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The potential of virtual reality to support adolescent mental well-being in schools: A UK co-design and proof-of-concept study

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ABSTRACT

Mental health interventions delivered via virtual reality (VR) technology are available for treatment of adult anxiety and phobias. VR for other mental health needs is now being explored. A small number of studies have examined VR acceptability and helpfulness for adolescents in conjunction with clinician support. No studies have examined the potential of VR to support adolescents in schools as a form of prevention. We present our early-stage work to produce and field-test a youth co-designed VR intervention for use in schools to support adolescent well-being. Co-design decisions led to a focus on stress reduction via emotion regulation, supported by a mindfulness-based approach. The prototype for field testing offered both structured and user-selected practices which the young person could hear and experience in a fully immersive, calm virtual environment. Two mainstream and one specialist setting field tested the resource, implementing it in different ways. Fourteen adolescent participants tested the resource in school. Users tolerated and liked the resource, and it was welcomed by schools. Adolescents with complex needs around emotion and attention seemed to particularly benefit from the resource compared to heathy stressed adolescents. Field-testing outcomes led to the development of a prototype ready for pilot testing.

1. Introduction

Adolescence represents a time of heightened vulnerability to mental health conditions. Young people are calling for investment in educational settings to safeguard their well-being (Sharma et al., 2021). In the global north, and increasingly in low-and middle-income countries, schools are considered suitable sites for the delivery of prevention programs which can reduce the risk or severity of adolescent mental health difficulties (Fazel et al., 2014; Hugh-Jones et al., 2021; Patel et al., 2018; van Loon et al., 2020). Yet globally, insufficient human resources, expertise and curriculum space are barriers to the delivery of face-to-face prevention programs in schools (Patel et al., 2018). Even then, evidence on the long-term effectiveness of popular psycho-education with self-help curriculum approaches, usually delivered by teachers, is mixed (e.g., Feiss et al., 2019; Waldron et al., 2018). Targeted approaches, delivering support to those young people with elevated need, appear more effective than universal approaches (Kambara & Kira, 2021; Werner-Seidler et al., 2017), but are resource intensive and risk stigma (Gronholm et al., 2018). Continued innovation is needed to address this "fundamental and unmet challenge" (Holmes et al., 2018) to reach populations of young people with effective prevention strategies to reduce the risk of mental health conditions.

1.1. Digital mental health

For several reasons, digitally-delivered mental health support (which includes technologies) is one area of innovation that could be an asset to schools and to young people (Bakker et al., 2016; Hollis et al., 2017). Current levels of digital and technology use are predicted to remain stable (Anderson & Jiang, 2018) and there are already many technology innovations aiming to nudge adolescent behaviour change in the health prevention field (e.g. Ozer et al., 2016). In the sphere of mental health, young people appear open to technological approaches (Hugh-Jones et al., 2022; Liverpool et al., 2020) and teachers express positive curiosity (Pine, 2020). Digital and technological approaches can be "particularly captivating" for adolescents given their developmental

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interest in abstract exploration, play and learning, representing an opportunity to deploy mental health prevention (e.g. boosting self-awareness or coping skills) in ways that engage young people in developmentally appropriate ways (Giovanelli et al., 2020).

Yet to be effective for mental health, digital and technological innovation needs to be embedded and usable in the everyday lives of young people (Torous et al., 2019), especially in contexts, such as schools, that may be triggering mental health risks (e.g. school stress, bullying, relationships conflict; Holmes et al., 2018). The innovation should be effective in helping young people in situ to manage daily, challenging situations (e.g. stress; Firth et al., 2017). Schools also represent an established human support, risk management and mental health referral structure into which digital prevention approaches could be integrated. Finally, digital support in schools could reach many young people, overcoming some of the resource challenges, and may be perceived by young people as less- or non-stigmatising than traditional forms of support (Hollis et al., 2015).

1.2. Virtual reality

To date, most digital mental health innovation has focused on online interventions and apps (Torous et al., 2018). However, the public mental health app market is now saturated and complex for young people to navigate, meaning potential access to support is frustrated (Torous et al., 2018). Low trust in mental health apps and poor adherence remain barriers to the effectiveness of apps and online provision (Alqahtani & Orji, 2020; Lecomte et al., 2020; Leech et al., 2021). There is now increasing attention to serious games, augmented reality (AR) and virtual reality (VR) for the delivery of mental health support (Halldorsson et al., 2021). Our focus is on VR, which involves using computer technology to generate a three-dimensional simulated environment that allows the user to immerse themselves in, and interact with, a virtual world through hearing, vision and touch. VR environments are delivered via a lightweight headset covering the eyes. The inner headset displays the simulated, 360-degree environment in an immersive way (i.e. nothing outside the headset else can be seen) and can be accompanied by audio. Interaction with the environment can be via a handheld point-and-click mouse (Appendix A). Multiple environments can be created meaning immense potential for personalization and sustaining engagement. VR for mental health has further benefits, including delivery standardisation and user control over frequency and intensity of use (Halldorsson et al., 2021).

In VR and mental health research, adult anxiety and exposure therapy have received the most research attention to date (Carl et al., 2018; Freeman et al., 2017; Park et al., 2019) with some studies on borderline personality disorder and psychosis interventions for adults (Falconer et al., 2017; Freeman et al., 2019). VR for adolescent mental health is extremely novel, especially as a form of prevention. Halldorsson et al. (2021) recent review of clinical applications of digital technologies for children and young people identified only three studies of VR, only one of which was a randomised controlled trial. Halldorsson et al.'s review concluded that there is a case for exploring the potential applications, acceptability and effectiveness of this type of technology for adolescent mental health but that it needs to be heavily co-designed with users and other stakeholders. They emphasized that, as with all technologies, end-user co-design is critical to determine the key aspects of technology that are compelling, needed and effective. Other stakeholders' involvement in co-design is needed to support simultaneous implementation research to optimise access and sustainability (Giovanelli et al., 2020).

Although there is much interest in technology for mental health, there are few empirical studies with adolescents (Georgeson et al., 2020). As a step towards this, we report our co-design (Stage 1) and field test (Stage 2) of VR for preventative adolescent mental health support in UK secondary schools. Our aim in Stage 1 was to co-design with young people and stakeholders a VR resource for adolescent wellbeing that could be deployed in UK secondary schools. Co-design is "collective creativity applied across the entire design process" (Thabrew et al., 2018, p418). This creativity can drive the technology content, aesthetics, navigation, usability, data management/security, and implementation into a users' everyday life , e.g (Hugh-Jones et al., 2022). In our study, potential users and stakeholders (teachers, mental health professionals) worked in partnership with researchers and software developers to identify a prevention target and therapeutic approach which a VR environment could support (i.e. priority setting) and in response to those priorities, through iterative product development and user testing cycles, to jointly design a VR product that met the user's needs and preferences (as experts by experience) in ways that were sensitive to their age and context of use, i.e. schools (Bevan Jones et al., 2020).

The aim of Stage 2 was to field test the VR co-designed product in UK secondary schools, focusing on how schools implemented the resource, adolescents' reasons for opt in, how they experienced it and what future developments schools or adolescents suggested either for the resource, its implementation and evaluation.

2. Study 1: co-design methods and outcomes

Stage 1 received approval from a university research ethics committee (PSCY-24, 5/4/2020). Signed informed consent was secured from all participants and, for adolescents under 16, also signed guardian consent.

2.1. Recruitment and participants

Co-design stages and participants are shown in Fig. 1. Via existing networks and local government / services, we recruited 18 mental health and education professionals, who worked directly with adolescents (e.g. teachers, children and families services, educational psychologists) and (at a later stage) three experts in mindfulness. We recruited 17 adolescents (aged 15–18y) with lived experience of prior mental health difficulties from two local secondary schools with whom we had existing research links. All adult and adolescent participants gave signed informed consent, with signed parental consent for under 16 s. All adolescents self-reported to be currently well and were involved in priority setting and user testing.

2.2. Priority setting

Fifteen of our recruited cohort of mental health and educational professionals attended a one-day in person workshop, where they could explore and play in VR headsets. They were introduced to the small amount of evidence about VR and adolescent mental health. Their remit in the workshop was to set the priority adolescent mental health need to address in the study, the preferred therapeutic approach for use in the VR and an initial implementation plan for its deployment in UK

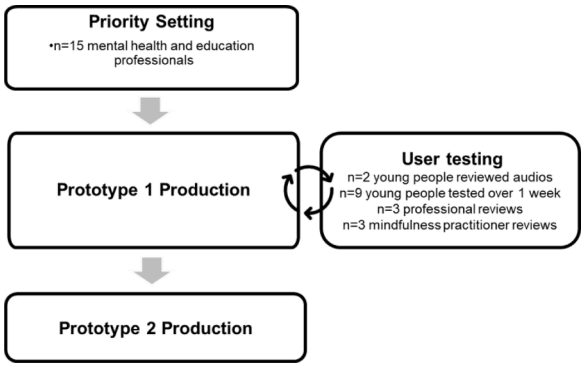

Fig. 1. Co-design stages and participants.

secondary schools. Discussions involved ranking of young people needs, reviewing evidence on therapeutic approaches, and identifying barriers and solutions to VR acceptability and implementation in schools. The workshops were facilitated by the project team who recorded the stakeholder's priority setting proposals. Our recruited adolescents could not attend workshops as they were in school. They were consulted about priority setting online when they began engagement as user testers (detailed below).

A first decision emerging from priority setting, and endorsed by young people, was that the priority was to target adolescent stress by improving emotion awareness and regulation skills. All reported that they perceived adolescent stress, and lack of skills to manage it, as a pervasive risk factor for poor mental health. This choice aligns with research evidence about the importance of managing stress for good mental health. Stress is defined as a type of emergency state created by a real or perceived threat (stressor) (Lazarus & Launier, 1981). It is related to but different to anxiety, which is worry and fear about future situations, with the probability or occurrence of harm being low or uncertain Daviu et al., Sandi and Beyeler (2019). Stress is common amongst adolescents and is a transdiagnostic risk factor for mental health. The adolescent brain may be particularly sensitive to stress as developmental changes in the hypothalamic-pituitary-adrenal axis appear to elevate stress reactivity, meaning adolescents may become more sensitive to stressors (Eiland & Romeo, 2013). Various normative stressors are reported by adolescents, including peer relationships, school performance, home life, emerging adult responsibilities and teacher interactions (Anniko et al., 2019; Byrne et al., 2006). Coping with such stressors or 'daily hassles' (defined as the ongoing stresses and strains of daily living; DeLongis et al., 1982) is a strong predictor of psychological health (Serido et al., 2004). Thus, stress management is a good focus for prevention approaches (Konstantopoulou et al., 2020). Emotional regulation is an adaptative skill which can support stress management and helping young people to recognize and regulate emotions is an established focus for mental health support (Young et al., 2019). Furthermore, as good emotional functioning is beneficial for academic performance (Zins et al., 2007), schools may be particularly accepting of digital innovations which support this.

A second decision from priority setting was to use a mindfulness-based approach given its effectiveness for stress reduction (Pascoe et al., 2017) and acceptability amongst youth (Zoogman et al., 2015). Even brief practices delivered online can improve state mindfulness (Mahmood et al., 2016) and, when delivered as a face-to-face, structured program, people often report naturally drawing on newly acquired mindfulness skills to manage their everyday situations (Hugh-Jones et al., 2018). An active ingredient in practicing mindfulness programs is attention to present moment embodiment (Hölzel et al., 2011). There were concerns in the study team that this could not be achieved within VR where the aim of the technology is to create a space disconnected from the immediate material context. Experience in VR can, however, be emotional and therefore embodied, and people's emotional states can be affected by how present they feel in the virtual environment (Riva et al., 2007). We were interested in the potential of VR to overcome some of the barriers to the implementation of mindfulness in schools (Hudson et al., 2020) and how immersive experience to help young people practice mindfulness. Early studies suggest this is possible (Falconer et al., 2017; Navarro-Haro et al., 2019). Final decisions from priority setting around implementation were to deliver a structured, self-paced program in the VR and for VR use by youth in schools to be by youth opt-in.

2.3. Prototype production and user testing

Based on the identified priorities, we produced Prototype 1, with iterative points of user testing by young people and professionals to refine prototype development. Co-design of digital interventions is often agile, meaning iterative design cycles, or sprints, are deployed to respond rapidly to user testing in order to improve the product ready for a next iteration of testing (Thabrew et al., 2018).

In response to priority setting outcomes, we first developed a mindfulness program that broadly mirrored the Mindfulness Association's Mindfulness Based Living Course, adapted by an accredited teacher (TN) registered with the British Association of Mindfulness-Based Approaches (BAMBA). Audios of two mindfulness practices were created and reviewed by two adolescent user testers who were asked to listen to the audios several times and complete an anonymized online feedback form (Appendix B details their feedback and recommended improvements).We used their feedback to develop two complete mindfulness VR environments, delivering a settled mind and body scan practice with visuals and audio (see Appendix C). Each environment had ambient noise (e.g., bird song), optional male or female narrators and lasted eight minutes, with an optional one-minute practice introduction.

We subjected these environments to another round of iterative user testing and rapid development with nine of our adolescent user testers. VR headsets were delivered to their home for one week. Testers were asked to use the VR product and as when they wished, with a minimum of two uses, to complete an online review form and to attend an informal online interview with the project research assistant to feedback (either one-to-one or small group as preferred by them). Reviews explored usage, experience, content and suggestions for improvements. Based on each participant's feedback, we made rapid iterative improvements to the VR environment before sending the headset to the next adolescent tester. During this stage we also developed a further two environments to be reviewed by successive adolescent participants.

We then invited 3 (of our initially recruited 19) mental health professionals who work with adolescents and three mindfulness practitioners ($n = 3$), to anonymously review Prototype 1 (four environments) for clinical safety, mindfulness integrity and likely helpfulness. The headset was delivered to their workplace for a minimum of one week. Professionals were asked to explore all four of the created environments and linked mindfulness practices and to complete a short online review form.

Details of the user testing questions and reviews are in Appendices Tables B1 and D1 - D3 along with the changes these led to in the product. Young people wanted us to design calm and non-distracting VR environments, and well-paced audios, indicating their goal of tuning into the mindfulness practice rather than be stimulated by the environment.

During user testing, adolescents took time to become accustomed to the VR but then enjoyed the calmness of the environments, were able to engage in mindfulness to some extent and were reporting the anticipated impact on emotion regulation: *"I thought the exercises were very calming and helpful. The VR aided the exercises as it felt as if it was its own world, and it was very easy to switch off from the outside." (Pp7, male, 17y, Table D2)*. One participant reported that "*I found it easier to separate myself from my life and focus on the recording through the use of virtual reality as I felt like I was somewhere else. The first few times I tried the exercises I struggled with getting into the correct mindset, I found it reassuring that audio repeatedly reminded me that it was okay not to be great at it in the beginning" (Pp5, female, 17y, Table D2)*. The adolescent user testers identified several ways to improve the VR environments, including minimising even minor visual distractions, offering day and night environments, and environment choice based on current feeling / mood. Suggested improvements to the mindfulness narration included better introductions, adding radio to locate narrator voice, and slower with more spaces to practice mindfulness silently. One participant (#3) did not like the headset and found it uncomfortable and claustrophobic, although also reported the environments were calming. Mental health professionals and mindfulness experts rated the product positively, did not have any safety concerns, and made suggestions for refinement (e.g. simplify mindfulness language, slow mindfulness narration with more scope for quiet practice; more scope for interaction and relating the audio to the environment more; see Appendices Tables D3 &4).

2.4. Prototype 2 for field testing

We incorporated participant design suggestions (reported in Appendix D) to produce Prototype 2, called 'Immerse'. Immerse was designed as a 6-week course, with 12 × 8 min mindfulness practices spanning breath and body work, noticing, acceptance and self-compassion. Each practice was accessed via a particular immersive environment (selected by the user by clicking the handheld mouse), spanning a beach, forest, desert, meadow, city park, red planet, waterfall and starry night, with day or night options. Young people wanted us to design calm and non-distracting VR environments, and well-paced audios, indicating their goal of tuning into the mindfulness practice rather than be stimulated by the environment. On entering the VR environment, users could select 'Instructions on how to use', ' What is Mindfulness'?, 'About Project Immerse' or go straight to an environment where the mindfulness audio for that week could be launched (see Appendix E for examples).

3. Stage 2: field testing methods and outcomes

Field testing is the controlled distribution of a new product to learn about its functioning in real-world settings. The aim of Stage 2 was to field test Immerse in four UK secondary schools to learn about engagement, user experience, school implementation and needed developments. Stage 2 received approval from the Faculty of Medicine and Health Research Ethics Committee, University of [blinded for review] (PSYC-90 9/9/2020). Signed informed consent was secured from all participants and, for adolescents under 16, also signed guardian consent.

3.1. School recruitment

Four large urban mainstream secondary schools were approached to take part. Schools were eligible if they agreed to provide a quiet space for students to use Immerse and storage for the headset. All four schools agreed. However, two withdrew due to the pandemic, leaving two mainstream schools (Schools 1 and 2).

School 3 was a specialist academy who had attended Stage 1 workshops and had asked, and were accepted, to test the resource in their setting for children and young people (5–16y) with Social, Emotional and Mental Health (SEMH) needs. All of their pupils had an Education, Health and Care Plan.

3.2. Field testing procedures

One boxed headset was delivered to each school, pre-loaded with the Immerse program, with a single page of instructions for technical use, and with associated charging and hygiene items. Teachers / staff were encouraged to try the resource themselves before adolescents accessed it. Schools were asked to devise a way to implement the resource in their setting over a period of three months, and in ways that were manageable and meaningful for them. They were free to decide which year group to offer the resource to and the number of students they could accommodate over the field test period. Once schools had established its implementation approach, adolescents were invited to try it in the approach decided by the school. Adolescent participants in Schools 1 and 2 answered three questions (online) before starting Immerse (reasons for taking part, experience with VR and level of optimism that Immerse would be enjoyable). After using Immerse, and whilst still in the headset, adolescent users rated the environments they had been in and how they felt before and after each practice (1 = very unhappy and 5 = very happy) (Appendix E Figure E4). The headset program recorded which environments were accessed, when and for how long but could not identify individual users. Liaison teachers from Schools 1–3, and adolescent users from Schools 1 and 2, were invited to a feedback interview.

3.3. Results

3.3.1. How schools implemented immerse

Schools 1 and 2 decide to offer Immerse to Sixth Form students (16–18y) as they were perceived stressed and had free periods to access Immerse. They advertised it as a 'quiet and calm space to yourself in school' (as suggested by adolescents in co-design) and they explained that the study was evaluating if Immerse was useful and enjoyable. Despite our request for opt-in, both schools encouraged certain students to try Immerse. Participants in Schools 1 and 2 were invited to complete the full Immerse program in school, i.e., two x eight-minute practices per week over six weeks. They could remain for longer in the headset if they wanted, listening to ambient noise, or repeating the practice. Access barriers were reported in School 1 given social distancing impacts on space availability. School 2 had a suitable space. In School 3, keyworkers opted to suggest a young person try Immerse and guided them to certain practices but with freedom to explore environments. Keyworkers sat with the young person and once finished, explored with them how they felt. This was considered an important part of the deployment of VR in that setting.

3.3.2. Young people's use and ratings

Across Schools 1 and 2, eight young people tried Immerse (5 female, 3 male) (4 × 16/17y and 4 × 17/18y). Reported motivations for opting-in were for stress and anxiety reduction because their teacher had encouraged them and/ or because they were interested in VR. In School 1, after starting, three participants withdrew due to lack of time. In School 2, all four participants completed. The Covid-19 pandemic prohibited post-intervention interviews with young people. School 3 field tested Immerse with six adolescents. All 12 Immerse VR environments were accessed by the sample of participants across the three schools, and across 41 usages by the entire sample, the average rating of environments was 3.45 (range 1–5). School 1 and 2 user responses to 'how did you feel before the practice?' and 'how do you feel now?' showed an average mood increase from 3.15 (before) to 4.56 (after) out of 5. In School 3, the average mood increase reported across six users was 2.78 (before) to 4.17 (after).

3.3.3. Teacher feedback

School 1 reported general participant unwillingness to commit to a 15 mins per week for 6 weeks as students wanted a 'quick fix' for stress. School 2 reported that their four participants were engaged, especially one male participant (17y) with autism. The teacher believed that VR was less challenging for him than face-to-face support. School 2 also reported that a care-experienced young person (14y), who they described as 'borderline ADHD' asked to try Immerse and wanted to remain in the headset for 30 min at a time (repeating practices or listening to ambient noise in the environments). Staff reported that after Immerse he appeared more regulated and able to return to lessons.

School 3 deployed the resource with pupils with autism, ADHD, low mood and anxiety and reported some "breakthrough moments". They reported that 15 min in Immerse helped regulate a pupil who came into school in crisis, and that the pupils with ADHD could "sit through the whole thing". In another case, School 3 offered Immerse to a pupil who was unresponsive to staff support. The teacher stated: "She entered one of the VR sessions and after 15 min she seemed completely calm, and just began to open-up entirely. In terms of impact, in my opinion, this is as impactful as other interventions like theraplay style, music therapy and other interventions of a similar nature. It's made a real difference."

Feedback from field-testing has informed development of Prototype 3 (see Fig. 2 for opening environment) to be taken forward to a pilot trial. The key developments in Prototype 3 are: (i) a "Quick Relaxation" option at the point of entry and (ii) a new 'discoverable world' where users select from one of ten options based on 'What's Bothering Me?'. They are then provided with a mindfulness practice focusing on that need. Practices in this space have been augmented with a Breathing

Fig. 2. Screenshot of Prototype 3 discoverable world where users can choose their practices based on their needs or opt to progress in the structured mindfulness program.

Sphere and Box Breathing exercises (Appendix F). Prototype 3 also still offers a six-week structured mindfulness course for young people, comprising 12 practices delivered in order twice per week.

The pilot trial will examine implementation and usage in a wider group of schools and young people, including those with social, emotional, and behavioural needs. We will measure the impact on mental health outcomes and identify possible mediators and moderators (e.g., motivation, baseline stress and dispositional mindfulness) as well as on behaviour and functioning (e.g., attendance, attention in class). We will also make the resource available in 2D format via google cardboard, to assess the added value of a consolidating home component. We need to secure rich user feedback around implementation and deployment in schools, as well as potential stigma, therapeutic processes and mechanisms, and experiences in the VR environment.

4. Discussion

Research and clinical interest in VR technology is high (Georgeson et al., 2020), yet attempts to use VR to deliver public mental health prevention work in schools is limited. The aim of this study was to co-design and field test a VR resource in UK secondary schools to support student mental well-being. The priority setting stage of co-design informed our focus on emotion regulation; adult stakeholders and young people felt that stress was pervasive amongst adolescents and that it would be a useful mental health risk factor to target. Successive co-design stages emphasized that adolescents wanted calm spaces, which led us to simplify environments and ambient noises. They informed us that delivery of mindfulness practices needed to be particularly well-paced, with spaces of silence where they could practice unguided, as rushed or complex narrator would risk disengagement. Young people also informed the creation of day and night environments and the addition of a virtual source for the narrator's voice. Young people and stakeholders also informed the implementation approach; they decided use should be opt-in and that Immerse should be framed as a 'space' in school, rather than as a mental health or mindfulness tool.

Co-design processes led to the creation of a six-week mindfulness program, delivered in VR, to help young people have a 'space' in school to regulate emotions. As the field is emergent, and we know little about public health implementation options for this type of technology, our study schools were free to implement the resource as they wished, enabling us to learn from the field about what works.

Although "taking interventions online still represents a paradigm shift in how mental health care is conceptualised, both by the public and the services delivering interventions" (Sanderson et al., 2020), our field test of a VR resource, carefully crafted by listening to young people, suggests that adolescents, schools and mental health professionals accept technology for mental health in schools, and are curious about how VR could help young people in their everyday challenges in school. We found that some adolescents with complex needs may particularly value this technology. All approached schools were interested in this technology, and for the proposed purpose, although School 1 participants did not want a structured program and the associated time commitment. Given the high valuing of autonomy and privacy around mental health, we asked schools to permit young people to opt-in to use the resource, rather than being nominated (Wilson et al., 2011). However, some studies suggest that nudging by teachers may boost initial engagement with novel technology in schools (Grist et al., 2019; Sanderson et al., 2020).

The immersive environments in the VR headset were well tolerated and liked, and both staff and students indicated acceptance of the technology on site during field-testing. This mirrors the evidence on acceptability from young people using technology in clinical domains (Georgeson et al., 2020) and on VR generally (Pine, 2020). Adolescents in the co-design stage reported being motivated and able to do the narrated mindfulness practices, and indeed, asked us to embed even more time for them to do this silently. This is an encouraging early finding about the potential of delivering mindfulness-based practices via technology, given the challenges to delivery encountered by face-to-face delivery in schools (Hudson et al., 2020). Field-testing results also tentatively suggest adolescent users within school could experience emotion regulation via the mindfulness practices and calming environments, although the exact mechanisms remain to be identified. Although our measure of mood was crude, adolescents' ratings post-use suggest an affective benefit. Notably, use of Immerse in the specialist educational setting showed very high acceptability amongst some young people with complex needs (e.g., behaviour, emotion regulation, attention difficulties) demonstrating what can be discovered when schools are free to use this kind of safe, low-intensity and user-friendly technology in a needs-led way.

Deployment in the specialist setting was more blended with one-to-one support compared to none in the mainstream schools. However, although blending digital with human support is the most preferred and most evidence-based approach, it may depend on the purpose of the digital resource. For example, a VR calming space, where being able to be by yourself is part of the therapeutic process, may need minimal expertise or guidance from teachers. Yet despite evidence that digital resources can help (Grist et al., 2019), many young people perceive digital support as less effective than human support (Apolinário-Hagen et al., 2017), and there are debates about the necessity of virtual or real humans to overcome this reticence (Rizzo & Koenig, 2017). As with all

digital approaches, we need to better understand what person support promotes engagement and outcomes (Sanderson et al., 2020), as well as what gamification can do for independent motivation for longer-term engagement (Rizzo & Koenig, 2017).

Upscaling of Immerse is happening in some schools in northern England where cost to schools (£1500 per annum including maintenance and unlimited users) is not prohibitive and, for many, this kind of technology could be an important addition to their support portfolio.

4.1. Limitations

Our findings should be interpreted in light of the following study limitations. Ours was a small co-design and field test study to establish the case for a pilot feasibility trial. The testing sample was small and we chose, in this early exploratory phase, not to screen for adolescent mental health conditions; different user acceptability and experience may be reported by young people who have sub-clinical or clinical levels of psychological distress. To minimise burden and intrusion, we did not collect data on the School 3 participants' particular emotional and behavioural need. It is likely the deployment of a VR resource for emotion regulation would need to be carefully tailored to the needs of particular young people. Finally, without creating user IDs, we could not link user behaviour in the headset (e.g. duration of time in an environment) to their ratings of resource helpfulness. It remains unclear adolescents from our study if adolescents could effectively transfer any newly learned mindfulness skills to real world settings in order to manage emotional regulation; much is yet to yet to be understood about this process and what dosage and approach could optimise this.

4.2. Conclusion

Traditional, curriculum-based prevention approaches to safeguard youth mental health in schools are not succeeding as anticipated. We need to find more compelling ways to reach young people. VR represents one viable opportunity to capitalise on adolescent developmental windows and their engagement with technology. There is huge untapped potential for VR as delivery mechanism for preventive approaches to mental health in adolescents in schools. Our co-design study showed that young people and school stakeholders had clear vision for how VR could be delivered in schools as a preventative approach. Targeting stress as a transdiagnostic risk factor for mental health was endorsed by youth and adult stakeholders, as was a focus on building emotional awareness and regulation skills via a mindfulness-based approach. Study 1 and 2 findings suggest that a VR resource like Immerse has the potential to be an acceptable and helpful form of prevention support to young people in school. Specialist settings, and young people with complex needs, also demonstrated acceptability and creativity in their deployment of the resource. Our findings favour administration of a feasibility pilot trial. Major knowledge gaps exist around mechanisms of change, long-term effects, the optimal level of personalization and tailoring to specific mental health risks, age and setting.

Credit author statement

Authors SHJ, SW and MK conceived of the study. All authors contributed to project delivery. SHJ wrote the first draft of the manuscript and all authors contributed to iterative drafts, and all authors reviewed and approved the final draft. No other persons who satisfied the criteria for authorship have been omitted. Authorship order has been agreed, and no other persons who satisfied the criteria for authorship have been omitted.

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Declaration of Competing Interest

Two authors (SW and MK) own [*software development company - blinded for review*] and created the Immerse software. Evaluation of Immerse was conducted independently by authors SHJ and MU of the University of *[blinded for review]*

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Supplementary materials

Supplementary material associated with this article can be found, in the online version, at doi:10.1016/j.mhp.2023.200265.

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