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Using Augmented Reality and Gamification to Make History Field Trips More Engaging for University Students

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ABSTRACT

ARCH Project explores how augmented reality (AR) activities can be integrated into a field trip setting in order to address history and culture learning goals and enhance the learning experience for university students. The activity supplements the instruction of two tertiary courses focused on history and cultural conservation, with a goal to addressing relevant content learning objectives as well as boosting students' authentic enquiry, active observation, and a sense of belonging to a real-world local community. The navigation of the field trip environment is supported by three main components: 1) Interactive map with all relevant cultural and historical locations marked as clickable destinations bringing up basic facts; 2) Learning content and knowledge quizzes hidden behind trigger images in each location, displayed as digital overlays via Aurasma, an AR development platform; 3) Learning profile visualising students' progress by rewarding them with digital tokens. The article presents preliminary data from prototype development. Software prototyping and focus group methodologies were employed to gather feedback from students and teachers. The findings support the view that AR has a positive effect on students' motivation and engagement. While the affordances of mobile technology and AR platforms are helping to make AR an increasingly achievable tool in teaching and learning, the challenge of designing and implementing the overall AR experience remains significant at all levels: designers, teachers, and students. Cultural challenge of overcoming students' scepticism over the usefulness of AR for their studies, and the managerial challenge of designing, integrating and managing the AR experience are discussed. To identify the impact of this project and explore its effectiveness for enhancing student learning experience an evaluation will be carried out after project implementation.

Keywords: Augmented Reality, Field Trip, Mobile Learning, Location-based, Experiential Learning, Gamification in Education

Introduction

As mobile technology becomes widespread it opens new opportunities for teaching and learning. Augmented reality (AR) is among mobile technologies with particularly high appeal to educators thanks to its flexible design, the fact that it can be integrated in formal and informal learning settings, and because it enables students to interact with digital information embedded in physical environments.

This article presents preliminary findings drawn from the education project Augmented Reality Project for History and Culture Learning (ARCH Project) developed at the Hong Kong Polytechnic University (PolyU) exploring how a platform incorporating AR and gamification elements can be utilised to enhance students' educational experience during field trips. The project team used software prototyping and formative evaluation approach to develop a digital learning platform in order to explore the practicality and feasibility of employing AR in the instruction of two university courses, and in nudging students to engage in a deeper exploration of the university campus environment. The presented findings were collected during the launch of the prototype version of the system; hence, they reflect a number of performance and usability issues that were identified in the trial stage. The field testing of the prototype with the students in the real world context helped the project team determine which elements of the design worked well and which needed to be revised for the final version of the platform. The activity supplements the instruction of two tertiary courses focused on history and cultural conservation, with a goal to addressing relevant content learning objectives as well as boosting students' authentic enquiry, active observation, and a sense of belonging to a real-world local community.

The instructional approach adopted in the project is based in situated learning theory and constructivist learning theory, which support the idea that learning occurs when students are actively involved in the learning experience.

Literature Review

AR has inspired a lot of interest in the academic circles in the recent years. One of the earliest works on AR defined it as the augmented experience of the natural environment fed back to the operator via simulated cues (Milgram et al., 1994). Most authors propose that the term should encompass any technology that meaningfully melds the real and the virtual types of information (Dunleavy, Dede, & Mitchell, 2009; Klopfer & Sheldon, 2010; Chang et al., 2015). This holds a particular significance for educators, as it opens the scope for use of lightly augmented reality for teaching and learning. In this context, AR can be defined as the technology that overlays digital information onto the real world to enhance user experience. On the spectrum from lightly augmented reality to heavily augmented reality, lightly augmented reality refers to settings in which users interact mainly with real life objects and to a lesser degree with virtual information, whereas the reverse is true of heavily augmented reality (Klopfer 2008). The ubiquity of handheld devices opens more and more opportunities to create AR (Squire & Klopfer, 2007; Martin et al., 2011) thanks to the emergence of mobile AR (Feng, Duh, & Billinghurst, 2008). The mixed reality created by location-aware mobile devices is one typical example of lightly augmented mobile AR, as exemplified by Pokemon Go, the wildly popular mobile video game launched in 2016.

AR's potential as a transformative learning tool lies in its ability to create immersive teaching and learning experiences within the user's natural environment (Azuma et al., 2001; Dede, 2009; Johnson et al., 2011). Both forms of AR currently available to teachers, location-aware AR and vision-based AR, leverage the technological capabilities of mobile devices such as GPS, tracking, and image recognition, to enable digital immersion. Location-aware AR relies on GPS-enabled mobile devices to display digital contents on top of real life objects as the user moves around the physical environment. Vision-based AR makes use of the mobile gadget's camera. The user points the camera on the object such as QR code or trigger image to activate a media display. Many studies on the strength of learning with AR have focused on location-aware AR. There are fewer studies on vision-based AR, despite its high potential for education. The ARCH Project's use of vision-based AR endeavours to contribute to the research on this topic. Furthermore, while many AR systems presented in the academic literature were designed for teaching science and mathematics, the findings of the ARCH Project provide a perspective on how AR can support the teaching and learning of the humanities.

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Previous research has shown that AR has a compelling potential for education. Among the most often quoted affordances of AR is its ability to provide students with an opportunity to participate in situated learning (Wu et al., 2013). Situated learning theory asserts that students are more inclined to learn if they are actively involved in the learning experience. Unlike in most classroom activities where learning is imparted through abstract knowledge, the situated learning occurs within activity, context and culture, and often is not deliberate. Lave and Wenger called this process "legitimate peripheral participation" (Lave & Wenger, 1990).

The effectiveness of AR for situated learning has been reported in relevant research. Bernardos, Cano, Iglesias and Casar (2011) showed how AR can enhance users' experience in a hospitality environment by providing additional information about the standard objects within the users' physical setting, facilitating navigation, and motivating users to explore the environment. Chou and Chanlin (2014) reported a positive effect of using AR mobile touring system on students' enjoyment and effectiveness for location-based learning outcomes in a university campus tour setting. The study conducted by Chang, Hou, Pan, Sung and Chang (2015) indicated that the use of AR guidance system was associated with higher learning and sense of place effects among visitors at heritage sites. Kamarainen, Metcalf, Grotzer, Browne, Mazucca, Tutwiler and Dede (2013) documented gains in student affective measures and content understanding following a field trip experience combining AR with use of environmental probeware for secondary school science classes.

Methodology and Project Design

The study involved software prototyping and focus group methodologies to gather feedback from students and teachers. The preliminary data presented in this article was gathered in the formative evaluation carried out during the development stage of the project; therefore, it reflects the findings from prototype development. As the project has not yet entered the implementation stage, the final assessment is still to be conducted.

Development and Application

This project explores how AR activities can be integrated into a field trip setting in order to address history and culture learning goals and enhance the learning experience for university students.

The technology component of the study includes an AR experience running on wireless-enabled mobile devices powered by Android and iOS. The AR experience was created using Aurasma, a vision-based AR technology, which uses the camera on a student's smartphone to recognise real world images (trigger images) and overlay media on top of them.

While location-based AR technologies that make use of GPS can be easier to use in outdoor AR activities, they are not sufficient for precise position tracking because of lower accuracy (Pagani, Henriques, & Stricker, 2016). In our project the information has to be delivered to the user at very specific locations, sometimes less than 10 meters apart, both outdoor and indoor; hence, we opted for the vision-based tracking system, which can provide better accuracy. To guide students to the trigger images (hotspots) we modelled the visual information about the environment by uploading 360-degree photographs of each hotspot to the interactive map together with written directions.

Trigger images were created by the project team by taking photographs at 16 different historically or culturally significant real-life landmarks situated along the field trip routes. Each landmark contains at least three trigger images (hotspots). After locating the relevant images within a given landmark students can view the media embedded in

each image and take a quiz testing the knowledge of the concepts conveyed in the media contents. The field covered in this study included two separate environments: 1) PolyU campus, and 2) Ping Shan Village Heritage Trail, with a total of 10 individual trigger image-bearing learning sites (hotspots) between them.

The navigation of the field trip environments is supported by three main components: 1) Interactive map with all relevant cultural and historical locations marked as clickable destinations bringing up basic facts; 2) Learning content and knowledge quizzes hidden behind trigger images in each location, displayed as digital overlays via Aurasma; and 3) Learning profile visualising students' progress by rewarding them with digital tokens.

The location of trigger images is indicated on the interactive map. The triggers become accessible to students at the real location in the field, where students can experience AR visualisations overlaid on the physical environment: text, images, video and multiple-choice questions. All of the physical sites that were chosen for our project were contextualised within a specific problem-based narrative and embedded with a variety of media providing different perspectives on the topic, including video content produced in-house; e.g., short interviews with caretakers or employees of a given site.

The project team uses an Aurasma account to implement the system and manage the content. To start the navigation, students have to download the Aurasma application to their smartphones, and then search for and follow the ARCH Project's channel. Student learning profile and interactive map directing students to the physical locations are accessible via a separate interface on the project's website. Figure 1.



Figure 1. System architecture diagram.

Assessment

To date, four focus groups were conducted with a total of 35 volunteer student participants to obtain verbal feedback about their needs and feelings regarding the system.

The participants were undergraduate and graduate students studying history and culture courses at PolyU. Interviews with two teachers in charge of coordinating the AR-integrated field trips were also carried out.

In the focus groups students were asked whether they were familiar with or had previously used AR, whether they were interested in participating in AR-assisted field trips, whether they would be more interested in participating in AR-integrated field trips than traditional ones, and what kind of expectations they had for the system in terms of features, learning experience, and learning gains.

Overall, students' responses showed a positive attitude towards incorporating AR in learning activities outside the classroom, both among those who were familiar with AR and those who had not had any previous experience with the technology. The majority of students expressed their preference for AR-assisted field trips over traditional ones. Most students were attracted to the novelty of the activity and expected it to be fun, casual, and interactive.

For the final assessment, we plan to use measures of student attitude, content learning achievement and teachers' assessment to study the features of AR as a pedagogical approach. The feedback will be collected verbally and in writing post-AR experience. We expect a study participation of 40-50.

To assess how the AR activity affects the formation of students' attitudes towards the sites they visited and towards using the system we plan to gather the opinions about the field trip via a field trip opinion survey based on a 5-point Likert scale. Students will be asked to mark: 1) their degree of agreement related to focal topics conveyed in the field trips, 2) their degree of agreement related to features of the system, and 3) their perception of the activity. Students will also be given open-ended questions asking what they liked and did not like about the activity, what they thought the activity had helped them to learn, and if they had any suggestions for improvement.

Discussion

Although the project is still in progress and a full evaluation of the students' experience is planned to be conducted at a later stage, to date, the findings of our project support the view that AR has a positive effect on students' motivation and engagement (Dunleavey & Dede, 2014; Dunleavy, Dede, & Mitchell, 2009; O'Shea, Dede, & Cherian, 2009). Students' engagement with the technology was evident in their responses to the focus group questions and in prototype testing. Compared to conventional field trips, students perceive AR-integrated field trips as more attractive. AR-integrated field trips motivate students through increased interest in exploring the sites and curiosity to experience the technology.

There are documented benefits to choosing locations that students know conceptually or physically for situating AR experiences; e.g., the familiarity with a location may decrease some of the cognitive load created by the inherent complexity of the experience for the participating users (Perry et al., 2008). Situating the triggers in "contested spaces" (Squire et al., 2007); i.e., spaces that have compelling narratives, or are at the centre of conflicting interests, for example, in terms of cultural diversity, can further enhance the AR's potential to become a more meaningful learning tool. For the campus tour component of our project, the main objective is to help students discover unfamiliar social and cultural meanings embedded in familiar locations around the PolyU campus. This provides the structure for our choice of sites and the driving narrative of the tour, which brings into focus the perspectives of a variety of actors with diverse cultural and class backgrounds, including students of other departments, and employees of campus facilities.

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Here, our experience indicates that sometimes having a pre-existing relationship with the location, when combined with other factors, may have a negative effect on students' motivation to participate in the AR activity. While most students in our project expressed strong interest in participating in the Ping Shan Village field trip, an out of the way destination located in a relatively rural and remote part of the territory, the interest in taking the campus tour was significantly lower. When explaining the reasons why they were not interested in the campus tour students quoted close familiarity and "thorough understanding" of the facilities and workings of the campus, as well as unfavourable perception of the campus as a space where only "boring", classroom-based activities take place, in marked contrast to the novelty and "fun" afforded by field activities. Based on this feedback, we conclude that students' scepticism over participating in the campus tour was caused by their preconception of the campus as a predictable, quotidian and banal environment. This implies that while AR has been shown to have the potential to "enable students to see the world around them in new ways and engage with realistic issues in a context with which the students are already connected" (Klopfer & Sheldon, 2010), it is important to balance the sense of familiarity with sufficient degree of novelty in choosing the environment in which to situate the AR activity.

To date, the biggest challenges we encountered in our project fall into two categories: 1) the cultural challenge of overcoming students' scepticism over the usefulness of AR for their studies, and 2) the managerial challenge of designing, integrating and managing the AR experience.

Cultural Challenge

Students questioned the usefulness of the AR activity because it did not fit into the efficiency-driven approach they typically applied to academic tasks. In this type of learning approach, described as "surface approach", students see the task as a necessary imposition, a demand that has to be met in order for them to achieve some other goal; e.g., to pass a course (Biggs 1991). While recruiting the participants for our project we encountered reluctance by the students to see the activity as having some inherent meaning and how it can relate to their previous knowledge, an attitude that spoke to their lack of academic curiosity and passive role as recipients of data. The most often cited concerns included: impression that the activity was immature and trivial, viewing the activity as irrelevant because it would have little bearing on the student's final score, and concern about the time and inconvenience involved in learning how to use the technology. Furthermore, although students tended to speak critically about the presentational style of classroom teaching, they would nonetheless feel more confident about their AR learning experience if it were to be combined with face-to-face, didactic instruction by the course teacher in his role as field trip coordinator.

As noted in other research, AR is best suited for exploratory, open-ended, enquirybased activities, which does not lend itself easily to a standards-driven model of education based on achievements tests (Clarke-Midura, Dede & Norton, 2011; Klopfer & Squire, 2008). Our findings underscore this challenge, as outlined above. Further research is required to determine whether and how students' attitudes towards AR may be uniquely affected by the teacher-centred, efficiency- and examination-driven education culture prevalent in Hong Kong and East Asia.

Managerial Challenge

The managerial challenge of developing and implementing the project has been related to limitations with the current state of the art in image recognition and mobile technologies. We experienced technical problems within AR implementation, of which the most significant included: 1) trigger image recognition errors, and 2) slow media loading in Aurasma. Android-powered devices were more affected by the slow media loading issue.

As previously mentioned we opted to use Aurasma for the project because a visionbased AR system can provide better position tracking accuracy than GPS-based tracking. In a vision-based system trigger images are used for tracking elements in the environments. Our initial selection of images was done on an ad hoc basis and involved many natural images, however, we found out that the recognition rate for this type of triggers was very low as it required precise positioning and orientation of the camera relative to the object. To solve this issue we switched to images that involve simple and flat graphic designs yet are sufficiently unique as to be found only in the specific location they are tagging (Figure 2).



Figure 2. Examples of trigger images and their effectiveness.

Another issue we encountered while testing the system was slow video loading in Aurasma. We determined that to ensure optimal playback experience the solution is to keep the length of video overlays at one minute or below.

The summary of challenges encountered in the project and recommendations for addressing the problems is presented in Figure 3.

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Challenge	Recommendation
Cultural	
Familiarity dampens student curiosity and motivation to visit the site	Mix familiar with novel by locating some hotspots in unexpected spaces
Students view the activity as unnecessary	Hold a short briefing session to highlight the specific ways in which the activity complements the course, explain the logistics, and set up students' phones for the activity;
	Consider making the activity a component of course assessment
Students view the activity as inefficient	Cooperate closely with the course instructor to create compelling narratives that have a connection to the curriculum;
	Time the activity to line up with the curriculum;
	Make the activity problem based

Managerial

Aurasma won't recognise trigger	Avoid using natural images;
images	Use unique images that involve simple graphic designs
Media overlays won't load fast enough	Keep the length of video overlays at one minute or less
Hotspots become too crowded	Consider situating multiple triggers within one hotspot or setting up several hotspots in close proximity to distribute traffic more evenly throughout the site

Figure 3. Challenges and recommendations for improving project implementation.

Conclusion

While the affordances of mobile technology and AR platforms are helping to make AR an increasingly achievable tool in teaching and learning, the challenge of designing and implementing the overall AR experience remains significant at all levels: designers, teachers, and students. There is an opportunity to use AR in field trip environments that can unlock different learning experiences for students, and we plan to continue exploring the affordances of this technology in our project.

To identify the impact of this project and explore its effectiveness for enhancing student learning experience an evaluation will be carried out after project implementation. The results of this evaluation will be shared with the wider community.

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