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Virtual Reality as the Catalyst for a Novel Partnership Model in Initial Teacher Education: ITE Subject Methods Tutors' Perspectives on the Island of Ireland

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Abstract: This small-scale study explores the attitudes of fifty initial teacher education (ITE) subject methods tutors towards the use of virtual reality (VR) in education and considers whether VR could be a catalyst for reviewing the partnership model within ITE programmes. In addition, this study offers a novel solution to ITE tutors' challenges when managing their own technological and pedagogical development alongside preparing student teachers for technology-enhanced learning (TEL). Building on previous research on ITE tutors' use of TEL across the island of Ireland, this paper discusses the synergy between the cognitive apprenticeship model and reverse mentoring that upends the classic co-operating teacher/student teacher hierarchy and positions all partners in ITE programmes as learning leaders at key points in the partnership process. An online survey comprising 51 items was administered to a purposive sample of 50 ITE tutors from four ITE providers, two in Ireland and two in Northern Ireland (NI), who were selected due to their developing interest in the use of virtual reality in teacher education. Data analysis using SPSS combined with thematic analysis of open-ended responses revealed that although the majority of ITE subject methods tutors conveyed open-minded and willing attitudes to embrace VR in the future, they identified a number of systemic issues that need to be addressed first. These include the disconnect between innovative pedagogical practices presented in university-based modules and the stark reality of technological deficits in some classrooms; the pedagogical and resource-based 'readiness' of ITE tutors to embed VR in their subject-specific teaching; and the need for curriculum-focused, VR resources for school-based use. As a result of this study, an incremental, cyclical approach to growing the body of knowledge around VR pedagogy is proposed in conjunction with new forms of collaboration between the partners in ITE.

Keywords: teacher education; virtual reality; reverse mentoring; cognitive apprenticeship; pre-service teachers

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1. Introduction

For over two decades, research has revealed concerns about pre-service (or initial teacher education) course preparation to use technology effectively in the classroom. A study by Koehler and Mishra [1] found that pre-service teachers often lack the necessary knowledge and skills to integrate technology effectively into their teaching while Chen and Lin [2] revealed low levels of student teacher confidence and motivation to use technology in their teaching. Building on previous research focusing on initial teacher education (ITE) tutors' use of technology in teaching [3,4] across the island of Ireland, and to model effective practice for professional development partnerships between ITE tutors and student teachers, this research aims to examine ITE subject methods tutors' attitudes towards virtual reality (VR) in an ever-evolving technological environment. This study explores if VR could be a catalyst to reviewing the partnership model within ITE programmes in addition to providing a solution to ITE tutors' challenges when managing their own technological and pedagogical development alongside preparing student teachers to infuse their practice with technology-enhanced learning (TEL).

1.1. The Role of the ITE Subject Methods Tutor

Many studies over the past two decades have found that teacher educator instructors (also called ITE subject methods tutors) are critical factors in technology learning especially regarding the important part that they play as technology role models for pre-service teachers [5,6]. Goktas, Yildirim and Yildirim [7] assert that teacher educator instructors' competency and willingness to use technologies in teaching will enhance their lessons in the technology-integration process while demonstrating leading practices for pre-service teachers. Admiraal et al. [8] suggest that novice teachers need role models for technology integration on two levels: firstly, teacher educators modelling how technology can be used effectively in subject teaching and secondly, co-operating teachers in schools acting as role models and mentors for pre-service teachers by integrating technology in their subject teaching. The symbiotic relationship between the ideal context and the reality of the classroom strengthens student teachers' ability to reflect in-action during the lesson and to adapt to changing circumstances as well as reflecting on-action [9] post-lesson to determine the effectiveness of their teaching. Classical models of mentoring [10] involve the experienced teacher providing advice and guidance to the student teacher placed in their department either as formal or informal feedback or modelling good practice leading to cascade mentoring. This concept of mentoring the novice teacher, however, faced a major challenge during the COVID-19 lockdown when teaching pivoted to online inside a few weeks.

A study by Farrell [11] highlighted the added value that student teachers brought to the school placement setting during the swift move to remote teaching during this time. The pandemic spawned the development of responsive pedagogy and 'adaptive expertise' [12] amongst student teachers who were willing and enthusiastic about experimenting in practice with novel digital technology approaches that they learned in the university setting. They conveyed little concern about failing in practice implementation at this time due to their novice status and the unprecedented times giving rise to an opportunity for them to give something back to the placement school by being leaders in remote teaching. Consequentially, student teachers' use of technology during the COVID-19 lockdown "upended the classic co-operating teacher/student teacher hierarchy" [13] and positioned them as mentors or 'learning leaders' [14,15] supporting the experienced teachers in schools as the latter transitioned to the new pedagogies associated with online teaching. Hence, the state of reverse mentoring was born in many schools hosting student teachers. As Zauchner-Studnicka [16] states, in reverse mentoring, an understanding of interpersonal relations being characterised by a shape of apprenticeship or hierarchy no longer fits. Instead, it turns to reciprocity as both mentor and mentee take advantage of the mentoring relation (p. 546).

However, while student teachers have demonstrated reverse mentoring in digital technology during their school placement experience, student teachers' acquisition of 'professional competence' [17] requires collaboration with university lecturers and co-operating teachers to apply meaningfully learned knowledge and skills to their on-going school placement practice and development as a teacher. The expertise that student teachers can offer schools in relation to their digital competence along with the expertise that ITE subject methods tutors and co-operating teachers can offer student teachers regarding pedagogical content knowledge (PCK) [18] exemplifies socially constructivist learning and can be the spark to ignite collaborative and reflective practice at a whole school level [13] and help bridge the perennial theory/practice divide in initial teacher education [19,20]. Moreover, according to Martin [21], many teacher educators who are interested in effective technology application into classroom practice and teacher education programmes have adopted the TPACK framework (Technological Pedagogical Content Knowledge) [22]. TPACK is based on the work of Shulman [18] who asserts that at a subject level, pedagogy, content and knowledge (PCK) must be blended for successful teaching approaches. Rather than providing information on subject content and knowledge independently, Shulman demonstrated depth in the overlap between the two concepts. To address a growing need for guidance in technology integration, at the core of TPACK, technology, pedagogy and content combine to illustrate the optimum goal of a technology infused curricula. In Figure 1, the intersection of all three concepts at the core of TPACK clearly articulates the utopian goal for both classroom teachers and higher education instructors [21] involved in ITE programmes.

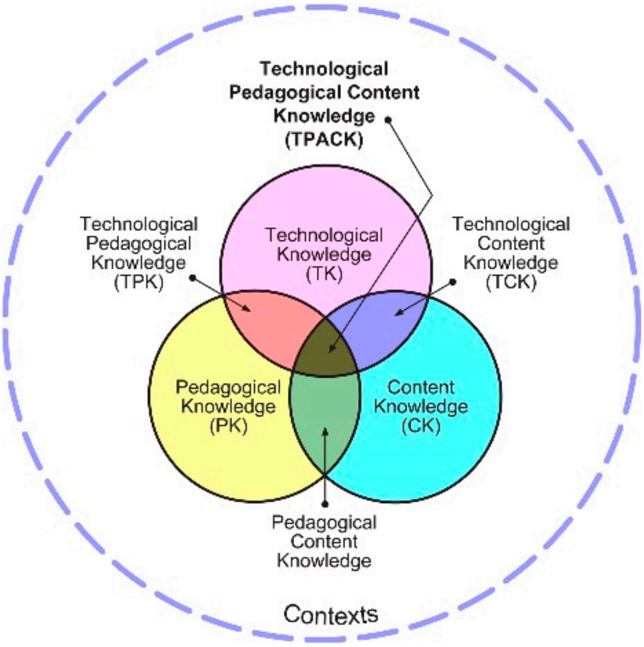

Figure 1. TPACK framework [23] (Source: http://tpack.org, accessed on 13 February 2023).

1.2. Mentoring and Cognitive Apprenticeship

Not all teachers are effective mentors of student teachers as it is widely accepted that at least four key elements of mentoring exist. Firstly, an awareness of the context-dependent nature of teaching including cultural conditions, curricular goals and classroom management approaches, all of which comes with practice and is often tacit knowledge not easily verbalised by teachers. Secondly, matching mentees and mentors to establish an effective quality relationship [24,25] promoting honesty, mutual trust and respect. The third feature is mentor training to ensure a supportive, facilitative approach to mentoring at all times. The fourth element focuses on the duration and frequency of the mentoring. At the heart of effective mentoring is the co-construction of knowledge promoted through the social negotiation process of the reciprocal relationship. The dual process of demonstration and dialogic pedagogy is supported by the cognitive apprenticeship model [26] in Figure 2 which formed the framework for the professional development of ITE tutors, student teachers and co-operating teachers who were learning to use virtual reality as a tool for teaching and learning as part of this initiative.

The cognitive apprenticeship model (*Ibid*) focuses on cognitive and metacognitive skills and processes. The four dimensions of this model are context, methods, sequence, and sociology. The context refers to the application of the skills to a realistic problem and in this case:

- Modelling the use of virtual reality (VR) in the classroom;
- Methods are the coaching and mentoring by the expert (1–3);
- Self-monitoring and correction by the novice (4–6);
- Sequencing reflects the changing demands of the learning including complexity and diversity;

- Sociology addresses the culture or community and the setting in which the expertise is situated.

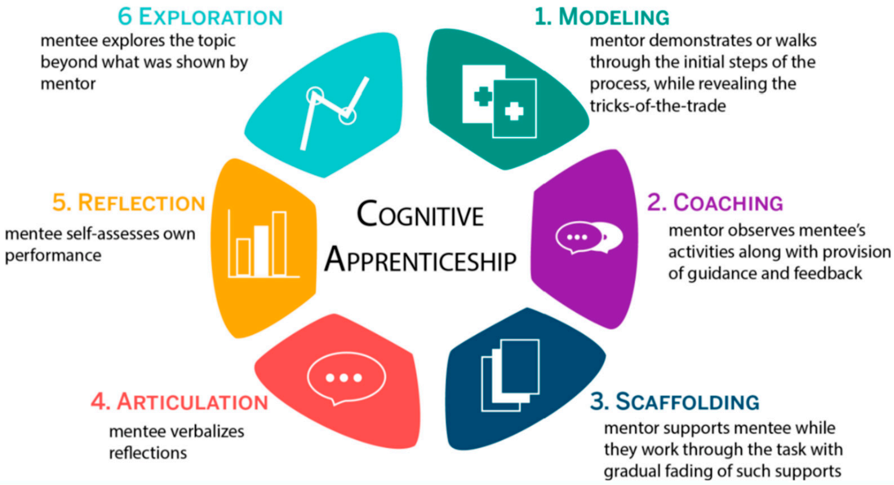

Figure 2. Cognitive apprenticeship model. Source: [26].

Using this model, ITE subject methods tutors who are adept in using VR for teaching and learning can highlight where VR is relevant to the learning process across a range of curricular areas. Student teachers, as apprentices, working alongside relevant ITE subject methods tutors may design and create their own VR Reusable Learning Objects (RLOs) enhanced by information hotspots, annotations, quizzes, sound, imagery and video to take into school placement. Where classroom-based co-operating teachers have little knowledge of VR they assume the role of novice (in the use of the technology) while the student teacher emerges as the VR technology expert in the role of 'reverse mentor' developing the co-operating teachers' technological pedagogical content knowledge [27]. As a result, the use of VR acts as a catalyst for the student teacher and co-operating teacher to experience a combination of cognitive apprenticeship and reverse mentoring as they learn from each other and gain experience of the new pedagogies associated with VR in the classroom. However, developing effective teaching practices with VR that are informed by relevant learning theories and taxonomies of learning is crucial to the modelling, coaching, and scaffolding stages of the cognitive apprenticeship model and this will be dealt with in the next section.

1.3. Virtual Reality as an Opportunity for New Pedagogical Approaches

VR is just one in a long history of technological innovations attempting to find its place in the digital classroom. First developed in the 1960s, VR is increasingly used in education and training worldwide from teaching mathematical concepts (e.g. [28,29]), to learning about thermodynamics [30], to enhancing writing skills of pupils with English as an Additional Language (EAL) [31], as an intervention tool for pupils with autism [32], as an assessment tool for pupils with ADHD [20] and as an effective tool for demonstrating vocational skills [33].

However, previous research on educational uses of virtual reality has pointed to the lack of relevant learning theory informing the pedagogical use of VR in educational settings [34]. Moreover, Mikropoulos and Natsis [35] assert that no technology produces learning in and of itself, but only as a part of "carefully designed learning activities" and teachers need to be cognisant of the fact that these "are more important than an exotic interface that contributes to intuitive interaction" (p. 774). Therefore, integrating VR resources into the taxonomies of teaching, is a key skill for ITE subject methods tutors, co-operating teachers and student teachers alike. Evaluating which learning activities suit the provision of virtual reality-based resources, and which learning theories would support these are important considerations in the use of VR in education.

According to Jonassen [36], learning in the form of an active process in which the learner uses sensory input (such as VR) and constructs meaning from it is more likely to engage the learner in meaningful learning. This aligns with the constructivist learning theories espoused by Dewey [37], Piaget and Cook [38] and Vygotsky [39]. Constructivist learning theory is founded on the principle that learning is a dynamic process, where, through several supportive devices (environment—both physical and social, information, scaffolding, etc.) learners cultivate connections with their prior knowledge and previous experiences and build on or 'construct' new knowledge, skills and attitudes. VR has allowed for students to gain cognitive skills by way of experiential learning, such as exposing them to environments that would be too logistically problematic to visit in reality [40]. Building on the theory of constructivism, the concept of constructionism emerged during the 1980s when Papert [41] asserted that technology, together with the constructivist learning approach, created opportunities for learners to construct new knowledge and innovative ways of thinking. For Papert, it was important to visualise the process of knowledge construction, thus allowing for a more engaging experience. Constructivism and constructionism are complementary learning theories that are important to understand when designing VR experiences in education. Constructivism stresses the cognitive potential of VR in learning, whereas constructionism stresses the potential of the use technology and the physical activity associated with VR in learning [42].

Shin [43] asserts that as virtual reality becomes increasingly mainstream in education, the role of affordances in virtual environments becomes an important consideration. He contends that the heuristic role of presence and immersion affordance regarding VR's underlying link to educational affordances, such as empathy and embodied cognition, infers the personified thought process of VR learning environments in which technological qualities are shaped by users' discernment and setting. This aligns with the Emotional Learning (EL) that is related to one of the three domains (cognitive, affective and psychomotor) identified in Bloom's taxonomy of learning [44]. According to Bloom, the affective domain focuses on the attitudes, values, interests, and appreciation of learners in response to receiving information in various formats and leads to classification and internalising of feelings, emotions, values and beliefs and acting upon them. Moreover, the affective learning domain involves making use of our emotions during the learning process and harnessing this as we progress from a low order process, such as listening, to a higher order process, such as solving a problem. In their seminal research Krathwohl, Bloom and Masia [45] laid the foundation for the role of the affective domain in education. In the 21st century, the use of virtual reality in harnessing the affective domain for learning is a growing area of research especially around environmental science [46]. For example, a study by Bailey et al. [47] found that the impact of vivid and personalised messages in VR on energy-saving behaviour related to hot water use, was the most effective in promoting pro-environmental behaviours. A study by Tudor et al. [48] found that students were more aware of local environmental issues and motivated to act with the use of a mobile VR application than the traditional physical field trip. However, a meta-analysis of the use of VR in building empathy by Martingano, Hererra and Konrath [49] found that VR was better at eliciting emotional empathy (the ability to feel what another person feels) but not as effective at activating cognitive empathy (an ability to understand how another person feels) or empathetic concern (compassion and the ability to sense what another person needs from you). They assert that creators of VR learning experiences could increase cognitive empathy and empathetic concern by integrating explicit cognitive interventions into the VR experience as choice-points or augment existing experiences with narrator prompts, e.g., requiring learners to predict what they might do next or explain why they acted as they did during the VR immersive learning experience.

A systematic literature review of VR as a pedagogical tool to enhance experiential learning undertaken by Asad et al. [50] has synthesised and analysed the growing number of studies on the use of VR in education. These studies have highlighted promising findings including improved time on-task, satisfaction, inspiration and long-termcommitment [51–53].

Some experimental studies demonstrated the effectiveness of simulative and immersive devices in fostering cognitive learning skills, which require a high level of visualisation and awareness of experiences. An example of this is the modelling and interaction of DNA strands in a virtual setting that led to better learning outcomes than traditional instruction approaches such as lectures [54]. Allcoat et al. [55] found that when it came to recalling information, immersive virtual reality as a pedagogical tool outperformed video or textbook instruction, but this did not hold when interpreting the content. Furthermore, several surveys have shown that virtual reality enables students to enjoy the process of learning even in distance learning programs [56]. Mado et al. [57] also discovered VR to be an effective tool for pupil engagement in learning during remote learning due to the COVID-19 pandemic.

Cooper and Thong [58] consider four key aspects of educational VR namely, experiencing, engagement, equitability, and everywhere. Using VR headsets, the learners can assume different perspectives and gain an insight of the learning experience "by viewing through the eyes of their digital identity" [to engage with] "the process of building mental models by . . . immers[ing] themselves in the phenomenon" being studied (p. 67). While this immersive experience enhances engagement and time committed to the learning activity [59] it also offers equity of opportunity as the headsets can be worn anytime and anywhere. Due to its pervasiveness, Cooper and Thong [58] assert that VR has "the potential to totally transform teaching and learning (and daily life for many)" (p. 70). However, they also highlight "teacher self-efficacy, professional development opportunities, school leadership priorities, and the amount of access to VR in school" as potential inhibitors to the integration of technology into the classroom. This is further compounded by schools' policies on the use of mobile phones in the classroom combined with society's perception of the role of VR as an acceptable tool for learning (p. 71). Moreover, they declare that "the implementation of virtual and mixed realities may be a considerable pedagogical shift for many in-service teachers" (p. 70) making it all the more important to introduce these technologies as an integral part of ITE courses.

The affordances of VR to learning [43] could be lost if teachers across the continuum of education are not supported in their professional development or if school leaders do not support its uptake. Li et al. [60] found that the innovative integration of VR technology and educational teaching requires rational instructional design and the creation of a diverse, flexible, and effective support system and educational ecosystem for VR-based teaching. Du et al. [61] also assert that educational ecosystem support is likely to be an important factor influencing teachers' continuous usage intention for VR technology. A good place for this support to start is in initial teacher education. ITE subject methods tutors who are early adapters of innovative digital pedagogy can foster a cyclical model of professional learning in the use of VR and promote the use of VR technology in teaching, learning and assessment [62]. As Tondeur et al. [63] advocate, ITE tutors have a responsibility to act as role models when using new technologies as they have a significant influence on student teachers' future use of technology in the classroom. But how can ITE tutors support the co-operating teachers in schools hosting their student teachers? The partnership model of ITE programmes plays an important role in connecting universities with the host schools and teachers via the student teacher. By utilising the existing partnerships with schools, it is possible that ITE providers can disseminate professional development to experienced teachers using reverse mentoring. This paper aims to investigate the possibility of this novel partnership model and ITE subject methods tutors' readiness to use VR in this context.

2. Methodology

With the emergence of new technologies such as VR, which require a notable pedagogical shift based on the immersive nature of its use, it is imperative that ITE subject methods tutors are well positioned to scaffold student teachers in making a smooth transition into this more challenging context of teaching effectively with immersive experiences.

2.1. Participants

A purposive sample of four ITE providers, two from Northern Ireland and two from Ireland, were selected due to their developing interest in the use of virtual reality in teacher education. Providers of Primary ITE courses and/or ITE programmes that were not considering the use of VR were excluded.

A total of 50 responses were received from the cohort of ITE subject methods tutors that were targeted with the online survey, with 70% female responses and 30% male responses. Over three-quarters (78%) of the responses were from Ireland, with the remaining 22% of responses from NI. A wide range of subject areas were represented in the replies including English, History, Geography, Science, Mathematics, Music and Languages. As a result, the perspectives of the majority of ITE subject methods tutors are present in the findings. It should be noted, however, that one subject methods tutor may be responsible for more than one subject.

2.2. Materials

An online survey comprising six biographical items and 45 items addressing respondents' awareness of and attitudes towards VR in their own subject(s) and in general teaching was administered via Google Forms. The survey was designed by the researchers based on a systematic literature review of the available research into VR use in education to act as a baseline measure of the tutors' awareness, skills, affective engagement and readiness to adopt VR as a tool to support learning in the post-COVID-19 environment. A 5-point Likert scale was used for the attitudinal items and there were six free response items for respondents to provide more personalised responses or reasons for their choices. The survey had been piloted at a VR training event attended by over 30 co-operating teachers pre-COVID-19.

2.3. Procedure

Upon receiving ethical approval for this study, invitations to participate in the research were emailed to all ITE tutors across the purposive sample of four ITE institutions. Informed consent was obtained from each respondent prior to commencing the survey. Items were grouped into five sections: Biographical details; Impact of ICT usage at university on students' technology use in schools; Attitudes to VR in education; Awareness of VR in education; Training and Development needs for the use of VR in education. The survey was available for 8 weeks to accommodate the diversity in teaching times across the four institutions. Two sets of reminders were sent out at the start of week 6 and week 8.

2.4. Data Analysis

The data were analysed using SPSS version 26. The frequencies and descriptive statistics were represented graphically using MS Excel. Due to the small numbers of respondents in the subgroups, it was not possible to use inferential statistics to compare the data for NI and Ireland, or to determine if the number of years' experience as an ITE tutor impacted on attitudes towards VR adoption and use. However, the overall patterns in the data and the detailed comments provided in the free response text answers, provided a valuable insight into ITE tutors' readiness and experience of VR. A thematic analysis [64] was used to analyse the open-ended text responses as shown in Table 1.

The research questions for this study were:

- How do ITE tutors' attitudes and skills with new technologies impact on student teachers' technology adoption?
- To what extent is VR accepted as a tool for teaching and learning by ITE tutors?
- What are the professional development needs of ITE tutors to fully utilise VR in ITE?
- What is the role of the ITE student in supporting the rollout of VR in compulsory education?

2.5. Limitations

The aim of this small-scale research was to provide an in-depth study of four key ITE providers of secondary/high school education on the island of Ireland not for the purposes of generalisation, but rather to impact future open-ended discussions on policy and practice regarding the use of VR in ITE. Insights gleaned from this study are limited to the voices of teacher educators who were interested enough to engage in the survey and who emerged as mainly novice users of VR at the start of their learning journey using this form of technology-enhanced learning. Insights from experts in the field of VR in education was outside the scope of this study. Furthermore, the VR equipment used in this study was entry-level technology that is affordable to most schools. Therefore, this study did not glean insights into the use of VR in education using more expensive and sophisticated equipment that may be outside of the financial reach of most schools.

The next section will report the results using the research questions to group the findings.

Table 1. Themes offered as reasons for the disconnect mapped to elements of mentoring.

Themes from the Survey Comments	Element of Mentoring
University is not the same as school	Teaching Context
Equipment/resources/infrastructure	Teaching Context
School ethos/culture towards ICT	Teaching Context
Student teachers' confidence	*Student teacher self-efficacy*
School policy for IT	Teaching Context
Mindset of other adults	Mentor training
Class management/support of CT	Quality Relationships
Expectations placed on student teacher	Quality Relationships
Time to practice using VR	*Student teacher self-efficacy*
Lack of curriculum alignment	Teaching Context

3. Results

The aim of this study was to explore ITE tutors' attitudes and skills to integrate VR into subject-specific and generic education modules, so it was important to determine their current knowledge and beliefs towards the role of VR in education as a precursor to identifying online professional development training needs.

The majority of ITE tutors responding to the survey were either mid-career with 11–15 years of experience as an ITE subject methods tutor (48%) or were newly qualified as ITE tutors with less than 5 years in this role (40%). The remaining 8% of respondents had 6–10 years of experience and 2% had 16–20 or 21–25 years' experience in the role as shown in Figure 3. 62% of the overall sample held a postgraduate qualification beyond their teaching qualification such as H-Dip (60%) or MA (20%), MEd (18%) and 6% held doctoral-level qualifications.

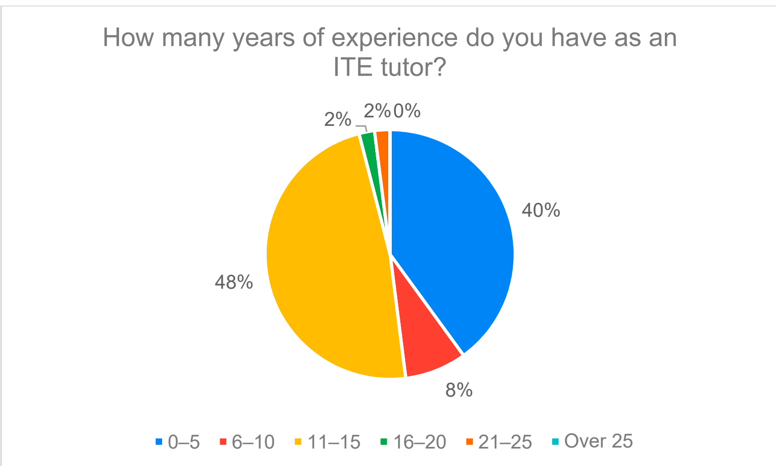

Figure 3. Years of experience as an ITE subject methods tutor.

3.1. How do ITE tutors' Attitudes and Skills with New Technologies Impact on Student Teachers' Technology Adoption?

In response to the first research question, 76% of respondents felt their influence was strong or very strong with only 6% thinking they had limited influence. This was further supported by over half the respondents (55%) disagreeing that there was a disconnect between what the students learn about the use of technology in university-based sessions compared to what they enact in practice (see Figure 4). With ITE tutors' attitudes playing a key role in the uptake of technology by student teachers, it was imperative to determine ITE tutors' attitudes to VR as a tool for teaching and learning.

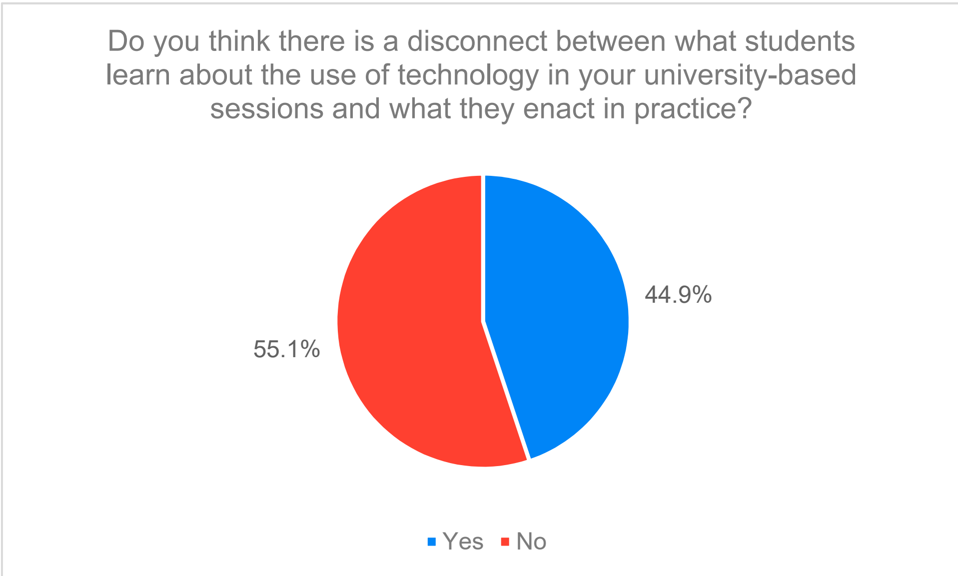

Figure 4. Perceived disconnect between university-based ITE provision and students' use of technology on placement.

From the open-ended questions, suggestions for a possible disconnect included lack of access to equipment/technology resources in schools and in particular, subject-specific resources, while other ITE tutors felt it linked to adopting a 'safe option' to avoid technology for fear of losing control of the classes (confidence issue) and lack of role models where experienced teachers are not utilising technology to enhance or transform their teaching as a result of the ethos of the school, school policy or the mindset of the teachers in terms of curriculum alignment or time restrictions for content coverage. General consensus emerged around the school context being different to the pre-service teachers' experience at university.

As indicated in Table 1, a thematic analysis [64] of the comments in the survey revealed strong mapping to three of the four key elements of mentoring [24,25] discussed earlier. However, it was notable that there was little explicit reference to the duration and frequency of the mentoring but a focus instead on the student teachers' self-efficacy when using VR (*italicised*) especially if reverse mentoring was to be adopted. From the ITE subject methods tutors' perspective, another theme emerged namely, student teacher self-efficacy. In their view, it would be important to model good practice when using VR and also provide sufficient time in university sessions for student teachers to practice these skills and build their confidence when embedding VR in their teaching prior to school placements.

3.2. To What Extent Is VR Accepted as a Tool for Teaching and Learning by ITE Tutors?

Over 35% of respondents had heard of VR but never used it either for entertainment, education or in real-life situations. A small proportion of ITE tutors (around 10%) had used it sometimes, while only 2% had used VR frequently in education or entertainment settings.

Nevertheless, Figure 5 shows that over half (57.1%) of respondents believed that VR has a use in teaching and learning in ITE programmes, while almost one-third (32.7%) felt VR had no role. In some cases the lack of applicability to the subject area was offered as the reason why VR was of no pedagogical use while other ITE tutors described VR as "expanding experiential learning in an otherwise inaccessible environment" or more generally that "VR will have a role in education in the future and ITE programmes need to prepare students for the future." In fact, some subject methods tutors had greater pedagogical insight into the potential of VR to transform the teaching and learning process, saying that

> "*VR provides opportunities for exploratory learning—particularly in relation to complex concepts. It is too often the case that such concepts are only engaged with in a cursory fashion with the result that deep understanding does not result. And the use of VR would enable the learner to manipulate the contexts within which the concept is being applied, make predictions and test them meaning this approach will result in deeper understanding*".

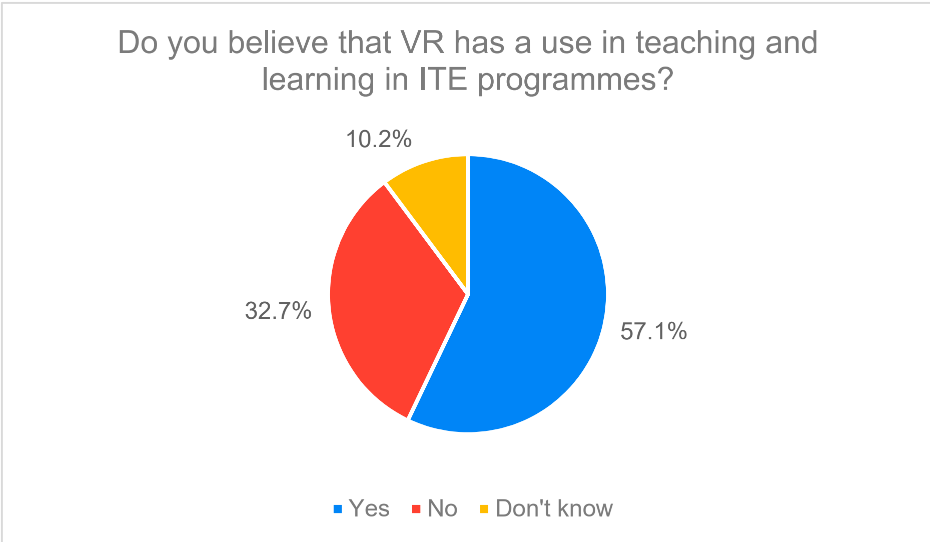

Figure 5. ITE tutors' attitudes towards the general usefulness of VR in ITE.

Based on the COVID-19 experience, the rich immersive experience of VR was also acknowledged as "the best alternative without face-to-face contact" for student teachers and that pedagogically

> "*VR has the chance to bring learning to life before students go into the school environment. It can provide a better learning experience and allow greater exploration of concepts and approaches to teaching and learning*".

Of the 50 respondents, 90% agreed that VR has a use for teaching and learning in post-primary/high schools today while the remaining 10% were unsure of its value; however, when asked if VR has a use in the ITE tutors' taught sessions (their subject methods), less than half (44.9%) agreed, and almost one-third (32.7%) again said No (see Figure 6). This revelation was further explored in the next question.

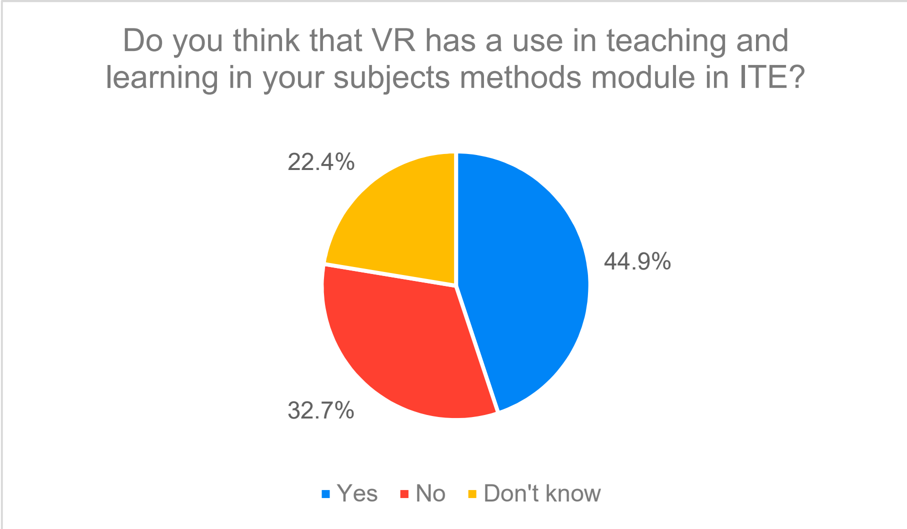

Figure 6. ITE tutors' attitude towards VR for subject-specific work.

3.3. Is VR Accepted as a Tool for Teaching and Learning?

For many ITE tutors, they did not see the potential of VR or its use in their subject area, with some declaring time and space requirements would prevent its use, or they felt VR needed further research and investigation before they would attempt to adopt it.

For those more positively disposed to VR, they valued its ability to assist with visualisation of some topics, maybe to promote the multi-sensory aspect of learning so student teachers could experience the value of VR for themselves, or it could be used to replicate learning scenarios for practising class management, or they just viewed it as 'good pedagogical practice' for innovative teaching and motivating students. However, some ITE tutors did highlight the need to consider theories of learning that align with the use of VR and how linking sound educational theory to VR pedagogy could lead to better "buy-in" amongst student teachers and co-operating teachers alike.

In terms of VR's role in ITE in the future, 92% of respondents agreed it had a place, while the remaining 8% remained unsure. For many, the post-COVID-19 teaching context was viewed as the opportunity to transition to the use of some VR as part of the ITE tutor's toolkit especially as it becomes more widely available. The ability of VR to enhance the learning experience, be engaging to use and a motivational tool for learning were all mentioned by ITE subject methods tutors, as well as developing students' soft skills (like teamwork and co-operation), and that VR could change the nature of teaching on ITE programmes. In general, the responses showed open-mindedness and a willingness to experiment with VR technology in the coming years.

It was interesting to note that only 10% of respondents thought VR has a place outside of education **only**, while 83% of replies declared VR has endless opportunities in education saying it generates excitement in learning and it has real value in education revealing a much stronger commitment to VR than previously demonstrated.

3.4. What Are the Professional Development Needs of ITE Tutors to Fully Utilise VR in ITE?

In terms of determining the professional development needs of ITE subject methods tutors, they self-reported their own personal skills as the greatest barrier declaring a need for technical support and know-how to be able to effectively use VR with their students for subject-based work as shown in Table 2. Next, the ITE tutors cited concerns about health and safety with limited access to headsets and therefore the need for students to share the better-quality headsets. Time was noted both for locating appropriate teaching resources and also for embedding them into their teaching. Finally, student teachers' attitude and skills were mentioned as their least concern.

Table 2. Rank order of the barriers expressed by ITE subject tutors to using VR.

Rank	Barrier
1	Technical support for ITE tutors
2	Your skills for training your student teachers
3	Getting access to headsets
4	Health and safety of sharing headsets
5	Time to find/create VR resources
6	Time in the module to use VR
7	Student teachers' resistance to using VR on placement
8	Digital technology skills of the student teachers

It was noted in Figure 7 that all ITE tutors were keen to be trained and many were willing to participate in training in their own time or using flexible working hours. Although one-third of ITE tutors felt continued professional development (CPD) should be completed during 'normal' working hours and not as an additional workload.

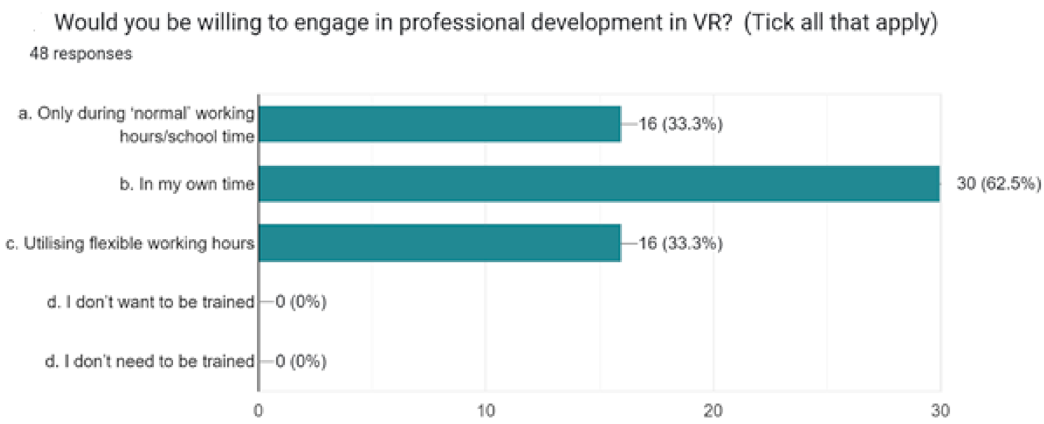

Figure 7. ITE tutors' preferred time for professional development.

3.5. What Is the Role of the ITE Student in Supporting the Rollout of VR in Compulsory Education?

Linking back to the cognitive apprenticeship model and reverse mentoring model that underpins this study, we asked ITE tutors what role the student teacher plays in rolling out VR to schools. Over 80% of ITE tutors view student teachers as the 'change agents' modelling how to ***embed VR*** (with or without headsets) into classroom teaching. It is interesting to note from Figure 8 that tutors see the ***creation and use*** (15%) of the non-immersive experiences (e.g., using iPads/mobile phones) as being 'easier' or more likely to occur, than the ***creation*** of immersive experiences requiring headsets (10%) in Figure 9.

In summary, the literature indicates that positive attitudes and modelling good pedagogical practices are needed from ITE tutors to encourage student teachers to use VR as a tool in teaching and learning. Although ITE tutors have a very limited awareness of VR and are therefore not 'ready' to embed it into their subject methods, there is a willingness to learn as there is consensus by over 90% of ITE tutors surveyed that VR has a place in ITE programmes in the future.

The stages of rollout of VR use are likely to be using existing VR experiences with/without headsets before encouraging the student teachers to create their own subject-based VR activity and then finally collaborating with school-based mentors/co-operating teachers to co-create VR experiences with a strong curriculum focus. Reaching this stage would align with the concept of 'reverse mentoring' between ITE student teachers [62] and ultimately their ITE subject methods tutors who will gain insights into the VR activities co-created during school placement visits, thus completing the iterative cycle of professional development and pedagogical competence.

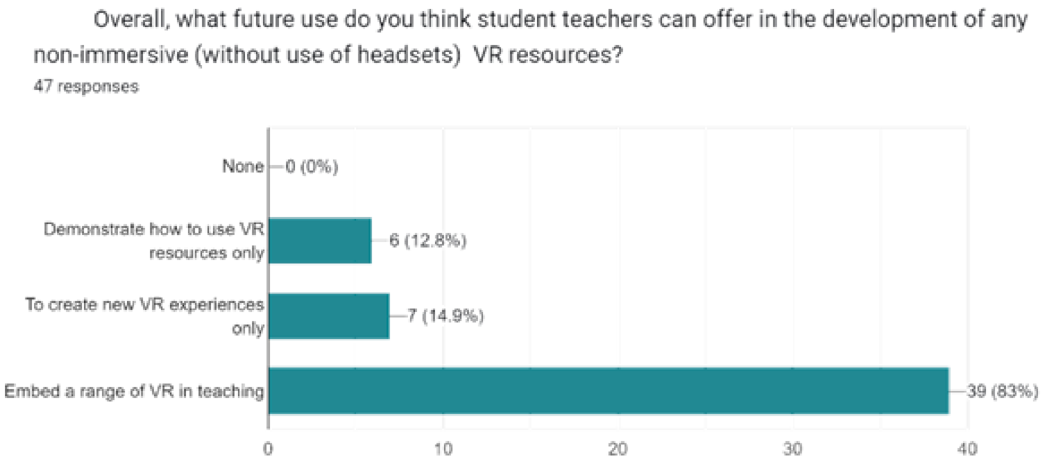

Figure 8. ITE subject methods tutors' perception of student teachers' use of non-immersive VR.

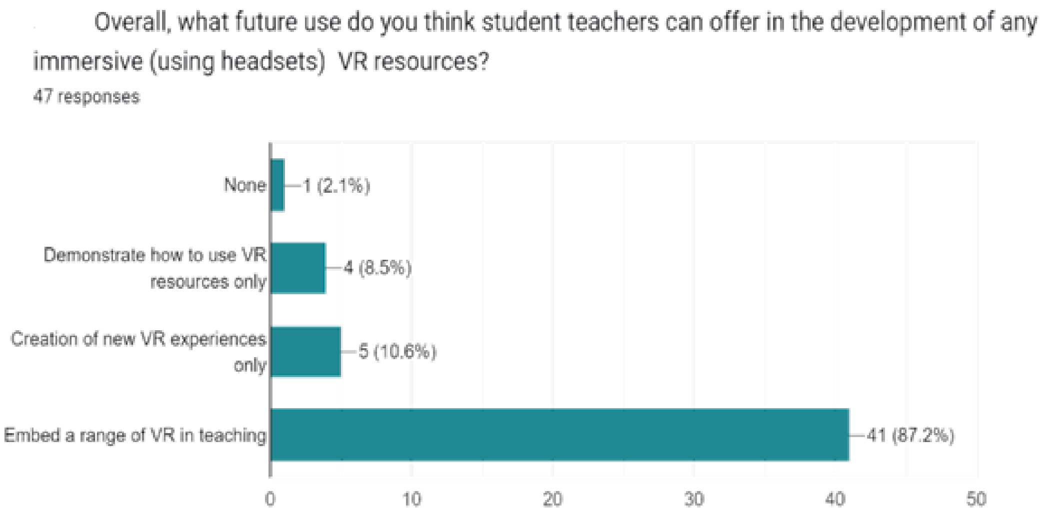

Figure 9. ITE subject methods tutors' perception of student teachers' use of immersive VR.

4. Discussion and Next Steps

The disruptions caused by COVID-19 have placed a spotlight on the in-built capacity and adaptability of ITE students to embrace change and work in 'democratic pedagogical partnership' [11] with those perceived to be more experienced than themselves. As Darling-Hammond and Hyler [65] note, now is the time to re-think and reconsider the relative roles of the partners in ITE programmes. This study demonstrates how VR in education presents a catalyst to re-invent subject-specific elements of ITE provision and re-evaluate the true meaning of partnership in ITE. To embed VR into teaching and learning both in ITE programmes and school-based practice, it is important to view these changes as part of an incremental, cyclical process [62] in partnership with others in the sector. ITE subject methods tutors need to be willing to invest time and effort in the cyclical process of the cognitive apprenticeship model, to introducing the use of VR as a pedagogy within ITE and to cascade their learning across a wider range of subject methods modules and ultimately into school placement via their students.

The findings from this study align with Tondeur et al. [63], whereby the majority of ITE subject methods tutors believe they have a strong influence over the adoption of VR technology by student teachers. However, the findings also mirror research by Heinz et al. [19] and McGarr et al. [20] suggesting a degree of disconnect between what the students learn about the use of VR technology in university-based settings compared to what they enact in practice. Some reasons for this disparity include lack of access to equipment/technology resources in schools to support the use of non-immersive VR, a paucity of subject-specific VR resources, student teachers' confidence issues in using VR technology in placement and the potential negative impact on placement assessment, and a lack of in-school role models [8] due to experienced teachers not utilising VR technology as a pedagogy based on school policies or a need to focus on content coverage over implementing emerging digital technology as part of innovative pedagogy.

While only a small number of ITE tutors have used VR pedagogy consistently in their practice, over half of the respondents believed that VR has a use in teaching and learning in ITE programmes and in compulsory schooling once it is supported by subject-specific examples and curriculum-focused resources. However, the views of many of the participants in this study echo the findings of Jensen and Konradsen [34] citing a lack of attention being given to relevant learning theory informing the pedagogical use of VR in educational settings. Moreover, ITE tutors are also in agreement with the finding of Mikropoulos and Natsis [35] regarding the importance of carefully designed learning activities being more important than the novelty of nascent VR technology. Therefore, evaluating which learning activities suit the provision of VR-based resources, and which learning theories would support these, are important considerations in the professional development of ITE tutors and in ITE pedagogy modules.

This study highlighted an open-mindedness and a willingness amongst participating ITE tutors to experiment with VR technology in the future once they are supported by the provision of active learning in flexible teaching spaces [66] in the university setting. ITE tutors who are positively disposed to teaching using VR, value its ability to assist with visualisation of complex topics [54], promote the multi-sensory [30] aspect of learning, view it as engaging to use and as a motivational tool for learning as well as developing students' soft skills such as teamwork, collaborative learning and empathy [49]. However, barriers do exist for ITE tutors in developing VR as a pedagogical tool in their subject methods practice. These include their own limited training and professional development, gaining access to sufficient headsets of a suitable quality, subject-specific VR resources and time to implement this new approach. Without a suitable educational ecosystem the usage of VR could decline [61] and without adequate investment in professional development for teachers across the continuum of teacher education, affordances of VR to learning could be lost [43].

A cost neutral approach to overcoming these barriers is the use of "reverse mentoring", whereby ITE students who are 'change agents' lead the transition on how to embed VR (with or without headsets) into classroom teaching. Initially, the use of the non-immersive experiences without the need for headsets [67] is more likely as an entry point to encourage a wide use of VR pedagogy with the use of immersive experiences requiring headsets to follow in an incremental way as technical and subject-specific resources become more widely available.

While, in general, the school context is different to the pre-service teachers' experience at university, there is a growing body of knowledge on strengthening the school-university nexus and bridging the theory-practice divide. Through sharing ideas and resources with colleagues and scaffolding VR pedagogy for ITE tutors, school placement tutors, co-operating teachers and student teachers alike, a purposeful Community of Practice [68] will emerge offering cycles of learning, development and growth as a pedagogue. Schemes such as the Teaching Council Researcher in Residence Scheme [69] is a good example of how student teachers, teachers and teacher educators can work on funded projects to showcase subject-specific VR pedagogy and cascade the learning back into ITE programmes in new and insightful ways. This is a very effective method of offering 'protected time' and 'access to technical experts' to facilitate the links between theory and practice in addition to supporting high-level resource creation by subject experts within the innovative, transformative and collegial environment of ITE.

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