Virtual and augmented reality and pre-service teachers: Makers from muggles?

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This study examined the impact of a brief immersive experience with virtual reality (VR) on pre-service teachers' self-efficacy and attitudes towards technology in education. The study found that although pre-service teachers were aware of VR and augmented reality (AR) technologies, they lacked experience using them. The intervention had a positive impact on their beliefs and confidence in using innovative information and communications technology in the classroom. The findings suggest that brief interventions can serve as a means for pre-service teachers to evaluate their digital skills and develop an action plan to enhance them. Additionally, the study highlights the potential barriers to implementation faced by teachers, including the pace of technological change, lack of embedding time and funding constraints. This research contributes to the limited literature on the use of VR in teacher education and suggests that immersive experiences with technology can foster positive attitudes towards innovation, curiosity and skill development. The study provides implications for teacher education programs and policymakers regarding the potential of VR and AR technologies in education and the importance of supporting teachers in developing their digital skills.

Implications for practice or policy:

- Teacher education providers should consider including immersive experiences with VR and AR to increase pre-service teachers' awareness and evaluation of their potential to support learning.
- Pre-service teachers and those responsible for supporting them can use VR experiences as a means to evaluate their level of digital skill and identify an action plan to develop and/or update such skills as appropriate.

Keywords: pre-service teachers, virtual reality (VR), augmented reality (AR), digital skills, self-efficacy, teacher education

Introduction

Virtual reality (VR) and augmented reality (AR) are undergoing significant growth as the economic potential of such technologies becomes clearer. In the United Kingdom, the market value of VR alone was reported by a technology company to rise by 390% between 2016 and 2020, reaching £354.3 million (Pham, 2017). The adoption and advancement of VR by global technology giants such as Facebook, Samsung and Google herald unprecedented commercial interest in this area with Facebook founder Mark Zuckerberg citing VR's potential as "the next major computing platform" (Urstadt & Frier, 2016). There are also many advantages offered by the technologies when used in educational settings (Di Natale et al., 2020; Ng, 2022; Radianti et al., 2020).

VR ranges from simple navigable 3D environments on a computer screen to a fully immersive experience which allows its users to "feel they are in and a part of the computer-generated virtual scenarios" (Ip et al., 2018, p. 3) and able to interact with these synthetic worlds. Whichever type of VR used, even with early iterations of the technology, it acts by "giving the user a sense of being there, taking control, and personally interacting with that environment with his/her own body" (Ausburn & Ausburn, 2004, ¶ 4). VR has been acknowledged as having potential to provide relevant immersive experiences in many fields, including education (Schott & Marshall, 2021). AR does not present an alternative to the user's immediate surroundings but supplements real-world experience "with virtual objects super-imposed upon or composited with the real world … so that the virtual and the real world co-exist in the same space" (Azuma, 1997, p. 356). This allows users to "engage with virtual information superimposed on physical landscapes (such as a tree describing its botanical characteristics or a historic photograph offering a contrast with the present scene" (Dunleavy et al., 2009, p. 8). VR and the cognate AR are not novel technologies, both emerging from developments in entertainment in the 1960s. Eventually the technology began to be used in professional education and training, exemplified by flight simulators, from the 1980s. In turn, VR and AR made some inroads into higher education and post-primary education in the 1990s, particularly with the emergence of virtual science and virtual fieldtrips (Merchant et al., 2014) but penetration was limited due to cost. There then followed a period of relative inactivity, until VR "started to attract headlines again after over a decade of silence" (Hussein & Nätterdal, 2015, p. 2), which is attributed to the emergence of head mounted displays (HMDs) from 2012, which were relatively inexpensive and easy to wear.

There have been challenges in using AR and VR, particularly in education. Elkoubaiti and Mrabet (2018) highlighted technological complexity and cost as two of the reasons for low adoption rates. They also highlighted health issues related to using apparatus such as VR HMDs, which were found to generate nausea and eye and head discomfort for some users. Others have argued that the new and lighter HMDs with a much-reduced latency and a higher resolution have improved the user experience (Ip et al., 2018), and, even as long as 2 decades ago, cost and technological complexity had also much reduced (Dickey, 2003). The research of Valentine et al. (2021) has suggested how educators can use VR with large classes without the need for investment in or management of a large amount of VR HMD equipment.

Elkoubaiti and Mrabet (2018) have also included a challenge that may be potentially more fundamental, relating to classroom control and pedagogy in the use of the technology (p. 339). They suggested that teachers may find incorporating VR and AR experiences within their pedagogical approaches not to be straightforward. Huang et al. (2010), reflecting upon early use of VR within classrooms, highlighted that those who "apply a new VR technology to educational settings… need to consider carefully how a pedagogy or a learning theory may influence the learning process" (p. 1172) and they suggested a constructivist approach. A further challenge is the potential for learners to use the virtual worlds as "tools for distraction" (Elkoubaiti & Mrabet, 2018) rather than for learning, alongside the fear that learners could be isolated from other learners. There are more prosaic challenges as some HMDs require smartphones to operate, which teachers often expect students to provide. There is a risk of a digital divide here, with many children not having access to such expensive devices. Additionally, school regulations may prohibit the use of mobile telephones by learners (Kőrösi & Esztelecki, 2015), and teachers who want to incorporate the power of those devices to access VR and/or AR experiences will have to navigate the constraints that some schools may establish. HMDs with integral screens overcome this issue, but the current cost may make these unaffordable for many schools.

Despite challenges, there are considerable affordances offered by these technologies, and both VR and AR now appear to be increasingly in use in education and training. The technology has been cited by researchers as being useful in a range of diverse fields such as dissecting a virtual frog (Lee et al., 2010), teaching science (Parong & Mayer, 2018) or learning about thermodynamics (Coller & Shernoff, 2009). Both VR and AR allow learners to explore very large features such as planets or microscopic structures such as cells (Elkoubaiti & Mrabet, 2018). VR also allows otherwise dangerous or challenging experiments to be simulated and experienced virtually. Places that would be risky, impractical or ethically unsound to visit can be experienced using VR (Schott & Marshall, 2018). As the technology becomes more integral to some educational experiences, there are now claims that "children are introduced to VR at a younger age as an effective part of K-12 primary, secondary and higher education" (Vaughan et al., 2016, p. 67).

Some research has suggested increased motivation for students as a result of using VR (Chiang et al., 2014; Huang et al., 2010) with a positive impact on understanding (Gonzáles, 2018). Serio et al. (2013) argued that their middle school respondents displayed increased levels of attention and interest and "the higher concentration and memorization levels that students claimed to achieve with AR technology, seems to cause this positive effect on learning outcomes" (p. 595), and Bower et al. (2014) summarised considerable research suggesting the AR can increase student motivation and improve student outcomes. The fusion of VR and/or AR with other technologies such as geographic information systems has opened up new possibilities (Kamel Boulos et al., 2017), and Minocha et al. (2017) pointed out that, while the "adoption of VR is still in its infancy … its development will progress and mature as educators (and students) perceive and exploit the affordances of this technology for their teaching and learning" (p. 10).

Teachers, teacher education and technology adoption

There are considerable challenges for teachers who have to engage in a continuous process of updating their ICT competences, including in VR and AR, alongside pedagogic competence developments and changing subject matter (Bowe et al., 2017), all within a system that is subject to neoliberal pressures of accountability and managerialism (Skinner et al., 2019). Pillay et al. (2005) noted that the causes of burnout for teachers are complex, but they included "keeping abreast of technological innovations" (p. 22) as one of the four pressures on teachers that they use as exemplars. Ventura et al. (2015) cited "the introduction of technologies [and] the need to develop additional technological competences" (p. 277) as causes of burnout in teachers, albeit much reduced in those with higher levels of self-efficacy.

It is unclear to what extent teachers who act as innovators in their use of information and communications technology (ICT), rather than merely early adopters (Rogers, 2010), are self-driven or whether they act as a perceived requirement of their chosen profession. Nor is it clear how and whether teachers can decide to pause in their innovation to concentrate for a time on embedding a technology. It is also unclear that, if teachers do not make that decision, then who does? Some teacher competency frameworks have a requirement that teachers undertake continuous development of technology skills. In one model of developing teacher competencies (in Northern Ireland), teachers are required to "keep up-to-date in knowing how to use the technology, hardware and software in their school" in their first year in post. In their second year of teaching, they must "keep up-to-date in knowing how to use the technology, hardware and software more effectively in their school, sharing information and skills with other staff" and eventually, in all subsequent years, are required to "help others to learn how to use the technology, hardware and software in their school and resources accessible on the Internet" (General Teaching Council for Northern Ireland, 2011, p. 27). This continuous innovation may be helpful in keeping teachers up to date and encouraging the use of cutting-edge technology in teaching, but the incessant need to stay abreast of rapidly evolving technologies, and to share that knowledge, is likely to contribute to professional pressures and possible burnout.

There may also be a parallel here with the pleasure periphery, a geographical concept used in the analysis of tourism. Coined in the 1970s by Turner and Ash, 1975), it refers to a continual process whereby marginal areas become "hot" tourist destinations, before being overdeveloped and effectively abandoned. People are attracted by their exoticism, their novelty and their exclusiveness. As these destinations become more popular, they are no longer frequented by the original pioneering group – akin to the innovators in ICT use – as those individuals go off to seek new destinations. Just like these ground-breaking tourists, innovators in ICT seem driven to find and to pursue the latest "new" technology, leaving later adopters to implement those technologies that are becoming mainstream. Just as with the tourist analogy, this process has to be continuous, as the novel soon becomes the established. This leaves little time for the embedding and serious evaluation of any technology. The pleasure periphery in geography explains a destructive process that brings few benefits but continually moves the problem. It remains to be seen whether AR and VR are just new versions of the same issue and whether they are game changers for educators, or just another novelty to be rejected when the next "new" technology emerges. This also may reflect the observation, in the *British Journal of Educational Technology*'s reflection of 50 years of educational technology research, that there were times when educational institutions were so keen to invest in new technology that:

> Funding was often sunk too quickly into expensive equipment that only somewhat reflected the curriculum, without spending enough time training staff, considering instructional design, or how the equipment would be maintained in the future. (Bond et al., 2019, pp. 25–26)

There may be challenges in the adoption of AR and VR, but this is not a new story. Docterman, in the foreword to Schifter (2008), discussed a technology introduced to schools that was initially resisted. Lacking training in the use of the technology, teachers were uncomfortable and felt that it offered no advantages for their classrooms. Introduced to schools after having initially been used in universities, teachers did not consider that it supported the pedagogic norm in schools, and thus uptake was low. The technology being described was the chalkboard, and the time was 1820s and 1830s. As Docterman said, "the technical part of learning to use the chalkboard was easy: the challenge came with the pedagogic demands accompanying it" (Schifter, 2008, p. x).

Professional development for teachers has been an on-going issue worldwide in developing the use of technologies (see Daly et al., 2009). In a broader review of the roll-out of technology innovations at school level, Fullan and Donnelly (2013) stressed the key role of professional development for teachers in terms of pedagogy, both as pedagogical content knowledge and also technological pedagogical knowledge. This has considerable resonance with the technological pedagogical content knowledge model (Mishra & Koehler, 2006). Whether or not professional development is available, problems such as reliability, the need for time to become familiar with the technology and the requirement for personalised, situated instruction have repeatedly emerged across all school sectors regardless of the innovation being introduced (Brand, 1998; Grant, 1996; Schofield, 1995).

As well as in-service, there is also a pressure on pre-service education provision to continually keep on top of ICT developments (Roulston et al., 2019), including VR and AR. The requirement for teachers to be able to "integrate augmented reality, virtual reality and mixed reality to give learners a real life experience" (Ally, 2019, p. 309) has been proposed as one of 15 competencies for using digital technologies, and this poses challenges to initial teacher education (ITE) tutors and to pre-service teachers. If the ambitious growth projections of VR and AR are to be believed, and the potential educational gains of these technologies realised, then it is imperative that tomorrow's teaching workforce, today's pre-service teachers, have access to similarly immersive, creative and pedagogically robust learning experiences designed and facilitated by well-informed teacher educators. Staff in ITE are the individuals who act as gatekeepers to the learning environments of the 21st century (Tondeur et al., 2019). Similarly, it is also important that the pre-service teachers enter a profession that is system-ready for these new teachers, including providing free access to reliable and up-to-date ICT resources, and with buy-in from school leadership and a positive milieu promoting ICT use across the school.

Pre-service teacher identity and self-narratives appear to be important determinants of whether they will use technology to support their teaching and the learning of their students (Burnett, 2011). In her study, Burnett found that few of the pre-service teachers indulged in "playful social" practices (Graham, 2008, p. 10) that would naturally develop their digital skills. Similarly, none of them had created digital media, despite acknowledging that the digital world an integral part of their social lives. Some research (see "Make or Break: The UK's Digital Future", Select Committee on Digital Skills, 2015) have suggested that only a small proportion (10%) of the general workforce, termed *digital makers*, currently require those skills that would allow digital content to be produced. It was deemed necessary that almost half of the working population (46%) should be *digital workers* – at the higher end of technological ability possessing basic programming skills and able to "evaluate, configure and use complex digital systems" (Select Committee on Digital Skills, 2015, p. 42). Over one third (37%) were identified as needing to be *digital citizens* – able to confidently use digital technology "to communicate, find information and purchase goods/services" (p. 42). In addition, only 7% needed to fit the definition of a *digital muggle*, someone for whom "digital technology may as well be magic" (p. 42).

The "Make or Break: The UK's Digital Future" report (Select Committee on Digital Skills, 2015) presented to the United Kingdom's House of Lords argued strongly that the development of higher order digital skills will be essential for the economies of the future to sustain, never mind flourish. Some research in higher education (see Coldwell-Neilson, 2017) has suggested that this need is recognised in universities, but there is a lack of shared understanding of the expected digital competence levels of incoming students and thus a lack of clarity as to what has to be addressed.

A minority take the view that the drive towards technological competence is misplaced and that titling the report as "Make or Break" is "intimidating … implying that the UK will be thoroughly broken if we do not get everyone using technology in the way the governments of the world desire" (Chambers, 2017, p. 158). However, most sources would argue that developing digital literacy skills is key to education:

> Economic prosperity is dependent on a workforce skilled in digital practices including information handling and problem solving and equipped with technical skills … schools have a key role to play in addressing the current skills gap which too often sees those leaving education ill-equipped for a digitalised work place. (McFarlane, 2019, p. 8)

The United Kingdom Government (2017, Digital skills for digital jobs section, ¶ 1) cited the estimation of an additional "1.2 million technical and digitally skilled people … needed by 2022 to satisfy future skills needs" and detailed how they aimed to address the digital divide and develop education. However, there is no recognition within the strategy of the key role that teacher educators may have, nor any mention of how the skills of the teaching profession will be developed, whether in ITE or in in-service provision.

Methodology

This research aimed to investigate pre-service teachers' baseline awareness of VR and/or AR and their evaluation of its potential to support learning.

The research questions were:

(1) Do pre-service teachers have an awareness of VR and/or AR technologies?
(2) Does this group see any potential in the technology to support learning and teaching?
(3) Can brief immersive experiences with VR impact upon pre-service teachers' self-efficacy regarding digital skill?

An exploratory convergent mixed-methods approach (Creswell, 2014) using qualitative and quantitative methods was employed in this research study comprising four stages. Stage 1 involved an online survey seeking to examine pre-service teachers' awareness of and attitudes towards VR in education. Questions were asked about participants' experience of technologies such as VR and AR to evaluate their affective and cognitive understanding of these immersive technologies. Further questions asked them about the value that they ascribed to the use of technology to support learning and teaching in general, the value of VR and AR, whether they had a place in school education and what barriers there might be to implementing such technologies.

Stage 2 involved a 4-hour hands-on VR workshop. A sub-group of the pre-service teachers recruited in Stage 1 were given this intervention in which VR and AR was demonstrated and explored in an educational setting, two of which were held in Northern Ireland and one in the Republic of Ireland. Within the workshop, pre-service teachers and ITE tutors worked in unison to explore a range of VR and AR tools including Google Tour Creator, the creating of 360-degree imagery and YouTube 360 content. Pre-service teachers progressed to the design, production, review and refinement of a variety of AR and VR learning artefacts that served as exemplars for teaching and learning via VR. The session showcased the expansive possibilities of AR and VR technology as a supportive tool for learning within various areas of the curriculum including geography, history and science.

Stages 3 and 4 comprised a post-workshop survey and subsequent focus groups to illicit further understanding of the participants' perceptions of VR and associated potential.

Four ITE providers in Ireland collaborated to implement this study, two from Northern Ireland (Ulster University, Coleraine and Queen's University, Belfast) and two from the Republic of Ireland (Dublin City University and University College Dublin). Precise data on socio-economic status, encompassing factors such as family income, parental educational attainment and occupation, can be difficult to procure due to privacy concerns and the inherent variability of these factors. For international comparison, however, a consideration of the socio-economic context of the study is relevant. Whilst individual socio-economic data were not collected at participant levels, the institutional contexts, within Northern Ireland and the Republic of Ireland, suggest the socio-economic status of participants is likely to be above an international mean. Postgraduate pre-service teachers from all these institutions were invited to participate in Stage 1 of this research. Responses were anonymous, and while no personal data that would allow identification of any of the respondents was collected, participants were asked to provide a unique identifier which enabled pre- and post-intervention responses to be linked. Ethical approval for this study was obtained from Ulster University.

Results

The pre-service teachers' experience of immersive technologies such as VR and AR and an evaluation of their affective and cognitive understanding of immersive technologies pre-intervention will now be outlined (n = 114). Changes will also be reported in those understandings for a sub-group of the whole ITE student body in the original survey (n = 38), highlighting changes in attitudes to the potential of this technology for use in schools and in ITE institutions.

Participants

In Stage 1, a total of 114 postgraduate pre-service teachers from the four ITE establishments (two in the Republic of Ireland and two in Northern Ireland) completed the online survey. All pre-service teachers were undertaking an ITE programme of preparation for employment within the secondary school sector, where pupils are aged between 11 and 18 years. Subsequently, up to 38 of them, comprising 20 from Northern Ireland and 18 from the Republic of Ireland, participated in the remaining phases, 38 in the surveys following the intervention, and 35 of whom took part in a focus group.

As shown in Table 1, over two-thirds of participants where under the age of 25, therefore considered, perhaps controversially, as Prensky's (2001) digital natives or Generation Z (Seemiller & Grace, 2016). The range of subject specialisms represented within the intervention group comprised science, technology, engineering and mathematics, humanities and languages in proportions broadly representative of cohort sizes within the four participating ITE institutions. The gender ratio of the intervention sample was consistent with that of the study population and indicative of the dominant percentage of females in post-primary teaching in Northern Ireland (Department of Education Northern Ireland, 2019) and Ireland (Department of Education and Skills, 2019).

Table 1
Biographical details of the participants

Student characteristics		**Intervention sample**		**Population**	
Gender		n	%	n	%
	Male	16	42.1	48	42.1
	Female	22	57.9	66	57.9
Age		n	%	n	%
	< 25	26	68.4	76	66.7
	26–30	5	13.2	19	16.7
	31–35	1	2.6	9	7.9
	36–40	3	7.9	5	4.4
	41–45	1	2.6	3	2.6
	45+	2	5.3	2	1.8
	Total	38	100.0	114	100
Subject specialism			%		%
		English	10.5	English	11.4
		Geography	44.7	Geography	17.5
				English &/or Geography	0.9
		Technology & Design	10.5	Technology & Design	3.5
		French	5.3	French	2.7
		Business	5.3	Business	2.6
		Biology	5.3	Biology	1.8
		ICT	15.8	ICT	7.9
		Science	2.6	Science	4.4
				Home Economics	6.1
				Physical Education	5.3
				History	9.6
				Music	9.6
				German	1.8
				Religious Education	2.6
				Mathematics	4.4
				Spanish	1.8
				Art & Design	5.3
				Chemistry	0.9

Pre-service teachers' awareness of VR and AR

To gauge pre-service teachers' prior awareness of VR and AR technologies, in comparison to other emerging and popular technologies, participants were asked to what degree they had experienced these technologies socially. Despite the surging growth of VR and AR, notably within the gaming industry and largely targeting the dominant age profile of the group, fewer than 2% of the group used VR frequently and over 7% did not know this technology at all. The majority (67.54%) had heard of VR but had never used it. The same is true for pre-service teachers' awareness of AR with broadly similar percentages reported (see Table 2).

Table 2
Pre-service teachers' prior experiences with emerging technologies (n = 114)

Emerging technology	Used frequently (%)	Used sometimes (%)	Heard of it but never used it (%)	I don't know this technology (%)
3D printing	0.00	10.53	79.82	9.65
Image manipulation	14.04	54.39	25.44	6.14
VR	1.75	23.68	67.54	7.02
AR	1.75	21.05	71.93	5.26
Drones	1.75	21.05	71.93	5.26
Robotics	0.00	11.40	78.95	9.65

When asked about the specific place of VR and AR in schools, 87.7% of the group stated that VR had a place, but this percentage reduced to 75.4% when asked if VR and AR had a place in their classroom. Respondents cited cost, insufficient skills and/or knowledge, lack of applicability to their subject area, concerns about classroom management and potential challenges for special education needs pupils as possible barriers.

When asked to consider technology in their classrooms of the future, perception of the likely presence of VR was divided with almost half believing it was likely (39.47%) or very likely (8.77%) to be used within their classrooms. Table 4 shows that a similar proportion (49.12%) considered VR to be an unlikely tool to be used within their classrooms. Despite these contrasting views, the perceived likelihood of VR's presence in pre-service teachers' classrooms of the future, to some degree, was akin to already more established technologies such as image manipulation (51.75%) and surpassed 3D printing (19.3%), drones (21.93%) and robotics (23.69%). The parallels with digital image manipulation tools are unquestionably challenged by one prospective teacher of Art and Design saying:

> The creation of art and design should be done by the hand for a multitude of reasons, mainly because it is raw and more honest, virtual reality could take the place of this or refine it. Technology has a place ... Photoshop, etc. … but not virtual reality**.**

Table 3
Pre-service teachers' expectations of use of emerging technologies in their classrooms (n = 114)

Emerging technology	Very likely (%)	Likely (%)	Unlikely (%)	Unsure (%)
3D printing	5.26	14.04	77.19	3.51
Image manipulation	18.42	33.33	45.61	2.63
VR	8.77	39.47	49.12	2.63
AR	6.14	17.54	56.14	20.18
Drones	3.51	18.42	74.56	3.51
Robotics	7.02	16.67	67.54	8.77

Pre-service teachers' were less certain of their potential use of AR within their classrooms. Over one fifth (20.18%) of participants reported that they were unsure of AR's role within their teaching. This is markedly higher than any other of the listed emerging technologies despite the relatively similar levels of use and awareness, shown in Table 3, for AR technologies.

Participants were asked to complete the statement "The one thing preventing me from using VR in my classroom is …". Many participants (*n* = 114) responded with more than one reason. It was most prevalently reported that a lack of availability of software, equipment, training and infrastructure was preventing the use of VR in their classroom (49.54%). This was followed by issues relating to money, funding, affordability and financial support (29.72%); and a lack of understanding and knowledge about the technology and how to use it (26.12%) (including some reporting feeling fearful about using VR). Just under 10% (9.9%) said they could not see how to relate VR to their subject, 4.5% had concerns about the long-term health implications of using VR and 4.5% listed their own views and opinions as preventing their use of VR in the classroom. Less than 2% of participants named school policy on phones (1.8%), the fact it may be not beneficial due to students' reactions to it (1.8%) (e.g., "some students may see it only as a novelty and not learn from it") and the implications for them professionally if pupils reacted badly to it (0.9%), as stopping them using VR in lessons.

This sample was also invited to complete the statement "If I used VR with pupils in my class, the teachers in school would think …". Almost half (44.44%) thought they would receive a positive response – words such as "interesting", "amazing", "exciting", "wonderful", "engaging", "innovative", "dynamic", "useful", were used – and some participants acknowledged colleagues may think they are ahead of the time but in a positive sense. In contrast, 37.96% anticipated a negative response, 3.70% a mixed response, 1.85% said it did not matter what others thought and 0.92% outrightly said they would not use the technology. Of those who believed that they would receive a negative response (*n* = 41), 41.46% believed that this would take the form of a personal critique – some envisaged comments would be made such as "I'm mad" and "I was a little crazy". That they were "advanced but annoying", "rocking the boat" and "making more work for everyone else in the department" and that this was due to them being "the new teacher, showing off all the bells and whistles used in my PGCE course". Few participants believed they would face cynicism (17.07%) and or the opinion that as a method of teaching VR was not educational or beneficial to learning (12.19%).

Pre-service teachers' digital self-efficacy

In the pre-intervention survey, all participants (*n* = 114) were asked to review Mairs' (2014) descriptors of 'digital muggle to digital maker', positioning how they feel they are like the descriptions provided using a Likert scale from *very like me* to *not at all like me*. Table 4 describes the spectrum of options available for participants to choose from, ranging from a digital muggle to a digital maker.

Table 4
Digital muggle to digital maker definitions provided to participants

Term	Description
Digital muggle	"no digital skills required—digital technology may as well be magic"
Digital citizen	"the ability to use digital technology purposefully and confidently to communicate, find information and purchase goods/ services"
Digital worker	"at the higher end, the ability to evaluate, configure and use complex digital systems. Elementary programming skills such as scripting are often required for these tasks"
Digital maker	"skills sufficient to build digital technology (typically software development)"

During Stage 1 of the study, pre-service teacher-participants, shown for the entire population in Figure 1 and the intervention sample in Figure 2, displayed broadly similar muggle to maker profiles. Over half (57%) of the population and 52.63% of the intervention sample considered their skills to be like or very like those at the more functional level needed to be digital worker. Only 1% of the entire population and none of the intervention sample perceived themselves to be very like the most digital proficient digital maker descriptor. Both groups were significantly below the predicted minimum 10% ambition of the "Make or Break: The UK's Digital Future" report (Select Committee on Digital Skills, 2015, p. 43), where it was anticipated:

> That almost everyone in the workforce will soon need as a minimum the skills identified in the 'digital citizen' band to do their job. Over half of the workforce will require skills significantly beyond those necessary at the lower level, with at least 10% of them as experts ('digital makers').

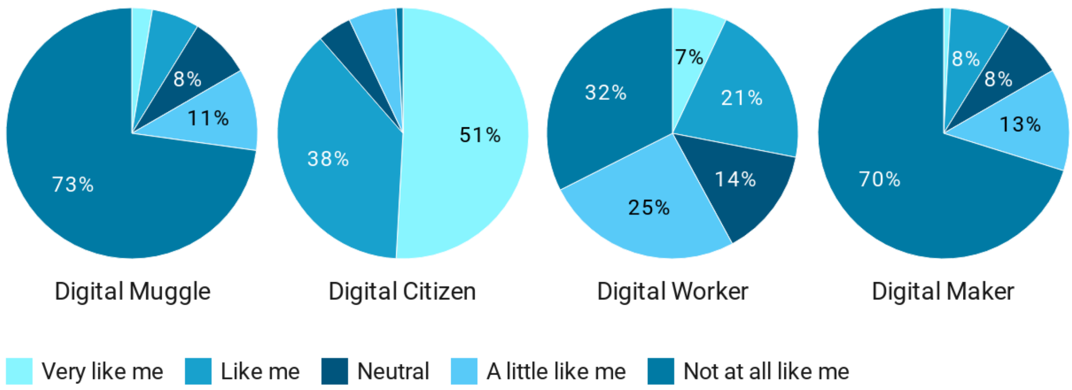

Figure 1. Pre-intervention self-efficacy (entire population)

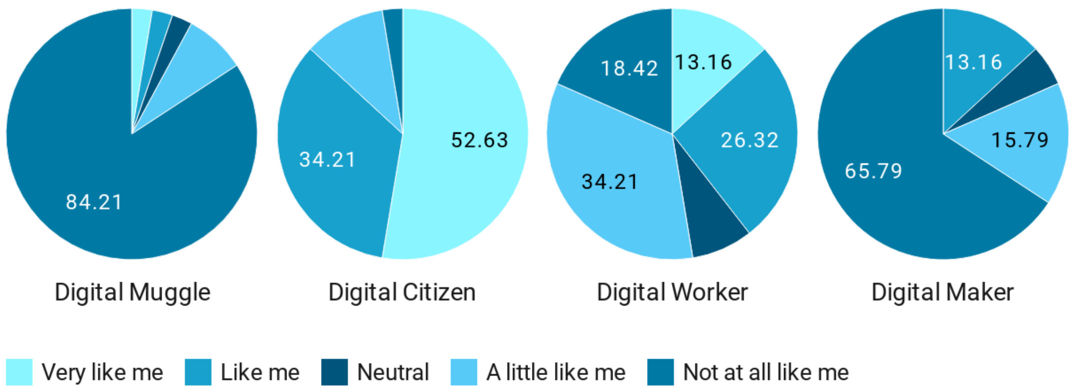

Figure 2. Pre-intervention self-efficacy (intervention sample)

Following the VR experience, pre-service teachers were asked, once again, to consider their likeness to the digital muggle to maker descriptors. A pre- and post-comparison for the intervention group is shown in Figure 3. Most notable is the marked increase in those pre-service teachers identifying as like a digital muggle and like digital maker. Post-intervention, there was a 13.17% increase in those participants identifying to be like muggles (having no digital skills) and a 10.54% increase in those identifying to be like makers (having sufficient skills to build digital technology).

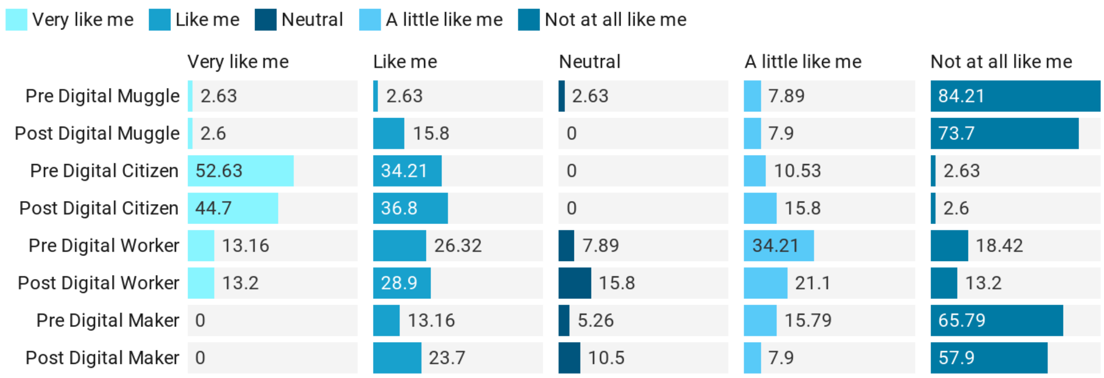

Figure 3. Pre- and post-Intervention self-efficacy comparison

Following the intervention, 100% of participants reported that they were more likely to incorporate innovative uses of ICT into their teaching and to be more adventurous in using ICT to support learning and teaching. Almost every participant (98.4%) also said that not only were they now more curious about the potential of ICT for learning and teaching they were also more likely to take risks with ICT in their teaching. The majority of participants (92.1%) agreed that as a result of the intervention they were more determined to develop their ICT skills, and over two-thirds (71.1%) agreed they would be more confident in using digital technology purposefully in their teaching (28.9% selected a neutral response). Only 10.5% divulged that after the intervention they felt more nervous about using ICT in the classroom, and 13.2% said they were more unsure about the value of ICT in learning and teaching (see Figure 4).

	Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
I1 More likely to incorporate innovative uses of ICT in my teaching	0	0	0	34.2	65.8
I2 More likely to take risks with ICT in my teaching	0	0	2.6	55.3	42.1
I3 More adventurous in using ICT to support learning and teaching	0	0	0	50	50
I4 More curious about the potential of ICT in learning and teaching	0	0	2.6	44.7	52.6
I5 More nervous about using ICT in the Classroom	13.2	50	26.3	7.9	2.6
I6 More unsure about the value of ICT in learning and teaching	13.5	63.2	10.5	5.3	7.9
I7 More confident in using digital technology purposefully in my teaching	0	0	28.9	39.5	31.6
I8 More determined to develop my ICT skills	0	2.6	5.3	52.6	39.5

Figure 4. Potential for sustained impact

After the intervention, the 38 participants were asked again to complete the statement “The one thing preventing me from using VR in my classroom is …”, as before, a number of participants responded with more than one answer (*n* = 35). The most common response related to the cost and funding of equipment and implementation (54.28%). More than one third cited a lack of physical resources such as Wi-Fi or headsets (40%), and over 10% (11.42%) cited school policies on phones, and 11.42% said not having enough know-how and experience and feeling unsure about how to use VR to deliver their subject content. Unreliable technology and Wi-Fi was given as a reason by 5.71%. Participants were also asked to complete another statement again “If I used VR with pupils in my class, the teachers in school would think ….”. As before, a number of participants gave more than one part to their answer (*n* = 34). Over half (55.88%) described other teachers having a positive response, using words such as “progressive”, “advanced”, “interesting”, “exciting”, “impressive”, “inventive”, “valuable” and “creative”. Over a quarter (26.47%) believed they would receive a more negative response; for example, the accusation that VR was a waste of time, a fad, a waste of money and resources. Almost 10% (8.82%) said they thought they would be accused of showing off, trying to be cool, and that the method was not beneficial to learning. Some thought their use of it may make others want to try it (11.76%), 8.82% anticipated a mixed reaction and 2.94% were cautious about any that response they received but hoped it would be positive.

Discussion and conclusion

This study found that pre-service teachers do have an awareness of VR and/or AR technologies and that few reported not knowing about VR and AR. Having an awareness about these technologies, however, did not correspond with participants having had experience using them with limited “playful social” practices (Graham, 2008, p. 10) with VR or AR. Prior to the intervention, fewer than 2% (1.75%) of participants said they used them frequently.

Aligned with the assertions of Di Natale et al. (2020) and Radianti et al. (2020), the post-intervention group recognised the potential of using technology to support learning and teaching and this can be evidenced in several ways. Every participant in this group reported that they were more likely to be adventurous in using ICT and in incorporating innovative uses of ICT in their classroom. Almost every participant (98.4%) said they were curious about the potential of ICT for teaching and learning and that they were more likely to take risks doing so. In addition, the majority (92.1%) of participants post- intervention recognised using ICT as a skill worth investing in, when they revealed feeling more determined to develop their ICT skills.

In the post-intervention group, only 11.42% of participants cited not having the knowledge, experience and feeling unsure about how to teach their subject content as preventing them using VR. It was not because they did not see the potential in utilising this tool. Whilst these participants recognised the potential in using technology in their lessons, they did have concerns – the most common relating to the cost and funding of the equipment required for implementation, followed by a perceived lack of resources and school policies on phones (potential safeguarding concerns).

Post-intervention responses indicated that the intervention had a positive impact on participants' beliefs regarding the use of innovative ICT, their own use of it in their own classrooms and their confidence in using it to support learning and teaching. For example, every participant revealed they were likely to be more innovative and adventurous using ICT to support their teaching. Additionally, over 90% (92.1%) of the same participants saw the benefits of investing in developing their ICT skills. This contrasts with the pre-intervention stage, in which the majority of participants said that VR and AR had a place in schools (87.7%); however, fewer responded that it had a place in their classroom (75.4%). Almost half (49.12%) believed it would be unlikely that VR would be used in their classrooms, and just over one fifth (20.9%) said they were unsure of the likelihood of AR use expected in their classroom.

The brief immersive experience with VR given to pre-service teachers in this study did impact upon their reported levels of self-efficacy regarding digital skills in several ways. Almost three-quarters (71.1%) of participants agreed they felt more confident in using digital technology purposefully in my teaching, not one disagreed with this statement; rather, the remaining 28.9% selected the neutral option. Only a minority (10.5%) reported post-intervention feeling more nervous about using ICT in their classroom. A reduction was noticed in pre-service teachers perceiving that they would receive a negative response from other teachers should they use VR – 37.96% pre-intervention and 26.47% afterwards. Prior to the intervention, the majority (41.46%) of those saying they would receive a negative response believed such a response would be in the form of personal comments about themselves. Post-intervention, only 8.82% of participants said that they expected this to be the case. An explanation for this could be confidence related – that the intervention increased pre-service teachers' confidence about being able to use the technology and about the benefits of using such a method to support a rich pedagogy in schools. As such, this then transformed their pre-intervention thinking from believing they would face negative personal comments for utilising technology and developing their digital skills.

In addition to increasing pre-service teacher's self-efficacy skills, post-intervention, it was highlighted that increased numbers of participants identified as being a muggle(having no digital skills) or a maker(having sufficient skills to build digital technology) (see Great Britain, 2015), signifying that the intervention served as a means through which participants assessed their levels of digital skill. Based on this, such interventions could be of benefit to teachers and their professional development as a means through which to evaluate their level of digital skill and identify an action plan to develop and/or update such skills as appropriate.

This intervention has yielded local impact by positively influencing pre-service teachers' attitudes, awareness and self-efficacy towards VR and/or AR technologies. Participants showed increased curiosity, willingness to explore innovative ICT practices and recognition of the value in developing their digital skills. Future work, where the value of each segment of the VR intervention workshop can be isolated, will help identify those aspects and activities that have returned most impact on attitudes, awareness and self-efficacy. We recommend that a larger and more diverse sample of pre-service teachers be used and further qualitative research methods incorporated to gain deeper insights. Long-term professional learning pathways should be explored to embed VR and/or AR technologies, including curriculum integration, collaborations and ongoing exposure to emerging technologies. These efforts can empower pre-service teachers to become confident and competent technology users, driving positive change in education.

It is apparent that pre-service teachers see VR and/or AR technologies as having value. However, it is reasonable to expect they will likely face the same barriers to implementation faced by other ICTs in schools. These relate mainly to sustained implementation, lack of embedding time and the pace of change in software and hardware development in a context of increasing pressures on teachers in a neoliberally driven results-focused environment for education. Nevertheless, it is apparent that a brief exposure to VR and AR technologies has potential to encourage pre-service teacher to calibrate their self-efficacy regarding digital capabilities and foster positive attitudes and dispositions towards innovation, curiosity and the value of the development of ICT skills.

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