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Virtual Reality in education: supporting new learning experiences by developing self-confidence of Postgraduate Diploma in Education (PGDE) student-teachers

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ABSTRACT

Emerging evidence has demonstrated that Virtual Reality (VR) supported lessons are able to enhance positive emotions and engagement as well as more memorable experiences, when compared to more traditional instructional tools such as readings from textbooks and videos. However, teachers' self-efficacy while teaching with VR technologies, VR safety in the classroom, the need for technical support and costs have been identified as potential obstacles for Pre-Service Teachers (PSTs) who are interested in the effective use of VR in the classroom. This study aims to explore how we may begin to address these obstacles by integrating VR supported lessons in Initial Teacher Education (ITE) courses. The originality of this study lies in the implementation of a short intervention in an already crowded Post graduate Diploma in Education (PGDE) curriculum and in analysing the impact on PSTs' self-confidence as a factor to initiate sustainable development. Participants were 198 PGDE Primary School student-teachers, who attended two-hour VRsupported sessions a week apart in February 2020. Findings suggest that engagement with VR lessons have encouraged participanting PSTs to explore this technology for their future practice across different subjects, impacting positively on their self-confidence.

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Introduction

VR is one of the most studied emerging innovative technologies used in several fields of education such as medical training, military training and architectural design learning (Cipresso et al., 2018), VR applications have gained popularity in education research due to their positive impact on motivation, increased time on-task, memory retention and enjoyment (Kavanagh et al., 2017). According to Allcoat and von Mühlenen (2018), VR supported lessons in Higher Education

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(HE) can enhance self-rated positive emotions, memory/recall skills and increase levels of engagement when compared with those taught using traditional teaching approaches. The increasing and fast-moving development of VR technologies in HE, and in school education (Bond et al., 2020; Granić, 2022), has encouraged researchers to focus on studying the benefits that VR supported lessons and their complementary innovative pedagogies could have on learning (Herodotou et al., 2019). Moreover, the rapid development of VR has, simultaneously, encouraged research on analysing the impact that tutors' and teachers' beliefs in their own abilities could have on the implementation of these innovative pedagogical approaches into technology-supported lessons (Oddone, 2016).

Despite all the benefits that VR could have on learning, it is not yet as widely implemented in classroom practice (Higher Education and Schools of Education alike), as might be expected. According to Kavanagh et al. (2017), there are several external barriers to classroom implementation such as costs, hardware and software usability, and internal barriers such as confidence in teachers' ability to use and create content as well as primary student-teachers' VR Technological Pedagogical and Content Knowledge (TPACK) to consider (Jang et al., 2021). The TPACK refers not only to teachers' VR knowledge, but also to their ability to choose this technology in conjunction with the appropriate pedagogical approaches that could support learning when teaching specific subject content (Fragkaki et al., 2020; Mishra, 2019). However, it is arguable that these barriers are generally the same internal (within any individual) and external (outwith the individual control) barriers that educators would encounter with the implementation of any innovative technology in classroom (Islahi & Nasrin, 2019). In addition, they could be overcome by planning ITE lessons with opportunities to observe, discuss and practice VR in educational situated contexts (Rowston et al., 2021).

However, models of ITE professional learning and evidence of their impact on Pre-Service Teacher (PST)s' follow-up implementation of VR supported lessons are yet to be developed despite evidence that such training is both instrumental and critical for the implementation of VR in the classroom. A study conducted by Yakubova et al. (2021) showed that teachers who are very keen to use VR in their classrooms were mainly those who had access to technical and financial support and received some training or had previous knowledge of how to use this technology. In support of this idea, Jansen (2020) discusses how the pre-existing knowledge of the VR technology and the use of VR in classroom, as well as planning for VR supported lessons, could positively impact on teachers' attitude towards this technology. A positive teachers' attitude could make the difference on how and when using VR in the teaching and learning process might occur (Albirini, 2006).

Considering the need for studies that analyse support provided to PSTs for using VR, this study aimed to deliver a short-term intervention to explore its potential impact on PSTs' confidence and on their learning and teaching practice. More specifically, it aimed to answer the following research question: How a combination of exploration and planning for learning using traditional instructional pedagogies alongside VR supported lessons in the ITE PGDE science courses could impact on PST's learning experience and self-confidence in implementing VR into their regular classroom practice?

This study takes forward Cooper et al. (2019) suggestion that further research is needed into the impact that ITE could have on facilitating and supporting PSTs to integrate VR technology into their teaching strategies. However, it also places this research in the context of an ITE crowded curriculum such as that on the PGDE courses. The PGDE primary science course at the University of Glasgow (UoG), School of Education (SoE), can be an intensive learning experience, covering a wide range of pedagogical theories and approaches. For this reason, we aimed to promote a more manageable short-term intervention which focussed on the impact of VR lessons on PSTs' learning experience and self-confidence as a mean to building on our PSTs' willingness to try this technology in their classrooms and their interest for future professional development.

From knowledge-building to teacher self-confidence

To support the pick-up and implementation of new technologies, a first step is to understand how these technologies work and the types of knowledge they seem to facilitate. VR is an immersive, multisensorial, 3D experience (Gigante, 1993) which preserves the key elements of reality by human perception such as immersion, interactivity and presence (Sherman & Craig, 2019). The direct interaction with the created virtual environment may promote active learning (Allcoat & von Mühlenen, 2018) and positive emotions (Diemer et al., 2015), and it seems to have a particular impact on spatial and mathematical thinking (Macedonia, 2019). The emerging 4Es (Experiencing, Engagement, Equitability, Everywhere) VR Education Model (Cooper & Thong, 2018) illustrates the positive impacts that this technology can have on learners, especially in STEM Education where the visual-spatial representation of concepts is essential and often difficult to reproduce in the classroom compared to textual representations. (Reilly et al., 2017).

In a recent systematic review, Radianti et al. (2020) reviewed the main learning theories that would be compatible with VR. The authors pointed out that VR could support cognitivism learning design through the positive impact it has on analogical thinking and problem solving, as well as constructivism learning design with its strong link to situated learning. Radianti et al. (2020) have also highlighted that declarative knowledge, communication, collaboration, and soft skills development, as well as procedural knowledge are the most recognised forms of knowledge that VR can support, with experiential, situated and game-based learning as some of the most cited learning theories by educators who have used VR in their lessons. However, trying to fit VR supported learning into existing educational paradigms, could be considered more an imaginative exercise than real research into innovative pedagogical approaches which would enhance the VR potential in education (Lege & Bonner, 2020). One of the main issues is to define how VR design features can support students' learning and in what context (Scavarelli et al., 2020). In addition, the wrong choice of hardware and software, as well as the extended use of VR alone during lessons, could cause potential negative psychological, physiological, and emotional impact on learners, with disconnection between the intended learning and the obtained outcomes (Castaneda et al., 2018). Cognitive overload and extraneous load are other important factors to take in consideration with VR supported lessons (Andersen et al., 2016), which could be reduced by integrating VR technology with other instructional strategies from the more traditional to the more innovative. (Sari et al., 2021).

All these considerations are key to ensuring that teachers develop an informed understanding of VR technologies; however, making the leap to creating VR-supported lessons and implementing innovative classroom activities require confidence in one's ability to deploy VR effectively. Given the newness of VR and the issues of access mentioned above, teachers need to be confident that they can explore the pedagogical potential of VR, try out the equipment, and reflect on the types of knowledge and pedagogical approaches that would best be integrated in these learning environments.

While from a pedagogical point of view the research is still limited and a more systematic approach is needed, in this study we aim to build on Cooper et al.'s (2019) work based on teachers' self-efficacy to implement VR supported lessons, but we also aim to offer a different point of view by looking into the development of teachers' self-confidence. We provide an account of confidence below distinguishing it from the notion of self-efficacy. Confidence is considered as the strength of one's belief in the ability to handle something (Uglanova, 2014), as opposed to the strength of certainty and affirmation of capability which is the definition of self-efficacy (Bandura, 1997). We focused on self-confidence because self-efficacy is multifaced and it could be defined as a personality trait that spans in several domains including motivational, cognitive, and affective domains (Cramer et al., 2009), and, more importantly for this study, it could require a lifetime to change (Bandura, 1993). We considered this an issue because, to be able to make a difference on PSTs' confidence to use VR technology, any intervention in ITE should be long enough to impact on PSTs' confidence regarding their capacities to work effectively with VR technology, but also short enough to be fitted in an already crowded demanding course such those on the Post graduate Diploma in Education (PGDE). According to Asrial and Arsil (2020), self-confidence is directly correlated to an individual's attitude towards a specific matter. Moreover, attitude toward innovative tools such as VR could impact on

PSTs' willingness to use them in their practice (Yilmaz & Bayraktar, 2014), which in return could affect their self-efficacy on a long-term (Kent & Giles, 2017).

One could argue that confidence is an initiation point for short terms changes which in return could progressively impact long-term development. Confidence is a multi-layered concept too (Uglanova, 2014), which can be divided in two aspects: General Self-Confidence (GSC), which is a personality trait established since early years and defines one's own perception to be capable and successful; and Specific Self-Confidence (SSC), which is related to the ability to take decision "at hand" (Oney & Uludag, 2013). The latter is a constantly changing emotional state which can be impacted by specific and situated tasks (Axelrod, 2017). The relationship between GSC and SSC is still a matter of research. However, GSC has been considered a sum of several SSC (Suh, 2000). Based on Kanazawa's work (Oney & Uludag, 2013), SSC is part of those specific mechanisms that deal with specific and recurrent circumstances and limited to the context and the ongoing situation. According to Axelrod (2017), our behaviour is affected by both types of self-confidence which can be improved through life experience with the caveat that general self-confidence is mainly involved in unusual circumstances, while specific self-confidence is mainly affected by everyday performance and circumstances. SSC exerts higher levels of effect on the recurrent behaviours than GSC (Oney & Uludag, 2013). Based on this evidence, we explored the PSTs' learning experience with a specific interest in the impact of these lessons on their self-confidence as an aspect that could be improved by research evidence-based, well-designed hands-on lessons in ITE courses. This involves reflections on possible daily implementation of VR alongside with other effective pedagogy strategies in student-teachers' career, as we present in the research design below.

Materials and methods

198 PGDE primary student teachers, enrolled in the class 2019–2020, participated in this study. The process involved a purposive sampling approach where participants were selected deliberately to provide rich information (Palys, 2008). They were all PSTs, and they all attended the PGDE science course on which one of the researchers had a tutor's responsibilities.

The study followed the structure below as we conducted:

(1) An observational study of several VR supported lessons delivered at a school in Edinburgh, with the objective to inform the experimental design (Carlson & Morrison, 2009) of the current study.

(2) A series of professional conversations were carried out with several experts from the Edinburgh school, including the Head of eLearning and the classroom teacher who had already implemented VR in several subjects for some time.

(3) A risk assessment phase was carried out in collaboration with Scottish Schools' Education Research Centre (SSERC, 2020) to identify specific safety recommendations.

(4) Participants engaged in a two-phase intervention:

Phase 1: *Exploration and learning*. Several ideas of active learning strategies on the topic of Body System (Education Scotland, 2022) were explored by student-teachers to better understand benefits and disadvantages of different pedagogical strategies, from more traditional such as peak flow meters and body organ aprons and body systems models, to more innovative such as AR T-shirt Virtuali Tee and VR technology, ClassVR®, Avantis Education, with an immersive virtual tour of the human body.

Phase 2: *Microteaching*

PGDE primary student-teachers worked in small groups. They were randomly assigned to a set of instructional tools (from traditional to innovative), and they had to plan a micro-teaching cooperative lesson (Stahl et al., 2016) using this equipment. To provide a real context of classrooms (Scavarelli et al., 2020), children from a local school attending year P6 (age 9–10 years old, as per Scottish education system) were invited to visit the School of Education in the University and be "pupils for a day."

All participants had the chance to explore and learn about VR as an instructional educational tool in phase 1 but only 50 participants (i.e, 25% randomly selected) had the opportunity to plan a microteaching lesson supported by VR technology in phase 2, while the other participants planned their phase 2 microteaching supported by other more traditional instructional tools such as books and body organ aprons. A video showing the dynamics of the intervention has been published on the University of Glasgow, School of Education YouTube channel and available in this article as figshare file (https://doi.org/10.6084/m9.figshare.16641109.v3). Data was collected using a mixed method approach and an online modified version of the Cooper et al. (2019) survey. The quantitative and qualitative data were based respectively on a series of Likert scale questions, and open-ended questions to enrich the quantitative data with participants' opinions. A total of 34 responses (i.e, 17% of the total) were received. Within the 34 respondents to the survey, 24 (70%) (group A) specified that they had the chance to explore, learn and microteach using VR supported lessons, while 10 of them (30%) had only experienced VR on phase 1 (exploration and learning) (group B). Quantitative data have been analysed by exploring the percentage of answers of group A versus group B. While qualitative data have been thematically analysed following a general inductive approach (Thomas, 2006), demographic and background qualification data have been collected. These data are not shown, but they have been analysed to set up the general study context with a strong prevalence of females (30) vs. males (4), with 68% in the age range between 25–44 years old and 68% without a STEM background. ***Ethical Clearance:*** Ethical approval was sought and granted by the University of Glasgow College of Social Sciences ethics committee.

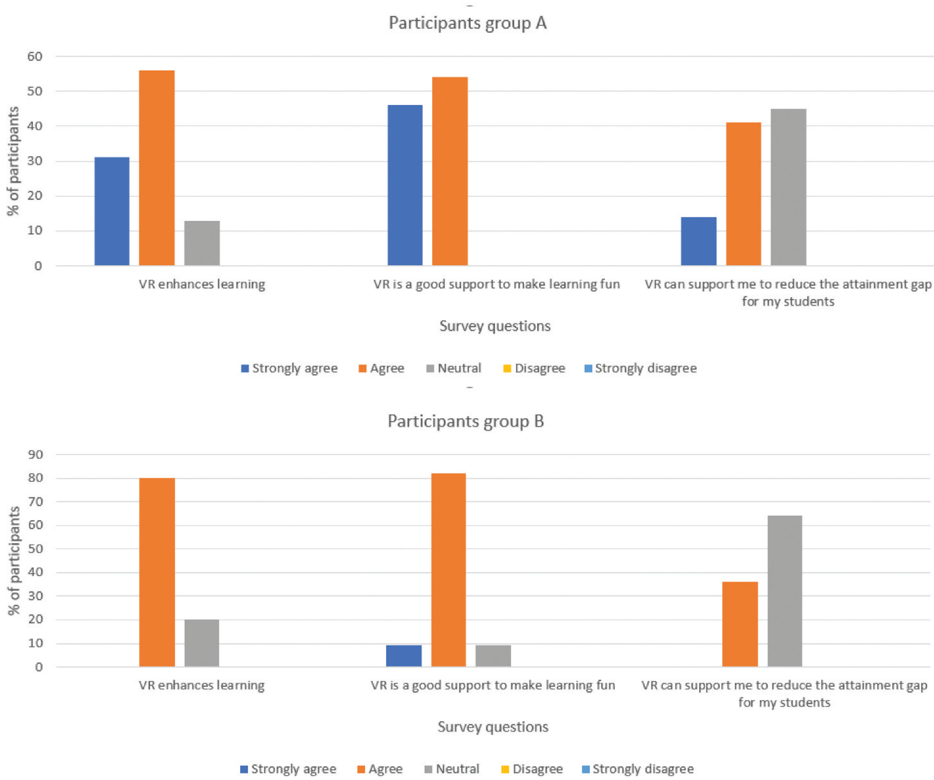

Figure 1. Participants' answers in relation to their general opinion on VR pedagogical potential

Results

VR's pedagogical potential: enhanced engagement and boundless learning

Figure 1 shows that 87% of group A (who participated in phase 1 and 2 of the intervention) agreed or strongly agreed that VR enhances learning compared to a total of 80% of group B (who participated only in phase 1).[1] 100% of group A compared to 91% of group B agreed that VR is a good tool to make learning fun. 55% of participants in group A agreed or strongly agreed that VR can help to reduce the attainment gap compared to the 36% of group B. Participants were asked to explain their answers.

The open-ended responses confirmed PSTs' positive attitudes and beliefs in the potential of VR for engaging learners in interactive learning:

> The opportunities to explore new places and things are endless. They can engage children and make them feel as though they are outwith the boundaries of the classroom.

> They also learn in a different way, they are able to see things I'm (sic) a more realistic way and see things they have never seen before.

> It has the ability to spark and capture their interest. If we can capture their interest they will want to learn.

Participants' observations around the potential benefits of VR ranged from identifying this approach to learning as "exciting", "fun", "immersive" and capable of bringing learning "to life". Such attributes are common in descriptions of VR in educational contexts (Cooper et al., 2019; Kavanagh et al., 2017). It was interesting, though, to note the richness of benefits that student-teachers could see even with such a short introduction to VR and their excitement for implementing these technologies in their future classrooms across the curriculum:

> In my placements to date, there has been little focus on science and technology in school. I would be willing to extend this and be mindful of different ways technology could be brought in to cross curricular activities, because I believe working using cross curricular methods to be most engaging for pupils.

Some PSTs could see themselves using VR as a tool to engage learners with knowledge of science and technology. At the same time, VR as a technology seemed to offer "cross curricular methods" of delivering the content which learners would find motivating and interesting to learn with.

While our data shows a general willingness to explore VR as a way to enhance pupils' learning, a few participants also showed hesitation:

> I really want to use technology but need to read about it/talk about it/understand what it is for and what it can be used for first of all. Once I know all this then I can plan how to access it and how to incorporate it into lessons.

As we further explored our participants' responses, we were able to link this hesitation not only to the lack of sufficient knowledge about VR (which could be considered an internal barrier), but also to a set of significant external barriers that made teachers question their readiness and confidence in their ability to implement VR in their future classes. This data will be discussed in the next section.

PSTs' perception of external barriers to the implementation of VR supported lessons

Figure 2 shows that while WiFi access, classroom management and other colleagues' opinions might not be an issue, technical support and costs have been the most rated barriers followed by risks related to VR supported lessons from both groups. Teachers' explanation of their answers offers a deeper insight on their opinions:

> Probably due to lack of knowledge around technology and a bit of fear around it as I can be slow at to pick some technical stuff up so avoid it at times.

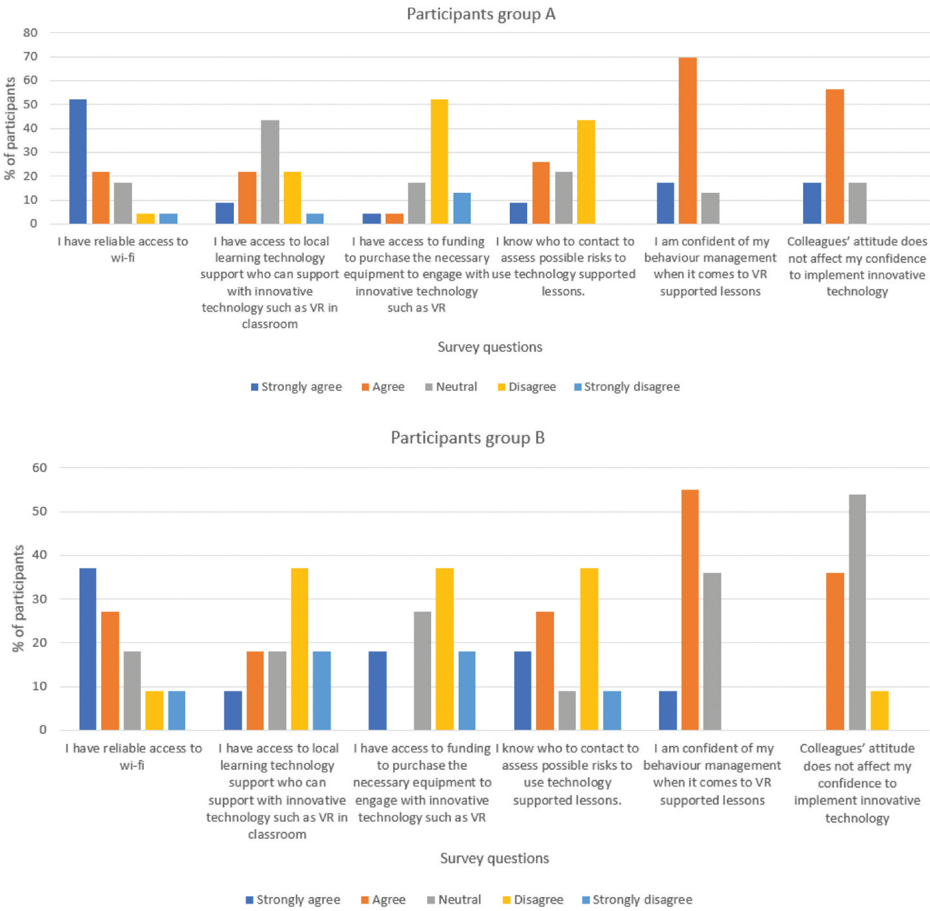

Figure 2. Participants' answers in relation to potential external barriers to VR.

PSTs' concerns with the cost of the equipment was linked to the effectiveness of VR:

> New technology interests me and I see its worth however the issues around the cost of equipment and the potential of investing in the wrong technology concerns me (eg, VHS vs Beetamax)

To invest in VR, as some of the student-teachers noted, demands evidence that clearly demonstrates that such an investment is proportionate with the gains and learning outcomes. Without opportunities to explore and determine if VR is the "right" learning technology to bring into the classroom, which our course aimed to provide, student-teachers seemed less likely to move towards implementing it even though they may be open to try out new technologies.

The survey data (Figures 2 and 3) also indicates that, after student-teachers have taken the course, confidence in trying to work with VR-based lessons is no longer a significant barrier to the implementation of VR-based lessons. While participants' access to funding to purchase VR equipment and contact with specialists who can support the implementation of VR in their classrooms remain

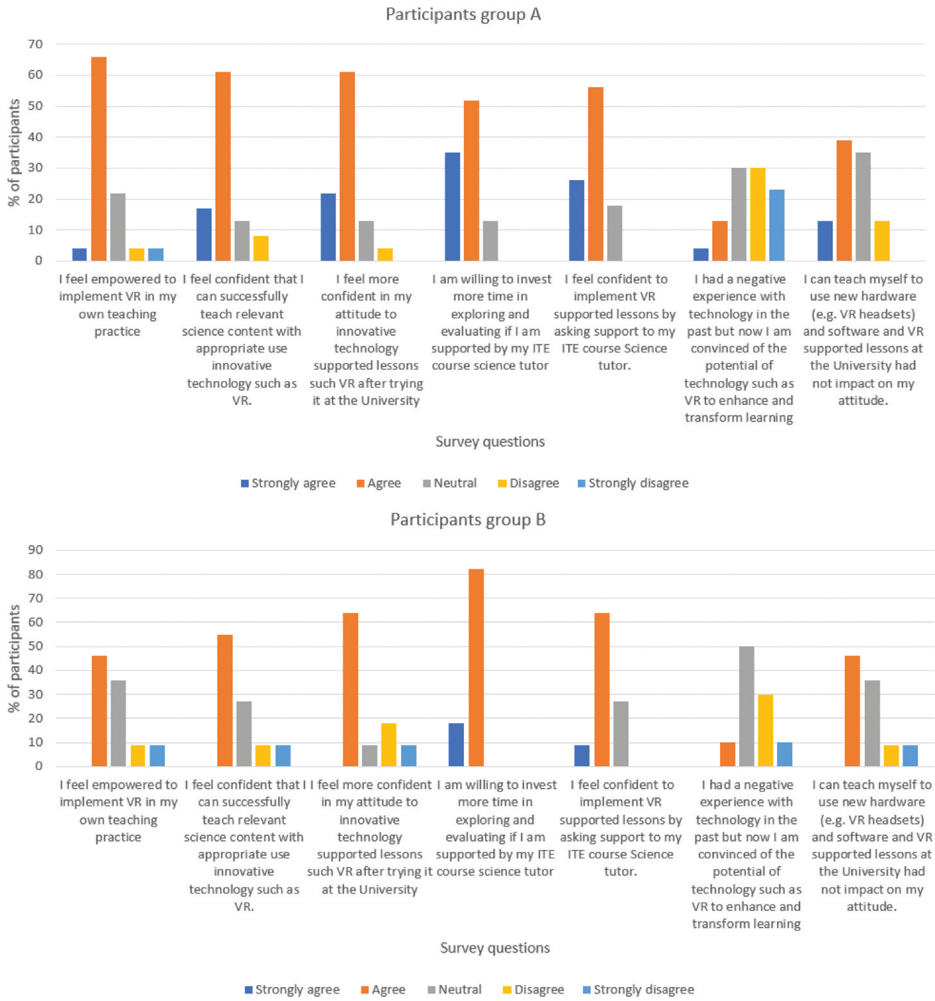

Figure 3. Participants' answers on their confidence in their ability to implement VR in teaching.

important external barriers, the exploration of VR-based lessons in the PGDE programme enabled teachers to boost their confidence (also see next section).

However, the open-ended questions of the survey also reveal that such confidence is sometimes constrained by the multiple demands on teachers' schedules and their prior knowledge of how to integrate these technologies into an already heavily packed curriculum:

> I understand the need to use technology and have done throughout placements. My main downfall is the pace that it changes and that educators deliver training from an assumed stance that people are familiar with many aspects of the technological world.

> I enjoy using technology, however, as a student teaching with so many other thoughts and implications filling my mind, I have found trying new technologies in the classroom daunting.

Our participants indicated that they need more time for practice and reflection, and, with the fast-paced life of a school, some feared that the VR-based lessons might potentially "reduce the effectiveness of 'ordinary' teaching".

Teachers' confidence in their ability to implement VR in their teaching

Decisions regarding the uptake of VR-based lessons rely on weighing the benefits for learning against the perceived barriers to implementing VR. Phase 1 and 2 of the project gave teachers opportunities to explore these aspects and to determine the extent to which they might be interested in developing VR lessons with their learners. Such decisions were also determined by the level of teachers' self-confidence which, as our findings show, has improved throughout the course. In Figure 3 participants were asked how they felt after exploring and using VR in their ITE science course. Interestingly, those who explored and planned the microteaching VR supported lessons mostly agreed or strongly agreed that they felt empowered to implement VR in their practice, they felt confident that they could successfully use VR technology, and most of all they felt more confident after trying VR at the University. They would be willing to invest more time to engage with this technology and would feel confident to use it by asking support from their ITE tutor.

Although working with VR has been a new and "daunting" experience for the majority of our PSTs, the participants were able to see that the threshold of learning how to use it is manageable and their confidence in using the technology beyond this course increased:

> The experience of using VR doing the micro teaching lesson was valuable to my teaching as it gave me a hands on experience of using such resources in a real life situation.

> I will usually adopt an innovation after seeing it in use first. This way I can make sure I fully understand how to use it.

> Using this form of technology in the ITE course has provided me with the confidence to continue to implement and utilise it throughout my learning and teaching. I still feel like I would need a bit more guidance but it has encouraged me to try new and exciting things that are growing in a fast paced society.

Given the newness of VR as a technology for learning, teachers' confidence also seemed to be dependent on the provision of support and further learning and practice opportunities beyond the intervention in this study:

> This course has increased my confidence, but I will need to continue to explore more.

> I like to wait and have a play about with the technology. This way I can ensure I've learned about it before introducing to the children.

Future directions based on lessons learned

Oftentimes, the certainty of learning and implementing a new approach, strategy or digital technology cannot rely only on the teachers' enthusiasm and own opinion on the new tool, but it comes after repeated encounters, consolidated knowledge, confidence in one's ability to implement it well in the classroom and pedagogical reasoning (Greener & Wakefield, 2015). However, according to Digirolamo and Hintzman (1997) 'the encoding of a repeated object is biased toward the attributes of its first presentation'(p. 1); in other words, the first encounter and impression of any experience will impact one's memory for a long time. In line with this evidence, our study demonstrated that it is very important to pay attention to the impact of the first encounters with a new digital technology (in this case VR). VR supported lessons at ITE could facilitate an easier first impression of this technology, with any issue easily overcome due to the tutors' support impacting positively on the participants' willingness to use this technology in the log-term future (Nourani et al., 2020). The exploration of this aspect helped us to contribute to the understanding of how PSTs' move from feeling hesitant and uncertain about the educational place of VR to feeling confident that they can make informed decisions and follow up on further opportunities to use VR in their lessons.

A short intervention as the one we piloted in our PGDE programme has shown us the enthusiasm and richness of PSTs' responses when given the opportunity to explore VR, to understand its educational potential in context (via the planning of the microteaching), and to potentially seek new opportunities for consolidating their VR knowledge and practice. To determine long-term impact, we would need to take a longitudinal view and see how PSTs' attitudes, confidence level and classroom practice change through time and space. At the same time, PSTs realise that new digital practices are necessary for a teacher's toolkit as the educational system needs to keep up with new developments and the unforeseeable ways that innovative technology could shape children's future (McDiarmid & Zhao (赵勇), 2022), and their current ways of building knowledge.

> Children are so immersed in technology that to have them in classrooms that have not changed significantly this century is a shame on our education system. Pupils need to be inspired and VR and other new tech is vital to their engagement and future.

A long-term view could also confirm the benefits and barriers that PSTs were able to identify during our short-term intervention. Feedback from student-teachers seemed to be driven by the generally positive "first impression" of VR, intentionally directed in this study to educational uses of this innovative technology, as opposed to incidentally forming impressions, to create a more memorable experience (Gilron & Gutchess, 2012). Participants were able to contextualise VR experiences within their pre-existent knowledge and experience of teaching practice as well as their future career. They wished for more opportunities to engage with VR while supported by university tutors:

> It would be interesting to see if there would be any courses related to implementing such technology into areas in the curriculum which I would definitely attend. This would be great to go to and impart learned knowledge amongst other teachers. By getting more comfortable with the use of the VR in the micro teaching sessions, it has made me more open to trying new things. I thoroughly enjoyed using it as it is something that children would find engaging, given that some adults really enjoy it too!

While this study provides key insights into teachers' first responses to VR, follow-up research could focus on more Technological and Pedagogical Content Knowledge learning experience. Yet, to continue the professional explorations of VR, PSTs need to feel confident that they are able to engage with these technologies and have a clear starting pathway which our short intervention enabled. At the end of the course, student-teachers knew more clearly how to approach VR- supported lessons and, even if VR as a space for learning may still be "daunting", our participants seemed to have crossed that potential threshold of pedagogical concepts that would allow them to move further in exploring VR pedagogical potential (Meyer & Land, 2003).

Listening to our participants, as researchers we also have important work to build forward. PSTs believe in the value of evidence-based approaches to learning and are seeking proof, so they are able to make informed decisions about their time invested in learning new digital technologies. For these reasons, researchers need to continue and explore VR-born educational approaches, terminologies that best support learning in VR and practices that are suitable for this medium. While we have looked at the compatibility between existent learning theories and VR-supported environments (Radianti et al., 2020), researchers will have to continue to investigate how to make the most of the features of VR environments and the types of experiences they enable. This requires that we work with teachers and students to best understand how to deploy VR-based lessons and to push our own terms, theories, and approaches beyond our current knowledge thresholds.

Note

1. We present data in relation to each of the two groups of participants not to make any strong claims of differentiation between the two, but to indicate patterns in the responses of our participants who had the experience to explore the potential of VR with and without the planning of a lesson.

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Disclosure statement

No potential conflict of interest was reported by the author(s).

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