Jl. of Interactive Learning Research (2016) **27**(4), 293-316

A Framework for Designing Collaborative Learning Environments Using Mobile AR

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Smartphones provide a powerful platform for augmented reality (AR). Using a smartphone's camera together with the built in GPS, compass, gyroscope, and touch screen enables the real world environment to be overlaid with contextual digital information. The creation of mobile AR environments is relatively simple, with the development of mobile AR browsers such as Wikitude and Layar that provide simple tools for user AR content creation and sharing. In this paper we illustrate how these tools can be used within collaborative educational contexts based upon five projects that we have implemented from 2011 to 2015. Throughout these five projects we explored how we could use a mash up of mobile social media to design collaborative learner-generated mobile AR projects in a variety of higher education curriculum contexts. Via a meta analysis of the five projects the paper develops a pragmatic framework for implementing mobile AR to facilitate learner-generated projects, with a particular focus upon enabling new pedagogical strategies.

Introduction

The educational promise of new technologies is the potential to enable new learning experiences. One of the affordances of mobile learning (mlearning) is the ability to enable situated learning experiences beyond the confines of the classroom. Augmented Reality (AR) is essentially the overlaying of digital information upon a view of the real world environment using the combination of a digital camera and a viewing screen. AR can take the form of text, geolocation data, 3D models, animation, and digital images and video. Fitzgerald et al., (2013) categorize AR at one end of a continuum of mixed reality between experiencing the real environment and a fully virtual environment such as that experienced with head mounted displays like the Oculus Rift. AR provides opportunities for new forms of interaction with our environment, and makes a powerful companion to mobile learning coupled with the affordances of smartphones that include a range of environmental sensors alongside a quality camera and high resolution touch screen and ubiquitous internet connectivity. The New Media Consortium Horizon Report has signaled the maturing and relevance of both mobile learning and augmented reality for education in its annual report since 2010 (Johnson, Levine, Smith, & Stone, 2010; Johnson, Smith, Willis, Levine, & Haywood, 2011). A 2011 report commissioned by JISC (Butchart, 2011), the UK higher education, further education and skills sectors' not-for-profit organisation for digital services and solutions, also highlighted the potential of mobile AR in education:

Thanks to advances in smartphone technology augmented reality is accessible to a wide audience for the first time. A new class of AR "browser" and tools for authoring and hosting content makes it possible for almost anyone to create augmented reality learning experiences. (Butchart, 2011)

While mobile AR has been around for some time, it has only recently received wide-spread public attention, due in large part to the hugely popular mobile AR game of Pokémon Go (Niantic Inc, 2016) receiving over 100 million downloads in less than three months (Perez, 2016). Mobile AR authoring tools have matured to the point where knowledge of complex coding or computing is no longer required to create interactive AR environments. AR interaction with real world environments is typically triggered either via marker-based codes (similar to QR Codes), geolocation, or a combination of both. Mobile AR browsers use the built in camera of smartphones to decode digital information or virtual objects triggered by visual markers, or alter-

natively utilizing the built in GPS of smartphones to trigger location based digital information, events or objects. Several examples of freely available multi platform (iOS, Android, Windows Mobile, Symbian) mobile augmented reality browsers can now be used to host and share user generated AR content, including: *Wikitude*, *Layar*, *Junaio* (now bought by Apple Inc.), and *Aurasma*. Butchart (2011) summarized the strengths and weaknesses of several mobile AR bowsers in a table within his 2011 report. Of those listed, Wikitude provides one of the simplest multi-platform mobile AR browser platforms for developing and sharing user-generated content, and is a good choice to begin exploring mobile AR content creation with. Thus in our projects we focused upon the use of Wikitude, as a core element of a mash-up mobile social media tools to design collaborative learner-generated mobile AR projects in a variety of higher education curriculum contexts.

Augmented Reality in Education

A review of the literature identifies the potential of AR to enable new learning experiences for students within authentic contexts beyond the confines of the classroom. Cook (2010) argues that "The nature of learning is being augmented and accelerated by new digital tools and media, particularly by mobile devices and the networks and structures to which they connect people" (Cook, 2010, p. 1). Butchart (2011) identified mobile AR browsers as a simple platform for AR content production and sharing. However, Butchart (2011) found that mobile AR has been predominantly used within a teacher-directed paradigm for new forms of content delivery in new contexts. These contexts take the form of training, discovery based learning, educational games, creating 3d models, and augmented books. However, Butchart found little evidence of the use of mobile AR browsers as the basis of student-directed projects.

Fitzgerald et al., (2013) categorized mobile AR projects in education using a simple taxonomy according to: device type, mode of interaction, method of sensory feedback, personal or shared experience, and fixed or portable experience. Of the six projects Fitzgerald et al., use as examples only one project involved student content creation as co-designers of the AR experience. While Fitzgerald et al., found examples of the use of mobile AR content to enhance constructivist learning by facilitating collaboration and student inquiry, they did not find examples of student creation of mobile AR. In exploring the state-of-the-art of mobile learning, Cook and Santos (2016) argue that "a key evolving pedagogical affordance of mobile devices

is the ability to use social media and apps to enable new patterns of connected social learning and work-based practices" (p. 318). However, Cook and Santos note that there is "still a focus on content" (p. 318), whereas the potential of mobile AR is "to be used for situated and constructivist learning, particular where collaboration and student inquiry form key aspects (p. 319)."

Thus we argue that in general mobile AR has been predominantly used to augment traditional methods of content delivery or augment learning experiences by situating access to digital content within authentic contexts. In contrast, our goal has been to utilize mobile AR as a catalyst for new pedagogies that enable collaborative learning, learner-generated content and contexts, and student negotiation of learning outcomes.

Mobile AR Examples

Two local examples of mobile AR represent responses to a natural disaster event, the devastating earthquakes that rocked Christchurch city in February 2011. The earthquake resulted in severe damage to many of the city's historic buildings, trapped and injured many thousands of people, and resulted in the deaths of 185 people. The first example of mobile AR in response to the earthquake involved the use of a quadracopter drone (AR-Drone) equipped with twin wireless cameras remotely operated via an iPad App to enter semi collapsed buildings to search for survivors without risking rescuers' lives in after shocks. The use of an inexpensive ARDrone for remotely video streaming of rescue operations received national news coverage in New Zealand (Hampton, 2011). The second mobile AR project in response to the damage to historical buildings as a result of the earthquake involved the development of a mobile AR App to provide a historical view of the city's buildings prior to the quake and their subsequent collapse and demolition. The cityviewAR App (Hit Lab NZ, 2011) provides a way of preserving the city's building heritage through the virtual lens of a smartphone. Initially developed as an Android App, CityviewAR has been exported as a standalone App for both iOS and Android, and is also available as a channel for the Junaio mobile AR browser Application. The CityviewAR App is designed to be used for virtual earthquake reconstruction, and to allow public feedback on proposed new building designs as part of the city redevelopment. The 3D models used within the CityViewAR App were produced by a local Christchurch architect. While neither of these two examples are explicitly educational projects they do provide examples of how mobile AR can be used to authentically augment situated contexts.

Two educational examples of mobile AR include the CONTSENS projects (Cook, 2010) and the Zapp project (Meek, Priestnall, Sharples, & Goulding, 2013). The CONTSENS projects were funded by Sonyericsson and included two social constructivist education projects.

1. A Guided Urban Walk - exploring the impact of urban planning on society using mobile phones
2. Exploration of a historical ruin of a Cistercian Chapel using mobile AR students worked in teams to compare the ruin with an overlaid model of the original site.

While the CONTSENS projects were highly developed and situated within authentic contexts, they did not facilitate student-generated content or contexts, but relied upon pre-developed content used within pre-defined parameters. Therefore in our view the CONTSENS projects did not focus upon enabling new pedagogies, rather the aim was simply to raise awareness of the potential of mobile augmentation. Additionally the CONTSENS projects were short day-long projects, using loaned mobile devices with no longitudinal technological or pedagogical scaffolding provided. The ability to create transformative learning experiences from such short-term engagement is therefore limited.

The ZAPP project utilized mobile devices to enhance geography education. The Zapp application "determines the geographic coordinates of points on the distant landscape using the intersection of a line of sight from the mobile device with an on-board digital surface model" (Meek, et al., 2013, p. 336). While this is a highly interactive use of mobile devices allowing new ways of interacting with the users' environment, the complexity of the mapping data requires pre development and loading on the users mobile device before embarking on a specific fieldtrip location. Thus the project does not enable student mobile AR content creation, but rather presents a pre-determined activity for students to explore.

New Technologies Enabling New Pedagogies

In exploring the state-of-the-art of the pedagogical affordances of mobile learning Cook and Santos (2016) argue for the potential of mobile learning to augment learning experiences. Munnerley et al., (2012) argue for a pedagogy-first approach to AR in education rather than a rush to simply embrace new technologies. We believe that the intersection of mobile AR

and pedagogy enables the design of new learning experiences and in collaborative and connected learning environments that focus upon learner-generated content and learner-generated contexts. Foundational pedagogies that inform the design of collaborative and connected social learning include social constructivism (Vygotsky, 1978), connectivism (Siemens, 2004), rhizomatic learning (Cormier, 2008), and heutagogy (Hase & Kenyon, 2001). Frameworks that provide a practical link between pedagogical theory and practice include Puentedura's SAMR framework. Puentedura (2006) developed a simple framework that identifies four levels of educational technology adoption, called the SAMR framework (Substitution, Augmentation, Modification, Redefinition). We argue that the SAMR framework aligns with a conception of three levels of creativity: replication, incrementation, and redirection (Sternberg, Kaufman, & Pretz, 2002). Puentedura argues that the predominant mode of educational technology adoption is effectively the substitution of current activities and assessment practices using new technologies, for example using PowerPoint on a mobile device. The second level of educational technology adoption takes the form of augmenting current practice and activities, adding elements of student interaction, for example using Slideshare to host PowerPoint presentations. The third level involves a rethink of what activities and assessment practices are possible within an educational context using new technologies, for example modifying activities and assessments to involve student-generated projects. The third level involves transforming the learning experience by using new technologies to redefine practice and assessments beyond what was previously possible without the use of the technology. Hockly (2012) applied the SAMR framework to the design of mobile learning activities, highlighting the potential to design learning activities that were previously impossible.

Both the CONTSENS and the Zapp mobile AR education examples represent the augmentation of a teacher pre designed student activity. An example of an educational AR project with transformative learner experience goals closer to ours was the ARstudio project (Munnerley, Bacon, Fitzgerald, & Steele, 2014), however the ARstudio project focused upon teacher-designed AR content. Our mobile AR projects are driven by the incorporation of learner-negotiated projects that harness the geolocation services of smartphones to create an AR environment for learner mobile content production and sharing, thus representing a redefinition of previous teacher-delivered content and teacher-directed assessment and course activities.

Methodology

Between 2011 and 2015 we implemented five mobile AR projects to explore the potential of mobile AR to enable new pedagogies within a range of different educational contexts. While the five projects were not explicitly designed as a single longitudinal action research project, each project was designed using a common methodology with the authors as core members and designers of each project. Thus each project effectively represents an iterative action research cycle, with the prior project experiences informing the design of the following projects, allowing us to refine the design of a framework for learner-generated mobile AR projects.

The research question that linked each of the projects focused upon using mobile AR to enable new pedagogies that redefine the role of the teacher and the learner: How can we use a mash up of mobile social media to design a simple framework for collaborative learner-generated mobile AR projects?

While each project drew upon a different cohort of participants we used a common supporting structure that involved the design of the project learning community as a community of practice comprised of the authors as academic advisors, course lecturers from different countries invited to participate in the project, and their student cohorts. Each individual project description and selection of participants is detailed further in the following case studies section of the paper.

In each project we began by surveying the participants to scope their prior experience of mobile social media and augmented reality. We used a simple Surveymonkey survey to facilitate this. The results of the pre project survey did not vary much: participants predominant use of mobile social media revolved around Facebook, and participants had no experience of mobile augmented reality as either users or producers prior to the projects. Participants' ownership of smartphones grew through each subsequent project iteration whereby in 2011 we supplied students with smartphones or they shared them in teams, whereas from 2012 onwards we used a BYOD (Bring Your Own Device) approach to each project.

Participants utilised a range of (cross-platform) mobile social media tools for communication, collaboration, and content creation and sharing. Participant activity and user-generated content were curated using an agreed hashtag for each project, and participants used this common hashtag on all their project related social media communications and content. Several hashtag curation tools were used to collate participant social media activity including TAGSExplorer (Cronin, Cochrane, & Gordon, 2016; Hawksey, 2011) for Twitter conversational analysis.

Data collection and analysis for each project relied upon the curated streams of social media activity and content sharing by the participants. Additionally participants for each project used a common project hub for discussions, beginning with Wikispaces in 2011, moving to Wordpress in 2012, and subsequently using Google Plus Communities for the 2013-2015 projects. Each project participant was encouraged to create and maintain a personal blog as a project journal and to provide reflections on the project as blog posts. We were mainly interested in collecting stories of participant change in perspectives and critical incidents than collecting comparative quantitative data. Participants' individual blogs were curated via project blog rolls linked to the project hub. Twitter was used for asynchronous communication between the globally disperse participants, and Skype or Google Plus Hangouts were used for synchronous communication and presentations throughout the projects. Project coordinators used Google Docs to collaboratively design the projects and create shared timelines and goals.

Each project was linked via a common approach to exploring new pedagogical strategies. The design of the pedagogical strategies behind each project leveraged collaborative and connected social learning including: social constructivism (Vygotsky, 1978) – student team projects, connectivism (Siemens, 2004) – connecting students and experts within a global learning community and encouraging active participation within a professional network, rhizomatic learning (Cormier, 2008) – decentralising the locus of control in the learning environment and designing learning activities to facilitate collaboration and discussion rather than content delivery, and heutagogy (Hase & Kenyon, 2001) – involving students in the design and negotiation of learning outcomes and assessment activities. In terms of the SAMR framework, rather than focusing upon using mobile AR as a substitution of pre existing course activities we wanted to explore some of the unique affordances of mobile AR to redefine the possibilities around collaborative mobile social media (and in particular augmenting mobile video) production and sharing. Thus in each project we explored: location services, collaborative media production, and mobile social media for publishing and sharing of learner-generated projects.

A Framework for Learner-Generated Mobile AR

Over the course of five project iterations we developed and refined a simple workflow for mobile AR content creation, publication and sharing. The first step involved creating interactive points of interest (POIs) using

Google Maps as an editor. Each participant created a Gmail account and a Google Maps account. Mobile content (photos, audio, video) is geotagged via a smartphone's in-built GPS, allowing mobile content to be located within a geographical context, linked within collaborative *Google Maps* and viewable in *Google Earth*. This adds a rich layer of contextual information to mobile movies, effectively augmenting a mobile movie (or other mobile produced content) with geographical data. Each POI also includes links to wider online content where the students can provide more in depth outlines and critique of their projects, such as links to project blogs, YouTube channels, or image slideshows. Adding new mobile video applications such as *Vyclone*, *Vine*, and the *YouTube* online *Editor* to the projects enhanced the creation of mobile movies embedded within the POIs. The customized geolocated content created in Google Maps is then exported as a KML file using the built in export to KML option within Google Maps. Participants then created a free developer account on the Wikitude site (http://developer.wikitude.com). The exported KML file is then imported into Wikitude via the Wikitude web tools option. As a contextual tool Wikitude limits the display of POIs to within around 70Km of the user (as identified by the GPS on the user's smartphone). Customizing a Wikitude World involves the appropriate categorizing of the content, and uploading of an illustrative image icon. Once published, the Wikitude world is then available publically for anyone to search for within the Wikitude App as long as there are local POIs within range. Thus Wikitude creates a local interactive mobile AR experience, with the full (global) data being viewable on the original shared Google Map. A slideshow overview of this mobile AR content creation and hosting process is available at http://bit.ly/1qV4NyG. Mobile social media also provided a way to publish and share students' creative output with a wider global audience, using social networks such as *Twitter*, and *Google Plus.*

A summary of the steps in our basic mobile AR creation framework include:

- Create a Google Map
- Add Points of Interest and link to web-based mobile social media
- Export the Google Map content as a KML file
- Create a Wikitude Developer account
- Use the Wikitude Publisher Tool to create a Wikitude World
- Import your KML file as the Wikitude World content
- Categorise your Wikitude World and create a 512x512 pixel PNG icon
- Publish your Wikitude World
- Download the Wikitude App and search for your Wikitude World

This approach has led to the development of a framework for user-generated mobile AR that explicitly maps the design of an ecology of resources and the design of learning activites as triggering events facilitating collaboration and discussion, to new pedagogical strategies, illustrated in Table 1.

Table 1
An ecology of resources for mobile AR

Supporting Learning Theory	Supporting Mobile EOR	Supporting Learning Activities
Rhizomatic Learning	Design of an ecology of resources around mobile social media and AR	Activities designed as Triggering Events
Social Constructivism	Collaboration tools for project planning: Google Plus Community, Google Docs	Student determined project and student negotiated assessment
Heutagogy	Wikitude development project	Student generated content
Authentic learning – situated content	Google Maps	Geotagged content
Authentic learning – situated context	Wikitude App	AR experience
Connectivism	Google Plus, Facebook, and Twitter	Publish to Global Network and Share

This ecology of resources (EOR) framework provides a simple gateway into user-generated mobile AR that is founded upon an explicit design of a learning experience that is informed by new pedagogies such as rhizomatic learning, social constructivism, heutagogy, authentic learning, and connectivism. This EOR uses: a Google Plus Community to facilitate student collaboration and team projects (social constructivism), Wikitude as a platform for a student-determined project (heutagogy), Google Maps to locate student-generated content to its context (authentic learning), and sharing of this learning experience with local and global networks (connectivism) via mobile social networks such as Twitter and Facebook. While we have focused upon using Wikitude as a mobile AR development platform there are other alternative platforms, with one of the most popular being Aurasma. A generic mobile AR ecology of resources that supports this framework can be comprised of a flexible bricollage of mobile social media tools that facilitate five key elements: (1) a participant team hub (for example: Google+

and Google Docs), (2) a mobile AR content creation platform (for example: Google Maps, Wikitude, and Aurasma), (3) a cloud-based AR content host, (4) AR content publication and sharing via social networks (for example: Google+, Facebook, and Twitter), and (5) a mobile AR viewer App (for example Wikitude, or Aurasma). This framework is illustrated in figure 1.

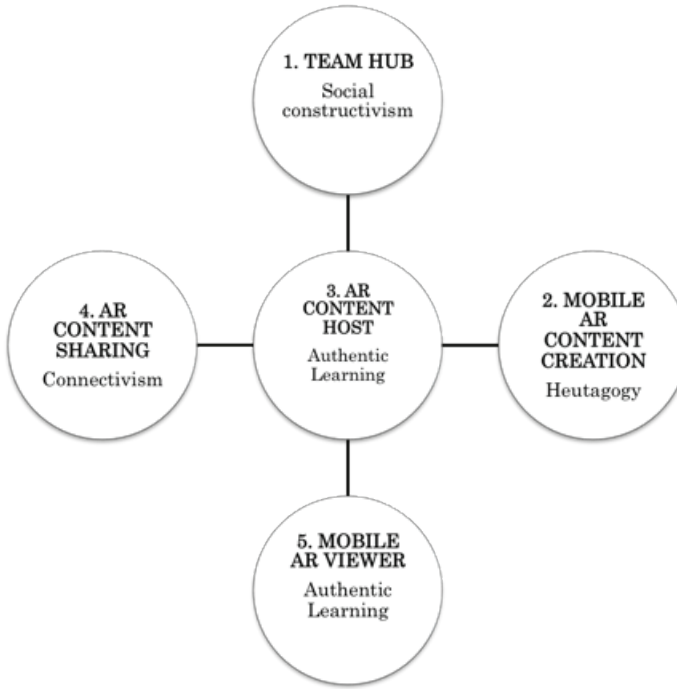

Figure 1. Key elements of a mobile AR EOR framework supporting Rhizomatic learning.

Utilizing mobile social media facilitated the data collection for each project iteration throughout the development of the framework involving the collation of mobile social media tools used via a common hashtag for each project. Content was shared via embedded links in Twitter and Google Plus posts, with an agreed hashtag, allowing searching via the hashtag. This is illustrated in the following five case studies.

Case Studies

In this section we illustrate the design of learning experiences using mobile AR to enable student-generated content and contexts through five iterations of mobile AR projects within a variety of curriculum contexts. Each of these projects have a more detailed description and analysis in prior publications, including 2 journal articles, 1 book chapter, and 2 conference proceedings:

- iArchitecture 2011 (Cochrane & Rhodes, 2013)
- iCollab 2012/13 (Cochrane et al., 2013)
- MARMW 2013 (Cochrane, 2014)
- MoCo360 2014 (Cochrane, 2014)
- Mosomelt 2015 (Cochrane, Narayan, & Burcio-Martin, 2015; Cochrane, Narayan, Burcio-Martin, Lees, & Diesfeld, 2015)

In this paper we focus upon a meta analysis of the five projects. Each of these projects represents an action research cycle in which we have explored and refined the application of learner-generated AR content creation projects within the context of building global learning communities. Each project involved the formation of a community of practice of lecturers and students exploring the potential of mobile AR to create and share creative projects with a global audience. Based upon these experiences we have also facilitated three conference workshops on mobile augmented reality (Cochrane & Narayan, 2011, 2012; Cochrane, Narayan, Antonczak, & Keegan, 2013). Table 2 outlines a comparison of the participants and the curated mobile social media activity in each of the mobile AR project iterations.

Table 2
Mobile AR project iterations

Year	2011	2012/13	2013	2014	2015
Project Title	iArchi[tech]ture	iCollab	MARMW	MoCo360	MosomeIt
Project Hub	Wikispaces http://bit.ly/UmiprK	Wordpress http://bit.ly/Uk8lQk	Google Plus http://bit.ly/1fFBhYT	Google Plus http://bit.ly/1nPaf2b	Google Plus http://bit.ly/mosomeIt
Participants	N=70 students N=7 lecturers N=5 Courses N=4 Countries	N=70 students N=5 lecturers N=4 Courses N=4 Countries	N=9 lecturers N=6 Courses N=2 Countries	N=295 students N=6 lecturers N=5 Courses N=4 Countries	N=38 lecturers N=3 facilitators N= Contexts N=6 Countries
Project Focus	Virtual cultural exchange	Students as Social media reporters	Exploring AR learning design	Student negotiated collaborative projects	Lecturer professional development
Collaboration and content curation tools	Twitter via #icollab11 Storify	Twitter via #icollab TAGSExplorer http://bit.ly/1fuq4t6 Tagboard	Twitter via #marmw2013 TAGSExplorer http://bit.ly/1fnEmw8 Tagboard	Twitter via #MoCo360 TAGSExplorer http://bit.ly/1nfFhE2 Tagboard	Twitter via #mosomeIt TAGSExplorer http://bit.ly/1DuYB6J Tagboard
Video streaming	Qik	Bambuser	Bambuser	Bambuser	G+ Hangouts
Collaborative video production	YouTube	YouTube http://bit.ly/1rFk87D	Vyclone http://bit.ly/1bdR8c5	Vyclone http://bit.ly/1nvJ3v9	Vyclone http://bit.ly/1RMyqTH
Video hosting and sharing	YouTube http://bit.ly/1p4jBIR	YouTube http://bit.ly/1nvLrCm	YouTube http://bit.ly/1qZDSBG	YouTube http://bit.ly/1my5OZi	Vine http://bit.ly/1KDTzaR
Geolocating participant projects	Twitter	Google Maps http://goo.gl/maps/rKLjA	Google Maps http://goo.gl/maps/pkldm	Google Maps http://t.co/h04smraufh	Google Maps http://bit.ly/1GfULjc
Mobile AR	Wikitude & Junaio	Wikitude	Wikitude	Wikitude	Wikitude

iArchi[tech]ture

The iArchi[tech]ture project in 2011 (Cochrane & Rhodes, 2013) was our first attempt at designing a global learning community around student-generated mobile AR projects. The context of the iArchi[tech]ture project was virtual cultural exchange collaboration between Architecture students in New Zealand, Audio engineering students in the UK, teacher education students in Spain, and Sociology students in Germany. The Architecture students formed teams to create and share mobile AR projects highlighting critical elements of Architectural designs around Auckland City. The use of mobile AR allowed the international students to view the New Zealand students' projects within their authentic geographic contexts. One example student Wikitude world project created a virtual tour of highlights of the Wynyard Quarter of Auckland City. This particular student project was subsequently funded by the Auckland City Council for use as a tourist information guide to the city. Example student feedback on the project included:

I found the iArchi[tec]ture course to be interesting and informative. I was exposed to a broad range of technologies including apps, hardware, and social networking and marketing tools. The course provides a good platform for enhancing an online presence, which is vital to creative professionals in a competitive market. (Student blog post, 2011)

iCollab

The second iteration of student-generated mobile AR projects (iCollab) involved international student teams (New Zealand, Ireland, Germany, UK) creating and sharing their own projects relevant to their own course contexts by linking to their projects via a shared collaborative Google Map (Cochrane, Buchem, et al., 2013). The Google Map content was then exported as a KML file, imported into Wikitude, and shared as a Wikitude World. Students were then encouraged to create their own mobile AR content for their negotiated projects. The iCollab project highlighted the nature of trust involved in collaborating via social media. A small number of participants within one student cohort involved in the iCollab project decided to move the other students' geotagged POIs from their original positions on a collaboratively edited Google Map into Antarctica. While this practical joke was amusing, the incident could have destroyed a sense of trust within the international collaborative project. The issue was solved by uploading a saved

KML file version of the shared Google Map, thus resetting the POIs to their original locations. The incident provided a relevant foundation for discussing the ethical use of social media in education. One example student project resulting from the iCollab community was an interactive Google Map of Irish history, myths and legends http://bit.ly/P1XHeZ. Example lecturer reflections on the project included:

Coordinating a project with students in 5 countries, crossing 12 time zones, and working in different terms has its challenges. But the project coordinators decided at the start to view these differences as an asset. Students in each location share their work and students in other locations can engage and connect — sometimes immediately, sometimes later that day, sometimes much later. (Lecturer blog post, 2013)

MARMW

The third iteration of a mobile AR project (MARMW) involved a week-long workshop for lecturers interested in exploring the design of mobile AR projects within their own curriculum contexts, with input from a selection of the #icollab COP global participants both face to face and virtually via Google Plus Hangouts (Cochrane, 2014). We were able to use examples from our previous two mobile AR projects to build upon further within this project iteration. Consequently the resulting participant projects were very creative. We also utilized a Google Plus Community to facilitate the sense of building a learning community around the MARMW project. While we retained participant's individual blogs as their own eportfolios and team projects, we found that the G+ Community and Google Plus Hangouts enabled more collaboration and input from the invited international experts into participant projects than the previous two iterations. One example participant team project involved the creation of a virtual AR tour of Auckland City's Aotea Square using the Wirewax App https://www.wirewax.com/8004622/. Example participant feedback included:

The #marmw2013 workshop has been a great exercise in exploring new ideas and discovering different approaches to filmmaking, sound recording and the relevance location can have on this content. It has given me the opportunity to try out new ways of working and to test some of my knowledge of mobile geo-spatial and augmented reality. Most of all, the workshop has put me in contact with some extremely switched on people who have opened up a huge body of ideas to pursue with my students and hopefully through further collaborative projects in the coming year. (Participant Google Plus post, 2013)

MoCo360

The fourth iteration of a mobile AR project (MoCo360) involved global mobile movie production across five courses from four different countries (Cochrane, 2014). This was our most ambitious collaborative mobile AR project of the four iterations, and the most rewarding in terms of the impact upon students' learning (as evidenced in their reflective blog posts) and the resultant negotiated team projects that demonstrated a high degree of student collaboration and creativity. The MoCo360 project began with three lecturer designed and facilitated short-form mobile video production collaborative activities, followed by students forming mobile video production teams and negotiating their own projects. As with the third project iteration, creating a Google Plus Community as a hub for the six student cohorts facilitated a real sense of community around the project. The use of a social media hashtag for curating the stream of mobile social media around the MoCo360 project enabled a visual analysis of the community built around the M0C0360 project. We utilized Hawksey's (2011) TAGSExplorer visual Twitter conversation analysis to graph #MoCo360 Twitter conversations by geolocation onto a shared Google Map (http://bit.ly/1kN3QIi). One example student collaborative mobile AR project was the exploration and curation of student-generated forced perspective movies http://theforcedperspectiveproject.wordpress.com. The forced perspective project illustrated the potential of global student collaboration:

Hey guys! By the end of the day we will have an instructional video on how to film forced perspective. It will be uploaded here, on Twitter and on our site: http://theforcedperspectiveproject.wordpress.com/ Watch this space!!

Here it is guys! We said we would. The instructional video is here if you guys want to know how its done. The more people who help us the better and it only takes 2 minutes to make and upload a video. Cheers!

300 views on http://theforcedperspectiveproject.wordpress.com/ Thank you to everyone who's had a peek and remember there's still time to upload your own vids! Thanks again from everyone on The Forced Perspective Project team and we hope to here from you all soon!! # TFPP # moco360. (Student Facebook posts, 2014)

Mosomelt

The fifth example exploration of mobile VR was integrated into a cMOOC (Mosomelt) that was designed as an authentic lecturer professional development experience via a network of lecturer communities of practice across higher education institutions nationally and internationally (Cochrane, Narayan, Burcio-Martin, et al., 2015). The Mosomelt (Mobile Social Media Learning Technologies) cMOOC, was designed as a series of 24 triggering events over an academic year to scaffold a network of lecturer communities of practice across New Zealand, and internationally, exploring the educational potential of mobile social media. Core participants of the iCollab and MoCo360 projects were invited as guests to share their experiences with the Mosomelt cMOOC participants via commenting on the Mosomelt Google Plus Community, and via a series of Webinars using Google Plus Hangouts. The #mosomelt hashtag was used to curate the mobile social media activity of the Mosomelt cMOOC. The week 11 Mosomelt activity explored mobile AR, providing an opportunity for the participants to co create an AR world using Wikitude and reflect upon how this framework could be applied to their own teaching contexts for designing student-generated mobile AR assessment projects (http://bit.ly/1OLkl52). The co created Mosomelt Google Map (http://bit.ly/1GfULjc) was used to create a Wikitude mobile AR world. Example impact upon the participants is illustrated by the following exert from a participant's reflective blog post:

Embarking upon the Mosomelt cMOOC at the beginning of 2015 was a side step into the abyss, taking me from a place of certainty into the unknown world of digital mobile learning… When looking back on my cMOOC experiences they can be categorised in two ways; the technologies and my own development. On the surface, the cMOOC introduced me to a broad range of digital technologies which included Vine, Vyclone, Bambuser, audioBoom, Twitter, WordPress, and Google Communities, Docs, Hangouts and Cardboard, with a new digital tool being introduced each week… Perhaps of greater impact though, has been the professional and personal development that has taken place this year… For me the cMOOC experience has been about discovery and opportunity. The 'c' in cMOOC has come to represent many things: connectivism, conversations, community, collaboration, creativity, coffee and a can-do attitude. They were all present and arguably all necessary for the creation and continuation of such an environment. I look forward to a future of ongoing transformation both for my students' learning and my own professional development. (Participant blog post, 2015)

Discussion

The goal of our mobile AR projects has been to explore new pedagogies that enable collaborative learning and learner-generated contexts. To achieve this we have used mobile AR as a catalyst for designing learning experiences that act as triggering events for pedagogical change. Hase and Kenyon argue that "people only change in response to a very clear need" (Hase & Kenyon, 2007, p. 112). Similarly Cormier (2008) makes the argument for the role of the teacher to design "triggering events" to facilitate authentic student participation within learning communities. Therefore our mobile AR projects were designed as triggering events to support a conceptual shift from merely substituting current educational practice via mobile devices towards redefining learning experiences as authentic participation within global communities. Through the five iterations of the projects we identified several key issues surrounding global collaboration, including a transposed academic calendar between the northern and southern hemispheres, negotiating the differences in time zones via a mix of asynchronous and synchronous communication, and collating the resultant variety of mobile social media streams via the use of negotiated project hashtags. As the global lecturer COP developed over the five years we established a strong sense of trust and community among the participating lecturers, enabling us to design increasingly more adventurous collaborative projects.

We wanted to find a way to sustain our global collaborations and mini-projects, especially when diverse student numbers and shifting semester dates work against us, while still retaining a sense of community across space and time. Hopefully #MoCo360 will give us a bit more flexibility; by connecting under the #MoCo360 banner we can still work together – hopefully all year round in an #iCollab sense – with the option of dipping into projects right through to full-on international collaborations (depending on constraints or lack of) while still remaining a collective. (Lecturer reflection on the #moco360 project, 2014)

Table 3 summarises how we attempted to achieve this within the five iterations of our mobile AR projects.

Table 3
Designing Mobile AR project triggering events

Project	Triggering event	Activity design	Conceptual shift	SAMR
iArchitecture: Virtual cultural exchange	All students invited to become members of a global learning Community using Twitter, Wikispaces, and Qik livestreams	Architecture student teams create and share Wikitude worlds that illustrate how geolocation can enhance a project linked to their Wordpress blogs. Global student teams give feedback on projects	Teacher modeled participation within a global learning community	Modification of prior use of course LMS to active community participation
iCollab: Students as Social media reporters	iCollab lecturers invited into each class remotely via G+ Hangouts to introduce elements of the collaborative project	Students create and share a team presentation on how mobile social media has impacted their learning context, linking their profiles on a shared Google Map, exported to Wikitude	Students become active participants within a global learning community	Augmenting students online profiles within a global collaboration
MARMW: Exploring AR learning design	G+ Hangout series with international guest lecturers	Lecturers invited into a global COP to brainstorm AR learning activity design and shared via Google map (globally) and Wikitude (locally)	Lecturers become part of collaborative curriculum design community	Redefining assessment strategies
MoCo360: Global collaborative student mobile production teams	Students invite peer participation into an original mobile video production project, shared via Twitter and Facebook Page	Establishment of international student team projects linked to a shared Google Map	Student negotiated assessment activity as participation in a global team	Redefinition of learning as global project negotiation
MosomeIt: Lecturer professional development cMOOC	Week 11 activity exploring mobile AR	cMOOC participants create a POI on a shared Google map, embed user-generated media, and export the map as a Wikitude World	A gateway exercise into user-generated mobile AR	Redefining assessment strategies around user-generated contexts

Each project focused upon creating and nurturing a learning community across varied contexts that previously without the use of mobile social media would have been impossible. We began by establishing learner-generated eportfolios created from a mashup of best-in-class mobile social media platforms enables student creativity and collaboration that is in stark contrast to the typical 'digital myopia' (Herrington, Reeves, & Oliver, 2005) enforced by the reliance upon institutional learning management systems.

Mobile social media is inherently collaborative, but requires a significant rethink of assessment design, utilizing collaborative user-content generation tools such as Vyclone for collaborative video. The project lecturers explicitly engaged with and modeled the educational use of mobile social media within the curriculum. This required reconceptualising mobile social media from a purely social domain to an academic and professional domain of use. Assessment activities were designed to leverage the unique affordances of mobile social media. Mobile social media can utilize a variety of collaborative presentation and interaction tools, such as Prezi, and wireless screen-mirroring via an AppleTV connected to a large screen display (Cochrane & Withell, 2013), for example: Google Maps and Google Earth were used as a collaborative platform to collate and curate student projects from around the world, where student teams linked their geotagged content within a shared Google Map. This added the dimension of authentic global context to student projects, with the ability for students around the world to share in the experience of learning of others within the original context. Linking geotagged content into points of interest on a shared Google map from a variety of new and emerging mobile Apps gave the projects a relatively simple yet dynamic and collaborative experience. Example Apps used included: Vyclone for collaborative video recording, the online YouTube video editor for collaborative video editing and annotation, Flickr, Instagram, and Picasa for collaborative photo sharing/curation, Junaio for embedding QR tags within augmented reality. The exported geotagged data from the Google Maps were then used to create Wikitude worlds (layers) that displayed the local POIs as an AR view for each group.

Limitations

The rapid development of mobile devices and mobile apps creates a constantly changing horizon for what is possible using mobile AR, and there are many alternative and emerging mobile AR applications that can be used within student-generated projects. This provides flexibility and customisation options for a mobile AR social media framework, and opportunities for extending and redefining pedagogical designs based upon mobile AR projects. A limitation of relying upon an ecology of resources of social media to support the project activities and interaction was the limited longeviety of many of these social networks and collaborative platforms. For example, Google Plus has undergone several changes throughout the timeframe of the the projects, and the collaborative video creation and sharing

tool Vyclone was shut down in 2016. This forced us to be agile and keep up to date with choosing appropriate tools for each project, and manage participant expectations. We attempted to develop a culture that was comfortable with rapid changes in technology. A limitation of the research was a lack of explicitly gathering quantitative participant evaluation beyond asking for reflective blog posts, and participation in the project social media networks (Table 2), from which we have included indicative examples. Academic rigour in the use of social media was achieved by requiring students to post blog entries of a high academic standard and create a professional online identity. Specific activities were dependent upon each participant's context, and involved elements of learner negotiation, however the collaborative element of such projects needs to be clearly defined, as student experience of being active members within an authentic professional global community of practice was found to be limited before the projects. Our initial survey of each project participants revealed that participants' had limited social media experience beyond Facebook, and creating a professional online social media profile was a new learning experience for the majority of participants (Cochrane & Antonczak, 2015).

Conclusions

Reflecting upon the implementation of five iterations of mobile AR collaborative projects has enabled us to create a simple framework for designing learning environments that focus upon redefining teaching and learning around the affordances of new mobile AR technologies and learner-generated contexts. Through a meta analysis of these five projects we explored how we could use a mash up of mobile social media to design collaborative learner-generated mobile AR projects in a variety of higher education curriculum contexts. For example we have demonstrated that the use of geolocation data to augment mobile social media including mobile movie production and sharing does not necessarily involve specialized computer programming skills, and can enhance student collaboration and learner-generated contexts. We believe our experiences provide a useful learning design template or framework for application within other educational contexts that focus upon enabling new pedagogies. We also highlight the need for establishing a significant level of trust among the participants of global collaborations that takes time to establish. This trust can be nurtured through the use of mobile social media both asynchronously (for example via a Twitter hashtag and following each other) and synchronously (for example via G+ Hangouts) as key elements of a supporting ecology of resources.

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