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Making geography mobile: using location aware technology to improve student performance in physical geography

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Abstract

With the increased availability of new technologies, geography educators are revisiting their pedagogical approaches to teaching and calling for opportunities to share local and international practices which will enhance the learning experience and improve students' performance. This paper reports on the use of handheld mobile devices, fitted with GPS, by secondary (high) school pupils in geography. Two location-aware activities were completed over one academic year (one per semester) and pre-test and post-test scores for both topics revealed a statistically significant increase in pupils' performance as measured by the standard national assessments. A learner centred educational approach was adopted with the first mobile learning activity being created by the teacher as an exemplar of effective mobile learning design. Pupils built on their experiences of using mobile learning when they were required to created their own location aware learning task for peer use. An analysis of the qualitative data from the pupils' journals, group diaries and focus group interviews revealed the five pillars of learner centred education are addressed when using location aware technologies and the use of handheld mobile devices offered greater flexibility and autonomy to the pupils thus altering the level of power and control away from the teacher. Due to the relatively small number of participants in the study, the results are more informative than generalisable however in light of the growing interest in geo-spatial technologies in geography education, this paper offers encouragement and insight into the use of location aware technology in a compulsory school context.

Keywords: Location Aware Technology, Geo-Spatial Activities, Geography Pedagogy, Secondary Education, Student Performance

1. Introduction

Geography as a subject is on the brink of change in a number of spheres. With the increased availability of new technologies, geography educators are revisiting their pedagogical approaches to teaching and calling for opportunities to share local and international practices in response to government trends and curricular developments (Brooks, 2012;

Baldwin, 2012). From an employability perspective, increased career opportunities in business, government and non-profit organisations exist for those students studying Geographical Information Science (GIScience) due to the transferable skills it offers, such as problem-solving, spatial reasoning and interdisciplinary perspectives and mapping techniques (Richardson, 2008). Indeed, what was once considered as core geographical knowledge, such as maps, is being transformed by the use of Geographical Information Systems (GIS) but at what expense in terms of time devoted to curriculum content (Cunningham, 2005). The use of global positioning systems (GPS) in association with mobile or handheld devices adds a further element to the technological developments in geography pedagogy. Location aware technology, such as Personal Digital Assistants (PDAs) equipped with GPS and headphones, offer a personalised geographical experience due to the presence of adaptive functionality in both time and space. Where in the past, on-site fieldtrips formed a key aspect of a geographer's career preparation, it is becoming increasingly likely that the much talked about "virtual" fieldtrip (Stainfield et al., 2000) will become a feature of 21st century teaching due to the increased availability of both location and context aware systems. Indeed, although site-based fieldwork is known to promote both social learning and knowledge-based enquiry, the potential shift towards "virtual" fieldtrips seems imminent in light of increased regulations and economic constraints (Cook et al., 2006; Herrick, 2010). Nonetheless at the heart of all teaching is the learner and the goal that altering pedagogical practices will enhance the learning experience and improve students' performance.

2. What is mobile learning?

Coyle et al. (2007) declared mobile learning as a complex and multi-faceted term as it means different things to different people. Kukulska-Hulme and Traxler (2005), Sharples et al. (2007, 2009) support definitions that focus on the learner being mobile and unconstrained by the physical space in which they are learning. This may or may not include the use of technology – reading a book under a tree could be considered as mobile learning using this definition. However the majority of people agree on the handheld nature of the technology (making the device mobile) and the learner having the freedom to move with the device. For example, O'Malley et al. (2005, p. 7) defined mobile learning as "taking place when the learner is not at a fixed, predetermined location, or when the learner takes advantage of the learning opportunities offered by the mobile technologies". Typical examples of mobile technologies were suggested by Wood (2003, p. 65) as being "PDAs, mobile phones, laptops and tablet PCs". Mobile learning is possibly best known for its ubiquitous nature (being everywhere around us) and also being pervasive (embedded in our daily routines so that it often goes unnoticed).

More recently Quinn (2011, p. 4) defined mobile learning as "any activity that allows individuals to be more productive when consuming, interacting with, or creating information, mediated through a compact digital portable device that the individual carries on a regular basis, has reliable connectivity, and fits in a pocket or purse" indicating the move to "productivity" and the acknowledgement that mobile learners can be users and also creators of the learning.

Mediascapes are just one tool that have found their way into classrooms and are being used for educational purposes. Created by Hewlett Packard (HP), a mediascape is "an experience… rich in interactivity – full of sound and music, images and text, videos and animations, narrative and dialog, all embedded in the space where you're standing" (HP, 2008). Using a GPS enabled mobile device (eg. PDA or smartphone) and earphones, the mobile device triggers multimedia as you move around a predefined space – it is context-aware. Mscapes can therefore superimpose a digital canvas on our everyday environment making locations "geo-tagged" with multimedia (Loveless et al., 2008) causing the presentation of information (visually or orally or both) as you enter and leave a space. As Stenton et al. (2007) note, it is like a linear guided tour. Depending on the design of the content being presented and the rules used to control the system, personalised

rich learning experiences can be created in a lively and interactive manner often adapting the content for the passage of time between visits to the same location (for example, if simulating a battlefield). With geo-spatial technologies of this nature becoming increasingly prevalent in the mobile phones of young people today, the question arises, can we use the pupils' own equipment in our teaching and in particular, for reinforcing the underpinning premise of geography – space and place.

3. Defining location aware technology

Location aware technology, on the other hand, can be embedded in handheld mobile devices such as PDAs with GPS and reused in a variety of locations or educational spaces. The term "location" or "context" are often used interchangeably to describe a particular point in time or space. For example, the statement "at 12 noon I was in a café" defines my location or the context for a particular event. Similarly in discussing geo-spatial technologies, the terms "location aware" and "context aware" are equally common when pinpointing a moment in time and space. Alatalo and Peraaho (2001, p. 1) declare "a system is context-aware if it can extract, interpret and use context information and adapt its functionality to the current context of use". Similarly location-aware systems have been referred to as those operating in social settings so a number of complex interactions exist such as user-system, system-components, system-environment. The usability of the application is measured as the extent to which it can function correctly in a social context (Mubin et al., 2006).

Numerous applications of location aware technology exist ranging from language learning (Fallahkair et al., 2004; Godwin-Jones, 2004; Kadyte, 2003; Ogata and Yano, 2004; Tan and Liu, 2004) to artworks in a museum (Lonsdale et al., 2003) where location, time and the user's profile are used to tailor the presentation of the content for each user. Informal uses such as authentic conversations enacted in Chinese (Chen and Chou, 2007) with adults learners based on topics relevant to the person's current location indicate the on-going nature of research into handheld devices. It should be noted that activities associated with online inquiry skills offer learners a more engaging environment (Cantu and Warren, 2003; Doppen, 2004; Sunal and Sunal, 2003) which increases students' motivation, extending their knowledge of the content domain (Edelson et al., 1999) and cultivating students' ability to use self-directed learning (Lim, 2004). The handheld, ubiquitous and pervasive nature of mobile devices supports these online inquiry skills and the benefits that ensue. However, as Li and Lim (2008) and Molebash (2004) posit, meaningful learning in an online environment can only be achieved through appropriate guidance and scaffolding. Two potential problems that may arise in the mobile learning process are students' lack of information literacy skills to manage the information presented on the mobile devices (Wallace, Kuppermanm, Krajcik and Soloway, 2000) and the need for high cognitive skills (Wagner, Holloway and Garton, 1999) to process and internalise the information "on the move". As Ge and Land (2003) indicate, question prompts and peer interaction can be used as effective scaffolding strategies in the mobile learning context.

In relation to teaching geography, Huizenga et al. (2009) completed a game-based mobile learning activity centred on Amsterdam city. Location aware devices were used by young people aged 12-16 years in a simulation of the "year and a day" rule of medieval Amsterdam. Despite a number of technical issues throughout the one day event, the young people found the experience engaging and enjoyable and they were motivated to develop their knowledge of this ancient law. It should be noted however that this study was not part of the formal school curriculum.

In contrast Facer et al. (2004) simulated the role of a lion in the African Savannah in their two-day teacher-led game with ten pupils aged 11-12 years as part of the formal secondary (high) school curriculum. The location aware experience was situated in the school playing field and the pupils mimicked the animals who were the "hunters" or "hunted" in this virtual fieldtrip. An important finding of this study was the high levels of engagement and motivation that prevailed when the pupils reflected on the

decision-making processes utilised in their role as an animal in the savannah compared to the passive, non-participatory attitudes adopted by the same pupils during the teacher-led discussions.

Primary school pupils have also experienced the use of handheld mobile devices for location-based activities as denoted by Wood et al. (2004) and Battista (2008). The former focused on the use of sound to capture pupils' (aged 9-10 years) perceptions of space and place in their local area. Battista (2008) involved pupils aged 11 years in a project to design and create a personalised interactive piece of fieldwork. The challenge for these pupils was the creation of the location-aware task, especially when they had not experienced a location aware activity prior to embarking on this project. In light of these studies, and others addressing non-geographical topics (Attewell, 2005; Mobilearn, 2005; Chen and Chou, 2007; Burkett, 2008; Li and Lim, 2008; Wake and Baggetun, 2009; Fitzgerald et al., 2010; Lui and Tsai, 2013) the notion of a "virtual" fieldtrip, presented via the PDA simulating being in a different location, may appeal to teachers, pupils and educational administrators or even parents especially if the learning context can be brought to the pupils digitally as will be described later in this paper.

Research to date reveals increasing use is being made of mobile learning (typically handheld devices) within undergraduate Geography field trip courses (Jarvis, 2010). However the question remains as to how to assess students' learning when mobile technologies are being used. Is it valid and reliable to continue using traditional paper-based tests of subject knowledge? Jarvis (2013) reported "a combined mediascape-essay approach… successfully captured the main elements of the learning and teaching experience and facilitated deeper learning and creativity".

In the context of this school-based study, and in the spirit of ethics, the use of a mediascape-essay was deemed inappropriate as a measurement tool for these students. All students were currently completing a two year geography programme culminating in a paper-based national examination of structured response style questions. For this reason, it was considered more ethically appropriate to retain the assessment process utilised in the national examination system. As a result, this research compares the use of a teacher-created mediascape anchored in the school grounds, with the hands-on practical process of pupils creating a mediascape in small groups in an attempt to determine which approach is most effective in supporting the internalisation of subject knowledge as measured via performance in paper-based national examination style questions for the two topics under consideration. Although a challenging task, pupils were asked to create the second mediascape as Firth (2011, p. 293) advocates "knowledge becomes meaningful through engagement with the disciplinary practices that govern the creation, validation, representation, interpretation and critique of knowledge within specific domains." The overarching goal of this research is to respond to the question "Why should geography teachers embed mobile technology into their curricular teaching in a formal school context?"

4. A Learner Centred Education Framework

Norman and Spohrer (nd, p. 1) acknowledge that "people learn best when [they are] engrossed in the topic, motivated to seek out new knowledge and skills because they need them in order to solve the problem at hand". Learner centred education (LCE) uses realistic, intrinsically motivating problems which will spark active exploration, reflection and reconstruction of knowledge and ultimately learning through solving problems over extended periods of time usually in a group. The teacher's role in this approach is to construct and scaffold the problem-solving process to ensure the intended learning outcomes of the activity are addressed naturally in the course of solving the problem. Ideally students are so engrossed in these authentic learning activities that the underlying instruction goes unnoticed by the learners. Typically the use of LCE motivates learners to improve their performance and to strive for the best they can achieve.

From the teachers' perspective, McCombs identified the four core domains of learner-

centred classroom practice to be promoting positive interpersonal relationships as the students work in groups, respecting the students' voice and providing a challenging learning experience, developing higher order thinking skills and encouraging students to be self-regulating within their group, and finally adapting to the individual differences and needs of the learners through scaffolding the learning and instruction.

From the students' perspective, Walczyk et al. (2007) propose that LCE is composed of five pillars, namely, outdoor activities, practical applications, dialogue among participants, teamwork, and opportunities to experiment. Lesh (2006) asserts that these five pillars result in deep learning in students and an ownership and empowerment as active participants to "be creative and to draw upon their unique perspectives to solve problems" (Allen and Lukinbeal, 2011, p. 243) thereby accepting responsibility for their own learning (Lukinbeal et al., 2007). In the context of location aware activities, it is the position of the students as identified by the GPS that triggers the presentation of information on-screen depending on the location of the students. For this reason, the students must be outdoors and able to move around freely in the location making the experience inherently practical and often unique to the pupils who could take different routes in the space. However the usefulness of the LCE approach when using location-aware technology remains under-researched. This study will investigate the extent to which the evidence from using location-aware technology can be explained using the five pillars as described above. Visual evidence of these pillars will be presented in the Analysis and Findings section later in this paper.

5. Research Design

The use of action research befitted the embedding of mobile technology into classroom teaching for a full academic year. Kemmis and McTaggart (1988, p. 5) describe action research as "a form of collective self-reflective enquiry undertaken by participants in social situations in order to improve the rationality and justice of their own social or educational practices and the situations in which these practices are carried out". The participants in this study are both the teacher, providing overall ownership and power in the process (Mills, 2003), and the students' "voice" as advocated in learner centred practice. For this reason it was imperative that data was collated from a variety of sources to ensure a 360° view of the process was obtained. These sources included teacher and student diaries, semi-structured focus group interviews, observations and digital photographs of the outdoor activities, quizzes presented via the mobile technologies and finally the paper-based end of topic assessments. McNiff's (1994, 1995) model of action research combined flexibility with the option of suggesting a possible solution at an early stage of the cyclical process. Since the solution to be tested was the use of mobile handheld technologies offering location-aware activities in the teaching of physical geography and map skills, McNiff's model matched the goals of the study. A further verification of the suitability of this methodology was the reported increase in use of action research in other ICT and school-based mobile technology projects (Kukulska-Hulme and Traxler, 2005; Somekh, 1995; Selwood and Twining, 2005; Attewell et al., 2010). McNiff's (1994, 1995) third stage of "implementing the solution" led to the creation of the Thames mediascape by the teacher as the first mobile learning activity, followed by the pupil-created mediascape treasure hunts.

5.1 The handheld devices

Based on the work of Economides and Nikolaou (2008), key attributes of a typical mobile device can be captured in three main categories: the physical characteristics of the device such as its size, battery life, weight, screen size and resolution; the functionality of the device and whether it meets the intended purpose in terms of memory, operating system, being GPS enabled; and finally the ease of use by the learner with navigation and buttons, touch screen, school-based safety features (no internet, email, camera or phone access), quick charge facility and good audio/visual quality on-screen. In addition, evidence of previously successful experiences using a particular handheld device

and the popularity of the brand or personal recommendation may also be deciding factors. Although modern smartphones have much of the functionality needed to create and run mobile online learning experiences, their screen size tends to be smaller than that of the PDA and also it can be harder to de-activate communication facilities on a Smartphone in keeping with school rules The robustness of the HP iPAQ 214 used in this study had already been verified in school-based mscapes work (Facer et al., 2004; Wood et al., 2004; Reid et al., 2007 and Quinn and Cartwright, 2009) which confirmed the presence of compatibility between the device and the Mscapes player toolkit, and the availability of maps in a format suitable for this handheld device. While the iPAQ214 was chosen for this year long investigation, it should be remembered that the device itself is only a tool mediating between the learner and the GPS feedback. It is the mediascape which presents the content of the learning experience.

5.2 The mediascapes

The base map of the school grounds upon which the River Thames was superimposed was a jpeg image of the school obtained from the Ordnance Survey of Northern Ireland (OSNI), imported into MS Paint before being converted into a MapLib file, compatible with Mscape Toolkit (Figure 1).

The Thames mediascape was designed as an anchored linear mscape, meaning it was attached to a specific location (the school campus) and linear in terms of forcing the students to experience the regions in a sequential fashion (from the source to the mouth of the river Thames) thus ensuring the key geographical features and processes were presented. In keeping with the requirements of LCE, the teacher was indirectly ensuring that the learning intentions for the subject content were being covered in full via the learning instruction embedded in the location aware activity. As shown in Figure 1, the Thames mscape was anchored on the school campus with the "hotspot" sites containing the teaching materials located in specific positions outdoors.

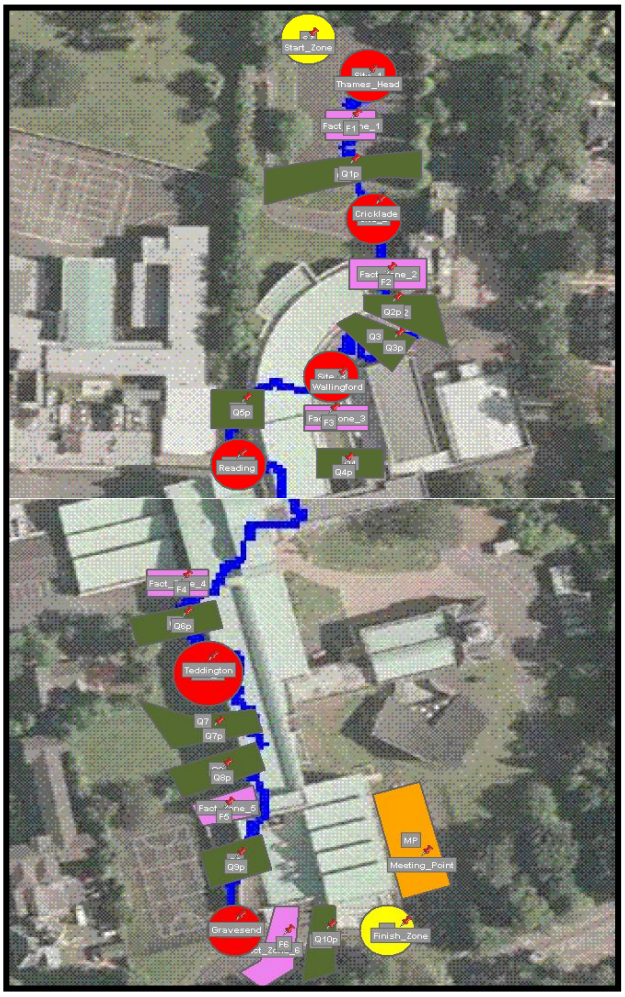

Figure 1. Thames Mediascape on the school grounds with hotspots visible.

The pupils were therefore able to walk the length of this "virtual" River Thames from its source in Thames Head, near Kemble in Gloucester (in the tennis courts) to its mouth at Gravesend, to the east of London where the River Thames meets the North Sea (in the school's overflow car park). At no time did the pupils leave the school campus nor were they exposed to any dangers such as steep banks or hidden hollows in the terrain, steps or busy pedestrian areas.

Regions and speakers were used to control the visual and auditory output to the users and these were "grouped" to improve the overall timing and choreographing of the controls for these features as users entered and exited a region. As shown in Figure 1, the majority of the

learning experience was delivered outdoors and depended upon the presentation of a slideshow with accompanying audio.

As Figure 2 reveals, when the pupils entered a hotspot, an image of the geographical feature typically found at that location was presented to the pupils on-screen eg. interlocking spurs, V-shaped valleys and gorges, waterfalls and rapids, meanders and oxbow lakes, sandbanks and floodplains. A voice-over with more specific information about the formation of the landform was provided and at key points (usually at the end of a river stage) the pupils had to complete a short quiz before being able to continue on their journey downstream. The key processes of erosion, transportation and deposition were also included in the mscape content (Figure 3). At the end of the mscape experience the pupils were presented with a 10 item quiz revisiting the key learning outcomes for the topic.

As noted later in the paper, it could be argued that this slideshow could have been presented in the safety and security of the classroom however, the use of the PDAs fitted with GPS, allowed pupils to "live" the walk from the source to the mouth of the Thames in a context which promoted the recall of prior experiences and facilities the mapping of the real with the virtual by remembering the location on the school grounds where a memorable image or piece of audio text or music was played.

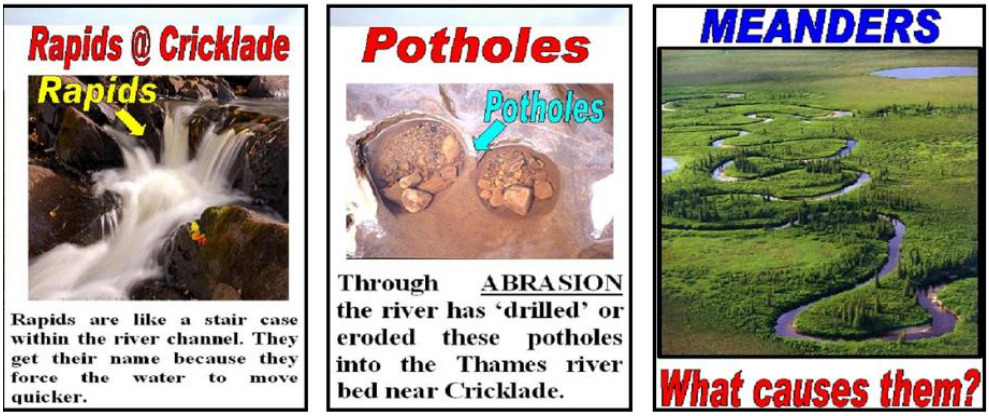

Figure 2. Images of subject knowledge content – features of a river.

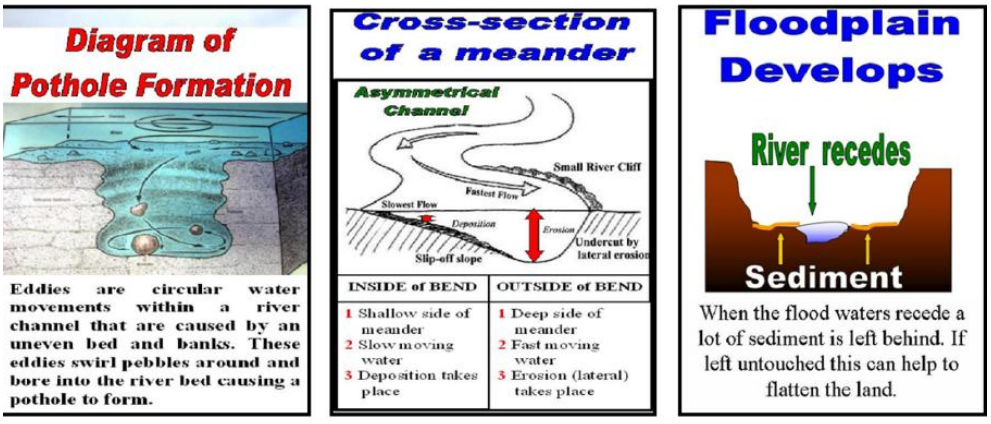

Figure 3. Images of the erosion, transportation and deposition explanations.

The second mscape was designed and created by the pupils. Treasure hunts are known to be activity-centred and require problem-solving skills (Pritchard, 2004), two of the core aspects of LCE. In the second school term, the map skills content was addressed via the pupil-created Treasure Hunt mscape activity. This task required the pupils to work in small groups of 5-6 students (allocated by the teacher) and pairs of pupils assumed a role in the production of their group's treasure hunt. For example, one pair may have been responsible for gathering the images, while another couple assumed responsibility for the sound recordings either as background music or voice-overs. Group leaders were responsible for coordinating the process, time management and overseeing the "bigger picture" of how the individual elements of the groupwork would come together in the final product. Relative to the LCE approach, the teacher provided an initial context or historical background on a number of the old buildings still present on the school campus. This information prompted students to build their treasure hunt clues around a particular theme or historical event from the past making an authentic storyline for the mscape treasure hunt. An additional stipulation made by the teacher was that each clue for the "players" was to include at least one map skill. Due to the map skills content being addressed through the design and testing of the clues, all group members participated in this stage of the group activity, a natural mechanism to ensure all the intended learning goals were achieved by all pupils. The additional benefit of using the Treasure Hunt context was the built-in revision process that would occur when each group experienced the other groups' mscapes and had to use their map skill knowledge to solve the clues.

As Figure 4 illustrates, the pupils reused the map of their school campus from the Thames mscape activity as a background for their Treasure Hunt indicating the pupils' perceived importance of space and location in the natural context as well as in their virtual world of the Treasure Hunt.

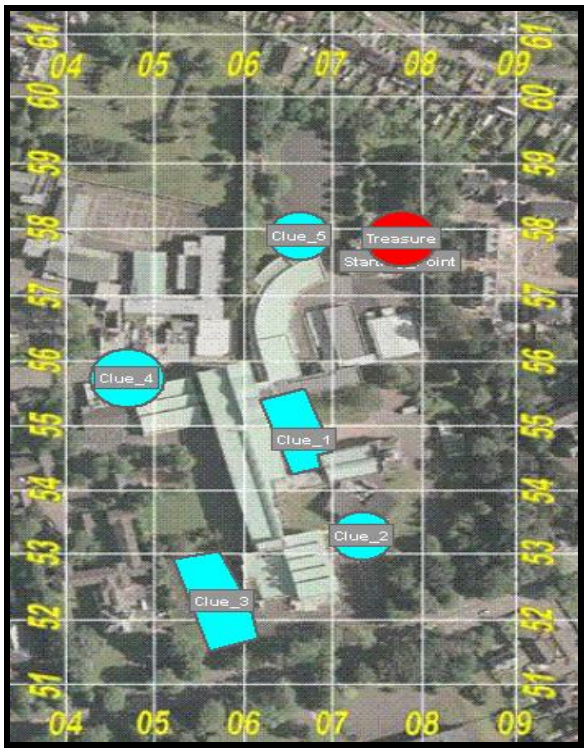

Figure 4. Example of a Treasure Hunt mediascape – Treasure hidden behind wall unseen from Starting point.

The hotspots for each clue were positioned to draw the players closer to the location of the Treasure. All clues embedded knowledge of a range of map skills and real treasure was left in the final location (such as coins of chocolate money, a teddy bear or a bar of chocolate) revealing the pupils' ability to move between the real and virtual contexts with ease.

5.3 Sample participants

The handheld mobile devices were on loan from Ulster Mediascapes, an educational consultancy company offering support to local schools wishing to integrate mobile technologies into their pedagogical practices. For safety reasons, it was agreed by the school principal that the mobile devices would be allocated to one geography class for the duration of an academic year in an attempt to determine the appropriateness of future investment in mobile technologies as part of the whole school

development plan. As a result, an opportunistic sample of sixteen students aged 15 years were identified due to the interest and enthusiasm expressed by their class teacher who was deemed an "innovator" (Rogers, 2005) in terms of utilising new technologies in the geography classroom. No parallel geography class was available to act as a control group in the study thus removing the opportunity for statistical comparisons on the effectiveness of the mobile technology intervention. Nevertheless, this study offers an in-depth insight into the potential of mobile devices equipped with GPS in offering location aware learning experiences in a formal school context for two core topics: the long river profile and map skills.

Ethical approval for the research was provided by the school principal, parents of the pupils and also the pupils themselves prior to commencing the study. No incentives were offered to the participants however the pupils may have viewed access to and usage of the mobile devices when learning geography as an attractive proposition which may have increased their willingness to commit to the study.

5.4 Tools

Semi-structured focus group interviews were completed one week after each of the mscape activities to offer opportunities for pupils' personal views to be shared through conversations thus providing rich data and vital insights into the research from the participants' perspectives (Kvale, 1996; Cohen et al., 2007). The adoption of a semi-structured interview reflects the age of the participants who need support to "expound the full significance of their actions" (Pring, 2000, p. 39). The focus group interviewees were four students selected at random from the class. To enhance the validity and reliability of the inferences being made by the researchers from this interview data, a whole class discussion of the outcomes occurred one week after the focus group. Any additional students' comments or alternative views were recorded and confirmation was provided by the class of pupils on the accuracy of interpretation of the interview data.

Observations during both mscape activities were made via note-taking and also through the use of digital photographs capturing specific "moments in time" as evidence of the broader, transferable skills being developed through participation in the mobile learning experience. These skills are discussed in detail in the next section, Analysis and Findings.

Group diaries were used for the second task where the pupils were creating their mscape treasure hunt. One member of each group was allocated the responsibility of recording the collective students' reflections on at least a weekly basis for the duration of the task. Final reflections on the location-aware learning experience after trialling each other's mscape treasure hunts were also included in the group diary. This data from the diaries was very effective in revealing the changing attitudes of the students over the course of the mscape creation process, the challenges they faced, any setbacks encountered and how these were solved. It proved to be a valuable record of the high points and low points experienced by the pupils at the key stages of design, creation and testing. The data was also useful in triangulating the inferences being made from the focus group and class interviews completed after the outdoor mscape activities as discussed above.

Two paper-based assessments were created based on past paper examination questions on each of the topics in geography. The pre-test for the long river profile was administered immediately before the Christmas vacation and so no feedback was offered to the students. On their return to school in the New Year, the pupils commenced the mobile learning activity for the River Thames. After one week of participation in the mobile activity and no additional teaching, the post-test (a parallel pre-test – with the order of questions altered) was administered to the students. None of the students commented either formally or informally on the familiarity of the questions in the test paper. It is concluded that the Christmas vacation (10 days) resulted in the students forgetting about the assessment and therefore any change in student performance could be attributed to the use of the mscape task.

Similarly for the OS map skills content delivered via the Treasure Hunts, the pre-test

was administered directly before the Easter vacation and no feedback was offered to the students. After the Easter holiday (10 days), the students experienced each other's mscape treasure hunts so again no teaching was provided apart from the use of the mscape itself. It is therefore concluded that any change in the pupils' performance could be attributable to the use of the Treasure Hunt mscape tasks.

6. Analysis and Findings

Using LCE as a lens for the analysis of the qualitative data emerging from the interviews, diary entries and observations of the outdoor events, it is clear that the adoption of this new pedagogy did not deter from the cognitive and affective learning outcomes traditionally found in the geography classroom. From the pupils' comments, the use of the mobile technology and LCE strategies promoted an active, participatory engagement in the two topics and motivated the pupils to assume increased levels of responsibility for their learning.

Each of the five pillars of LCE will be used to structure and categorise the discussion of the findings.

6.1 Outdoor activities

It was clear from the pupils' comments that using the mobile technology device was not an issue, pupils were happy to adopt a new style of content delivery. There was overall consensus by the pupils about their enjoyment of going outdoors to use the mobile devices and actively participating in the mscape activities:

"It was exciting because it was good to get out of the classroom and you learned better… I liked being active instead of just always listening to information".

"Using the technology outside makes you feel more engaged with the work".

"It was good because you actually went out and did it… and had to figure things out for yourself".

The last comment indicates that problem-solving and the motivation to "figure things out for yourself" was noted by the pupils. Additional evidence of motivation appeared in the diaries when pupils felt compelled to assume a leadership role to get the mscape creation back on track or increase the pace of production of the materials needed for their Treasure Hunt.

The outdoor nature of location-aware technology also has disadvantages especially if the activity is taking place during the winter months as occurred in the Thames mscape. A few pupils noted

"Being outside, having the use the PDA in the cold was the biggest disadvantage for me. I liked it [the mscape task] and enjoyed using it [the PDA] but did not like being cold".

The touchscreen nature of the technology meant the pupils were unable to wear gloves during their first mscape experience and so painful hands and the extreme cold distracted their attention from the content being presented on the PDA screen at times. In addition, the pupils began to rush through the screens so they could go indoors again to warm up.

GPS drift can also occur during the winter months causing the hotspot areas to "move" and so images/sounds may not be presented as the designer had intended. The treasure hunt mscape was planned for the summer term – after the Easter vacation – and so the weather was warmer and drier, and there was less likelihood of GPS drift. The impact of bright sunshine on the PDA screen could have been a problem, however the pupils were used to this with their mobile phones and knew how to position themselves to keep the PDA in their own shadow making the screen clearer to read. Not to be disheartened by the bright weather and reflections on the screen, the pupils declared "you always want something to take you out when the weather is good".

6.2 Practical applications

The use of mobile technologies in formal curriculum contexts may be considered quite a challenging leap for many teachers: not just from the pedagogical perspective but also in terms of the focus of control and power moving to the pupils who are expected to assume

increased levels of responsibility for managing their own learning. Interestingly the pupils were oblivious to this change in power or authority and looked towards the use of mobile devices as a natural progression reflecting the changes in society in general, saying:

"…there should be a place for it [mobile technology]. It brings a more practical element into the subject and you get to experience what you are learning about. Pupils are already familiar with this type of technology so it can appeal to them on a level which textbooks and written notes cannot".

By walking the course of the River Thames (albeit on a much smaller scale) within the school grounds, the pupils indicated that their familiarity with the real physical locations resulted in them creating associations or "mental markers" between the reality and the simulation making the recall of key facts and diagrams easier. For example, at the upper stage of the river the image of the tributaries had the background sound of cows mooing in the fields, as it happened this hotspot was close to some trees on the perimeter of the school grounds and the pupils frequently looked across at these trees for the cows! Similarly, as the River Thames meets the sea at Gravesend the sounds of ships horns and seagulls are included in the mscape and the pupils tended to look towards the main gates and wall where there was traffic on the main road associating the sounds with car horns or skywards for the gulls. In many cases they laughed with each other about these reactions to the sounds however these insignificant incidents were later reported to be valuable as "aides-memoires" for the subject content especially during the paper-based assessments.

In keeping with the goals of LCE to motivate pupils to achieve their full potential, the pupils' diary entries for the Treasure Hunt mscape revealed evidence of a rise in expectations over time, a desire to "get it right" and to have "great images and sound". Although stages of the creation process were described as "challenging" and sometimes "overwhelming", the pupils remained motivated through engagement in the task and applied their knowledge of both ICT and geography in this novel context. As one group noted:

"Mobile technology gave me a better understanding [of map skills] because you got out of the classroom and you got to put it into action… The use of the technology definitely helped me understand more and if used again I am confident it will make me better at Geography".

The practical application of the pupils' knowledge of map skills when completing the Treasure Hunt also resulted in a more competitive and individualised mobile learning experience for some pupils who enjoyed the challenge of solving the clues alone. The personal motivation to work individually solving the treasure hunt clues and competing against each other to find the treasure first was in contrast to the more negative comments from another group about the process of creating their own mscape Treasure Hunt.

"We would describe creating the mscape as boring and time-consuming. This part wasn't fun… In future our group would like to simply do the mscape, not create it!".

It is evident from this comment that the pupils appreciated the cognitive and affective benefits of using the location aware mscape activities as a tool to scaffold learning however they dismissed the possible learning opportunities they may have experienced in the process of creating their own mscape Treasure Hunt which required the application of the subject knowledge to a new and novel context of their own design.

6.3 Dialogue among participants

During the outdoor activities, the researchers noted "Participants were often heard shouting for joy when they got a quiz question correct. It seemed that the inclusion of questions captivated most participants". At other times the pupils were singing along to the background music of *Cry me a River* by Justin Timberlake, as they were walking from one information hotspot to the next. Observations were also made of pupils moving to assist one another if there was a technical glitch with the equipment or if a pupil had missed information about the river and was unable to move on to the next location until they had answered a quiz question. This supportive

collaboration and peripheral awareness of others who needed assistance shows the range of dialogue that occurred during the mscape activities, particularly the Thames mscape which was content-rich. For many students there was an unspoken dialogue, a companionship, as they walked in pairs along the course of the River Thames simulation, listening to their individual headphones and watching the on-screen instruction, yet aware of the presence of each other as they reflected on the information at each hotspot.

For other students, working in isolation was enjoyed and they avoided dialogue with the peer group declaring:

"I was given the opportunity to work on my own and I was able to take in the information. I did not have anyone talking to me like I would have had in the classroom… I was in charge of my own learning and there were no real distractions".

When faced with a problem, they used the media to solve it themselves without the help of others "if you missed information you could either get it from the picture or sound". In the majority of cases, the pupils were able to replay the information if they became distracted. Due to the knowledge-rich nature of the design of the Thames mscape, there was no real need for the pupils to communicate with each other as each experience was identical making collaboration and dialogue superfluous.

In contrast, the LCE approach to the Treasure Hunt mscape, was organised as a group activity making it imperative that the group members communicated and collaborated with one another to ensure the objectives of the task were achieved and the goal of a correctly functioning Treasure Hunt was achieved. When discussing this mscape activity, pupils often referred to it as "game-like" and "fun", yet motivating and engaging at the same time. The observations of the creation process revealed "animated and lively interactions" between pupils, a sense of excitement and anticipation combined with phases of apprehension and problem-solving. Group diaries reported "brainstorming ideas for the storyline" for the Treasure Hunt and later "negotiating within the group to ensure everyone had an input into where the clues regions would be located" or in one group's case "there was disagreement with where to place the clues but in the end we all agreed, with a bit of compromising!". Not all dialogue was face-to-face, some pupils continued their work outside class time and used online discussion forums, email and instant messaging to communicate with each other.

In general, the mobile technology facilitated the transition between individual and groupwork as many pupils utilised the Vygotskian approach of working alone and with more knowledgeable peers when completing the Treasure Hunts outdoors:

"You needed the technology to provide the clues and give hints. You couldn't ask it questions so you chatted to other pupils to solve the clue".

"It was a fun process… when you couldn't solve a clue you discussed it within the group to get to the next part".

6.4 Teamwork

As discussed above, teamwork existed through supportive dialogue with the majority of evidence arising in the small group activities associated with the creation of the Treasure Hunts. Valuable teamwork which addressed the learning intentions for the map skills topic was facilitated through the role assumed by the teacher.

In the first mobile learning activity, the Thames mscape, assumptions about the teacher's expectations were made by the pupils. Due to the individual nature of the mobile device and headset, some pupils revealed "I thought I had to do the work myself…" while other pupils argued:

"The activity provided us with the opportunity to come together. We were all doing the same thing [Thames mscape] so it gave us something in common".

This latter statement may account for the observed "companionship" that began around the middle stages of the Thames mscape, where pupils seemed to come together and walk in parallel with the person located nearest to them,

while listening to their individual headsets and instructional materials.

Another role of the teacher was the allocation of pupils into groups. Careful consideration was given to the group constitution to provide a balance of skills within and between groups resulting in friends being parted in most cases. As was revealed in the group diaries, this was accepted by the pupils as being a fair process. The interviews further supported this viewpoint as pupil reflections uncovered the personal benefits of this decision:

Pupil A: I worked with other people that I normally would not have worked with before.

Pupil B: That's what I also liked about it.

Researcher: Pupil C, what about you?

Pupil C: You got to learn that you could actually work in a group, whereas before you maybe thought you couldn't. You also found you could get along with people you didn't know very well.

Due to the teacher's insight into the pupils' personalities, the allocation of groups worked effectively and supported the LCE process resulting in all pupils achieving the final goal of a working mscape Treasure Hunt which addressed a variety of mapping skills.

Any challenging task faces minor setbacks and can raise concerns, and the creation of the Treasure Hunt mscape was not exempt from these problems. Both the group diaries and also the interviews revealed leadership problems in the groups:

"Sometimes you had more work to do than others. That was unfair, at times some people just sat there and it was me doing most of the work".

However in most cases, this inequity in workload was addressed as the "reluctant learners" felt a social responsibility to the group and would re-engage with the tasks later, admitting:

"I didn't create enough work in my group… At times I got confused and lost, and I didn't know what to do… but you knew others were relying on you and you didn't want to let them down".

Despite feeling frustrated at times, sympathy was evident from most group members who acknowledged:

"At times some group members felt overwhelmed with the amount of content".

However each group found their inner strength and worked through these problems saying:

"We all pulled together and worked hard as a team, but looking back on it we had put a lot of hard work into the mscape".

When it came to the outdoor activities with each group completing all the Treasure Hunts (including their own), the collaborative nature of creation process led the pupils to believe that the groups would remain in tact during the outdoor experience of using the other groups' treasure hunts too:

"I was happy to do the treasure hunts as a group".

However as noted earlier, some pupils were keen to compete against their peers to find the treasure first and so "a few in our group tried to do one or two of the treasure hunts themselves. They said that they enjoyed this as they felt they were more in charge of their learning".

6.5 Opportunities to experiment

The initial excitement of being chosen to participate in the mobile learning activities in geography indicated the pupils' willingness to trial new ideas and to move away from the traditional models of learning that prevailed in other subjects. Referring to the location aware activities and use of the mobile devices, one pupil reflected "It was really different compared to other things we do… No other class was doing this, it was unique".

Other pupils agreed, declaring "It was good to try something different and I would like the chance to experience it again… I thought the treasure hunts were not as serious as being in the classroom. You did not feel under lots of pressure".

Due to the long term use of the mobile devices over a complete academic year, it could

be said that the novelty of technology itself would have diminished leaving the GPS-enabled PDAs being regarded as a tool-for-learning and therefore no longer creating a "halo effect". The pupils' comments indicate that embedding the technology into the classroom teaching not only altered the teacher's pedagogical practices but also impacted directly on the pupils' perceptions of themselves. In terms of developing problem-solving skills, the pupils confirmed that:

"It really did increase your confidence because when you figured things out, you felt good about yourself".

In addition their self confidence rose when they learned other new skills in ICT, which they could apply to their geographical task:

"…it really makes you feel good. I was introduced to a couple of different things, such as Audacity and I learned how to use it. I was proud of myself because I learned something new, not only for Geography but for other subjects too".

From a more personal perspective, pupils' social circle extended as they worked with others beyond their normal friendship group, especially for the Treasure Hunt task. Interestingly these new group formations were sustained during the outdoor activities, instead of returning to their established friends. The mobile devices also provided pupils with the choice of working alone or with more knowledgeable others. Two pupils characterised the synergy between the technology and the person saying:

"It all worked together as one. You needed the technology to provide the clues and give the hints but you couldn't ask it questions so you chatted to the others in the group…".

"It was a fun process between pupils and the technology… When you couldn't solve a clue, you discussed it within the group to get to the next part of the mscape task".

The ease with which the pupils adapted to the use of mobile technologies and were able to read and interpret the location aware tracking facility on the PDA screen as they moved from one information point to the next, further reinforces the need to consider contemporary geographical technologies including location aware or context aware technologies, GIS and virtual fieldtrips.

Finally as discussed at the outset of this study, the effectiveness of the mobile learning was being measured via the traditional paper-based examination style questions for the topic of the long river profile and mapping skills. As the pupils were an examination class, there were ethical implications why it was important to acknowledge and use the assessment system which pupils would experience in their national examinations.

6.6 Assessment performance

Most pupils agreed that their knowledge of both the long river profile as illustrated by the Thames mscape and also their map skills, from the Treasure Hunts, had improved as a result of using the local aware activities. As one pupil stated "you need the technology to allow you to use the skills which enables you to completely understand the topic".

Although this study is predominantly qualitative due to the small sample size, an empirical measurement of the "effectiveness" of the GPS-enabled mobile technology was deemed necessary. As discussed earlier in this paper, pupils were assessed before the Christmas and Easter vacations and no feedback was offered due to their 10 days of leave from school on each occasion. On the pupils' return to school the mscape activities were completed and no other teaching was provided. The pupils were reassessed using a parallel version of the original test (with the order of questions changed) and the pupils' scores recorded.

As Table 1 reveals, a Wilcoxon Signed Ranks test revealed there was a statistically significant increase in the test scores ($Z=-3.415$, $p=0.001$) for the long river profile assessment and similarly for the Ordnance Survey map skills assessment ($Z=-3.521$, $p=0.000$) from the pre-test to post-test. Since no formal teaching occurred between the two tests in both cases and only the use of the mobile technologies with GPS was available to the students, it can be concluded that the use of the mobile technologies is effective in improving students' performance in the two topics under

investigation. It should be noted however, that the sample size is small (n=16) and therefore these results cannot be generalised.

Assessment	*Mean (s.d)*	*Z-score*	*Probability*
Pre-test (Thames)	59.88 (24.73)	-3.415	p=0.001
Post-test (Thames)	73.06 (19.98)		
Pre-test (Treasure Hunt maps)	36.38 (12.02)	-3.521	p=0.000
Post-test (Treasure Hunt maps)	61.00 (16.11)		

Table 1. Pupil attainment in topic tests.

7. Concluding discussion

The recognition of contextual factors, resulting from changing government policies, has influenced the pedagogical practices of geography teachers (Brooks, 2012). In addition, opportunities now exist for geography teachers to embed new technologies into their classroom practices such as GIS and location aware technology delivered via mobile handheld devices equipped with GPS however as Merrill (2002) and Wang and Hannafin (2005) aver "technology itself cannot make instruction effective nor make learning meaningful".

This study investigated the use of GPS-enabled PDAs with a class of sixteen pupils aged 15 years. The location aware technology was used for an entire academic year and the pupils focused on two key topics, namely the long river profile (including landforms and geographical processes) and mapping skills. An action research methodology was adopted and data was captured from pupil interviews, diaries, researcher observations and performance in standard assessments relevant to this age group.

As Norman and Spohrer (nd) note "Technology is a catalyst for change… [and] also a barometer of that change providing a perspective on what is working and what is not" (pp. 4-5). The analysis of pupils' scores revealed statistically significant increases in the pupils' performance after using the mobile devices to complete the mscapes indicating the positive role of location aware technology in promoting effective learning as measured by increased pupil performance. Due to the small sample size, this result needs to be treated with caution. Ideally a large scale sample is required for generalizable results however the current study offers hope and inspiration to other educators wishing to introduce location aware technology into their teaching practice with the goal of enhancing pupils' learning.

Although the computer is seen as a tool for the learners to construct, explore and collaborate together, in this study the first mscape, based on the River Thames, revealed that the pupils were more likely to work alone due to the individualised nature of the handheld device and use of headsets to hear the voice-overs and instruction materials. In general, location aware technology is considered to be a personalised experience and therefore it is not surprising to find the pupils working independently for the majority of the time with minimal verbal interactions. Nevertheless, it was observed that pairs of pupils appeared to converge and walk together, in parallel, listening to the instructional content being delivered. This "companionship" or peripheral presence challenged the perceived individualised learning experience expected by the teacher revealing both the flexibility of the use of mobile devices in accommodating an alternative pedagogy and also the shift in control from the teacher to the pupils when the mobile devices are being utilised.

In contrast to the information-rich Thames mediascape created by the teacher and experienced by the pupils, the use of the LCE approach for the second mscape activity required pupils to work in groups creating their own Treasure Hunt mscape. This technological creativity and small group learning is in keeping with Chen and Choi (2010) and the formation of a group-based learning community. Most of the group members sustained a positive and supportive "community" spirit however concerns were raised by group leaders about the unequal distribution of the workload at times. Wiley and Ash (2005) posit that "the interaction between the educational task and the nature or structure of the multimedia environment… is of primary importance in planning curriculum,

designing multimedia technology, and researching the effectiveness of multimedia instruction".

Due to the newness of the mobile technologies and also the pupils' limited familiarity with the mscape software, the tensions between the pupils' aspirations for their Treasure Hunt and their lack of knowledge of how to achieve their goals using the software resulted in a few pupils becoming disengaged in the task or disenchanted by the overall experience of creating a mscape. Through a combination of discussion and social conscience, the disenchanted pupils were re-established into the group context and all pupils were engaged with the task by the time they were testing each other's Treasure Hunts. As Ge and Land (2004) claim "peer interaction and collaboration is advantageous for students in providing and receiving explanations, constructing ideas, resolving conflicts, and negotiating meaning". Despite these minor setbacks, all the groups successfully created and tested their mscape activity prior to it "going live" with their peers in the other groups.

Completing the Treasure Hunts was perceived to be enjoyable and beneficial experience which the pupils wanted to repeat in the future, reinforcing the findings from Wright (2011) who declared pupils were found to be more engaged and willing to participate in their learning when the mobile devices were being used, and they requested regular use of the mobile technologies to support their learning in class. However it was clear that "using the product" was preferred over the "process" of creating the Treasure Hunt with some groups even suggesting they opt out of any future mscape creation activities.

The information presented on the handheld devices tends to be multimedia which complements and enriches that available via textbooks as shown in Figures 1-4. The design of the mscapes embedded multimedia into all aspects of the experience as it supports pupils' learning. Background music from popular culture was introduced as Rodway-Dyer (2011) reported that "audio feedback can help students to reflect on their learning and develop deep learning approaches that are associated with higher attainment in assessments". As revealed in the analysis, strains of the music were heard during and after the mscape event indicating pupils' appreciation and level of enjoyment of the mobile learning activity and their on-going reflection on aspects of the content. The inclusion of a map of the school grounds with the River Thames superimposed over it, is considered a beneficial strategy for engaging pupils in the activity and assisting students to maintain their attention (Matei, 2010) and retention of formation (Forsythe, 1986), "Achieving location information or being in the actual place helps students to learn and memorise about the learning context" (p. 15) as supported by the pupils comments regarding their ability to recall information using the mental markers from the Thames mscape. In addition, the map of the school grounds was also effective in orientating the students during the Treasure Hunts.

In conclusion the broader relevance of this study rests in its contribution to the current calls for change in geographical pedagogy worldwide. The revised curriculum in New Zealand offers geography students greater autonomy and a more participatory approach to learning through the use of GIS technology situated in a problem-based learning framework (Kinniburgh, 2010). This study may encourage the use of LCE as an alternative pedagogical approach if location aware technology is available in the schools. In addition the shift in power and control away from the teacher is highlighted in this study due to the personalised nature of the handheld devices. As Wright (2011) notes "teachers of more than 10 years practice are likely to be most comfortable with coping with the potential destabilising effects of introducing unfamiliar, untried tools to a classroom setting" indicating that the early adopters of geo-spatial technologies and in particular, location aware activities may be the more mature teachers whose management style adapts easier to such a power shift.

In a study of undergraduate geography students, Rodway-Dyer (2011) revealed that audio feedback requires careful attention of "optimal time length, style, tone of voice, register of language and timing". These criteria also apply to location aware technology and

were particularly evident in the first mscape where the very cold weather negatively impacted on the pupils' level of concentration and commitment to completing the mscape experience. Some students advised a shorter more concise mobile learning experience saying there was information overload at times. In addition, they suggested there could have been an option to "view more detail" to initiate the presentation of more in-depth explanations of the geographical processes which would have allowed the pupils to skip certain parts and finish the experience sooner in the cold weather. In this study, as the pupils became cold they had to walk faster between the hotspots and listen attentively to the information to ensure they selected the correct option to sustain the pace of exposure to the information.

The major limitations of this study were the presence of one geography teacher, a small sample size of 16 pupils, and the non-existence of a control group for the statistical comparisons. Wright's (2011) finding that increasing years of teaching experience, increases the level of comfort when embedding unfamiliar, untried tools to a classroom setting highlights the importance of replicating this study with other geography teachers, new and experienced, to establish if professional experience is a determining factor in the successful use of mobile technologies for teaching. In addition it could be argued that the application of innovative active teaching methods devoid of technology could also foster some of the relationships revealed in this study. Indeed Treasure Hunts and orienteering are frequently used as outdoor learning activities to promote authentic usage of map skills. However the use of mobile technology appears to intrinsically appeal to young people fostering a sense of ownership of the learning process and motivating them to engage in informal, personalized learning in which they gain independence and control over the pace and place in which they learn.

Further consideration is needed on the viability of the roll-out of the use of location-aware technology – is the use of GPS-enabled PDAs scalable at a whole school level? How would teachers be trained to use location aware technologies and by whom? To what extent will this level of technological investment become dated or obsolete in a few years' time? These questions should encourage further research into the use of location aware technology within a formal school context.

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