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Experiences of using mobile technologies and virtual fieldtrips in Physical Geography: implications for hydrology education

D. G. Kingston[1,2], W. J. Eastwood[1], P. I. Jones[1], R. Johnson[1], S. Marshall[3], and D. M. Hannah[1]

[1]School of Geography, Earth and Environmental Sciences, University of Birmingham, Edgbaston, Birmingham, B15 2TT, UK
[2]Department of Geography, University of Otago, P.O. Box 56, Dunedin, New Zealand
[3]Marlin Productions Ltd, Birmingham, UK

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Correspondence to: D. G. Kingston (daniel.kingston@geography.otago.ac.nz)

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Abstract

Education in hydrology is changing rapidly due to diversification of students, emergent major scientific and practical challenges that our discipline must engage with, shifting pedagogic ideas and higher education environments, the need for students to develop new discipline specific and transferrable skills, and the advent of innovative technologies for learning and teaching. This paper focuses on new technologies in the context of learning and teaching in Physical Geography and reflects on the implications of our experiences for education in hydrology. We evaluate the experience of designing and trialling novel mobile technology-based field exercises and a virtual field trip for a Year 1 undergraduate Physical Geography module at a UK university. The new exercises are based on using and obtaining spatial data, operation of meteorological equipment (explained using an interactive DVD), and include introductions to global positioning systems (GPS) and geographical information systems (GIS). The technology and exercises were well received in a pilot study and subsequent rolling-out to the full student cohort (∼150 students). A statistically significant improvement in marks was observed following the redesign. Although the students enjoyed using mobile technology, the increased interactivity and opportunity for peer learning were considered to be the primary benefits by students. This is reinforced further by student preference for the new interactive virtual field trip over the previous "show-and-tell" field exercise. Despite the new exercises having many advantages, exercise development was not trivial due to the high start-up costs, the need for provision of sufficient technical support and the relative difficulty of making year-to-year changes (to the virtual field trip in particular). We believe our experiences are directly relevant to the implementation of such novel learning and teaching technologies in hydrology education.

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1 Introduction

Education in hydrology is changing rapidly as a result of a number of factors. These include, but are not limited to, a diversifying student population, new and emerging major scientific and practical challenges that our discipline must engage with (e.g. climate change), shifting pedagogic ideas and higher education environments, the need for students to develop new discipline specific and transferrable skill sets, and the advent of innovative technologies for learning and teaching (Nash et al., 1990; Wagner et al., 2007). This paper focuses on new technologies in the context of learning and teaching across the discipline of Physical Geography and reflects on the implications of our experiences for the future of education in hydrology.

Mobile technology can be defined as portable (handheld) computers, typically with global positioning system (GPS) capability (e.g. personal data assistants (PDAs), smartphones). The possible benefits for learning from the use of mobile technologies are thought to be especially pertinent for field-based subjects such as hydrology in that they permit greater locational flexibility in terms of where learning takes place (Siau and Nah, 2006; Walton et al., 2005). In particular, the possibility for situated and context-aware learning, such as through the use of GPS, has the potential to provide a key learning tool. This is because of the importance of field-based learning for facilitating "active learning" (i.e. learning by doing), and as such the potential to integrate theories, concepts and skills in a practical environment (Kent et al., 1997; Fuller et al., 2000; Boyle et al., 2003).

Despite the many educational benefits of field-based learning, fieldwork in itself is not intrinsically linked to effective learning (Lonergan and Andreson, 1988). Furthermore, the relatively high expense of providing field experience is resulting in increasing demands for accountability with respect to the effectiveness of fieldwork (McMorrow, 2005). Aided by advances in technology, the concept of virtual field trips (VFTs) has become increasingly prevalent over recent years as a means to enhance the effectiveness of time spent outside of the classroom (e.g., McMorrow, 2005; Hirsch and Lloyd, 2005). This is because VFTs can be used to provide essential background information that may otherwise have to be delivered in the field (Stainfield et al., 2000). Similarly, learning tasks embedded in VFTs can be used for post-fieldwork revision, assessment or further study (e.g., Hirsch and Lloyd, 2005). Finally, VFTs can provide opportunity for some sort of "field" experience where this would not otherwise be possible, for example due to large student numbers, financial constraints, logistics, or distance from intended field site (Poland et al., 2003; Turney et al., 2004).

This paper evaluates the redesign of a fieldwork-based geographic skills module taught at first year undergraduate level in the UK. This revamp was facilitated by the introduction of mobile technology and a VFT as teaching aides. Although primarily concerned with field mapping and climatology, there are strong parallels that can be drawn in terms of the teaching requirements across the discipline of Physical Geography. As such, the mobile technology based field-exercises, VFT, associated pilot-tests and focus group response presented herein provide an important opportunity to investigate the effectiveness of these two learning tools across the spectrum of undergraduate Physical Geography subjects (including hydrology). In the context of this special issue, we reflect on the implications of our experiences for education in hydrology.

2 Background and rationale for changes

The Physical Environment of Birmingham (GGM106B) is a compulsory Year 1 module open to BSc and BA Geography students at the University of Birmingham, UK. This module is a cornerstone of the first year Geography programme, and comprises an introduction to basic geographical skills in local field environments using the city of Birmingham as an urban, open-air laboratory. The module includes linked projects on mapping techniques and urban climatology. The mapping component was based around paper maps and did not train students in modern computer mapping techniques such as geographical information systems (GIS). The use of mobile technology offered potential to develop these modern mapping skills and then apply them to real

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world applications in the urban climatology project. This approach develops student understanding of pertinent theoretical geographical concepts, rather than simply being a case of introducing technology for technology's sake.

The climatology project required collection of in-situ field data for mapping and assessment of the thermal characteristics of an area of southwest Birmingham and an analysis of diurnal weather variation. This was preceded by a tour of the University weather station, which comprised an explanation of the operation and role of the various weather-recording instruments included on a standard UK Meteorological Office Surface Climate Station. As climate drives the water cycle and such weather stations record hydrological variables (e.g. precipitation and rainfall), this element of the project is of direct relevance to hydrology education. Due to the relatively large numbers of students taking the module (typically 150–200), it had become impractical to take all of the students to the weather station at once. Therefore, students were split into groups of 20–25, with seven tours being re-taught by staff over one afternoon. Clearly, this re-teaching takes-up a relatively large amount of staff time. Furthermore, due to module scheduling, the tour occured in January when day length is relatively short. This timing resulted in the last group of students visiting the weather station near dusk, which combined with the occasional occurrence of inclement weather, meant that this exercise was not always popular (with either students or staff). Although the students were asked 20 questions on the type and operation of instruments in the module assessment, the tour was essentially an observational show-and-tell exercise.

3 New learning and teaching innovations

Whilst still providing a basic introduction to mapping (including co-ordinate systems, projections, grids and datums), a new practical mapping exercise was produced based on sources of spatial data, together with the concept of accuracy and precision of spatial data. Particular emphasis was given to the use of GPS. As such, the new exercise aims to familiarise students with important basic skills relevant for geographical

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analyses (such as of hydrological processes). The exercise itself involves collecting spatial data using GPS-enabled PDAs for various areas of the University campus and plotting these on digital UK Ordnance Survey maps (using the ArcGIS software) and Google Earth images (Fig. 1). The exercise is assessed though a critical discussion of the differences between the collected GPS data, the Ordnance Survey map and Google Earth images.

The air temperature mapping component was redesigned to incorporate the use of GPS and GIS and progressed from the new mapping project through its practical application of skills. The new exercise comprised use of a GPS-synchronised GIS (using ArcPad software) on the PDAs to record and map temperature readings across a predefined area. These data were transferred to the more powerful desktop-based ArcGIS software to create a temperature surface (using spatial interpolation) to overlay with a map of the local area. A discussion of the reasons for the recorded variation in urban air temperature formed the assessment for this exercise.

To overcome the aforementioned issues with the weather station field visit, a DVD-based interactive virtual weather station "field tour" was produced (Fig. 2). The DVD is presented by the same staff who gave the original show-and-tell tour, and the content is very similar. The total running length of the DVD is approximately 40 min, and consists of a series of short (2–3 min) video sequences explaining the role and operation of various instruments. Each sequence is followed by a set of multiple choice questions, which must be answered correctly before the next sequence can be viewed (Fig. 2b). This means that whilst the DVD-based VFT is still essentially a show-and-tell activity, interactivity on an individual level is forced by the need to answer formative questions. Furthermore, the division of the DVD into short sections provides opportunity for reflection and repeat viewing of the explanation of the weather station operation.

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4 Evaluation

To facilitate a comparative analysis of the old and new exercises, Year 1 student volunteers were recruited who had taken the old module (including paper maps and weather station visit), and were given a week to complete the new exercises (using GPS-enabled PDAs and VFT weather station DVD). They completed a short questionnaire about the exercises, after which a focus group meeting was held to discuss further their opinions.

The feedback from the questionnaires was very positive (Table 1), particularly for the question of whether useful skills had been gained, and whether the new exercises represented an improvement over the previous versions. The focus group discussion largely confirmed the results of the questionnaire (i.e. students found the new exercises to be more educationally valuable and enjoyable than the old module design). This was stated as being due, in part, to the more active nature of the new tasks (i.e. the incorporation of fieldwork in the mapping project, the need to answer questions within the DVD). The use of PDAs was generally considered to be enjoyable, fun and exciting, while the opportunity to learn about using GIS and GPS was a definite attraction for all. The students particularly enjoyed the flexibility of being able to watch the DVD at a time of their own choosing, as well as being able to watch it more than once. Given the choice, all students said they would choose to take the redesigned module.

The issue of using relatively sophisticated forms of technology was not found to be a barrier to learning, even to those who considered themselves to be technophobes, with the difficulty of the exercises considered about right. Although the instructions were thought to be as clear and straightforward as possible, some complaints were made about the PDAs being a little awkward to use, due to their small screens, fonts and buttons (reflected in the relatively low questionnaire score for ease of use of PDA). The need for sufficient (timetabled) technical support with respect to both the PDAs and the GIS software was identified, which was subsequently provided as the revised module came into operation, along with a very basic dummies' guide and FAQ sheet.

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Although the PDAs were considered to be a significant attraction of the new exercises, there was some nervousness about having to take care of them, especially in a situation of group responsibility.

Despite the high rating for the improved clarity of explanation of the operation of the weather station in the DVD compared to the field trip, and subsequent increased confidence in taking readings from the instruments, most students did not want to remove the existing real field visit to the weather station from the module. However, once reassured that there would still be a member of staff on hand when they actually took their first set of project measurements from the weather station, all were happy to have the existing tour replaced by the DVD.

The module has now run in its new form for four years. The cohort mean mark has been consistently higher for the redesigned module (Fig. 3), with a mean of 60.0 % for the three years preceding redesign versus 63.8 % for the following three years. A two-sample *t*-test shows that the difference in marks between the two three year periods is statistically significant at $p = 0.05$. Additionally, there has been a much greater proportion of first-class grades (i.e. a mark ≥ 70 %) compared with the old module (Fig. 3). Written feedback from module development questionnaires (Fig. 4) confirms findings from the original focus groups. Overall, the response has been very positive with comments including "the practicals allow better understanding of topics" and "for someone not 'into' physical geog. it was a very interesting course ☺".

5 Discussion and implications for hydrology education

This paper focuses on mapping and climatology applications but the mobile technologies and virtual fieldwork experiences have direct implications for hydrology education and Physical Geography learning and teaching more widely. The increased interactivity, use of technology, and opportunity for learning by doing provided by the new exercises are considered key causes of the positive student feedback and improved marks achieved by the students. Although the appeal of using the PDAs was undoubtedly

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high for the students, as with the DVD it is the enhanced interactivity and opportunity for learning by doing that are considered to be the driving forces behind the enthusiasm and success of the students. This emphasises the imperative that it is the nature of the learning exercise, rather than the technology used, that is of most importance when considering the role of technology in education.

From a lecturer's perspective, the DVD is advantageous in that it avoids deja-vu style repeat teaching and has represented a significant time-saving now that the module has run for a number of years. However, the front-loading of staff time in terms of designing the exercises (particularly filming and editing the DVD) should not be underestimated, together with technical issues associated with these tasks. The relative difficulty of making slight year-on-year adjustments to the content of the DVD (in comparison to actual field-based teaching) should also be noted.

The experience of running this redesigned module provides a certain level of insight into student perception of virtual versus actual field exercises, although caution is required before any general conclusions can be drawn from this (small-scale) study. The strength of feeling expressed in favour of DVD appears somewhat surprising; but this may be because the old field exercise was not a particularly good example of "hands-on" fieldwork; it was primarily an observational visit with little interactivity (beyond rhetorical questions and answers) or opportunity for learning by doing. Therefore, it is likely that the increase in interactivity, rather than the transfer to virtual environment, was the key factor in terms of the enthusiasm for the DVD. It is also important to note that the students were still required to use the weather station; the VFT is just being used to effectively deliver important information in preparation for students going into the field to make their own meteorological observations.

The weather station DVD is amenable to distance learning and also possible distribution to hydrologists in less developed countries to aid in knowledge exchange. The concept of developing an interactive virtual introduction to the principles and operations of field-based equipment could also be applied to other hydrological observations (e.g. discharge or water quality). The DVD offers potential for retraining and lifelong learning

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to update skills as well as providing a vehicle to enthuse interested laypersons in environmental observation. (To discuss the availability of the DVD please contact David Hannah at d.m.hannah@bham.ac.uk).

The skills learned from using the GPS-enabled PDAs for field mapping are directly applicable to more hydrology-orientated studies (such as mapping precipitation or soil moisture). Competence with such modern technology is an important transferrable skill needed by hydrologists to be effective in a changing and increasing spatially and temporally complex world. Skills with such technology are highly likely to improve the employability of graduates.

In terms of the wider-scale significance of these findings for hydrology, it can be tentatively concluded that where virtual fieldwork and mobile technologies have the potential to increase interactivity of the educational experience, they should be welcomed. However, extreme caution is needed before the decision can be made to deprive students of actual field experience. There remains significant value in making first-hand observation related to hydrological and other phenomena because this is vitally important in understanding the complexity of environmental systems and how theoretical knowledge can be applied in a real world context.

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Table 1. Responses to questions from the nine focus group participants (questions 1–5, 7, 9–12 answered on a likert scale, with 1 indicating a difficult/negative response and 5 easy/positive response).

Exercise	Question	Mean response
UK Ordnance Survey vs. Google Earth mapping	1. Ease of use of PDA	3.3
	2. Clarity of instructions	4.6
	3. Difficulty of exercises	3.4
	4. Enjoyment of exercises	3.9
	5. Useful skills gained	4
	6. GPS exercise an improvement (compared to previous mapping exercise)?	8
	7. GPS exercise: overall rating	4.2
Temperature mapping	8. Temperature mapping exercise an improvement (compared to previous version)?	8
	9. Temperature mapping exercise: overall rating	4.1
Weather station VFT	10. Explanation of operation of weather station	4.4
	11. Difficulty of DVD questions	3.4
	12. Confidence in taking measurements	3.8
	13. Prefer original visit	1
	14. Replace visit with DVD	3
	15. Use combination of both	5

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Fig. 1. Sample output of GPS tracklogs for the University of Birmingham campus, from Google Earth (left), and ArcMap (right).

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a b

Fig. 2. **(a)** Start screen for the interactive DVD, **(b)** example formative multiple choice question from the DVD.

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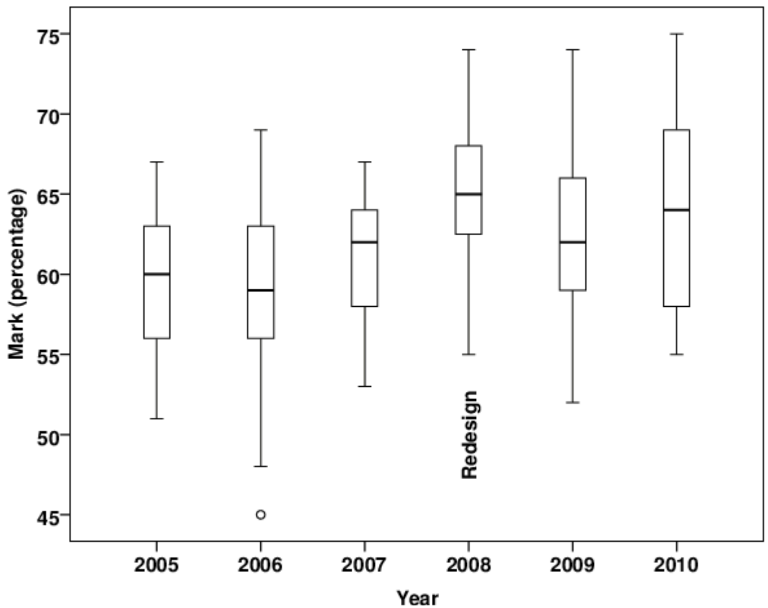

Fig. 3. Pre- and post-redesign marks for GGM 106B (median mark indicated by horizontal line, inter-quartile range indicated by box).

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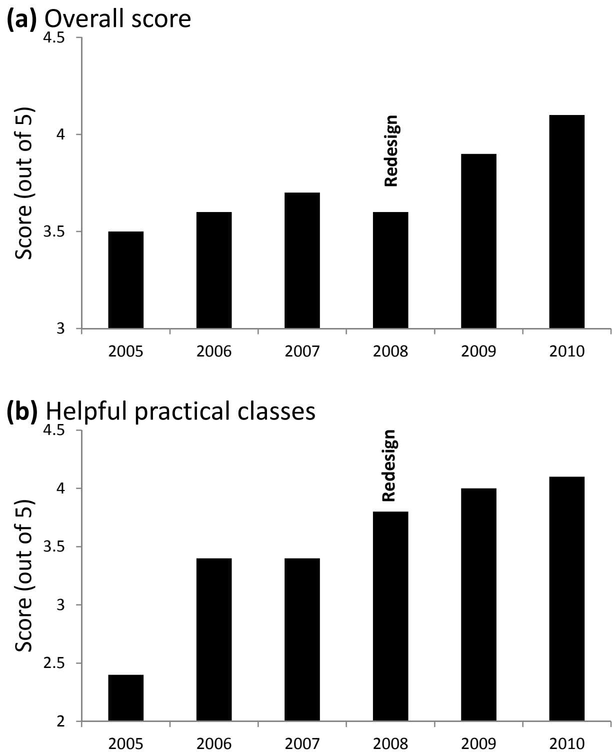

Fig. 4. Pre- and post-innovation cohort mean student feedback **(a)** overall scores and **(b)** scores for how helpful practical classes were.