Should you be using mobile technologies in teaching? Applying a pedagogical framework

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ABSTRACT

The extent of how mobile devices, such as smartphones and tablets, are seamlessly incorporated into the personal day-to-day life is not often considered by University instructors. Unfocused incorporation of mobile technologies into the classroom can de-emphasize intended learning objectives if students struggle using the technology itself or by acting as a distraction. The effective inclusion of mobile technology is not a simple process as the inclusion needs to be purposeful and have the potential to improve the student learning environment, while working alongside more traditional face-to-face learning. This paper presents a pathway to help instructors address both pedagogical and technological considerations of incorporating mobile learning into the curriculum. The pathway developed through the adaptation of the iPAC framework, feedback from international practitioners and tested with worked examples. In all cases the instructors' reflective responses to the eight pathway questions indicate a clear structured activity, engaged students, and considers equal access, prior experience and contingency planning. This pathway indicates an effective methodology for instructors to assess whether the mobile learning intervention is appropriate and adds value to their teaching. Further external evaluation of the pathway with additional teaching examples will enhance the effectiveness of the methodology.

Keywords m-learning; Learning Spaces; Experiential learning; IPAC

Introduction

In the age of ubiquitous computing (Caudill, 2010) mobile devices, such as tablets and smartphones are becoming more affordable (Melhuish and Fallon, 2010) and are blended into the everyday fabric of life. There should, therefore, be an expectancy for instructors and educators to keep up with the pace of mobile technology advancement (Courts & Tucker, 2012) and where appropriate incorporate this technology into their teaching practice. Indeed, students have access to handheld or mobile technologies that are more powerful and better connected than conventional desktop computers (Guy, 2010). To quote Ally and Prieto-Blazquez (2014, p. 143) "the evolution of wireless technologies and the development of applications for mobile devices in higher education have been spectacular".

Smartphones and tablets are devices which offer the opportunity to record, transfer or provide information to the user, in any location. Access to a wide array of mobile applications, coupled with the portability, and multifunctional nature of the digital device are the strengths to support student learning (Welsh et al., 2015). This gives the user a sense of control and ownership, a key motivational factor (Jones & Issroff, 2007), but are often viewed as a disruptive influence by faculty in a formalized setting (Sharples, 2002). However, it would be wrong for faculty and instructors to assume today's students are equipped with prior knowledge and experience to fully exploit the learning opportunities offered by mobile devices (Fuller & France, 2019), since many undergraduate students are still largely unaware of the potential offered by mobile devices to support their own learning (Woodcock et al., 2012). Nevertheless, mobile enabled learning opportunities should be developed as the potential pedagogic benefits are immense (Kearney et al., 2012).

Universities now have the opportunity with mobile devices to move away from a model of fixed, dedicated general computing spaces towards a mobile learning and wireless computing paradigm that turns any space into a potential learning space (France et al., 2015). Mobile learning is more than 'e-learning on the move' (Jarvis & Dickie, 2010) given the possible interactions and connections open to students. The concept of mobile learning constantly develops, adapting to new technological advances and pedagogical possibilities.

Various characteristics of mobile learning have been identified in the literature. Herrington et al. (2009) suggests how mobile learning can make authentic learning possible with access to real world situations and can be captured through a set of design principles which summarizes the learning

process. Within the social cultural views of learning, the FRAME model by Koon (2009) considers both the social and personal aspects of the learning process and technical characteristics of mobile learning. The model advocates enhanced collaboration among learners, access to information and deeper contextualization of learning. Kearney et al. (2012) extends the FRAME model to include considerations of mobile pedagogy to develop a mobile pedagogical (iPAC) framework, (see iPAC section) informed by social constructs of personalization, collaboration and authenticity to enable practitioners to create meaningful and authentic mobile learning pedagogies.

There is a growing recognition in university-level education of the importance of innovative teaching and learning and a move away from traditional views of one approach to teaching. It is still the early stages of this innovative work and the territory is uncharted for the most part. In assessing what has been done and the impact of this, there is research on the students' experience of using mobile devices, particularly as it relates to experiential learning (Glass, 2015; Welsh et al., 2012; 2015, Whalley et al., 2018) but empirical research dealing with the effectiveness is limited (Chatel & Falk, 2017). There is however a real gap from the instructor's perspective with regards to any guidelines or materials on best practice. Why are mobile technologies being used? There needs to be a general consensus on the most effective methodology for incorporation of mobile learning in to course design and assessment.

The aim of this paper is to explore and to develop a pathway that addresses both pedagogical and technological considerations of incorporating mobile learning into course design and assessment. A set of guiding questions have been developed and form a series of pathway prompts (see Figure 1) for the instructor to contemplate the impact on teaching practice of integrating a mobile learning initiative into the curriculum.

Alternative learning spaces and field-based experiential learning:

Field-based experiential learning (Healey & Jenkins 2000, Sauer 1956) is built on Kolb's experiential learning theory where the learner is actively experiencing an activity, in our case a field-based experience, and then is asked to consciously reflect back on that experience. Through engaging in field-based experiential learning the ability of a student to make connections between disparate concepts or

disciplines, creates “critical citizens who are able to exercise power over their own lives and especially over the conditions of knowledge production and acquisition” (Giroux, 1997, p. 218). Field Trips as a form of experiential learning are an important step in applying knowledge beyond the classroom. The use of public spaces and public discourse are central to field-based experiential learning in education, but it is often challenging to ‘bring’ the public space and/or discourse to life for students especially in larger courses beyond using static images and recorded video.

Traditional methods of teaching and inquiry, including the traditional delivery of a field-based course no longer match current information landscapes and how knowledge is generated and delivered (Philips & Johns 2012). Traditional approaches to education create an environment where there is an inability to engage students authentically in conversation with students having the predisposition to remain passive listeners (Krakowka 2012). Educational technologies, and specifically mobile learning technologies, are a means of providing students with more active engaged field-based experiential learning opportunities. Through the use of educational technology, we have the ability to question the traditional approach to the delivery and creation of knowledge (Garrison & Kanuka, 2004). It requires an alternative way of framing educational ‘tools’ rather than thinking of them as an aspect of our pedagogy, we must view them as foundations of the frame. Educational technology is therefore the building material of an alternative active learning approach which can occur in multiple ‘learning spaces’ pedagogy.

The use of mobile technology and other forms of emerging media and technology is driven by a desire to push the boundaries of what is perceived as learning spaces. For many people the concept of a ‘learning space’ in higher education is an area where a faculty member can speak with a sea of students intensely listening and frantically taking notes (Anderson & Armbruster, 1986). These traditional learning spaces, including labs or tutorials, are still instructor focused or are spaces where students are for the most part passively involved (Johnson & Johnson, 2008). To facilitate this traditional view of a ‘learning space’ university lecture timetables are often dictated by complex schedules where teaching is limited to two or three 50-minute engagements per week. These preconceptions and scheduling models work perfectly well if the concept of the ‘learning space’ is one where an individual broadcasts knowledge to a group of students in a specific fixed place or designated space, this can be argued to include the traditional instructor-led field trip to a particular site. The idea of what exactly a ‘learning space’ is continues to evolve, as higher education shifts from viewing learning as less a function of transmission to a more

constructivist paradigm. This creates a greater emphasis on collaborations, reflections and experiences allowing students to be active agents in their own learning. The first steps for universities to adhere to modern concepts of learning spaces was to construct and design classrooms for active learning opportunities. The next step was to transform universities to adapt to the concept of a 'learning space' which included the idea of learning on demand (Dabbagh & Kitsantas, 2007), learning experientially (Richards, 2015), or even virtual worlds (Tokel & Isler, 2015; Furió et al., 2013). The pedagogical approach or acceptance that a 'learning space' does not have to be a fixed physical location, and where students are active learners and responsible partners (Hill et al., 2016, Healey & Jenkins 2000) in their learning. The fixation on physical lecture halls or lab spaces is linked to university campuses being sites of learning, but sites of power through the control of knowledge production (Lefebvre, 1991). It is the notion of the 'Ivory Tower' of academia where membership and access is tightly controlled; providing alternative 'learning spaces' and empowering students to be active drivers of their own knowledge acquisition is a troubling reality for traditional approaches to teaching and learning (Furlong, 2013). Shifting pedagogical approaches must embrace the unique innovative uses of technology and emerging media in generating alternative 'learning spaces', specifically in a field-based experiential learning approach (Hill et al., 2016).

The nature of geography as an active enquiry-based discipline, allows for field-based experiential learning opportunities to be seamlessly integrated into the curriculum. With the expanding availability of mobile devices and applications that can be used in the field there is an increasing opportunity for their use within geographic education (Armstrong & Bennett, 2005; France et al., 2013; Welsh et al., 2015). Field-based learning is considered a signature pedagogy and fundamental to teaching and learning of geography (Hovorka & Wolf, 2009). With the adoption of new technologies, the nature of how and where field-based learning occurs can be expanded and different forms of engagement can be offered to students. (Kent et al., 1997; Young 2010; France & Haigh, 2018). Field-based learning is believed to enhance contextualization and enhancement of knowledge through observation, increasing problem solving abilities and increasing student engagement with the curriculum (Day, 2012; Fuller et al., 2006). Mobile geographic education systems can provide access to relevant course material, allow for onsite spatial analysis of data and visualization of the collected data (Day, 2012; Pánek & Glass, 2018). As mobile technologies become more prevalent, their integration into field-based learning could be used to enhance

the student experience, independence and learning of complicated concepts (Armstrong & Bennett, 2005; Fuller & France, 2019).

iPAC: a methodological approach to assessing mobile technologies and field-based learning

The iPAC framework was developed in 2012 as providing a framework to act as a way of measuring or evaluating the use of mobile technologies in a learning context (Kearney et al., 2012). The iPAC framework is used to evaluate or measure how students are using mobile technologies in any particular learning activity. The project developed a learning tool kit (http://bit.ly/33LWpLU) and a survey that can be used with students to assess their use of the specific mobile technology learning tool.

What makes iPAC an interesting framework generally and something which we used a starting point for our own research and paper? The distinctive pedagogical features discussed in the iPAC framework moves the focus of mobile devices as simply tools to review our thinking in terms of their applicability to learning. This is achieved through what the IPAC tool kit refers to as the '*signature pedagogies of mobile learning*' involving three principal constructs: Personalization; Authenticity and Collaboration. The iPAC framework offers a shift of incorporating technology as more than just tools in terms of student learning. We do however identify a gap in the approach which the iPAC framework offers when it comes to the instructor and the actual development of the assignment around the use of the mobile technology. Our approach was hence to adapt the student perspective of the IPAC framework and modify it to the instructor perspective.

TABLE 1 AROUND HERE

The adapted Table 1 outlines how the principal constructs and sub-constructs from the iPAC framework were modified to prepare a pre-emptive guide for instructors to complement the retrospective iPAC survey.

In the following section we outline the methods and the iterative process used to compile an initial set of themes centred around pedagogical principles and technological logistics for mobile learning, and how they can be merged with the framework developed under the iPAC approach.

Pedagogical approach to mobile technologies and field-based experiential learning - adapting the iPAC approach

The integration of mobile learning into an existing learning environment has the potential to follow varying paths (Ally & Prieto-Blazquez, 2014) so it would be disingenuous, and potentially discouraging, to attempt to map an implied singular path for effectual integration that would apply to all instances. With this in mind, a more flexible pathway was proposed, which would provide guidance on pedagogical principles and technological logistics of mobile technology implementation and a path to follow for its effective use in your teaching.

In the initial development stage of the instructor pathway, a list of common considerations, assumptions and problems associated with mobile learning technology was compiled based on personal experiences and previous studies on mobile technology (e.g. Armstrong & Bennett, 2005; Jarvis et al., 2016; Kearney et al., 2012). Ten major themes emerged which highlighted potential barriers to the use of mobile technology (e.g. access to the technology, clear learning objectives, avoiding the "novelty factor"). The themes were distilled into ten questions designed to prompt the user to contemplate the purpose and logistics of mobile technology implementation in their teaching prior to its use to create seamless integration. The initial series of questions were sent to members of the International Network for Learning and Teaching (INLT) as well as select faculty members at the University of British Columbia, University of Chester, and McMaster University with questions of how they could be improved and/or refined. From these, 21 responses were received, which provided valuable feedback on the questions and supported that we were working on something that would be beneficial to others with over 90% agreeing they may be helpful.

While there was overall satisfaction with the questions provided, four respondents expressed a desire to have a question (or definition of a question) specifically addressing technological support from both the perspective of the student and that of the instructor:

> *A question along the lines of 'do you know who can offer you support as you adopt the technology' before and during its use on the course?*

What support measures are in place for students who struggle with the technical aspects of the technology?

There was also, in varying forms, a discussion of cost whether it is to the instructor or the student. This speaks to the accessibility of the introduction of mobile learning as there may be a need for the institution to be proactive in preparation of new learning paradigms.

With regard to the 'equal access' question, perhaps that could be refined to further ask more specifically about whether the instructor has explored options for, say, students borrowing relevant technologies from a campus centre or library or whatnot.

FIGURE 1 AROUND HERE

Using the responses, the pathway questions were further refined and parsed into questions both pedagogically and technologically focused (Figure 1). The separation of question type allows the user to gain insight into the potential disparate challenges tied to pedagogical and technological concerns. While technological concerns can often be solved with funding it is the pedagogical questions that create the path to a valuable student experience. Tied to the pathway is a series of potential solutions (Tables 2 and 3) to any roadblocks hit along the way.

The questions are designed to be hierarchical, starting with the broadest questions and moving towards more specific considerations for mobile learning technology use. When considering a question, if the answer is no there is a brief guiding statement and further information can be found in Table 2 for pedagogical framework questions that focus on the underlying intentions of the assessment and Table 3 for the practical technological logistics considerations. Following the pathway (Figure 1), if after considering the question, and the answer is yes, follow the path to the next question. Both the technological and the pedagogical questions must be considered to reach the centre which represents effective use of mobile learning technology.

TABLE 2 AROUND HERE

TABLE 3 AROUND HERE

Worked examples

In seeking to illustrate how instructors can use the pathway for their own teaching practice, three worked examples from the UK (Chester) and Canada (University of British Columbia and McMaster University) were selected. In each example the specifics of the application of mobile technologies vary greatly illustrating the importance and applicability of an overall pathway effectiveness. Summaries of the teaching applications from which the perceived pedagogic and technological characteristics were tested against the pathway (see Figure 1) are as follows:

UK: University of Chester

Student investigation of a coastal dune ecosystem using mobile technology.

An Environmental Change field course provides a backdrop for second year students to experience fieldwork in the coastal dune system of Harlech, UK. The objective is to use a range of mobile applications (e.g. ArcGIS Collector) to record (via a tablet) and analyse primary field data. Students worked in small teams, on a single fieldwork day, to record vegetation abundance, morphology and micro-climate information from the foredunes to the hind dunes. On return to the University of Chester, the data was seamlessly transferred to ArcGIS to produce individual Story Maps of the coastal dune system.

Canada: University of British Columbia

Augmented Reality walking tour of Downtown Vancouver engaging with historical political economy of the city

Field trips are an important aspect of basing a first-year human geography on active learning pedagogy. The objective of the adoption of an app-based AR walking tour was to address the logistics of providing 150 students with a field trip experience outside the classroom. The University of British Columbia based experience takes students on a two-hour walking tour covering the political economic history of the development of the Downtown core of Vancouver in British Columbia Canada.

Canada: McMaster University

Using Twitter to bring together ideas in an interdisciplinary learning course based on exploring and understanding Hamilton, Ontario, Canada

The course *'Exploring Hamilton' (*https://bit.ly/2YXxjGR)is offered as an inquiry course for upper-year students in the McMaster University Arts & Science Program. The course brings together 25 students with a myriad of academic interests ranging from English literature through physics and explores geographical questions of the City they call home for their undergraduate education. An assignment of particular acclaim to the students is using twitter as a platform to share, with both the class and the community at large, what they found interesting on a walking tour of downtown Hamilton

TABLE 4 AROUND HERE

Application of summaries to Pedagogical Framework and Technological Logistics Pathway

Responses of the three worked examples to the pathway questions are presented in Table 4 and illustrate positive instructor feedback, where the instructor can justify the use and support of the mobile learning activity within the teaching session. In all cases the instructors' reflective responses to the eight pathway questions, indicate a clear structured activity, engaged students, and which considers equal access, prior experience and contingency planning.

Whether conducting Twitter based interactions around Hamilton, mapping vegetation along the dune system of Harlech, or Augmented Reality walking tour of Downtown Vancouver, it is evident from the responses to the pedagogic pathway questions, the same support and thought is given to the application of the mobile learning activity. These worked examples involve varying degrees of integration, but each can be deemed an impactful mobile learning activity which has been effectively integrated into the curriculum.

Final Thoughts

As higher education evolves there is ever more importance being placed on being innovative in teaching and learning and a move away from traditional views towards teaching. That being said we are still in the early stages of much of this innovative work and the territory is uncharted for the most

part. In assessing what has been done and the impact of this, there is some very detailed rigorous research on the impact that mobile technologies and emerging media in general has on the students' experience, particularly as it relates to experiential learning (Armatas et al., 2005, Cheng et al., 2019, Li et al., 2019). There is however a real gap in any research or material on best practices from the instructor's perspective that could be further explored more readily if a standardized framework of mobile learning implementation was followed. The construction of the mobile learning pathway gave the opportunity to reflect upon past interactions with students in a general sense and, more specifically, how mobile technologies were incorporated into teaching and learning practices. As the research focuses around developing best practices for mobile learning it became clear to us that it can become exceedingly easy to incorporate mobile technologies with the best of intentions without putting sufficient thought into the questions of '*why*' the technology should be used. Is the injection of mobile learning adding anything to the learning potential of the students? Occasionally technological assumptions can lead to issues of access or insufficient digital literacy that may make the technology the limiting variable in the learning experience. This is where the opportunity to explore and develop a series of pedagogic and technological questions which result in a set of mobile learning guidelines for instructors provides value.

Conclusions

This paper goes some way towards developing a pathway to address both pedagogical and technological considerations of incorporating mobile learning into course design and assessment. The pedagogical and technological questions enable the instructor to assess whether the mobile learning intervention is appropriate and adds value. Supporting information for the instructor is provided in the pathway, which offers a series of potential solutions if barriers are encountered. This paper suggests the pathway is appropriate and was effectively tested with three worked examples. The outcome indicated that the examples were appropriate for mobile learning technologies. There is still the requirement for further external evaluation of the pathway with additional teaching examples.

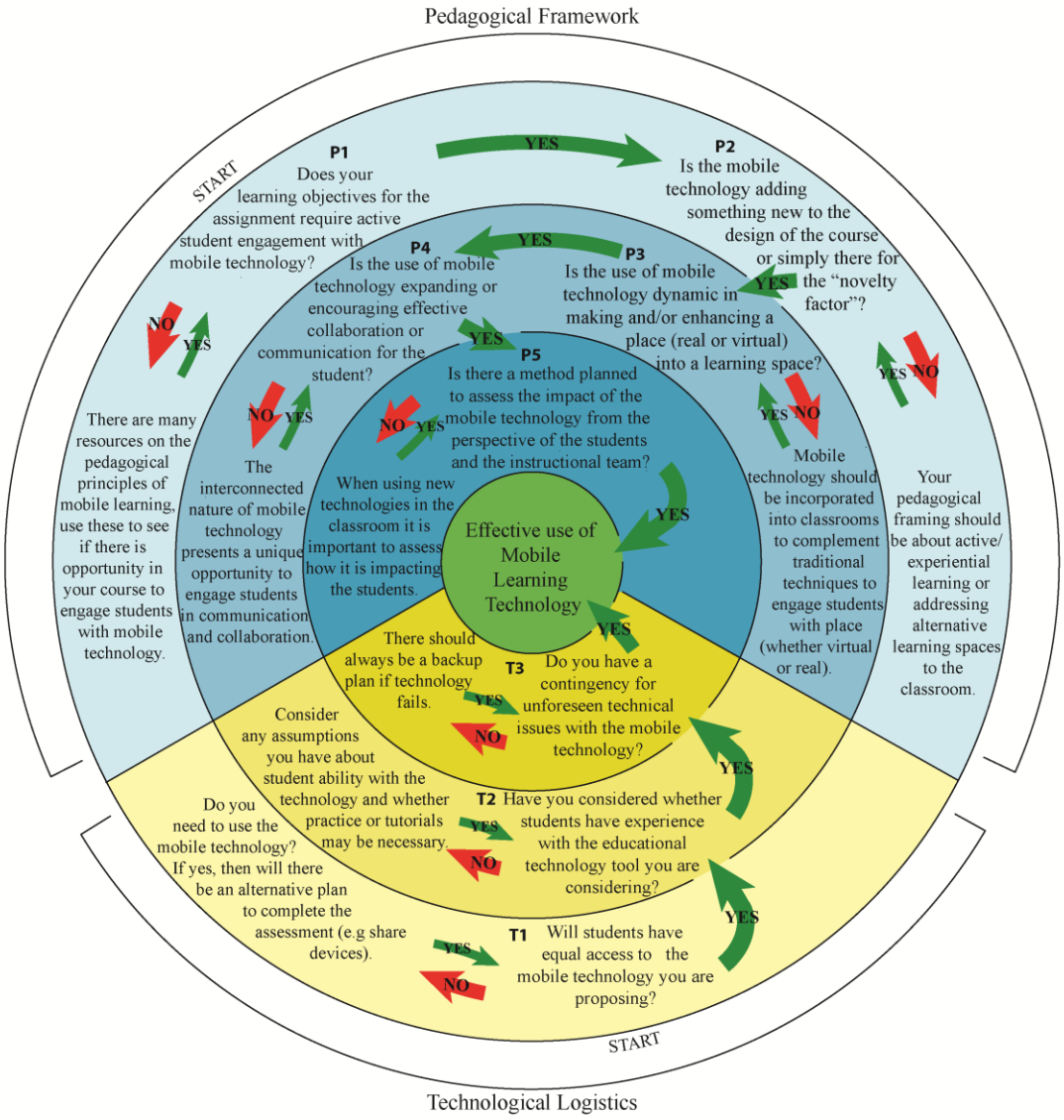

Figure 1: Pathway with guiding questions to prompt consideration of the applicability and the implementation of mobile learning in a course or assessment. To implement mobile technology effectively there are two critical components that must be considered: the pedagogical basis and purpose of implementation; and the technological considerations and issues that might be encountered. These two components should be considered individually, as shown on the pathway by the Pedagogical Framework (P) and Technological Logistics (T), with the centre of them resulting in the effective use of mobile learning technologies. When considering a question, if the answer is no there is a brief guiding statement and further information can be found in Table 2 for pedagogical framework questions that focus on the underlying intentions of the assessment and Table 3 for the practical technological logistics considerations.

Table 1: The principal constructs of mobile learning technology that should underpin planning and implementation in the classroom.

Principal Constructs	Sub Constructs	Application
Personalization	Agency	The use of the mobile technology should be an important element in ensuring the student is engaged with the assignment/learning task
	Customisation	When incorporating mobile technology into curriculum design the instructor should focus on how its use allows for the continuous reimagining of learning spaces (real or virtual)
Authenticity	Setting	Acknowledging that the use of mobile technology enables adaptive learning spaces
	Task	Mobile technology should contribute to making the learning experience design more fluid rather than more complex
	Tool	The selected tool should be familiar to students. Either because they use it all the time (cell phone) or they are familiarized to it (using a particular app/GPS tracker to collect data)
Collaboration	Conversation	The use of mobile technology should allow students to engage in a dialectical way with instructors and each other.
	Data sharing	If the objective of the assignment/learning exercise is to produce data (visual/statistical/reflective) then this should be built into the experience and not be a separate step.

Table 2: Supplementary resources and information on the pedagogical framework, to be used if the answer to any of the pedagogical questions in the pathway are 'no'. These resources and suggestions can be used to find further information on mobile learning technology.

Pedagogical framework		
Question		**Resources**
P1	Do your learning objectives for the assignment require active student engagement with mobile technology?	If there is no active engagement of the student with mobile technology, then its effective application within an assessment is limited. For examples of mobile learning technology uses see Traxler (2009); Masrom and Ismail (2010); Kearney et al. (2012); Park (2011) and Jarvis and Achilleos (2013)
P2	Is the mobile technology adding something new to the design of the course or simply there for the "novelty factor"?	Before implementing mobile technology, consider these questions: Does the mobile technology fit in as part of the course? Is there any alternative tool/approach? Do you feel pressure to incorporate mobile technology into your teaching and learning because others are doing it? If the mobile technology is being used more for the novelty factor or to "keep up" with other faculty, it may not be the best learning tool for the planned assessment. If you are questioning whether the planned use of mobile technology is pedagogically supported, see Jarvis & Achilleos (2013); Granberg (2010); Martin & Ertzberger (2013); Jarvis et al. (2016).

P3	Is the use of mobile technology dynamic in making and/or enhancing a place (real or virtual) into a learning space?	Using mobile technology should enable you to move away from more traditional teaching spaces (such as showing images in a PowerPoint or describing places) to more innovative and tangible connections with place. A key aspect of the teaching of Geography at any level is about the interactive nature of the discipline. Places need to be engaged with in order to be understood. Field trips are the traditional approach but more global world and many of us teaching students from a diversity of places - we can't assume they want to know only about certain places that we are familiar with close by. Day (2012), Armstrong and Bennett (2005) discuss some aspects of using mobile tech to address place and changing learning spaces. See Dabbagh and Kitsantas (2012); Tokel and İsler (2015); and Krause (2005).
P4	Is the use of mobile technology expanding or encouraging effective collaboration or communication for the student?	The ability to engage students in collaboration on multiple scales and with various groups of people (peers, instructors, wider public) is supported by mobile technology, bringing these interactions beyond the classroom and into other learning spaces. Increased collaboration and communication are often considered fundamental to the successful application of mobile learning technology (Park 2011; Kearney et al., 2012). Social media, such as twitter, can be seen as an opportunity to communicate Geography to a wider audience while using mobile technology outside the classroom to create new learning spaces. See Motiwalla (2007); Kukulska-Hulme and Shield (2008); Koole (2009) for further information and examples of collaboration and communication with mobile learning technology.

P5	Is there a method planned to assess the impact of the mobile technology towards the learning goals from the perspective of the students and the instructional team?	Various authors have found that student achievement levels are higher due to having increased motivation and interest aided by interactive technology (Chen & Wang, 2004; Civelek et al., 2014). When there is any type of change in learning activities within a classroom there is a need for assessment. There are numerous interesting articles on mobile learning technology assessment, refer to Figure 1, from Parsons (2006) for a framework for assessment. As an example of a survey, based on the IPAC framework there are suggested surveys for evaluating the perception of a mobile learning activity from the perspective of the students and instructor: http://www.mobilelearningtoolkit.com/ipac-surveys.html.

Table 3: Further resources and information on the technological logistics, to be used if the answer to any of the technological questions in the pathway are 'no'. These resources and suggestions can be used to find further information on mobile learning technology.

Technological logistics		
Question		**Resources**
T1	Will students have equal access to the mobile technology you are proposing?	Ensuring equal opportunity for access to mobile technology is pivotal to its successful use within classes. If there are access issues, alternative plans must be made to accommodate any discrepancy between students. Potential alternatives include allowing students to share devices, allowing students to complete the assignment using pen/paper or other devices (such as a laptop). There may be opportunities for institutional or governmental funding to acquire a 'class set' of mobile technology which can be explored. See Elmes (2017); Unwin (2017)
T2	Have you considered whether students have previous experience with the educational technology tool that you are considering?	Consider any assumptions that are being made about using technology (e.g. the students will have used the app/technology before) and how these can be addressed. See Kim (2014) for a useful process for unpacking assumptions. Is there another pedagogical approach that can be used if there is an issue with students learning the technology to ensure that they have the opportunity to learn the central concepts? When considering using the technology, ask your students in the class or former students about their familiarity with the app/technology to gauge their potential knowledge. If there may be a steep learning curve to the technology, budget in time in the course to ensure students know how the technology works. The first time trying new technologies, try making it a low-risk assignment to reduce student stress when trying the technology.

T3	Do you have a contingency plan for unforeseen technical issues with the mobile technology	There must be plans in place for those moments the technology does not work. This can be something as simple as having the opportunity to sketch a field area instead of taking a digital image. While the goal may be to use mobile technologies there must always be preparation from when things don't work. There are few resources (if any) specifically discussing when things fail using mobile technologies. This is something that needs to be taken into account within the design. If the mobile technologies fail is there a backup plan.

Table 4: Worked examples of the pedagogical framework and technological logistics pathway.

	Instructor Response to the Pathway Questions		
Pathway Question Number	UK: University of Chester	Canada: University of British Columbia	Canada: McMaster University
P1	Yes: Students utilise a bespoke Collector App to record species diversity, morphology and map the GPS location of the quadrats.	Yes: Students download a free AR-app based experience which allows for audio, images and interactive text to be triggered at specific GPS coordinates	Yes: Students have access to twitter on their personal mobile devices. If they do not have a twitter account, or would rather not use their personal account, they may create an account under a pseudonym.
P2	Yes: Technology enables real time offline data collection in the field, which on return to University, seamlessly transfers to the Cloud. Students learn new skills, making them more digitally literate. GIS skills are developed within the module.	Yes: Technology allows students to experience the field trip during their own time and as active participants in their own learning. Stored audio files and images housed within the AR app allows students to re-engage with the content of the walking tour as needed	Yes: The technology allows students to upload their thoughts and see those of their colleagues in real time via Twitter. The use of hashtags allows students to track the posts and re-engage with the content generated at a later date.

P3	Yes: This is active outdoor learning, with student centred data collection and teaching. Tablets are used to record fieldwork data along the transect. Locations are logged on a map dynamically to better understand the sand dune system succession.	Yes: This is an active outdoor learning experience where students spend two hours walking around parts of Downtown Vancouver and engaging with the different spaces through the AR app	Yes: This gives students the ability to follow the thoughts and conversations of their classmates during the two-hour walking tour and actively participate in the conversation.
P4	Yes: Students work collaboratively on Tablets in small teams to collect field data through mobile Apps. This facilitates prompt data sharing and analysis via the Cloud between students and the teaching team.	Yes: Although students download the app on their own phone, they are encouraged to complete the experience with a classmate. Students are encouraged to interact with different locations e.g. bakery staff and library staff, along the way	Yes: The entire idea of this assignment is to encourage students to converse throughout the walking tour as they share their thoughts. Students are encouraged to generate new ideas within small groups based on the collective interests of the class. This work gives the instructor an idea of the classes interests to assist in developing future content.
P5	Yes: At the end of the Story Map assignment, a student feedback questionnaire is completed to reflect on their learning experiences and impact of using mobile technology	Yes: At the end of the AR app-based experience students are asked to complete a worksheet which focuses on specific factual aspects of the walking tour as well as reflective elements surrounding the experience	Yes: At the end of the assignment students are asked to reflect on their interests of the walking tour and contrast those to the collective interests of the class.

T1	Yes: A class set of Tablets are available for all students to ensure equal access to the technology. One/two Tablets per student group is utilised in this example.	Yes: In the five years the walking tour has run only once did a student not have a smartphone. They were provided with the possibility of accessing the audio files but choose to do the walking tour with another student	Yes: In the two years this assignment occurred all students had a smartphone. The students did have an option of acquiring a digital camera from the McMaster University Library if they did not have a phone to use. Photos could be taken and later uploaded to twitter.
T2	Yes: The initial data entry in mobile phone/tablet is easily achieved through the use of a bespoke Collector App using drop down menus. instructors are available in the field to support students. Weekly workshops support mobile data transfer and analysis to ArcGIS Online, through to the production of an individual Story Map.	Somewhat: Students are familiar with downloading and using location aware apps such as Google Maps, but the Explore-AR app does have specific steps in order to start the tour. Students are provided with clear instructions on a handout during lecture time and the instructor and teaching assistants are available via email and office hours to address any questions or concerns	Somewhat: There are students who may not want to use twitter or any social media platform to share their photographs and thoughts. Students are told this is not a requirement as simple accommodations can be made such as submitting the work directly to the instructor.

T3	Yes: Preparatory fieldwork sessions are held to discuss logistics and organisation of the fieldwork day. Tablets are loaded with appropriate apps and are in waterproof cases to ensure usage in all weathers. If there are technological issues during the fieldwork activity spare tablets are available.	Yes: The handout (see above) includes clear instructions on how to deal with any technical issues that may occur. Students are given a 10-day period during which to complete the experience addressing any issues that might arise with weather or other course requirements	Yes: Students have the assignment explained to them weeks prior to the walking tour. This gives plenty of time to address any issues with the technology prior to the start of the assignment. The instructor always brings a few digital cameras on the tour for those whose smartphones stop working or batteries fail.

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