Teacher Perspectives on Mobile Augmented Reality: The Potential of Metaverse for Learning

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ABSTRACT
Augmented Reality (AR) assumes that virtual content is intermediated between the viewer and the real world, but the extent of that intermediation, and the ways in which it is intended to enhance the real-world experience, can vary between tools and contexts. The links between an overlay and the physical world may be weak or strong, and the roles of location, collaboration and mobility may differ widely between AR experiences. This variety of options within the AR space means that educators need to be guided in understanding how AR might be used in the classroom and impact on student learning. In this article we report on a study involving teachers, both in-service and pre-service, investigating their attitudes to the application of AR in their practice. The participants were given the opportunity to create mobile AR experiences using the Metaverse AR tool and were invited to respond to a survey designed to capture their responses to its educational potential. Their responses revealed that the evolving nature of AR tools is leading to new ideas about how they may be applied in education, but that generating these new ideas requires a degree of experience that pre-service teachers do not have. We also found that even experienced teachers tended to focus on content rather than on how AR can help students learn. There is therefore a need to provide suitable professional development to teachers of all levels of experience if they are to fully realise the educational potential of AR in their practice.

Author Keywords
Mobile Augmented Reality, Metaverse, teacher education

INTRODUCTION
The origins of AR (augmented reality) date from the late 1950s, but only in the 21st century have we seen AR applications being developed for the consumer market (Yuen, Yaoyuneyong & Johnson, 2011). In the continuum between real and virtual environments, AR resides towards the "real environment" end of the spectrum (Milgram, Takemura, Utsumi & Kishino, 1995). This link to the environment enables AR to be a mobile technology, with the user able to navigate in physical spaces during AR experiences. As highlighted by Goodwin-Jones (2016, p. 9), AR provides the "ability to add-on digital assets to explore and expand scenes and locales from the real world".

Augmented Reality for Learning
AR allows for the embedding of digital, location-specific and contextual information into a physical site and enables learning to be enhanced and contextualised (Schrier, 2006; Cheng & Tsai, 2013; Akçayır & Akçayır, 2017). Both AR and VR (virtual reality) provide opportunities for immersive learning (Ferguson et al., 2017) but there are some useful observations to make about AR as compared to VR.

> "AR interfaces allow users to see the real world at the same time as virtual imagery attached to real locations and objects... AR interfaces enhance the real-world experience, unlike other computer interfaces that draw users away from the real world and onto the screen." (Billinghurst, 2002, para 2).

There are a number of potential advantages to maintaining this link with the surrounding physical world. For example, some users feel unsafe if their view is "locked" into an immersive virtual world, whereas AR allows them to "keep control", to see the real world around them. Such safety-related issues are important in collaborative mobile systems for use in classrooms where AR gives mobile users the freedom of sight needed to move around (Kaufmann, 2003). There are direct educational benefits too. In an experiment with the *Hololens* AR tool, the participants noted that it was a more collaborative and tactile experience than VR, sustaining teacher and student interaction, making it better suited to the classroom (Pearson Education, 2019).

Augmented Reality Affordances
AR has specific affordances, when compared to other technologies, which make it a promising tool for learners (Bacca, Baldiris, Fabregat, Graf & Kinshuk, 2014). Specifically, these affordances offer the ability to;

1) Blend two environments (digital and real) to place learning within a physical learning environment and make learning more concrete and situated. The application of augmented reality to support explorations of sites, attractions and destinations has been effective in multiple contexts (Noh, Sunar & Pan, 2009);
2) Integrate a range of digital artefacts that 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);

3) 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, Steinbügl, Dünser & Glück, 2005; Huk, 2006).

Augmented Reality from a Teacher Perspective

There is evidence for the potential value of AR in education, but this can only happen if teachers are confident in their ability to integrate AR tools onto their teaching and are able to identify the learning outcomes that can be met by using such tools. It has been suggested that "digital native" pre-service teachers have strong positive beliefs in technology but have less confidence in using it in the classroom, lacking the technological depth to effectively link technology to their teaching practice (Lei, 2009). Presumably, similar issues also face "digital immigrant" teachers from previous generations. With this in mind, this article explores the perceptions of both young inexperienced teachers and older experienced teachers towards creating AR experiences in their own professional practice.

The next section provides an analysis of various aspects of AR tools, followed by a discussion on the features needed in an AR tool to support constructivist and constructionist learning, The Metaverse tool is then introduced, and the ways in which it meets these criteria are explained. This background material is followed in turn by the methodology, results, discussion and conclusions, including future work.

CATEGORIES WITHIN AUGMENTED REALITY

Although much of the literature tends to treat AR as a single type of experience, the "reality-virtuality continuum" (Milgram, Takemura, Utsumi & Kishino, 1995) makes it clear that there may be many different types of AR experience that have different ways of combining the virtual and physical worlds. Since the presence of the physical world is a constant in AR, the variation in experience depends on two things; the nature of the virtual content and the level of linkage between that virtual content and the background view of the physical world. The technical distinctions that underpin these differences in experience are the nature of the tool, the nature of the trigger and the nature of the overlay and its linkage to the context. Educators wishing to integrate AR into their teaching practice therefore have to navigate a wide range of potential options when selecting a suitable tool.

The Nature of the Tool

A categorisation of AR that has a significant impact on the learner experience is the nature of the tools that are used; hardware, software and supporting. Currently there is a major distinction between AR tools that require specific hardware, such as the *Hololens*, and those that simply require a smart mobile device that can run an AR app. We might also make a distinction between AR experiences that can be created in software directly on a mobile device, and those that are created using software running on other devices and then deployed to mobiles. A further element is whether there are other supporting objects involved in the augmented reality experience. For example, mobile devices may be embedded in other physical constructs to simulate devices such as ground penetrating radar (Winter & Pemberton, 2011). Support tools also include some physical triggers (see below). From an accessibility perspective, educators will often be limited to free or low-cost applications that run on consumer mobile devices.

The Nature of the Trigger

The most common link between virtual content and the physical world in augmented reality is the use of real-world triggers to display virtual content. There are five types of trigger that can be used.

- A pre-supplied trigger that is recognised by the application (often in the form of a QR code or defined image, e.g. a *Quiver* colouring page)
- A pre-supplied trigger that has been created and added to the application by the user (e.g. an image added to *HP Reveal*)
- A user trigger where the user chooses to view augmented content at their current location, triggered neither by the location itself nor by anything at that location (e.g. an optional setting in *Aris* where users can navigate to location-based content without needing to be at that location)
- A physical location trigger, identified by its latitude and longitude or some other locating infrastructure such as beacons (e.g. *Pokemon Go!*)
- A type of object or string of text that can be recognised as such by an Artificial Intelligence (AI) service (e.g. the language learning app *Drops*)

All of these can have value in different learning scenarios, but teachers need an awareness of the applicability, pros and cons of each option within these scenarios.

The Nature of the Overlay and its Linkage to the Context

As well as differences in the types of trigger, there are also important differences in the types of overlay that AR systems use. These may include text, images (2D or 3D), videos (2D or 3D) or digital artefacts (2D or 3D). These overlays may also vary in their level of interactivity. Simple overlays may be text, images or videos that can only be viewed. Interactive overlays may allow various manipulations of the virtual components that make up the overlay.

The linkage to the physical world also varies between AR applications. In some cases, particularly those that are user-triggered (such as *JigSpace*) the AR content is presented in a hologram style, i.e. it is a projection onto an arbitrary background that has no relation to the AR content. In other cases, the linkage is very explicit, such as the overlaying of information on an artefact at a museum, or an AR view that reads information from the trigger (such as the colours added to a *Quiver* trigger picture by a user). Between these two extremes there may be a link that is in the design of the experience. For example, a question rendered as an AR overlay may be triggered within a particular space that requires the user to find the answer somewhere within that space.

Educators need to consider the nature of the overlay more than anything else, since it is in the overlay that the actual learning content will be embedded. The link to the context may be the most defining characteristic of AR, but it is not necessarily the most important aspect of a learning experience.

CONSTRUCTIVIST AND CONTRUCTIONIST LEARNING WITH AUGMENTED REALITY

As explored in Kerawalla, Luckin, Seljeflot and Woolard, (2006) AR can encourage students to engage with a learning activity in a deeper and more meaningful way. The information overlay of digital material over a physical environment provides learners with a way to explore and expand their own understanding. However, there are different levels of knowledge construction when comparing students exploring a knowledge space (seeing information in an AR experience), having constructivist opportunities (being able to actively engage with content through performing operations) and having constructionist opportunities (constructing artefacts, either within an AR experience or creating the experience itself). In many AR contexts, the learning process is strongly focused on the learner being the consumer, not the designer, of the AR experience, but enabling them to create their own artefacts and experiences provides additional learning opportunities.

Previously, student-developed AR experiences have been difficult to support due to the complexity of the development tools and the cost of acquiring the necessary hardware and software to create meaningful experiences. More accessible AR tools that provide simple trigger-based AR experiences provide only limited learning opportunities and interactions. Supporting more powerful interactions or triggering based on locations or images not already recorded (such as object or text recognition) has typically required sophisticated tools and coding with a steep learning curve. However, AR technologies are increasingly able to support the development of sophisticated AR experiences with little or no coding. These tools have provided opportunities for development of more powerful AR experiences by teachers and students using mobile devices and have therefore provided new opportunities for constructionist learning activities.

Constructionist Learning with Metaverse

The aim of this study was to enable both experienced and inexperienced teachers to consider what constructionist learning activities they might be able to use with their own students using augmented reality tools, where learning is reinforced by the construction of digital artefacts. This meant we needed a tool where users could create overlays, link them to specific triggers and create an experience that could be meaningfully linked to its physical context. Given the various learning-related factors identified in the previous section, we also wanted to ensure that the platform was accessible, using free software tools, where the AR experience could be deployed on consumer mobile devices, with a range of possible trigger types. Finally, we wanted a tool that could support socio-technical meaning making by being easy to understand, encourage sharing, and being intuitive to use (Ke & Hsu, 2015).

After looking at a range of possible tools, we selected *Metaverse* for the following reasons: 1) It is free to use, 2) the studio app (where Metaverse “experiences” are created) runs in most browsers and the mobile app where these experiences are deployed will run on both iOS and Android mobile devices, 3) the studio app allows users to create and import their own content, and 4) a number of different types of experience can be created depending on the scenes that are selected and combined, with various options for triggers and overlays. The following section outlines some of the specific features that Metaverse offers.

Metaverse Experiences

According to the *Metaverse* blog site, “Metaverse is a democratized platform that lets anyone create interactive content in augmented reality.” (MetaverseApp, 2019). *Metaverse* provides a number of features that make it interesting from an educational perspective. It includes a studio tool for creating AR “experiences” that can scaffold student learning and integrate multiple online resources (Carmona-Vickery, 2018). Unlike tools such as *Quiver* and *HP Reveal*, there is nothing in *Metaverse* that requires you to directly connect an experience to a physical trigger, giving flexibility in creating experiences. For example, an experience may be simply a series of scenes, such as polls and quizzes, that may be about the environment but are not explicitly linked to it. *Metaverse* does, however, provide the ability to tie an experience to a location-based trigger, which is not possible in many other AR tools. The location can then become a fundamental part of the learning experience. An experience may require students to undertake an activity in a physical space such as solving a problem, conducting an experiment or simply exploring their environment, then using the overlay features of the application to check or validate their findings.

In addition to location-based triggers, other features that mark *Metaverse* out from some other AR creation tools include the integration of a Google AI service and the ability to import user-created artefacts. These additional features also lend themselves towards building more advanced AR experiences. The ability to integrate Google AI computer vision tools can enable learners to directly interact with the environment and not require pre-defined triggers to be recognised. Metaverse leverages Google Cloud’s Vision API and databases to recognise and identify a set of common objects and text. The API draws on existing pre-trained machine learning models to identify images. Using the links to the API made available in

Metaverse, students can take photos of objects or text that can be checked to determine if they match the desired object or text. For example, in one of the experiences we created for our participants to try out, we used object recognition to respond to any example of eyewear.

In addition, *Metaverse* enables students to import their own virtual objects (these can be student-created or drawn from open source repositories). This enables 3D images or other digital content to be added as overlays to the physical environment. Students can also code their own custom blocks to be used in their experiences. These blocks can be used to provide additional functionality and also be shared with others in the *Metaverse* repository. Experiences can make their source public, so students can see how they work and use them to inform their own code.

Students can develop a range of different skills in creating their own AR experiences in Metaverse, with computational thinking skills being one of the most generic. To create these experiences, students need to utilise complex sequential processes with conditional branches and iterations to enable many of these experiences to work. Figure 1 shows that even a simple experience requires an understanding of how to manage both sequences of scenes and conditional logic. In this case the 'eyewear' experience mentioned above uses object recognition to determine if a photo taken by the user is recognised as eyewear by the Google AI service. If it is, the user wins a token, if not they are invited to try again. Even in this simple example there are 4 sequence steps and one selection.

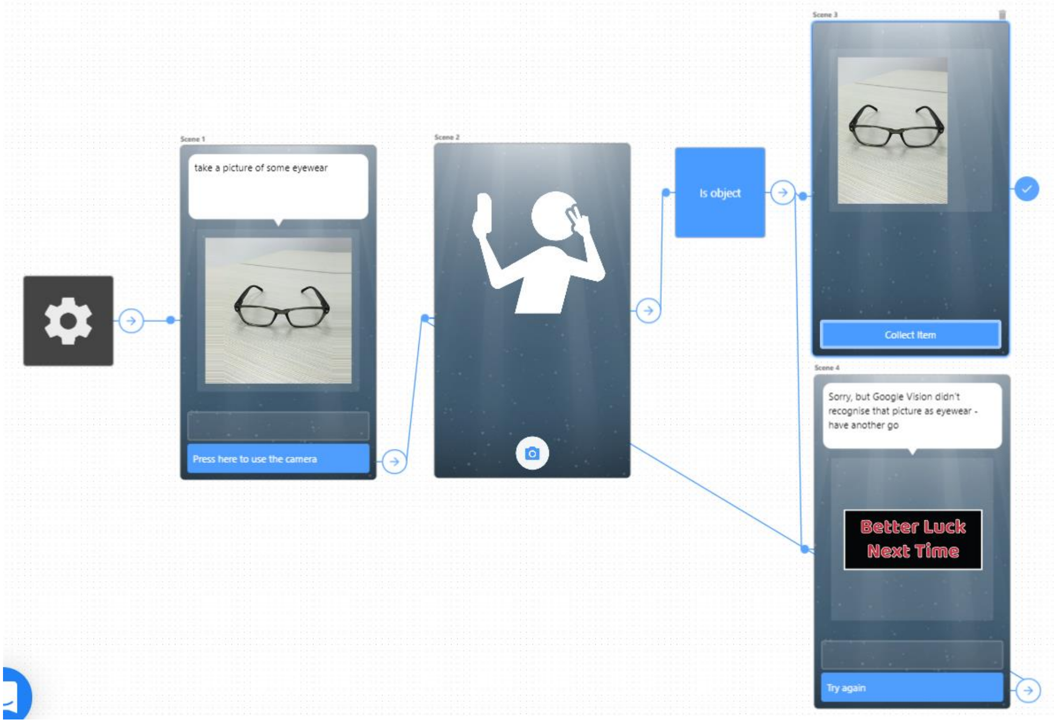

Figure 1. A simple object recognition experience in Metaverse involving sequence and selection

METHODOLOGY

Against this background of various types of AR tool available, the selection of *Metaverse* as a suitable example, and the intention to utilise the constructivist and constructionist aspects of tool use for learning, the main research question addressed in this study was:

What are the perceptions of teachers towards the potential of using an AR tool (Metaverse) within their teaching?

A sub question was based on the impact of teaching experience on the ability to incorporate such tools into learning. Therefore, we also asked:

Are there differences in attitudes towards the potential of AR tools within teaching between experienced and inexperienced teachers?

To address these questions, we administered a survey that gathered both quantitative and qualitative data. Qualitative data were also gathered through observing the AR artefacts that were created by the participants. For the study, we ran separate workshop sessions with two different participant groups. The participants were a convenience sample based on those who were enrolled in relevant teacher education programmes at two different higher education institutions in New Zealand. One group comprised 20 pre-service teachers still in teacher education (inexperienced). The other group comprised 58 in-service teachers undertaking part-time postgraduate study (experienced). In this article, when we refer to "participants" we are referring to all those who participated in the research activity, regardless of group. Where we need to differentiate between the two groups, they are referred to as "experienced teachers" or "inexperienced teachers". The imbalance between the group sizes was due to not wishing to exclude any of the teachers on these programmes from the opportunity of engaging with the research. Low risk ethics notifications were made to the host institutions to allow for anonymous, voluntary data collection.

In the two workshops, the participants from both groups were given same treatment. They had the option of working through a VR creation activity or an AR creation activity. Following both sessions, all participants were invited to fill in a voluntary and anonymous survey. This article relates only to the data from those creating an AR Metaverse experience.

Before the participants engaged in the research activity, a short introduction was provided that defined the concepts of AR and VR and showed some examples of how both are currently used to support educational goals. The participants who chose the AR option were then invited to try out a simple *Metaverse* AR experience that had been created by the researchers as an indicative example of what was possible with the tool, then given an opportunity to develop their own experiences based on simple sets of instructions. Some elected to bypass these instructions and create their own experiences using other resources such as online videos.

The first set of instructions showed the participants how to develop an experience that included a quiz, which would require the end-user to explore their surroundings to answer the questions. Through this activity the participants could explore how *Metaverse* enabled the integration of virtual objects into experiences (we used virtual objects provided within *Metaverse* but drew the participants' attention to the fact that user-created virtual objects could be uploaded and used) and basic computational thinking concepts to design conditional branches to evaluate the answer. The second option focused on designing an experience using Google Cloud's Vision API. The participants were asked to design an experience that required the evaluation of either an object or text and utilizing the Vision API to check if the text or object was recognised as correct by the system. These two activities were selected to cover the main experiences offered by *Metaverse*. They were designed to be short and simple activities that would provide the participants with an overall impression of the tool and its potential uses.

The participants were then invited to try creating their own experiences, after which they were asked to complete a voluntary survey. The main questions in the survey were designed to find out what the participants enjoyed or did not enjoy about the *Metaverse* experience, their perceptions of *Metaverse* as an educational tool on 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, and to what extent their preferred mode of teaching was through social/collaborative learning and/or face-to-face teaching. The survey also asked some simple demographic questions about gender, age range and education sector.

RESULTS

28 (out of 58) experienced teachers completed the survey on their experience with *Metaverse*, while 5 (out of 20) inexperienced teachers completed the same survey. The others either chose to work only on a separate VR activity or declined to fill in the survey.

Quantitative Analysis

Table 1 shows the results from the quantitative Likert scale questions included in the survey.

Question	Inexperienced teachers (n=5) mean response	Experienced teachers (n=28) mean response
Did you enjoy your experience with Metaverse?	3.8	3.4
I am keen to integrate technology into my future teaching	4.6	3.7
I am keen to incorporate learning opportunities that can happen outside the classroom (during class time)	4.8	3.7
My preferred mode of teaching would be through social/collaborative learning	4.6	4.0
My preferred mode of teaching would be face-to-face	4.2	3.6
How confident are you as a user of technology?	3.2	3.3

Table 1. Comparison of quantitative data from experienced and inexperienced teachers - Likert scale 1=highly negative, 3=neutral, 5=highly positive.

While it is impossible to draw categorical conclusions from such a small data set, we might note that the inexperienced teachers were slightly more positive about the tool and the various teaching modes. Both groups seemed to be similarly neutral about their confidence in the use of technology, even though all the inexperienced teachers were under 30 while all but one of the experienced teachers were over 30 and two thirds were over 40. This might be of some interest when considering the idea that the inexperienced younger teachers might be expected to be more "digitally native" than the older, experienced teachers, but this was not the case, reinforcing similar findings by Lei (2009), despite the decade that has passed since that study.

Table 2 shows the responses to the one multiple-choice question included in the survey, about the potential of the tool for education. This shows that none of the participants were already using an AR tool in their teaching, but that most of them liked *Metaverse* and already had some ideas about how they could use it in their own practice. However, ten of the experienced teachers disliked the application and could not see the value of using it for learning.

Response to Multiple Choice Question "Metaverse provides educators with a way to create their own AR apps, without any coding required. What do you think about the potential of this tool for your own educational purposes?"	Inexperienced teachers (n=5) number of responses	Experienced teachers (n=28) number of responses
Already use it (or a similar AR tool) in my own teaching	0	0
Like it, and have some ideas about how I can use it in my own teaching	4	17
Like it, but can't see how it would fit in my own teaching	1	2
Think it's okay, just not sure if really can offer much to me or teaching in general	0	4
Think it's just a gimmick that offers little or no real learning opportunities	0	3
Hate it.	0	2

Table 2. Comparison of quantitative data from experienced and inexperienced teachers – multiple choice question

Interestingly, we could see no particular pattern in any of the demographic factors (age range, gender, type of school). Even the level of confidence in using technology did not correlate strongly to enjoying the experience or seeing the potential for the application. The only apparent correlation (though the small data set precluded generalization) was between enjoyment of the activity and seeing the potential of the application for learning.

Qualitative Analysis

Open ended questions were used to follow up the responses to the quantitative questions. Of the experienced teachers who had negative responses to the application, most referred to the difficulty of creating an experience in it. Although these teachers are exposed to digital tools on a regular basis, they found *Metaverse* relatively complex. Another comment that appeared several times was that it relied on suitable mobile devices in the hands of students, which is not always realistic.

> *"Too hard to do without mobile devices"*

> *"Too inhibitive without phones"*

The experienced teachers who responded positively saw the application as being potentially motivating for students. Terms associated with the application included 'fun', 'surprising' and 'visually appealing'.

> *"It would be great to engage children in their learning through interactive participation while answering fun questions."*

Similarly, the inexperienced teachers reacted positively to the use of Metaverse for learning, for example:

> *"I really liked it. I could see us using this."*

However, when questioned on how they thought they could actually apply it in their teaching they were unclear. They felt that it had promise but wanted to explore it a bit more. Comments included:

> *"I feel like if I explored this app more and in depth, I would find it would fit my teaching and I would be more inclined to use it in teaching experiences."*

There was a similar lack of clarity from some of the experienced teachers about how the tool might actually be used in the classroom. Responses like the following were common:

> *"Simple instructions, can create a variety of interesting tasks"*

In other words, there was a perception that the tool was interesting but did not immediately suggest specific learning applications. This might be contrasted with our previous experiences of using much simpler AR tools such as *HP Reveal*, where teachers seemed able to quickly identity useful school-based applications.

Nevertheless, there were experienced teachers who did go beyond generic positive comments to discuss specific learning applications for *Metaverse*. Many of the open-ended responses to how the tool could be adopted in teaching focused on the aspects of reading, writing and storytelling. This an interesting focus for AR and seems to link to the narrative nature of a *Metaverse* experience that links a series of scenes together. The ability to link these scenes in a conditional manner prompted one respondent to note that it could be used for 'pick a path' stories where the narrative is conditional on user feedback. Other narrative related applications suggested were storyboarding and outlining strategies. The related focus on language also linked to some teachers suggesting the value of *Metaverse* for experiences that involve the use of the Te Reo Māori language. Other suggestions included giving context to static displays or student project work, and several references to how to app could support inquiry learning because questions can be embedded inside experiences. Potential across the curriculum was recognised.

> *"To use as an activity to gain their understanding - All Curriculum areas, Te Reo, Reading, Inquiry"*

A repeated concern from the inexperienced teachers was that they felt they needed help to explicitly develop the appropriate skill set.

> *"Would love to use these sort of things in teaching although I think due to the lack of my own knowledge around it, it wouldn't be as effective teaching."*

> *"I think if I were to implement it, I would like to be taught a bit more about how to use this app. Explicit teaching would benefit me as I would like to know the best ways to use this app and how I can purposefully and properly implement this into my teaching."*

This lack of comfort and confidence is probably not surprising considering the nature of these inexperienced teachers, since they were still in the process of undertaking practicums and not yet teaching their own classes. It is understandable that there was some cautiousness about first understanding the application and getting more support in its use and application. Teachers who are already practicing are less concerned about knowing everything in advance and are more confident about taking risks in the classroom (Howard & Gigliotti, 2016), and this seems to have been reinforced in our own results.

When looking at the *Metaverse* experiences that were created by the two groups, only the experienced teachers seemed willing to embrace the opportunity to experiment. Most of the experiences created were just "play", with the participants in this group creating various mashup type *Metaverse* experiences combining AR characters (mostly animals for some reason), jokes, videos and user interactions. Few of them chose to focus on a particular teaching scenario, though one group created a physical education exercise routine with AR overlays showing the activities and timers. Another group embedded a series of learning tasks including reading comprehension. In contrast, the inexperienced teachers were not confident to create and share their work in *Metaverse*.

DISCUSSION

Although our study was small, based on an informal learning activity, and drawing data from a short voluntary survey, it revealed some interesting insights into our participants' perspectives on the ways that they might be able to integrate AR tools into their future teaching practice. Although the majority of teachers from both participant groups enjoyed the experience, this only translated into concrete ideas for how to use AR in the classroom for the experienced teachers. We also noted that age range was not a significant factor in confidence in using this type of tool in the classroom, and that we cannot assume that young trainee teachers are any more or less likely than mature teachers to embrace new technologies. One lesson we might draw from this study is that if we expect newly qualified teachers to be able to introduce digital learning into their classrooms, then they should be given the opportunity to develop these ideas in collaboration with more experienced teachers who, even if their technology skills and confidence are similar, have the teaching experience to see how new technologies can be integrated into their broader practice.

CONCLUSIONS AND FUTURE WORK

The aim of this study was to explore the perceptions of teachers towards the potential of using an AR tool (*Metaverse*) within their teaching, and whether the level of teaching experience impacted on their ability to incorporate such tools into learning. Although the study was based on a very small number of participants (only 33 provided survey responses), there were a number of findings that seemed to provide some insights into our questions. One finding that reinforced previous findings in the literature was that while inexperienced "digital native" teachers were, on average, somewhat more positive about using this type of tool in their teaching, they were no more confident in the technology skills than older, more experienced teachers. The experienced teachers, however, were able to leverage their experience to see how such tools could be integrated into practice in specific ways. Although we were interested to see the constructivist and constructionist learning that might be developed from using an AR tool such as Metaverse, there was little in the qualitative data that indicated that the participants had considered this aspect, with discussion around content delivery taking precedence over cognitive development.

These results suggest some areas where future work might be usefully focused. In particular, we need to structure a study that effectively enables us to get beyond the teachers' focus on learning content to address the underlying learning theories and mechanisms that might uniquely justify an AR learning experience. To do this we need to work not only with teachers but with their own students in school, since developing teacher confidence and skill in using AR is only the first step in using AR to foster learning.

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