Using Augmented Reality to Engage STEM Students with an Authentic Curriculum

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Abstract. This paper reports on the introduction of a set of 'Augmented Reality' (AR) tasks, offering an innovative, real world and problem based set of activities for a group of first year University Gaming and Computer Science students. Our initial research identifies a gap in the perceptions of STEM students between the usefulness of discipline based modules and a compulsory 'Professional Development' module where more 'employability' based skills were delivered. It had a history of poor student engagement and attendance, and failed to provide a compelling narrative/links to the outside world. The AR tasks were designed to facilitate group-working and multi-channel communication, and to engage students through the use of a more creative technology. Framed as a rich case study, insights are captured through student blogs, video interviews and a questionnaire. Initial findings indicate higher levels of satisfaction, enhanced student engagement and a greater awareness of the value of transferable skills.

Keywords: STEM · Professional development · Academic skills · Student engagement · Augmented reality · BYOD

1 Introduction

This paper reports on the introduction of a set of creative 'Augmented Reality' (AR) tasks, offering innovative, real world and problem based activities for first year University Gaming and Computer Science students. Our initial research identifies a gap in the perceptions of STEM students between the usefulness of discipline based modules and a compulsory 'Professional Development' module where more 'employability' skills are embedded. It had a history of poor student engagement/attendance, and failed to provide a compelling narrative.

The extensive review of the literature of augmented reality (AR) by Carmigniani and Furht [1] provides a taxonomy of systems and applications, including education. In common with most analysis of AR they focus on how systems deliver content and an interactive, context aware, experience for the user. Since the introduction of AR (1990 s) [2] augmented reality systems have been used in many areas of education, including

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higher education [3] and STEM subjects such as maths [4] and physics [5] Yuen et al. [6] suggested five directions for AR in education – books, gaming, discovery based learning, object modelling and skills training. Each area benefits from the context sensitive delivery of interactive material that can enhance an essentially 'real world', authentic experience. Concluded their overview they noted: "*... most current educators will find that, while it is possible for them, as individuals, to create AR content using the tools mentioned earlier in this paper, truly user-friendly AR creation tools may still be just over the horizon.*"

While this is probably still true for the more sophisticated AR experiences, there is a significant sub-set of simple AR application creation tools that allow those with limited technical ability to become AR creators. These newer, user friendly technologies [7] have combined with the rise of smartphone usage [8] to enable the majority of students to access educational AR applications via their own device. Our study is located within the user-generated content of SMART devices, in that our students are creating their own artefacts using the Aurasma AR 'App'.

1.1 Theoretical Context for AR

The theoretical basis for AR in education can be seen as an extension to the Cognitive Theory of Multimedia Learning that suggests images/other media give more impact to the learning experience. However, in this study we focus on the use of AR as a creative tool. We aim to harness the process of creating AR to provide a context for a range of higher education skills within a Collaborative Learning (CL) framework. A systematic review of the literature in computer supported CL by Shawkey et al. [9] shows AR as one of several computer systems that can be used to facilitate CL and this view is confirmed by Lin et al. [10].

Collaborative Learning is based on the idea that students learn as much, or more, from each other than they do from an instructor – this is particularly relevant to higher education where it is expected that the majority of the work is done by the student outside of the lecture theatre. Vygotsky's theories of learning as a social, constructivist process [11], where individuals establish a shared view of a problem and how to solve it, underpins CL and offered useful insights into the design of the revised set of student tasks [12, 13]. By utilising mobile student devices learning can take place at a time and virtual / physical location and time of the students choosing and offers the advantages of more personalised learning across multiple platform, both personal and institutional [14].

1.2 The Case Study Approach

Drawing upon [15] Stake (1983) we see this case study as a rich case in its own right: comparing and contrasting our student groups feedback offers a rich and deep analysis. Case studies offer insights into both what is common and particular about a case, and a uniqueness that Stouffer [16] refers to as pervasive, extending to factors such as the nature of the case, historic setting, physical context, cases through which this case is

recognised and those informant through whom the case can be known. Thus for a complex and nuanced case, looking at our students through this lens offers the advantages of multiple data collection tools, Institutional documents; field notes from the researchers during the process of the intervention; student blogs and video focus groups analysis all that offers insights into the students sense of meaning making after the event as they reflect upon their experiences [17].

1.3 Method

12 sets of 'small focus group' interviews were conducted in class using a set format to ensure uniformity. By their participation students received an authentic research experience which they can use to base similar techniques to get user feedback from their own projects later in the course. All participants took part voluntarily and were aware that participation/non- participation would not have any impact on their marks. The researcher was introduced as a member of staff from the Education department, interested in teamwork and technology projects.

The focus groups were filmed and permission gained for edited clips to be embedded within our own project website and for dissemination purposes. For data transcription purposes, each student had a 'number' placed in front of him/her, to enable accurate analysis. The course tutor led on the filming, and coached different members of the class in how to film as the focus groups took place, thus assisting students to develop another skill to add to their PDP.

Institutional documentation; field notes from both authors; video analysis; blog postings and in class artefact showcasing all contribute to this case study.

2 The Augmented Reality 'mini' Project

2.1 Soft Skills for STEM Students

It is particularly difficult to get technically motivated students from STEM disciplines to consider the softer skills, even when they are aware that these are desired by employers and are likely to be the differentiating factor in recruitment between equally technical applicants. Within the perceived context of a lack of STEM graduates, there is a significant problem that too many lack the soft skills to enable them to be ready for work [18]. Other studies have shown that there is a gap between what companies want in terms of skills, and what is provided by higher education institutions; with communication skills and independent problem solving being identified [19, 20].

The Personal Development Planning (PDP) is a common element in most UK Higher Education as Universities are required to provide a transcript to record their learning and achievement and a process by which they can monitor, build and reflect on their development [21, 22]. Key aspects of this are for students to become more independent, adopt a pro-active approach to their study, extra-curricular pursuits and career planning. In addition to these principles the PDP for first year students in Computer Science and Computer Gaming Technology degrees includes an introduction (or reminder) of basic

academic skills. This has traditionally been delivered through a series of one hour tutor led classes/lectures on topics such as:

Self-Evaluation Exercise, Note Taking, Group Work, Presentations, Library and referencing Skills, Report Writing, Keeping a Log Book, Time Management, Submitting Work, Plagiarism and the creation of the PDP portfolio.

End of year Course Reviews identified issues of poor engagement with the module, seen in low pass rates and tutors comments on lack of attendance. Despite the tensions of delivering a STEM curriculum with a high discipline based content, students clearly needed the 'softer skills' developed through this module. Thus a redesign was needed, and a more creative approach considered [23].

2.2 Why AR?

Media interest in AR and application framework development had a surge of activity in 2012, but to some extent AR is regarded as a solution in search of a problem [24]. However, although wider commercial applications remain elusive it has been seen as a promising area for education [25].

Our students were aware of AR but had little experience apart from a few who had played AR games. At all times care was taken that if a student did not wish to engage with the AR mini project they would still be able to complete their PDP tasks and would not be disadvantaged.

AR systems such as Aursama [26] are ultimately financed by revenue generated from advertising/commercial applications. However, to boost user numbers they encourage individual creation of AR artefacts through free user accounts. An advantage of Aurasma is that it allows the complete AR creation process to be carried out on a mobile device with the freely available app (iOS and Android). The Aruasma app runs on a mobile device and uses the camera viewfinder to recognise a trigger image. Once trigged an 'Aura' (i.e. the pre-recorded media) can be viewed on the screen of mobile device. We utilised a 'Bring Your Own Device' (BYOD) model, which included all students even if they did not own a SMART device.

2.3 Project Design and Tasks

Previous studies [27] showed the value of using an interesting and inherently engaging technology (in that case a Virtual World) to facilitate group work and to promote broader skill acquisition. Then, as now, ability with the technology was secondary to the development of the skills needed to achieve the tasks.

Student brief: Self-selecting into small groups of 3/5 groups were asked to create a name and logo and to engage with the University Library, in the broadest sense, by producing an AR artefact. They were encouraged to plan, script and story board their short video. Apart from asking them to observe the intellectual property rights of images,

videos and music, students were free to create their own videos. Weekly sessions were used for feedback, discussion and introducing the supporting materials on the student Virtual Learning Environment (VLE). Additional support was offered through email, discussion boards and comments posted on blog sites. Groups were asked to do a short 5 min presentation to the class. Most demonstrated reasonable presentation skills; in many cases showed considerable independent research around the topic. Because they were all related to the same topic students found it easy to ask questions; this promoted lively debate. Time/project management were demonstrated by group meetings and task allocations.

3 Evaluation

3.1 Emergent Themes from the Project

- Groups that met up in person seemed to achieve significantly more than those groups which used online communication exclusively.
- The subject of the project, developing AR artefacts for library purposes, did not seem to inspire them, although it did make them visit the library.
- Students could see the worth of cooperation and recording what they did so that the project could progress.
- For the tutors, working with an authentic task offered something concrete to relate abstract notions of academic skills
- Novelty of application helped the groups working as there was no 'expert'.

These themes are summarized from the overall feedback, as they were the most significant factors, most commonly expressed within the body of evidence.

All the participants were keen video game players and very proud of their choice of course - many had selected it specifically because of the core element of 'hard' programming with 'most' programming modules. This is seen as a key element of obtaining work in the gaming industry, and two students, from an arts and music background, highlighted the programming course element before disclosing their extremely exceptional skills in a different area.

They did not value the PDP module as highly as other 'programming' modules, but when prompted, did acknowledge the value for employment. Some groups already knew one another but for others it was a good way to make contact with fellow students at an early part of their course. The groups communicated in very different ways (see Table 1). Most groups reported a technical/communication issues that they had to overcome by researching their own solution. So despite a relatively easy set of well scaffolded tasks, students reported a genuine sense of achievement, which contributed to confidence and independence.

Table 1. Results from interview sessions.

(id) Group working style	Student comments
(1) Worked as a group on the project, meeting in the library.	"*It's very, very simple to use. It goes through everything that you need to know to create an aura*."
(2) Worked individually with Facebook as a point of contact. Some previous experience with AR, happy to do more with this project.	"*The beauty of it was that we were able to email each other as it was a very technology-based thing*."
(3) Worked individually and as a group, used Facebook as point of contact.	*"I first heard about it, I think it was 2011, demonstrated on an iPad."*
(4) Used Watsapp and the blog to communicate, worked together and visited the library. Made some progress with the project.	"*We found a book about sports which had an aura of somebody doing weightlifting*."
(5) Worked together as a group. Also made an aura from signs at the college.	"*We went for a book that stood out and that didn't have a plain background*."
(6) Used Skype and Facebook to communicate with regular face to face meetings. Posed to the blog as a group and individually.	Made aura for a book on confidence: "*We decided that this* [the book] *was relevant for this kind of PDP course*."
(7) Well organised group. Had problems but managed to create an aura.	*"It's been challenging but we've overcome it*."
(8) The group used the blog but also set up a Facebook page and website. Created a logo and group name.	"*We tried to find a decent trigger image that isn't too widely used and doesn't conflict with copyright*."
(9) Group met up regularly, communicated through Skype /Facebook and in person. Created a group name and a logo and attached some books related to the course.	"*For some reason the university computers just won't pick it up but we've tried our own tablets and it works absolutely fine so we don't know what's going on*."
(10) Worked together and Facebook chats to communicate but already knew each other.	They found the Aurasma app very easy to use "*If you follow the instructions, anyone could do it*."
(11) Used Facebook/Steam to communicate as well as face-to-face meetings. Aurasma app was easy to use.	The group task was commented on as "*It's a bit of a pain but it will help*"
(12) Met as a group but somewhat disorganized. 1 student made an aura and displayed it on their phone and had updated a blog.	"*When I first came to university I didn't know anybody. To be put into a group to meet people is quite nice*."

4 Conclusions

Developing user-generated content, where students have a large degree of autonomy in the design and implementation for the PDP course worked well, and the selection of AR offered the students the opportunity to learn about an interesting subject. There was a marked improvement in performance between this cohort and the previous PDP results. Non-submission improved from 34 % (in a cohort of 55) to 22 % (in a cohort of 78). The PDP is a pass/fail element attached to a larger module that teaches game engine technology. The change in those who engaged with the PDP is even more marked when you consider that in 2013/14, 15 % who submitted the main assessment but did not bother with PDP, but in 2014/15 there was actually one more student who submitted to PDP than for the main assessment.

Our case study has provided some interesting findings about STEM students and their engagement with 'softer skills'. With such a small study, it is not possible to generalise the findings, however, we have been able to identify some key features to be incorporated for the PDP design for the next iterations.

The first is to have a greater focus around team work and a clearer structure. The students interviewed were unfamiliar with group work of any kind. This because obvious in the interviews where many of the groups seemed clueless when they were asked about task progression. Secondly, as tutors, we need to model and scaffold teamwork in a more overt and clear way.

Finally, we are keen to provide more opportunities to practice communication. When interviewed a significant minority of the students struggle to make eye contact, hold a conversation and speak eloquently about a subject. Preparing and giving presentations in a supportive environment is an excellent way of developing these skills.

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