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Integrating Mobile Mixed Reality to Enhance Learning Before, During, and After Physical Field Trips

Kathryn MacCallum, University of Canterbury, New Zealand
https://orcid.org/0000-0003-3844-7628

David Parsons, The Mind Lab, New Zealand*
https://orcid.org/0000-0002-9815-036X

ABSTRACT

Physical field trips have long been used in education, but virtual field trips are increasingly being used to enhance them. This article focuses on the use of mixed reality to enhance a physical field trip before, during, and after the field experience as part of a project in teacher professional development. The context is a field trip to a landfill site, where students learn about waste management, recycling, and sustainability. Building on several different themes from the literature to create a single model of pre-, intra-, and post-field trip digital learning activities, three scenarios are outlined: One where a virtual field trip is used prior to a physical field trip to prepare students for their visit, a second where an augmented reality experience is used during the physical field trip, and a third where students build on their experience of virtual reality to create their own virtual tours. The article highlights how mobile mixed reality offers new ways to deepen the field trip learning experience through student- and teacher-created digital artifacts.

KEYWORDS

Augmented Reality, Mobile Learning, Teacher Professional Development, Virtual Field Trip, Virtual Reality

INTRODUCTION - MIXED REALITY AND FIELD TRIPS

Digital tools open up many new opportunities for students to enhance their learning during off-site physical field trips. At a simple level this may include things like taking photographs, making videos and sound recordings, and using these digital materials in various learning artefacts. However, mixed reality (MR), which provides various blends of virtual and augmented reality, offers much greater opportunities for making the field trip a more immersive, engaging and productive learning experience. Further, virtual reality activities can extend the field trip experience beyond a physical location, or indeed replace it with a virtual field trip.

Although the term "extended reality" (XR) has gained some currency as an umbrella term for all types of virtual, augmented and mixed reality tools (Vasarainen, Paavola & Vetoshkina, 2021), given that this study refers to learning activities that include both augmented reality (AR) and virtual reality (VR), we use the well-established term "mixed reality" to encompass the use of both virtual and augmented reality together in the same learning process.

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The inclusion of MR tools into the field trip experience can provide new opportunities to support learning before, during and after the physical field trip, merging real and virtual worlds to extend students' learning (MacCallum & Jamieson, 2017). Mixed reality can support a range of different learning experiences, depending on how the tools are used to enhance the field trip and which aspects of MR are being engaged with. Whereas AR enables the learner to interact with physical environments enhanced by digital materials, providing an in-situ experience during a field trip, VR experiences can be used before or after a field trip for preparation or to support post-trip reflections.

Recent advances in mobile technology have provided new opportunities for teachers and students to develop their own MR experiences. Accessible tools for taking 360-degree video and photos, including spherical images, provide easy ways for teachers and students to develop their own virtual field trips (VFT) using virtual tour and VR software, while AR tools enable them to create augmented place-based learning experiences, using either visual or location-based triggers.

In this article we explore some different scenarios of how MR can be used to not only enhance the experience of a physical field trip but contribute to learning before and after it.

BACKGROUND - PHYSICAL AND VIRTUAL FIELD TRIPS

Physical field trips, where students visit real-world locations as part of their learning, are a well-established feature of education in many countries, where students visit museums, theatres, zoos, and historical sites - activities that can have many valuable learning outcomes (Greene, Kisida & Bowen, 2014). Field trips have the potential to connect students to their learning situated in a real environment, promoting students' engagement, and supporting collaborative learning. Previous studies have shown that field trip experiences provide opportunities both for cognitive and affective psychomotor learning (Seifan, Dada & Berenjian, 2019; Houser, et. al., 2011) and enable students to develop thinking skills and prepare a substructure for their future learning (DeWitt and Storksdieck, 2008) while the real-world learning helps them to develop transferable skills (Scott, Fuller & Gaskin, 2006).

Replacing Physical Field Trips With Virtual Field Trips

VFTs have been well established as an alternative to the physical field trip even with previous generations of technology. For example, Bellan and Scheurman (1998) used a website to enable students to explore a historical location and perform similar activities to those they would engage with in a physical field trip at the same location, while Partin and Worch (2011) used an asynchronous activity in which students watched a video feed of a tour from their classroom and were able to ask questions by email. Stumpf, Douglass and Dorn (2008), comparing the impacts of a physical field trip, a VFT and a combination of the two, found no significant differences in learning outcomes. However, they did find that VFTs and physical field trips supported different learning outcomes and engagement.

As well as being able to provide increasingly immersive, realistic, and engaging learning experiences (McCauley, 2017), the more recent virtual alternatives to physical field trips are substantially cheaper and reduce the administrative workload and logistical constraints (Placing & Fernandez, 2002). Although they may take considerable effort to create, they can be reused many times across different contexts (Ramasundaram et al., 2005). Recent experiences with the COVID-19 pandemic have also shown the value of VFTs, where physical field trips have been impossible due to lockdowns and other restrictions.

Combining Physical and Virtual Field Trips

Despite the advantages of VFTs, they cannot fully replace the sensory and social aspects of the physical field trip (Robinson, 2009). Implementation aspects can impair the learning experience, such as problems with navigation, interactivity, and the communication of information (Kabassi et al., 2019). Importantly, however, the ability to undertake a field trip in a virtual environment does not

mean that educators are forced to make a binary choice between physical field trips and virtual ones (McCauley, 2017). When Spicer and Stratford (2001) examined student perceptions on the extent to which VFTs could replace real field trips, the students responded that a VFT could be most effective in preparing for, or revising after, a real field trip. In fact, different aspects of a VFT could be used both before and after a field trip to support both preparation and debriefing (Klem & Tuthill, 2003), though the more common approach is to use a VFT prior to the physical field trip.

Pedagogy

While technology continues to evolve and provide new opportunities, it is necessary for educators to consider the pedagogical advantages of these new technology tools. Exploring the technological affordances of MR along with the pedagogical benefits and approaches of its use will enable critical engagement around how technology can support new ways of learning that are pedagogically sound. In the previous sections we have outlined a few of the proposed learning benefits of field trips, whether physical or virtual. Both Bellan and Scheurman (1998) and Partin and Worch (2011) discuss the need for field trips to be integrated with both pre- and post-activities to ensure that they provide meaningful learning experiences. When designing these experiences, however, it is important that pre-experiences do not detract from the actual field trip. Harron et al. (2019) found that the students in their study explored the locations in the real field trip less than students who did not experience a VFT prior to the trip. While the reason was not certain, they propose that this was due to students being already familiar with the sites through the pre-experience, and therefore, the novelty of the location may have worn off. Excluding some aspects of the physical location from the VFT may help to address this issue by ensuring that students still have things to discover while on the real field trip. As highlighted in Harron et al. (2019), the need for effective pedagogical practices around the use of this technology is a vital component for ongoing adoption. This need to explore pedagogy in the context of MR supported field trips is the motivation for the project that informs this article, where the focus was for teachers to be able to integrate technology into their teaching in ways that support and enhance their pedagogical practice.

PROJECT CONTEXT

The three scenarios explored in this article are drawn from a larger and ongoing research project that was established to explore how MR could be integrated into the learning environment to support cross-curricular learning. The project, initiated in 2020 with two high schools in New Zealand, was developed to explore how MR could be incorporated into the classroom to engage new ways of learning and support diverse learning outcomes.

The project included a group of teachers from different subject domains working together to learn about different MR technologies and then integrate these technologies into their own classes. The teachers involved in the project could integrate the technology in any manner that achieved their subject outcomes. As a result, there was a large variety of approaches and technologies used by each teacher.

This article focuses on one part of that project and explores how MR can be used to augment the field trip experience. The following scenarios outline ways that MR has been, or could be, extended into learning in the field trip context, as developed by the participants in this project.

Method

The method adopted for this study was participatory action research (PAR). PAR is a qualitative research methodology and is considered a subset of action research. The key aspect of PAR is that "involvement is centered to those most affected by a problem. It engages them in planning, carrying out, and applying the results of the research" (Morales, 2016, p. 159) and is therefore highly suited to teacher professional development. Adopting PAR to examine how MR can be used in the classroom

allows for a reflective process, led by teachers working with others in teams or as part of a "community of practice" to improve the way they address issues and solve problems (Stringer, 2013).

The study drew on two action cycles of interaction and reflection, supported through workshops facilitated by the lead researcher. The focus of these workshops was to provide the participating teachers with foundational knowledge of the technologies that they could use in their classroom. Then as a collective, teachers explored how they could integrate these tools into their practice.

14 teachers participated across two schools (seven in each). Data was collected via regular reflective diary entries, focus groups, interviews, and practitioner focused showcases. This data has been used to illustrate the scenarios outlined in the following sections.

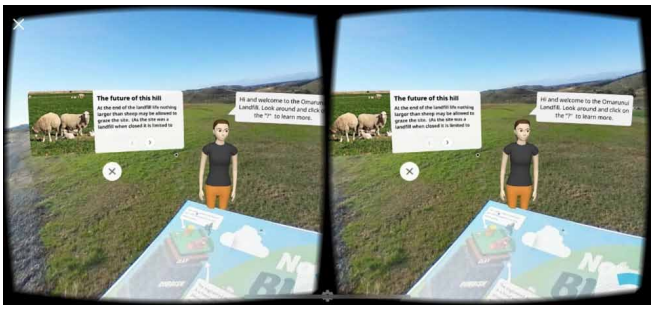
The before-during-after pedagogical sequence is well recognised as being important in gaining the full benefits from field trips (Harron, et al., 2019), so a focus of the project was to explore how MR technologies could contribute at all three stages, with an emphasis on how teachers and students can create their own MR experiences. Building on several different themes from the literature to create an integrated model of pre-, intra- and post- field trip MR learning activities, three scenarios are outlined: One where a virtual field trip is used prior to a physical field trip to help prepare students for their visit, a second where an augmented reality experience is used during the physical field trip, and a third where students build on their experience of virtual reality to create their own virtual tours.

SCENARIO ONE - VIRTUAL REALITY TO SUPPORT LEARNING PRIOR TO THE FIELD TRIP

The following scenario explores how a VFT can be used to support the learning of a group of students prior to their trip to a local landfill to learn about waste management, recycling, and sustainability. Prior to the field trip a VFT was created (using the Co-Spaces platform) of the key locations within the landfill. 360-degree photos were integrated into an interactive VFT, where students could explore and click on hotspots on the screen to find key information about the different locations they would visit on the physical field trip. Audio was also integrated into the VFT, including sounds typically heard at a landfill such as seagulls squawking, and a loader being driven around.

The students were asked to explore this VFT, either immersed in the experience using a mobile phone VR headset or through their laptops (Figure 1). After students had completed the VFT experience, they were then asked to relate what they had learnt from the embedded information, and what they had gathered from what they had seen and heard. The purpose was to identify any pre-existing ideas or gaps in their knowledge that could then be explored further while the students were on the field trip, or even prior to the field trip.

Figure 1. Stereoscopic view of the virtual reality field trip as viewed on a mobile device



Discussion

There is growing evidence to show that pre- field trip experiences using VFTs can help prepare students in advance, and optimise the time spent on location (Zakaria & Wilkie, 2020; Seifan, Dada & Berenjian, 2019). These experiences enable students to be more familiar with the layout and physical features of the trip, reducing the procedural effort of the visit (Harron, Petrosino & Jenevein, 2019). It also ameliorates the novelty effect of being on the field trip so students can focus more on the learning experience, and enhances recall by extending the opportunities for students to be fully immersed within the field trip experience (Harron et al., 2019).

As well as these benefits, VFTs can maximise learning activities before the physical experience. Having this virtual experience before the actual trip can support students to prepare for data collection ahead of the field trip (e.g., sampling strategies). It can also help them to prepare by making predictions, planning their inquiry, formulating hypotheses, familiarising themselves with the intended physical field trip, making a risk assessment, and understanding what is involved in a field trip, even if the planned location for the physical field trip is different from the VFT (Minocha & Tudor, 2017).

In this scenario the VFT enhances the preparation stage before the physical learning experience. While preparatory work is common before engaging with a field trip, often this is in the form of teaching, and activities around the topics that the students will engage with while on site. For example in Orion and Hofstein (1994), they explore this preparation in terms of three aspects, 1) cognitive preparation, giving the students the requisite skills and understanding of basic concepts required to undertake the activities while onsite, 2) geographic preparation, to help the students understand the location they are visiting and the overall path they will be taking, and 3) psychological preparation, to prepare the students for the event by giving the students a detailed description of the forthcoming learning event, including the length of the trip, what they will be doing there and what to expect from the trip, and overall conditions such as health and safety issues. While this detail can be transmitted through various explanations, activities, and discussions, some of this can be better represented through a virtual experience, where the details are contextualized within the location, providing a more meaningful connection and giving students agency over the pace and focus of their preparation.

As highlighted by one of the teachers within this project:

The [VFT] provided an opportunity to engage more with the landfill field trip. The tour deepened this experience, as you could actually show them what they would see, not just talk about it… a really neat little activity that the students could hook into, and it provided them with initial information about our local landfill area and provided an opportunity to go deeper into the ideas before the actual tour.

In preparing students for a physical field trip with a VFT, it is important that teachers provide appropriate experiences that support the learning process. Opportunities for interactive engagement within the VFT are important. As highlighted in Spicer and Stratford (2001), designing the experience in such a way that students can independently explore the locations and determine their path provides a richer experience. The careful integration of multiple paths and the integration of multimedia within a VFT has been shown to support students' feelings of self-determination (Robinson, 2009). In fact, this independent exploration is a benefit that is often not supported in physical field trips (Minocha & Tudor, 2017).

The Student Experience

Although this project was not designed at this stage to evaluate learning outcomes, but rather to explore the opportunities for integrating MR technology into teacher professional development, some student feedback was gathered from the experience of using the VFT as preparation for the physical field trip. The most common feedback was that this VFT helped the students set a foundation for their learning during the physical field trip:

It helped because when we saw the things with the information, I had more of an understanding about the things at the landfill. (Student 1)
You kinda knew what we would be seeing and already knew a few facts about the landfill. (Student 2)

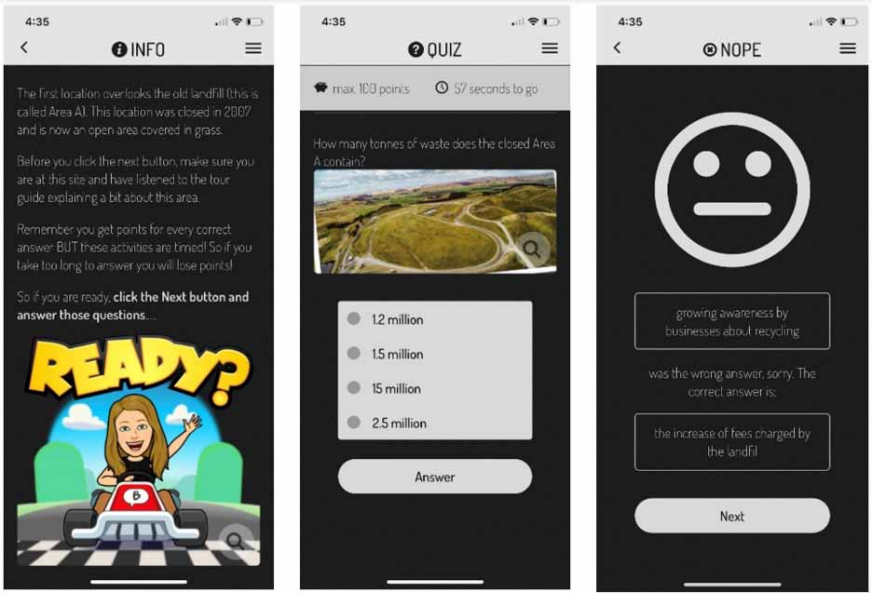
However, the feedback also underlined the value of the physical experience in this combination of the VFT and the physical field trip:

It was quite hard to see all of the landfill from your phone [used in a VR headset] but when you're there it is so much easier to see and understand. (Student 6)

SCENARIO TWO - AUGMENTED REALITY DURING FIELD TRIPS

As part of the ongoing project, in addition to the VFT, an AR experience was created for the students to engage with while on the field trip. This has not yet been evaluated with students but will be added to the teacher's toolkit of applications for future field trips with other classes to the same landfill site. During the field trip the students will undertake a scavenger hunt activity using a mobile based AR tour created using ActionBound. The learning experience was developed around key locations within the field trip (similar to the key locations explored in the VFT). The AR activities will be undertaken in teams and draw on the information that students would be able to acquire through listening to the guide or reading the informational posters that are available onsite (Figure 2). The AR experience therefore acts as a learning check during the field trip. Drawing on a game-based approach to engage the students, the teams answer questions or undertake the activities and score points, with the winning team achieving the highest score. This type of staged-content, gamified support for learning in the field has been shown to enhance the learning experience and outcomes (Chen, Liu & Hwang, 2016).

Figure 2. Sample screens from the AR activity to supplement learning during the field trip



Discussion

AR in field trips can take many forms. Fitzgerald et al (2013) outline a taxonomy of mobile augmented reality that considers factors such as the technology, the mode of interaction, the method of sensory feedback, whether the experience is personal or shared, the level of portability and the learning activities. When designing an AR experience for a specific context, these factors come into play in different ways. For example, from a technology perspective, in the context of the field trip to the landfill, which takes place outdoors, although visual triggers could potentially be used (e.g., images on information boards) a more flexible approach to content triggers is to use GPS location. However, because the site is remote, network coverage is poor, so from a portability perspective, it is helpful if the AR application can be preloaded onto a mobile device so it can be used without a network connection. The learning activities that can be integrated into the field trip can vary. They could be collaborative, require students to engage with the artefacts and people at the site to answer question, or require students to undertake activities to apply their learning, such as gathering data or conducting experiments. AR experiences can be used to support understanding contextualised within the location, engage learners more deeply in activities with active, situated learning, and provide aspects of game-based learning which can be self-directed.

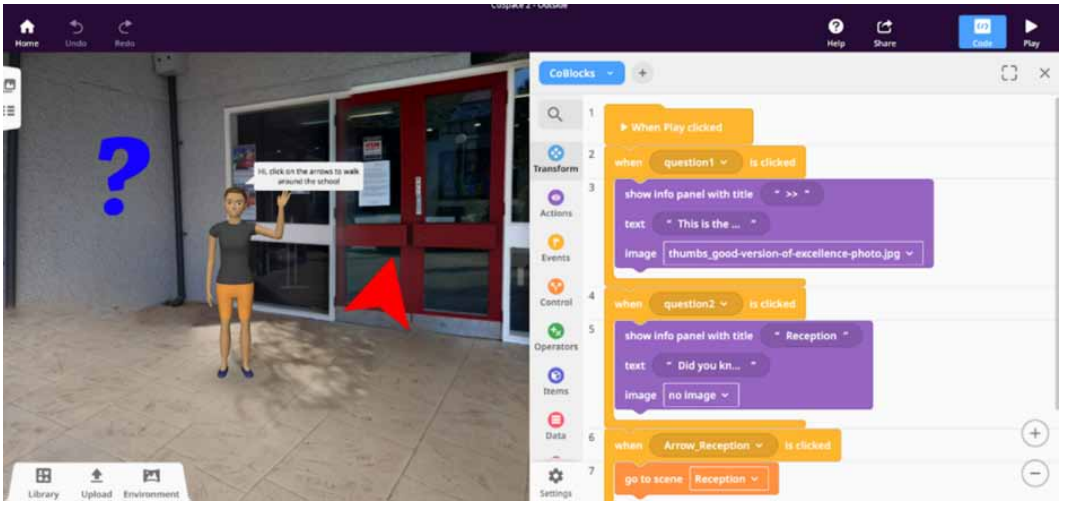
SCENARIO THREE - VIRTUAL REALITY TO SUPPORT LEARNING AFTER THE FIELD TRIP

Once back at school, after the field trip, as part of the debrief, students were able to create their own VFTs based on their own school environments. Having experienced a pre-created VFT prior to the field trip, and then experiencing the relationship between the VFT and a real-world field trip, students were able to apply this experience to creating their own VFTs by taking their own 360º photos and integrating information they had researched themselves.

In the actual project, the students did not create a virtual field trip based on the landfill visit, but rather created a virtual tour through their school. The focus was to situate their learning within the school context, particularly where recycling bins were located throughout the school and including details they learnt about the importance of recycling and sustainability.

While in this example students did not create a VFT based on the location, it could have been a possible outcome. At sites which are more complex and where students could have visited different locations from each other, such as in the example of the museum by Harron et al. (2019), getting students to create their own VFTs assembled from their own 360º photos and notes from the locations could have provided another way for students to reflect on and consolidate their learning. However, having students create VFTs based in their own schools provided resources that could be used in the future, for example for students who are new to the school. The tools that the students used to create the VFT also required them to code the interface to enable the VFT to be interactive. Therefore, the requirement to programme the interface provided additional learning opportunities to extend their computational thinking, and digital and coding skills (Figure 3).

Figure 3. Sample screen of students' work developing a virtual tour of their school, incorporating coding skills



Discussion

Generally, in the literature, using VFTs as a tool to support reflection after a field trip means revisiting the same experience through the same VFT. While this can enhance student recall of the field trip and further explore different locations, especially locations they may have not seen while on the trip (Harron et al., 2019), the creation of their own VFTs provides additional opportunities. In this project, students were asked to create their own VR experiences to support a deeper engagement with the ideas explored in the field trip but in another context. The act of creating these field trips required students to build on their knowledge of recycling and waste management and provided opportunities to develop skills through the creation of digital artifacts.

The opportunity for students to create their own experiences was powerful. As related by one of the teachers involved:

The project helped our team to uncover how enthusiastic our akonga [students] are to embrace the opportunities that these technologies offer. Students have been incredibly engaged in the process and have found ways in which to use AR and VR to help them understand concepts that would have otherwise been less accessible. Students have been able to build experiences for each other to enrich their learning also; this reinforces a strong sense of mahi tahi [sharing learning].

SUMMARY AND CONCLUSION

This article has outlined three scenarios that use MR tools to enhance the learning experience around a physical field trip to a landfill site, recognising the importance of a pedagogical structure that provides for pre-, intra-, and post- activities when organising field trips. It outlines how MR has been integrated into each of these three stages of learning. The first scenario has described how a virtual field trip is used in preparation for the physical field trip. The second scenario has described how AR can be used during a physical field trip to enhance the learning experience, engage students, and encourage collaborative enquiry. The third scenario provides one example of how VFTs can be used in a creative way as a follow-up experience for student learning. The work reported in this article is based on a process of professional development for teachers and therefore has pedagogy at its heart. The model

of integrating MR into these three stages of field trip learning is grounded in extensive literature that supports this relationship between virtual and physical field trips and the benefits that can accrue.

Future Implications

Because the aim of this project is to upskill teachers to be able to integrate MR tools into their own practice, the primary output of this work is not empirical data but evidence that these teachers have developed their capabilities to create learning experiences for their students. This article outlines some of the activities undertaken so far, as well as contextualising the work within the broader frame of mixed reality as a technology that can support the field trip experience. As the project continues, further field trip experiences will be used as the context to explore the outcomes of virtual and augmented complementary activities, both for teachers and students.

Implications for future work in this area focus on the different potentials for virtual and augmented reality tools and artefacts to be integrated into all three phases of the field trip experience. There are many different ways in which teacher and student created digital artefacts can be used to enhance the learning experience in each of these phases. With the continual development of virtual and augmented reality tools, new opportunities will arise for us to continue to enhance the traditional field trip concept with innovative approaches to learning with mobile devices.

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David Parsons is National Postgraduate Director for The Mind Lab in Auckland, New Zealand. He holds a PhD in Information Technology and a Master's degree in Computer Science, and has wide experience in both academia and the IT industry. He is the founding editor in chief of the International Journal of Mobile and Blended Learning (IJMBL) and has published widely on technology-enhanced learning, software development, and agile methods. He is President of the International Association for Mobile Learning, a member of the Australasian Society for Computers in Learning in Tertiary Education, and a certified member of the Association for Learning Technologies.