Comparing the attitudes of in-service teachers to the learning potential of low-cost mobile augmented and virtual reality tools

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ABSTRACT

Virtual and augmented reality tools running on mobile devices are both seeing increased use in education, and there is a growing body of literature examining the uses of each for enhancing learning. However, in most cases, researchers have focused on either one or the other approach and there is relatively little examination of how educators perceive the relative learning potentials between these two related but different technologies. A further issue is that sophisticated virtual and augmented reality tools are too expensive for widespread classroom use. The study reported in this article therefore sought to examine the perceptions and attitudes of a group of in-service teachers towards augmented and virtual reality by providing them with an opportunity to explore examples of affordable smartphone-based implementations of both technologies in a workshop session. The participants were introduced to several virtual and augmented reality activities using freely available tools, deployed on mobile devices, and then given the opportunity to create either an augmented reality experience or a virtual reality experience. The results suggested that there are some qualitative differences between the augmented and virtual reality tools used in this study in the context of teacher attitudes towards their learning potential. This study provides some insights into what factors educators might consider when considering adopting low-cost mobile virtual or augmented reality tools in the classroom.

Author Keywords  
Augmented Reality, Virtual Reality, Mobile, Metaverse, Google Tour Creator, Survey

INTRODUCTION

Both virtual reality (VR) and augmented reality (AR) are increasingly being used in schools by teachers seeking to leverage opportunities provided by new technologies for learning. Despite the conceptual similarity between virtual and augmented reality, in that they both occupy the space between entirely real and entirely virtual worlds, the products that are currently available that enable users to create their own artefacts provide significantly different affordances. The study reported on in this article was designed to compare the attitudes of in-service teachers towards working with affordable augmented and virtual reality tools as part of their professional development, with a view to how they might be applied in the classroom.

AR AND VR TERMINOLOGY

The terms “augmented reality” and “virtual reality” both appear around 1990, but the concepts and technologies of both had been evolving for many years (Yuen et al., 2011). Researchers in both AR and VR often refer to Milgram et al.’s (1995) reality-virtuality continuum, which asserts that both augmented and virtual realities both occupy a space somewhere between the real world and a fully virtual world. However, this continuum, based as it is on an analysis of hardware functionality, does not fully capture the conceptual aspects of the distinctions between AR and VR and their specific affordances for teachers and students. For the purposes of this article we use the term virtual reality (VR) to refer to applications where the user interacts immersively with content (whether 2D or 3D) using a mobile headset, and augmented reality (AR) to refer to applications where a (mobile) device is used to overlay content on the real world, whether or not that content is directly interacting with reality.

AFFORDANCES OF MOBILE AR AND VR IN EDUCATION

The primary affordance of AR as a general technology is that it allows the real-world to be augmented with additional information, usually contextual, while the primary affordance of VR is that it provides an immersive environment that takes the user out of the real world and into another space. Both can be utilised to enhance the learning experience, but in this section, we focus on those affordances that are particularly relevant to the educational context, where there are some significant differences between the affordances of VR and AR.

AR Affordances

AR has specific affordances that make it a promising tool for learners (Bacca et al., 2014). These affordances include the ability to blend digital and real environments to situate learning within a physical space. This situated nature of AR means that it supports the exploration of sites, attractions, and destinations in multiple contexts (Noh et al., 2009). In addition, a range of digital artefacts can be created, shared, and collaboratively explored. Creating digital artefacts for AR experiences supports socio-technical meaning-making interactions for active and collaborative knowledge construction (Ke & Hsu, 2015). Users can also engage with 3D digital objects from multiple perspectives. The creation and manipulation of 3D objects has been shown to support the development of a range of cognitive abilities (Kaufmann et al., 2005; Huk, 2006).
In fact, this affordance can also apply to VR systems, but only with the more sophisticated technologies, whereas even low-cost AR systems can include this feature.

**VR Affordances**

Within the context of VR, there are a range of experiences, extending from those that are fully immersive to those that draw on elements of the virtual environment. Immersive VR may be supported through sophisticated technology, such as Head-Mounted Display (HMD) units and handheld input devices, but low-cost mobile VR, using mobile phones in simple headsets, still supports a range of affordances. Virtual reality affordances experienced by learners include spatial presence, contextual understanding of spatial and part-whole relationships, agency over highlight and focus, observation in-role and flexibility for self-guided exploration (Minocha et al., 2017). Shin (2017) identifies presence, immersion, empathy and embodied cognition as educational affordances of VR.

**COMPARING AR AND VR IN EDUCATION**

There is extensive literature on virtual, augmented, and mixed reality in education (e.g. Liu et al., 2017), though in most cases, articles tend to focus on one or the other. Work that covers both forms of technology is less common. Ferguson et al. (2017) note that both AR and VR provide opportunities for immersive learning, but according to Liou et al. (2017), students using an AR system when studying astronomy showed better learning and performance than another group of students using a VR system. The authors note, however, that the VR system was not immersive, which may have diminished its effect. We might also consider that the learning context of astronomy may have made a difference to the outcomes. A more recent meta-analysis of the broader VR and AR literature suggested related findings, that the physical learning context might lead to different choices between AR and VR, with AR more dependent on that context (Avci et al., 2019).

There are several potential reasons why AR might be more effective in learning than VR. It enables learning to be enhanced and contextualised by being situated in a specific physical location (Schrier, 2006; Cheng & Tsai, 2013; Akgöz & Akçayır, 2017). AR allows users to see those physical locations at the same time as virtual content, enhancing the real-world experience rather than drawing users away from it, as VR does (Billinghurst, 2002). The advantages of maintaining this link with the surrounding physical world include both psychological and physical safety (Kaufmann, 2003) and the ability to maintain collaborative interaction between teachers and students (Pearson Education, 2019).

In a study looking at using AR tools for teaching geometry (Kaufmann, 2006) the main affordance of AR was that it allowed easier exploration, where students could actively "walk around" geometric objects which are fixed in space. Students were able to explore the shapes from all angles including laying on the floor and looking up to climbing on a chair and looking down. This ability to integrate spatial understanding relation to the learner’s own body, which allowed them to directly manipulate tangible shapes provided more powerful learning opportunities (Kaufmann, 2006). Although this study related to technology that is now somewhat dated, the factor of physical orientation remains important in the uses of AR.

In contrast, the ability of VR to immerse a user into an environment may provide a richer learning experience. VR has been effectively adopted in contexts where students need to explore a location, but that location is not available or is unsafe. A study by Sacks et al. (2009) identified that students exploring a VR environment for hazards scored higher in risk identification than those who just studied photographs and documents. The benefits of VR here are in providing a realistic experience but in a safe way. However, it should be noted that AR provides equally compelling features in this context, since it can be used to avoid hazards in the real environment. For example, in Behzadzadeh et al. (2015), AR was used to provide contextual information on buried utilities hidden underground to help prevent accidental utility strikes. A more unique affordance of VR is that it can give students an immersive experience of a location to be visited in the future; a virtual field trip to precede a physical one and help to deepen the physical experience (Minocha et al., 2017).

In some cases, it may not matter which approach is taken, either a VR or AR experience, but the learning context will often favour one over the other. To determine which is more suitable, it is important for teachers to understand how each works and the relative affordances of each in the context of learning goals. The next section explores teachers’ perceptions and the need to expose teachers to these technologies in order for them to understand how they work before adoption into teaching.

**PERCEPTIONS OF TEACHERS TOWARDS AR AND VR**

The adoption of AR or VR by teachers will rely on teachers having the opportunity to explore and integrate these tools into their learning activities. However, adoption will largely be influenced by the ease of use and availability of suitable tools. These tools will need to make it possible for teachers and students to be able to create their own learning materials to ensure relevance.

In the past, creating AR or VR experiences required sophisticated tools and knowledge of programming and 3D modelling (Shim et al., 2016). However, there are now an increasing number of tools available that enable users with limited technical ability to develop quite sophisticated experiences.

When selecting tools for the development of AR/VR experiences, teachers will need to consider a number of issues. Liarokapis and Anderson (2010) highlight the following important considerations when selecting a tool:

- It must be simple and robust
• It needs to provide the learner with clear and concise information and be easy for learners to use and support learning
• It should enable the educator to easily configure and integrate it into their learning process
• It should be cost effective and easily extensible
• It should support easy interaction between learners and educators

Selecting a tool to support the creation of AR/VR experiences will, therefore, require balancing several important needs. It should be sophisticated enough to allow for enhanced learning, but still easy to use and develop. It should align to current learning processes but not be too customised such that its application would be too narrow for widespread adoption. For AR/VR to be adopted into mainstream education, teachers will need to invest time and effort into understanding and adapting these technologies, so if tools do not meet these requirements, it is unlikely they will be adopted.

In addition to identifying tools that support easy creation of experiences, teachers also need to be exposed to the concepts of VR and AR and see how these technologies can provide enhanced learning opportunities. In a study of 120 pre-service teachers, only half (51%, n=112) were aware of examples of educational AR. In addition, only 21.8% (n=48) of those surveyed had used augmented reality and of those, only 7.8% (n=18) had created their own experiences (Uygur et al., 2018). Though not explored in that study, it may be that awareness of educational VR is similarly low.

When assessing perceptions of VR and AR in education, it is generally the students’ perceptions that are explored, not the teachers’. Teachers are usually the ones driving experiences, often enthusiasts and early adopters. It is, however, important to understand the broader teacher perspective if these technologies are to move into wider adoption. Wider exposure is therefore needed for teachers to explore how these tools work and understand how they can be used and integrated into their own teaching contexts. This study, therefore, not only explored teachers’ perceptions of AR/VR but also provided an opportunity for teachers to try a hands-on experience of creating their own learning artefacts.

Given the increasing popularity of both AR and VR in education, and the debate in the literature regarding their relative merits as tools to support learning, the main research question addressed in this study was:

What are the perceptions of teachers towards the potential of using low-cost mobile AR and VR tools within their teaching?

A sub question was based on the impact of existing attitudes of teachers towards technology and teaching approaches on the ability to incorporate such tools into learning. Therefore, we also asked:

Are there differences in attitudes towards the potential of low-cost mobile AR and VR tools within teaching related to broader attitudes about technology and teaching?

METHOD
To address our research questions, we administered a survey that gathered both quantitative and qualitative data from a group of teachers who were engaged with learning about AR and VR technologies that could be used in the classroom. The participants were a convenience sample of a group comprising in-service teachers participating in a workshop held in 2019 (the same workshop was held for two separate groups). This two-hour workshop was offered as part of a part-time postgraduate programme of study in which the teachers were enrolled. The programme focuses on developing teachers’ use of and leadership with digital technologies integrated into their practice. This workshop focused on introducing teachers to AR and VR technology and exploring how it can be used to support new and engaging teaching and learning opportunities.

Before the participants engaged in the research activity, they were given an introduction to the various distinctions between augmented and virtual reality and had the opportunity to experience using different AR and VR tools in order to become familiar with the main affordances of the technology.

Following this introductory stage, the participants were invited to experiment with either an AR tool or a VR tool, working in groups of 2 or 3. In both cases the tools were chosen to enable the participants to create their own digital artefacts rather than simply to experience prebuilt products. This was to ensure that the participants were exposed to the experience of constructionist learning using these tools. Online written and video guides were provided to scaffold these activities.

At the end of the workshop they were invited to fill in a voluntary and anonymous survey. A low risk ethics notification was made to the host institution to allow for anonymous, voluntary data collection. 85 participants completed the survey.

SELECTING TOOLS FOR THE WORKSHOP
There were two aspects to the selection of tools for the workshop activities. First, we needed to provide the participants with useful and accessible experiences of both augmented and virtual reality. We wanted these experiences to be suitably interactive and to demonstrate the main potentials of each of these technologies. We also needed them to be the kinds of technologies that teachers could realistically use in their classrooms, since one of the main outcomes that we were looking for was how teachers felt they could potentially use these technologies in their own practice. Therefore, giving them experiences with very expensive equipment was unlikely to provide them with realistic scenarios for their own students.
As a result, we confined our tool options to those that were readily available using consumer mobile devices and free software.

Since the teachers who were participating in the workshop ranged from early primary to late secondary, we were also looking for a set of tools that might resonate across age groups. With these criteria in mind, for the first part of the workshop, where we exposed teachers to a range of tools, we chose two augmented reality tools and one virtual reality tool. The first of the AR tools used was Quiver, which was chosen because it was ideal for younger students, provided creative educational activities it shows how AR can provide interaction with overlays. The other AR tools chosen were Kupu, a Māori language learning app, which shows how AR can interact directly with the environment and applies across all levels of schooling, and the Google Translate mobile AR app, which provides multiple language translation options. These latter two mobile AR apps were also selected as they provided similar activities to those that could be designed within the tool selected for the second part of this workshop.

For VR we chose Google Expeditions, which shows how VR can be used with simple tools (Google Cardboard and a mobile device). It is also appropriate for all age groups, given the large range of expeditions available and the fact that older students could use the activity autonomously while younger students could be guided by the teacher. Its collaborative nature provided additional learning value. Another reason for choosing Google Expeditions was that an associated tool, Google Tour Creator, would enable teachers to create their own Expeditions later in the activity. It should be noted that although Expeditions was originally created as a VR tool, subsequent versions also provided for AR experiences. In this study, only the VR features of Expeditions were used.

The participants were then given an opportunity to develop their own AR or VR experiences, guided by instructional materials provided by the researchers. Due to time constraints, they could only choose one of the technologies. The tools that were selected to be used in this session were Metaverse (AR) and Google Tour Creator (VR), as they were generally easy to use and enabled something original to be developed in a fairly short time. Both tools allow the creation of products for deploying on mobile devices using web-based tools. The participants were invited to try creating their own AR or VR experiences, after which they were asked to complete a voluntary survey.

SURVEY QUESTIONS
This survey included both quantitative and qualitative questions. The quantitative questions were used to gather general attitudes (using a 5 point Likert scale) towards the technologies used in the workshop while the qualitative questions asked broader questions to draw out the teachers perceptions and attitudes to the technologies and tools that they had used in the workshop. The main questions in the survey were designed to find out what the participants did or did not enjoy about the experience, their perceptions of AR or VR as an educational tool in their own practice, and their level of confidence as a user of technology. They were also asked to reflect on the extent to which they actively integrated technology into their teaching, included learning opportunities that can happen outside the classroom, and to what extent their preferred mode of teaching was through social/collaborative learning and/or face-to-face teaching.

RESULTS
Of the 85 respondents, 43 had chosen to work with Metaverse (AR) while 41 chose to work with Tour Creator (VR).

Quantitative Analysis
Table 1 shows the results from the quantitative 5-point Likert scale questions included in the survey.

<table>
<thead>
<tr>
<th>Question</th>
<th>Metaverse AR (n=43) mean response</th>
<th>Tour Creator VR (n=41) mean response</th>
</tr>
</thead>
<tbody>
<tr>
<td>I enjoyed my experience with Metaverse / Tour Creator</td>
<td>3.3</td>
<td>3.4</td>
</tr>
<tr>
<td>I actively integrate technology into my teaching</td>
<td>3.8</td>
<td>3.9</td>
</tr>
<tr>
<td>I actively include learning opportunities that can happen outside the classroom (during class time)</td>
<td>3.7</td>
<td>3.7</td>
</tr>
<tr>
<td>My preferred mode of teaching is through social/collaborative learning</td>
<td>3.9</td>
<td>3.8</td>
</tr>
<tr>
<td>My preferred mode of teaching is face-to-face</td>
<td>3.3</td>
<td>3.7</td>
</tr>
<tr>
<td>I am confident a user of technology</td>
<td>3.5</td>
<td>3.9</td>
</tr>
</tbody>
</table>

Table 1. Comparison of quantitative data from teachers’ who trialled Metaverse and those who trialled Tour Creator - Likert scale 1=highly negative, 3=neutral, 5=highly positive.

These results do not indicate any significant differences between the perception of those who trialled the different technologies. There is no evidence, for example, that those who chose the AR experience are any more inclined towards situated or collaborative learning than those who chose the VR experience, despite their different affordances. One of the
largest differences between the two groups was in terms of confidence as a user of technology, so perhaps perceived difficulty was the reason that the less confident teachers chose to work with Tour Creator. However, the small number of participants means that the quantitative data alone does no more than raise questions that we might explore further through the qualitative data.

Table 2 shows the responses to the one multiple-choice question included in the survey, about the potential of the tool for education.

<table>
<thead>
<tr>
<th>Response to Multiple Choice Question “What do you think about the potential of this tool for your own educational purposes?”</th>
<th>Metaverse AR (n=28) count of responses</th>
<th>Tour Creator VR (n=29) count of responses</th>
</tr>
</thead>
<tbody>
<tr>
<td>Already use it (or similar tool) in my own teaching</td>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td>I like it, and have some ideas about how I can use it in my own teaching</td>
<td>23</td>
<td>26</td>
</tr>
<tr>
<td>I like it, but can't see how it would fit in my own teaching</td>
<td>6</td>
<td>6</td>
</tr>
<tr>
<td>Not sure if it can offer much to me or teaching in general</td>
<td>8</td>
<td>6</td>
</tr>
<tr>
<td>Offers little or no real learning opportunities</td>
<td>4</td>
<td>0</td>
</tr>
<tr>
<td>Dislike it</td>
<td>3</td>
<td>3</td>
</tr>
</tbody>
</table>

Table 2. Comparison of quantitative data from teachers’ who trialled Metaverse and those who trialled Tour Creator – multiple choice question.

Again, we see only a small difference between responses in terms of attitude, but overall a clearly positive response to their chosen tool and its potential for educational purposes. These quantitative data highlight some possible areas for further investigation in the qualitative data. For example, the literature suggests that AR may be a more effective technology for learning than VR, but the responses from our participants did not reflect this, with a slight preference for Tour Creator. In the next section we explore our qualitative data to seek further insights into the quantitative responses.

Qualitative Analysis

Qualitative analysis was based on the responses to the following open-ended questions that addressed attitude, potential and specific ideas for application:

- Please give us your feedback on what you liked/disliked about this experience.
- Metaverse and Tour Creator provide educators with a way to create their own apps, without any coding required. What do you think about the potential of the tool you experienced for your own educational purposes?
- If you think you could adopt the features of this tool in your teaching, please provide a short description of how/for what context?

Following the terminology used in Auerbach and Silverstein (2003) the data was coded in NVivo by identifying repeated ideas with descriptive coding (Miles, Huberman & Saldàña, 2014), which were then grouped into themes and theoretical constructs. Table 3 shows the results of coding the data from the two groups.

<table>
<thead>
<tr>
<th>Construct</th>
<th>Theme</th>
<th>Repeated Idea</th>
</tr>
</thead>
<tbody>
<tr>
<td>AR (Metaverse)</td>
<td>Easy or difficulty of use</td>
<td>Easy to use (8) Difficult to use (14)</td>
</tr>
<tr>
<td></td>
<td>Barriers to adoption</td>
<td>Can’t identify application (3) Unsuitable for age group (2) No suitable devices (3) Technical errors (2)</td>
</tr>
<tr>
<td></td>
<td>Positive attitude</td>
<td>Enjoyment (3) Liked application (9)</td>
</tr>
<tr>
<td>Learning affordances</td>
<td>Learning Features</td>
<td>Collaboration (3) Student Engagement (4)</td>
</tr>
<tr>
<td></td>
<td>Uses for Learning</td>
<td>Languages (2) Reading and Writing (5) Inquiry (4) Showcasing (3)</td>
</tr>
<tr>
<td>VR (Tour Creator)</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Although the data in Table 3 was gathered from two different groups of participants using two different tools, the coding revealed a very similar set of repeating ideas. Both groups identified a range of technical challenges in using the tools as well as concerns about the ability to use such tools in the classroom due to a lack of suitable devices. One concern was that the tools were not truly collaborative:

“Frustrating that you can’t all import [together]” (Tour Creator)

There were also many specific complaints about the constraints of the tools, such as

“There were limits on the size of the photograph I could use - this was frustrating” (Tour Creator)

There was also to issue of how long it would take to overcome these technical challenges, and what the return on time investment would be:

“Probably the challenge of these is the energy and time required for the setup of these tools, which is not straightforward” (Tour Creator)

“It would take me 1 minute to print a scavenger hunt sheet, or an hour to make a digital one with the same outcome for students.” (Metaverse)

Another issue of concern was respondents who said that they did not feel that the tool was appropriate to the age group of students that they taught. Interestingly, however, this seems to work in both directions with some believing the tool was for younger students and some thinking it was for older ones, but not for the ones that they taught themselves.

“Can only really see this as being useful for older students to use” (Tour Creator)

“I can’t see how I would use it in a primary setting” (Metaverse)

“Not sure if suitable for secondary school students.” (Metaverse)

Despite these reservations, in both cases there were many positive responses to the tool, indicating that that they were enjoyable and fun to use. e.g.

“Liked the ability to add points of interest.” (Tour Creator)

“The programme looks really good and I think it would be a fun exercise.” (Tour Creator)

“Metaverse was fun but surprising.” (Metaverse)

“I love the imagination that it involves and the way that it opens up the world to our class.” (Tour Creator)

One of the most interesting differences in responses to the tools was in perceptions of their learning affordances. For the AR application, collaboration and student engagement were the most common ideas,

“[I] would love to try Metaverse with students. Storytelling, collaborative work.” (Metaverse)

“It would be great to engage children in their learning through interactive participation while answering fun questions” (Metaverse)

“This is quite cool because you can create and actually make students find whatever they need to find e.g. objects etc.” (Metaverse)

In contrast, for the VR application there was an emphasis on students constructing their own digital artefacts and being able to experience realistic environments beyond the classroom.
“Students could create their own tours and develop their digital fluency.” (Tour Creator)

“Having the kids be able to create a virtual tour, with interesting information for any prospective families to [the] School.” (Tour Creator)

Another contrast in the results was the range of ideas that the participants had about specific application areas where the tools could be useful. Respondents who used the AR system focused on a few specific subject areas such as reading and writing and enquiry learning. While these also appeared in the feedback from those who used the VR system, there was certainly a broader range of topics that were felt to be appropriate for use as contexts for virtual reality experiences from the group as a whole, though in both cases some participants suggested a range of teaching contexts.

“Introduction of theatre form, situation analysis to create a drama scene- visual and historical scene gathering I would like to use many scenes on the one tour.” (Tour Creator)

“A trip to our local river for some science experiments and planting for river restoration. Images of the trip could be used could be used to also create a report in Google tour.” (Tour Creator)

“To create storyboards, show strategies, showcase projects and themselves.” (Metaverse)

“All Curriculum areas, Te Reo, Reading, Inquiry” (Metaverse)

**DISCUSSION AND CONCLUSION**

Overall, our data reveals a slight tendency to recognise a broader set of affordances for VR than AR, within the constraints of the two specific tools that were used in this study. We have also identified some differences in the ways that these tools are received in terms of their affordances for students, with AR being seen as more collaborative but VR as perhaps being more likely to support constructionist activities. We also saw a broader range of possible application areas suggested for VR than AR. Despite the quantitative data suggesting that the VR experience was (slightly) favoured over AR, the qualitative data indicated that it was both more difficult to use and presented more barriers to adoption. However on closer inspection, the responses in these themes from the VR group tended to be specific complaints about individual features of the tool, such as there being limits on the size of photos that could be used, whereas those from the AR group often complained that it was just too hard to create anything useful at all.

This article reports on a small-scale study of in-service teachers experiencing practical activities with mobile AR and VR tools and providing feedback on their attitudes to how these tools might potentially be applied in the classroom. The study was motivated by the limited range of previous research comparing the relative potentials of augmented and virtual reality from an educational perspective. The results of the study suggest that teachers respond in similar ways to the potentials and limitations of both technologies, despite their different educational affordances. The results also suggest that teachers may find VR somewhat easier to adopt and utilise across a broad range of subjects in their practice than AR, but the differing affordances of the tools show that both can make a valuable addition to the classroom.

There are, however, a number of limitations to this study. While we tried to choose applications that were at least broadly comparable (for example, they were both able to run on standard consumer mobile devices and both allowed for end user artefacts to be created), the evaluation was focused on these specific tools rather than the generic affordances of augmented and virtual reality. Using other tools may have revealed different results. We should also note that as teachers gain more experience with these tools perhaps their perceptions and attitudes may well develop in different directions. However the study does provide some insights into issues that educators face when considering how to integrate low cost mobile AR or VR tools into their practice and our results may provide new ideas about how educators can best approach such tools and how they might most usefully be supported by teacher educators in developing their skill sets in using technology in the classroom.

**REFERENCES**


