUM

Similar to 'e-learning', m-learning does not have a standard spelling either, with also 'm-Learning' and 'mLearning' seen in literature. Initial use of mobile devices for educational purposes may date back to 1972 (Parsons, 2014, though the mobile devices then were no better than a paper pad in functionality, memory and convenience). Despite some earlier studies, we contend that the m-learning research paradigm began to take shape at the turn of this century (Sharples, 2000), or more exactly, in the year of 2001, when the first academic conference specially on m-learning was held at the University of Birmingham (Traxler, 2021). In the following years, m-learning obtained growing visibility and significance (Traxler, 2007, 2009b). By citing the significantly increased number of Google searches for the keyword 'mobile learning' in 2005, Crompton (2013) notes that 2005 was the year when this term became widely recognised on the global scale.

The development of m-learning is largely techno-centric; in other words, the rapid growth is reliant on the advent of defining devices, i.e. smartphones and mobile tablets. Godwin-Jones was among earlier researchers who observed the "exciting opportunities" (1999, p. 7) brought about by emerging mobile technology. In 2008, Godwin-Jones (2008) noticed that the introduction of handheld devices (iPhone and Android) to the global market might release the potential of lighter, faster, and smarter mobile computing, and he (Godwin-Jones, 2011) soon witnessed rising use of mobile apps. Around ten years later, the major impacts of even more advanced smartphone features on education were iterated and lauded by him (Godwin-Jones, 2017).

Figure 1 below sets out a brief timeline of m-learning development during the past decades, together with that of its precedent e-learning. The technical and conceptual milestones of e-learning are adapted from Warschauer and Healey (1998) and Bax (2003), and those of m-learning are largely drawn from by Parsons (2014). It can be seen that m-learning does not flourish suddenly in the new century but has its roots in the 1970s to 1980s, when e-learning was also immature. It implies that m-learning is not a mere descendent of e-learning; they are simply on different phases of development with different technological devices and pedagogical concepts. This point will be further elaborated in the next section.

Figure 1. Technical and conceptual milestones of e-learning and m-learning



The authors would particularly highlight the distinctive difference that smartphones make to technology-enhanced education. Researchers observe that "it is perhaps the mobile phone that carries the most promise" (Stockwell, 2013, p. 212). Firstly, smartphones, as the major medium of m-learning, are able to integrate a range of handheld electronic tools, including cellphone, iPad, iPod, MP3, game console, eReader, or even Netbook (Rogers, 2011). More recently, wearable devices can also be well connected with smartphones (Mayer, 2020). In addition, more emerging technologies are being synergised to the uniform platform. Woodill (2015) outlines as many as 25 unique affordances of mobile technology, including geolocation, cloud storage, touchscreens and Internet connectivity, all of which may have potential to apply to educational settings. The potential benefits of Web 2.0 have long been noticed and practiced by educational researchers (Cochrane & Bateman, 2010; Kwan, McNaught, Tsang, Wang, & Li, 2011; Sazalli, 2014), and it is evidenced that user-generated content (UGC) and collaborative activities may help increase student engagement and retention (Blessinger & Wankel, 2013). More recent technical buzzwords are also making inroads into m-learning. For example, Internet of Things (IoT), closely related to mobile computing, is innovatively used in education (Elazhary, 2019; Ramlowat & Pattanayak, 2019); Metaverse has been explored to provide a fascinating and interactive environment for learners (Barry et al., 2015; Marini, Nafisah, Sekaringtyas, & Safitri, 2022; Marmaridis & Griffith, 2009). According to Bauld (2022), augmented reality (AR), virtual reality (VR) and mixed reality (MR) are immersive technologies that feature Metaverse-enhanced learning (Doerner, Broll, Grimm, & Jung, 2022). In recent years, the academia have been conducting numerous discussion and research on the educational applications of those three technologies, producing a large body of literature in the form of monographs and edited volumes (Daniela, 2020; Kaliraj & Devi, 2022; Liu, Dede, Huang, & Rechards, 2017; Tacgin, 2020), not to mention individual journal articles.

In short, modern smartphones can assume more functions far beyond making a call or text messaging and integrate more emerging technologies, and such an increasingly powerful and versatile medium can enable more possibilities for m-learning.

KEY POINTS IN M-LEARNING CONCEPTUALISATION

Despite the great promise, m-learning on the smartphone medium is still in its infancy after a short period of development, which requires new accounts on what it is and more explorations on how to develop it in future (Traxler, 2009a; Traxler & Vosloo, 2014). However heated the current discussion on m-learning is, there seems to be a lack of precise, unanimous and well-established understanding of this emerging field. This is the major hindrance to further pedagogical practice and in-depth academic research. Therefore, it is necessary to conceptualise m-learning clearly and comprehensively. This section would adopt the following three *D*- keywords - delimitation, definition, and description - to highlight the key points in m-learning conceptualisation. The three dimensions can be triangulated to review and explore the external periphery, internal composition and human-technology interaction in m-learning.

Firstly, 'delimitation' here means sorting out the external relationship of m-learning with previously established fields of technology-enhanced education, especially e-learning. As a new form or phase of technology-enhanced learning, m-learning is implicitly considered or treated as a descendent, derivative or branch of 'e-learning'. It is true that m-learning and e-learning share a lot in common (Traxler, 2005), but they may not be successive as the timeline of emergence suggests. After all, m-learning has been developing in technological, social and conceptual contexts which are quite different from that of e-learning. Discussing m-learning mixed with other technologies which have been well researched will result in missing out many of its unique features, and it will be problematic to indiscriminately transfer the principles and practices in e-learning to m-learning. Therefore, it is maintained that "[t]he differences between those two development paths are so significant that it requires a completely different approach to instructional design, graphic and user experience design, and information presentation" (Feser, 2015b, p. 35).

As a result, m-learning is becoming an increasingly independent topic in the research community, attracting new investigations to shed light on the uniqueness in the parallel parts with e-learning. It is pleasing to see that m-learning has secured its foothold as it "continues to gain identity and definition rather than lose them" (Traxler, 2009b, p. 2). In short, m-learning is not e-learning; rather, it has been developing towards an increasingly distinctive field both in practice and in theory.

Secondly, there seems to be a lack of satisfactorily comprehensive and workable definitions for 'm-learning' (Grant, 2019; Hockly, 2013; Traxler, 2009b). A good definition may be made with due attention to the integral dimensions of m-learning over mobile devices, mobile learners and mobile content. It is not surprising that earlier efforts to define 'm-learning' often showed overemphasis on the central role of mobile devices. Traxler (2005, p. 262) defined m-learning as "any educational provision where the sole or dominant technologies are handheld or palmtop devices". Definitions with similar technology-centredness can also be found in Quinn (2001) and Soloway et al. (2001). It is hardly possible to deny that handheld devices are the basis for m-learning, but the techno-centric approach may be so oversimplistic that it may preclude adequate attention to other factors in the ever-changing learning practice on mobile devices.

A better understanding of m-learning, therefore, should go beyond technological instantiations in specific tools and devices (Traxler, 2009a, 2010). Consequently, a learner-centred perspective can be seen among attempts to understand m-learning (Sharples, 2006; Traxler, 2005; Winters, 2006). Time and space are known to be two major constraints in traditional learning, while m-learning "has the potential to transcend these spatial and temporal restrictions" (Kearneya, Schucka, Burdenb, & Aubusson, 2012, p. 4). In m-learning, learners are offered "new ways of dividing up one's time and crossing boundaries", and it is a key mission to "extend these types of learning and enrich them with new possibilities" (Kukulska-Hulme, 2009b, p. 160). With this in mind, more recent definitions of m-learning tend to integrate the mobility of devices and learners. For example, Crompton (2013, p. 83) defines it as "learning across multiple contexts, through social and content interactions, using personal electronic devices"; likewise, Advanced Distributed Learning Initiative (2022), a US government agency, refers m-learning as "leveraging ubiquitous mobile technology for the adoption or augmentation of knowledge, behaviors, or skills through education, training, or performance support". The latter definition, though more complex, seems to allow for more learning scenarios for mobile learners.

In addition, Kukulska-Hulme (2009b) contends that three aspects should be included to interpret m-learning: not only the mobility of devices and learners, but also the mobility of learning materials. The last dimension, i.e., mobile content, may have received the least attention among the three. On the one hand, what materials can best fit the mobile platform remains largely unclear to researchers and education practitioners. Much of m-learning research only offers resources and activities that mirror those in the traditional learning environment, such as dictionaries, grammar books, drills and practice (Burston, 2014a; Kukulska-Hulme & Shield, 2008). This practice fails to well adapt the materials to the mobile environment by redesign and reorganisation. On the other hand, there is insufficient research to investigate how to encourage and guide content creation jointly with mobile users for learning purposes. It is observed that, equipped with a wide range of Web 2.0 applications, functions and affordances, mobile learners are no longer passive information receivers, but proactive participants in knowledge construction (Cochrane & Bateman, 2010, 2011; Sazalli, 2014). Traxler (2021, p. 11) envisages an m-learning process where "learners with their personal technologies and in amongst their mobile communities can define, own, produce, share and consume their own learning, can learn from each other, their experiences and their environment, physical and digital". There is much room for researchers to realize this vision. The effort to study mobile social media, in particular, is still quite limited (Qureshi, Khan, Hassan Gillani, & Raza, 2020).

Based on the discussion above, we can reach our inclusive and constructive definition of m-learning: it refers to the learning process enabled, empowered, and enhanced by mobile devices with convenient access to suitable supporting materials; learners may enjoy a highly portable and truly personalised experience of learning (Quan, Grant, Hocking, & Connor, 2022).

Thirdly, 'description' means to illustrate the distinct features of m-learning. The nature of m-learning is described as "disruptive" (Feser, 2015a), which means that it will bring about drastic changes to traditional education. Among the scores of descriptive words for m-learning, 'highly portable' and 'truly personal' in the real sense may connect key attributes of m-learning in a concise way.

On one hand, m-learning stands out in terms of portability to enable "continuity or spontaneity of access and interaction across different contexts of use" (Kukulska-Hulme & Shield, 2008, p. 273). In the related literature, m-learning is also described as 'untethered' (Masie, 2002), 'unplugged' (Gayeski, 2002) and 'wireless' (Roschelle, 2003), which means that users can get rid of the cables of desktop computers. The sheer size and weight enable mobile devices to "fit in a pocket or in the palm of one's hand" (Kukulska-Hulme & Traxler, 2005, p. 1). With handheld mobile devices, learners may enjoy the

cutting edge of learning almost anytime, anywhere (Kukulska-Hulme & Shield, 2008; Rogers, 2011). In this case, m-learning becomes potentially 'ubiquitous', 'pervasive' and 'ambient' (Kukulska-Hulme, 2005), or so-called 'here and now' learning (Martin & Ertzberger, 2013).

On the other hand, genuine personalisation, one major feature of m-learning (Kearneya et al., 2012), may be the most significant change to learning. Mobile devices are very familiar to the new generation of digital natives, who are brought up in an environment of abundant technologies (Prensky, 2001): smartphones may be ubiquitous in their palms from dawn until dark, and larger tablets, like iPads, are also among the frequently used equipment in a schoolbag. In this case, "mobile technology can assist learners at the point of need and in ways that fit in with their mobile lifestyles" (Kukulska-Hulme, 2009b, p. 162), so that m-learning becomes highly and truly personalised.

In short, it is maintained that 'highly portable' and 'truly personal' are the two major characteristics of m-learning. In fact, even simpler words have been used to illustrate the above-mentioned characteristics, as 3 'alwayses' - "always on, always with you, always connected" (Udell, 2015, p. 191), or 3 'justs' - "just in time, just enough, and just for me" (Peter, 2009, p. 114). High portability and genuine personalisation, having made m-learning distinctive, are likely to bring about more disruptive changes.

ENHANCED AUTONOMY AND EXACERBATED ASSESSMENT

Compared to e-learning, m-learning may probably be more conductive to autonomous learning. Apparently, m-learning is more learner-centred (Crompton, 2013; Wong, 2012): as owners of their private gadgets, mobile learners assume the control of almost the entire learning process, with little instruction or intervention from teachers. It is believed that learners will become more motivated in this way: "a sense of ownership and ability to personalize, and appropriate them according to individual needs can result in an increased willingness to utilize mobile devices for learning" (Pachler, 2009, p. 4). With rapid switches across time and space, the on-demand learning process is probably decentralised to fragmented pieces. Thus, the use of mobile devices for learning tends to be 'spontaneous', 'opportunistic' and 'bite-sized' (Traxler, 2009a). Mobile learners are able, and may sometimes be obliged, to formulate their own syllabus, monitor and manage their own pace and progress.

Portability and personalisation imply that m-learning is inherently informal and can be entirely independent from the teacher-classroom formal setting. There are advocates who propose to incorporate m-learning in formal learning as an integral part. However, it is our argument that the future development of m-learning should adhere to the informality nature across fragmented time and non-fixed locations, capitalising on insights and best practices from informal learning (Pachler, 2009).

On the other side of the coin, enhanced learner autonomy seems to exacerbate the evaluation difficulty. As mentioned above, assessing e-learning efficacy has been a headache for researchers, while m-learning, usually in an entirely "out of sight, out of control" environment, seems more challenging to evaluate. As "it is not computers teaching people" (Horton, 2001, p. 5), e-learning may still involve a certain degree of teacher intervention and classroom instruction, with computers serving as an aiding or assisting tool. It is not surprising that e-learning students may gather in offline classrooms or classroom-like computer labs. Compared to e-learning, which involves at least some fixed time and fixed sites, the m-learning process tends to be highly decentralised and dispersed to different time and space. In this case, many factors are unpredictable, such as learning context and process, and use mode (Sharples, Arnedillo-Sanchez, Milrad, & Vavoula, 2009). The difficulties of m-learning evaluation are depicted in detail as follows (Sharples, 2009, p. 17):

Mobile learning differs from learning in the classroom or on a desktop computer in its support for education across contexts and life transitions. This poses substantial problems for evaluation, if the context is not fixed, and if the activity can span formal and informal settings. There may be no fixed point to locate an observer, the learning may spread across locations and times, there may be no prescribed curriculum or lesson plan, the learning activity may involve a variety of personal, institutional and public technologies, it may be interleaved with other activities, and there may be ethical issues concerned with monitoring activity outside the classroom …

Thus, m-learning research has to "go across contexts and disciplines, and exposes methodological complexities" (Pachler, 2009, p. 2). Apart from elusive learning procedure, ethical concerns seem another major hindrance for the collection of m-learning data. There have been acute debates about matters involving intellectual properties, storage, distribution of information in this digital age. Compared to e-learning, more ethical challenges may arise as researchers set out to investigate into more informal m-learning. Among others, privacy is a tricky issue in m-learning research. Stalking-like observation by teachers is apparently impossible; monitoring via cameras or screen recording may be unethical or even illegal; private information, such as names, ID, geographical locations, etc. must always be kept confidential. That might be the reason why researchers must honour their promises of confidentiality and anonymity throughout the research, from initial interactions through use of the data, to writing up the research report or paper (Margulis, 2003; Nosek & Banaji, 2002).

So far, there have been few proved solutions to alleviate the changes and address the problems. Most traditional methods of evaluation may no longer be suitable; new techniques to collect relevant data tend to lack either rigour or validity. In an early conference paper, it was observed that m-learning research was characterised by unconfident trials, where questionnaires, interviews and focus groups were usually used to elicit participants' attitudes and achievements, with less observation and little statistics (Traxler & Kukulska-Hulme, 2006). Technical development can hardly address the methodological problems, so after quite a few years, such studies still "have not progressed much beyond pilot testing" (Burston, 2014b, p. 103). The limitations almost remain the same: the learning gains were only based on self-evaluation by students, and teachers' subjective assessment; statistically reliable measures of learning outcomes are very few; short duration and small number of participants may be weak to provide compelling evidence for m-learning efficacy (Burston, 2015).

Researchers have been endeavouring to overcome the obstacles and produced convincing results through quantitative data and large-scale longitudinal effort. In another analysis of a larger number of 110 experimental and quasi-experimental journal articles on m-learning, the mean effect size is found to be 0.523 (Sung, Chang, & Liu, 2016). It is encouraging that mobile-enhanced learning could result in moderate but meaningful outcomes. This evidence may contribute to a great momentum for future development of m-learning research and practice. More importantly, new concepts, techniques and approaches for m-learning evaluation are taking shape. 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; under every category there are a few specific factors to examine. Sharples (2009, p. 22) suggested a simpler way to approach the evaluation by checking three factors: usability (will it work?), effectiveness (is it enhancing learning?), and satisfaction (is it liked?). Then he further developed the approach to a comprehensive framework with his colleagues. This framework consists of three levels: a micro-level concerned with usability, a meso-level focusing on the learning experience, and a macro level dealing with integration within existing organisational contexts (Sharples et al., 2009; Vavoula & Sharples, 2011). It is apparent that only on the

third level, some traditional evaluative activities, e.g. pre-test and post-test, may be conducted to check potential improvement on specific aspects (still not easy to exclude the impact of variables, however), while the other two levels concentrate on the overall learning process rather than the possible product. This implies a vital principle in m-learning evaluation, that is, qualitative data may have a major and dominant role in m-learning. As m-learning is inherently informal and personalised, the subjective feedback is no less important than quantitative data. It is not to say that researchers are entitled to stop searching for quantitative evidence and rely on subjective recalls and assessment; rather, we should learn to check through observing and analysing the experience to decide whether productive learning has taken place.

FUTURE RESEARCH DIRECTIONS

The above discussion might shed some light on the research avenues of m-learning in the future. Nowadays, m-learning advocates attempt to "harness research studies with a solid theoretical underpinning and empirically validated practical recommendations" (Lim & Churchill, 2016, p. 273). For theory building, m-learning research may focus more on 'learning' than 'teaching' on the education continuum, since mobile learners are highly self-directed and autonomous and perhaps least instructed. Thus, m-learning may take advantage of existing knowledge from informal learning, educational psychology and even marketing, to shed light on what might be the best ways to attract and engage learners of new generations.

In addition, practice innovation of m-learning is more inviting and promising. In fact, mobile technology has made inroads into all aspect of our daily life, and increasingly sophisticated devices are bringing about novel user experiences in entertainment, commerce, and many more. Researchers keen on m-learning should not confine their trials to traditional methods, e.g. instructions, tips, drills and exercises. Rather, they may work on how to integrate technological affordances with traditional resources, such as dictionaries, so that paper-and-pen forms can be converted to electronic platforms for younger digital natives. More topics on digital connectivity can be tested in future research, such as incorporating social media in the learning process (Govaerts et al., 2018; Smith, Grant, Conway, & Narayan, 2016). Besides, m-learning must seize the opportunities to make intelligent and effective use of Web 2.0 to help learners develop their own knowledge management in preparation for lifelong learning (Leicht, Heiss, & Byun, 2018).

At the same time, it seems prospective if researchers adopt novel approaches and methods which are underused in traditional educational studies. During the process, the beneficiaries of m-learning should also join in this journey. Thus, it is proposed to include students as co-researchers and co-designers in the design and execution of m-learning research (Kukulska-Hulme, 2009a; Vavoula, 2009). Additionally, new research methods can be developed and applied to address the elusiveness of m-learning variables. For example, computer logging can be used to record app use automatically, which is triangulated with questionnaire results.

CONCLUSION

This chapter briefly reviews the history of e-learning and m-learning with the focus on the latter. It is contended that the change of the major medium from computers to smartphones is more than a matter of devices; it entails the shift to more informal and self-directed learning styles. In other words, the transition involves not only where learning may occur in the digital environment, but also how, to a greater

extent. Compared to e-learning, m-learning can achieve higher portability in three aspects: devices, materials and learners. Such "triad" underlines the potential contribution to a truly ubiquitous learning environment for all learners. In addition, the ownership and familiarity of mobile devices in everyday life help promote the penetration and personalisation of m-learning.

Apparently, learning via mobile devices has become an unstoppable trend (Kukulska-Hulme, 2009b). A new approach, form and style of education, m-learning is not a fad but the future; it is of the future and for the future. How to engage, retain and motivate mobile learners in the informal and spontaneous settings merits more attention. Now it is high time to embrace the concept, catch the trend and enhance the practice. Solid theoretical underpinnings and empirically validated practice in other disciplines may shed light on the avenues of future m-learning research. From a techno-centric view, m-learning may embrace wearable devices, Internet of Things and social media to enhance connected and interactive learning experience. From a collaborative perspective, mobile learners may be included as co-researchers and co-designers with feedback and UGC (user-generated content). In the methodological aspect, innovative indicators and techniques may be employed to investigate whether and how learning really happens in the mobile, open and distributed context.

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KEY TERMS AND DEFINITIONS

CALL: Abbreviation of ‘computer-assisted/aided language learning’, referring to a learning and teaching tool that embraces various information and communications technology applications and methods for language learners and instructors, e.g. corpus-based teaching, virtual learning environment, web-based distance learning, etc.

Collaborative Learning: A pedagogical approach that engages learners in pairs or group activities to actively grasp new concepts, complete tasks, address misunderstandings and so on.

E-Learning: Short for ‘electronic learning’, this is a broadly defined term that may apply to any digital media in the course of learning and training, covering the overwhelming majority of technologies in modern times. It may also refer to a network-supported transfer of skills and knowledge.

Learner Autonomy: A term used to describe students’ ability to take control and responsibility of what and how they learn during the process of learning, which entails higher levels of students’ self-resilience and self-direction.

M-Learning: Short for ‘mobile learning’, used to be considered or treated as a descendant, derivative or branch of ‘e-learning’. The term refers to the learning process enabled, empowered, and enhanced

by mobile devices with convenient access to suitable supporting materials; learners may enjoy a highly portable and truly personalised experience of learning.

MALL: Abbreviation of 'mobile-assisted/aided language learning', considered as a subtype of m-learning at large. This is an approach to language learning that involves usages of hand-held mobile devices, such as smartphones, iPads, MP4 players, etc., to enable language learners to communicate and interact with their teachers and peers beyond the limits of time and space.

Metaverse: A word that firstly appeared in the science fiction *Snow Crash*. Now it is a term used to describe a virtual world constructed by human using digital technology, which is mapped or transcended by the real world and can interact with the real world. It is a digital living space with a new social system.

Web 2.0: Also known as participatory web or social web, in contrast with Web 1.0, where users are limited to web contents in a very passive manner. This term refers to the easily-operated websites featuring user-generated content, participatory culture, and interoperability. Cases in point are social media portals (Facebook), video sharing apps (Tiktok), hosted services, etc.