When will Immersive Virtual Reality have its day? Challenges to IVR adoption in the home as exposed in studies with teenagers, parents and experts

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Abstract

In response to the pandemic, many countries have had multiple lockdowns punctuated by partial freedoms limiting physically being together. In 2020-21, during the COVID-19 pandemic parents were stressed and exhausted by the challenges of work, home schooling and barriers to typical childcare arrangements. Children were missing one another, their social lives and the variety of experiences that the world beyond the home brings. Immersive Virtual Reality (IVR) offers tried and tested ways to enable children to maintain beyond-household family activities and dynamics. However, it is not viewed as a solution. Instead, as demonstrated through a multiple method study involving a Rapid Evidence Assessment; workshops with 91 teenagers; interviews with 15 experts; a Delphi study with 21 experts; 402 parent questionnaires pre-pandemic; 232 parent questionnaires during the pandemic; and longitudinal interviews with 13 parents during the first UK lockdown in 2020, IVR is not viewed as having value in the home beyond gaming. Results highlight limited consideration of IVR as a way to enhance family life or the home, with a lack of evidence and direction from current research, innovation and policy. The paper empirically demonstrates that experts, teenagers and parents have limited expectations for VR. Further, with parental resistance to adoption and a lack of ideas or innovations in how Immersive Virtual Reality could be used, the likelihood of VR-headset adoption remains low as does its potential as a means of educating, entertaining and socially engaging children and teenagers.

1 INTRODUCTION

Immersive Virtual Reality (IVR) involves the use of specialised hardware such as headsets to enable users to engage in a virtual space. In the workplace, the future of IVR

looks bright, with the market expected to increase massively over the next 5 years (Fortune Business Insights, 2019b). There is significant growth in IVR use for complex industrial and social challenges where realistic representation is essential to successful outcomes, such as refitting an oil rig (Mostafa et al., 2015), product design (Duboe et al., 2018) and emergency simulations (CAICT & iLab, 2019). Significant growth is also anticipated in post-16 education (Fortune Business Insights, 2019c; Maida, 2020). IVR is already used for workforce training, from equipment maintenance to health (Duboe et al., 2018) and in colleges and universities (Pomerantz, 2019), most commonly for engineering, computer science and astronomy (Radianti et al., 2020). Using IVR, university students have been seen to be more engaged, spend more time on the learning tasks, and to acquire better cognitive, psychomotor and affective skills (Jensen & Konradsen, 2018).

In contrast to industry and post-16 education, beyond games and entertainment, the potential for IVR as a home-based technology had appeared to be fading away (Jenkins, 2019). The main selling points for IVR in the workplace such as realistic representations, learning complex tasks or solving spatial problems, have little relevance for most homes or family lives. Further reducing relevance to the family, most manufacturers recommend restricting use of Virtual Reality (VR) headsets to users who are 12 or older. Thus, despite ambitious hopes for VR headset adoption (Grand View Research, 2021; Hordijk, 2019), consumer purchases remain relatively low with global purchases for VR-headsets anticipated at only 7 million units by 2023 (Alsop, 2021). Although this could be parents complying with manufacturer recommendations, such adherence seems unlikely. For example, with console game purchasing behaviour age recommendations are often not followed.

Cost can be a significant issue for technology adoption, however, this is unlikely to be the case for VR-headsets with prices steadily reducing. Some VR-headsets are now cheaper than high-end tablets and increasingly VR-headsets are offered as a low-cost add-in to enhance new consoles sales. Even with more affordable untethered VR-headsets driving family purchase (Business Wire, 2019; Maida, 2020), recent surveys show that less than 1 in 5 families in the UK with children under 17-years-old live in a home with a VR headset (Aubrey et al., 2019).

The lack of uptake of IVR suggests that there is more afoot than recommended age restrictions and costs in prohibiting children and families in adopting IVR. Issues such as data capture, family disruption and a lack of visibility around content do add to parental concerns. However, these concerns are similar for other readily adopted hardware such as tablets or voice assistants. Families and particularly children do have requirements post-COVID that could be solved with IVR. Yet, IVR solutions for the family and the home enabling socialising, entertainment, learning, recreation, life and leisure are not emerging. In response, this paper explores the research question – ***Why is IVR not viewed as the way forward for education, collaborative entertainment and social engagement for children? Especially in a post-COVID world? Or perhaps more simply the question of why is IVR not being positioned more strongly for use by children and teenagers in the home?***

ICT (Information and Communication Technology) adoption is a dynamic, interactive and evolving process rather than a static and one-off event (Eze & Chinedu-Eze, 2018). It involves the interplay of human and non-human actors with adoption a complex and ongoing process. Understanding the relationship of ICT adoption and family dynamics (Tadpatrikar, Sharma & Viswanath, 2021; Sharaievska, 2017; Romero-Ruiz et al., 2017;

Carvalho et al., 2016; Carvalho, Francisco & Relvas 2014), and the linkages among the actors involved in an innovation is key to the improvement and acceptability of digital technology (Raunio et al., 2019). Previous research (Petrescu & Krishen 2019; Midgley et al. 2017) confirms the strength in using a diversity of methods and analytics in exploring adoption. This contrasts with previous studies that tend to predict ICT adoption at the same stages and focus on traditional theories applied in different contexts (Eze & Chinedu-Eze, 2018). Eze, Dean, & Chin (2014) have pointed out that several ICT adoption studies use traditional and utilitarian theories, but the diversity of such studies in terms of theory and methodology is low. Similarly, Mcafee (2006) criticized most adoption studies of relying too much on determinism as if ICT adoption is a predictable, straightforward, static and one-off event devoid of uncertainties. However, more often these theories focus on factors affecting an adoption decision at one decision point and undermine the interplay of the same or different factors as decisions progress (Eze & Chinedu-Eze, 2018). Several prominent adoption theories (e.g., Lawrence, 2010; Al-Natour & Benbasat, 2009) focus more on distinct roles and some stable characteristics of technology with little attention on how to handle the growing complexities of our life (Eze & Chinedu-Eze, 2018). To bridge the deterministic and utilitarian nature of most classical theories, a multimethod research design provides a more diverse set of interpretations and insights about the units of analysis. Such an approach draws on a more accurate and comprehensive picture of the phenomenon as a whole using multiple data sources, methods, research methodologies, perspectives and standpoints, and paradigms (Johnson & Christensen, 2017).

This paper presents the results of this study seeking to appreciate the challenges for IVR adoption in the home. As outlined in *Figure 1*, from November 2019 to June 2020 multiple methods were used to deliver a series of parallel interventions. We reviewed

the literature and evidence, interviewed experts in IVR, undertook workshops with teenagers, performed a Delphi study and surveyed parents. The study was extended in response to COVID through further survey questions and longitudinal interviews with parents. As can be seen from *Figure 1*, the research design is of parallel, iterative activities, with emerging data influencing the design of other activities and data collection. For example, as discussed below, possible use cases for IVR were used for the final round of the Delphi study and the parent questionnaire came from an analysis of the teenager data collected at the workshops. Similarly, the REA (Rapid Evidence Assessment) was both used to create the questions for the interviews and was influenced by the analysis of expert interviews in terms of future reviews.

The research design in *Figure 1* is reflected in the order of presentation in the following sections as per the section numbers in the figure. In section 2 the research methods are outlined. Section 3 presents the results of the REA highlighting themes and gaps that were developed for further exploration with experts, teenagers and parents. Section 4 presents the results from the workshops with teenagers. Section 5 presents the results from the expert interviews. Section 6 continues the focus on experts with the results from the Delphi study. Section 7 presents the results from engaging with parents through survey questions and longitudinal qualitative research interviews. Section 8 triangulates and discusses the results and their implications, highlighting the challenges for IVR adoption. Limitations of the study are considered in section 9 and section 10 concludes the paper

2 METHOD

A multiple method research design was used to gain insights relating to the lack of adoption of IVR in the family and home, with a range of methods as outlined in *Figure*

1. Each of these methods is further detailed below with a summary provided in *Table 1* at the end of the section.

2.1 Rapid Evidence Assessments (REA)

This investigation was underpinned by a Rapid Evidence Assessment (REA) of Immersive Virtual Reality for children, families and the home. REAs are an accelerated approach to identify, assess and synthesize the best available evidence on a topic (Muñoz-Chereau 2019). They aim to provide "*a balanced assessment of what is known (and not known) in the scientific literature about an intervention, problem or practical issue by using a systematic methodology to search and critically appraise empirical studies"* (Barends, Rousseau & Briner 2017). The REA approach reduces the time and scale of reviews delivering results quickly and requiring fewer resources than for a systematic review. REAs allow for a broader review of literature beyond academia, considering outputs from industry, government and stakeholders, as well as reviewing available IVR products and services.

The REA involved identifying the most relevant key words for the technological area of interest e.g. Virtual Reality, Immersive Virtual Reality, VR, IVR, headset, head-mounted display, HMD, etc. and the intended context of use e.g. children, teenagers, home, learning, families, games, etc. In addition, the REA presented in this paper was intentionally constrained by a focus on recent and emerging technology, with the aim to assess literature and experiences dating from 2018 onwards. The search used primarily the Association for Computing Machinery (ACM)'s Digital Library and Institute of Electronic and Electrical Engineers (IEEE)'s Xplore. Beyond this, Google and Google Scholar were the main search engines used. The REA also considered grey literature including papers and reports from corporates, policy makers, SMEs and charities. In

addition, VR experiences from providers such as Steam, Oculus and Netflix were reviewed.

The identified materials were considered in terms of their relevance, methodological quality, appropriateness, impact, insights, limitations and trustworthiness. They were summarised to reflect findings, practical relevance and insight into understanding how IVR is, and could be, used by families in the home. As detailed in section 3, the REA identified specific areas for further research and investigation that were answered by qualitative and quantitative interventions.

2.2 Teenager Workshops

With the focus on VR adoption in the home, a key group from whom to gather information are teenagers. This group are the most likely to engage with VR in the family and home in the future. To gather the views and perspectives of teenagers on Virtual Reality now and in 2025, a "Computer Scientists of the Future" workshop was held at the University of Sunderland in November 2019. Workshops are increasingly recognised as a legitimate research method allowing for group understanding to be developed through the fostering of engagement (Lain, 2017). Workshops also allow workshop facilitator and participants to have collaborative discussions and to give constructive feedback (Spagnoletti et. al. 2013). This collaboration and construction are particularly appropriate for workshops aimed at young teenagers, positively supporting their engagement.

The workshop included three 45-minute sessions on IVR. Firstly, in Huawei's 5G Technology Truck, see *Figure 2*, which included a VR-rig enabling teenagers to fly. Secondly, using everyday VR headsets to experience VR spaces, such as oceans, Paris and outer space and to play VR games, including Beat Sabre. The participants also

joined in small and whole group discussions of their experiences of VR and potential future applications of VR, such as tourism. The sessions were supported by two researchers, a teacher and a Student Ambassador. The teenagers were sat at circular tables in groups of 3 or 4 with each group supported by one of the adults. Some discussions were captured on video by the researcher.

The sessions were supported and structured by a workbook that scaffolded the session and collected quantitative, qualitative and speculative design data. Figure 3 provides a fragment of the workbook for an activity about VR tourism, with the VR section of the workbook provided in Appendix 1. Questions aimed to gather the views of participating teenagers on: VR for education and how VR might change education; Spaces, places and experiences that teenagers would like to use in VR and who with; Authenticity and usability and possible use cases for VR. A range of approaches and questions were used as detailed in appendix 1 trying to understand teenage perspectives. For example, in relation to the teenagers' expectations of adults' abilities with IVR we included the 'grandma test' which has been used in business strategy to test accessibility (Speculand, 2017). The question asked teenagers about their view of their grandmother using VR, with the typical north-eastern colloquial expression 'Granny' used in the question. The sessions and workbook were designed and iterated with the research team and teachers, then piloted with teenagers and refined.

- **Participants**: 91 participants from 5 different comprehensive schools in the north east of England participated with 66 male, 24 female and 1 transgender participant aged 13 (46), 14 (39) and 15 (6).
- **Ethical approval:** for the workshop was granted by the University of Sunderland Research Ethics Committee. Schools were recruited through existing networks, with teenagers given the opportunity to self-select whether to

attend or not. Teenagers, parents and the participating schools were provided with an information sheet, assent and consent forms prior to the event. The information sheet included images of the technology truck, VR-hardware and experiences. All of the teenagers gave assent and their parents/guardians had consented. All teenagers were able to leave the workshops at any time.

2.3 Expert Interviews

Problem-centred expert interviews are a widely used qualitative interview method often aimed at gaining information about or exploring a specific field of action (Döringer 2020). Experts are considered knowledgeable of a particular subject and are identified by virtue of their specific knowledge, their community position or their status (Kaiser, 2014). For this research, qualitative semi-structured interviews were conducted involving 15 experts from universities, technology corporates and stakeholder organisations. Qualitative interviews were selected as they emphasise the importance of investigating the experiences and perspectives of the interviewees for developing a better understanding of social reality (Edwards & Holland 2013; Flick 2018).
The semi-structured interviews were tailored to each expert and their area of expertise. They aimed to explore export perspectives on technology adoption currently and in the next 5 years, with questions relating to the connected home, interactive toys, voice assistants and, as reported here, virtual reality. The interviews lasted for an hour and were audio only, with approximately 10-15 minutes of the interview focused on IVR. The questions derived from the REA focused firstly on awareness of age restrictions and of the use of IVR for children and teenagers including awareness of issues related to VR data. Secondly, experts were asked to discuss current and expected user experiences of

Immersive Virtual Reality and VR headsets by children and teenagers, both inside and outside the home.

The interview data was recorded and transcribed. The transcripts were analysed using Template Analysis, a style of thematic analysis that involves the development of a hierarchical coding template from initial data analysis that can be further refined as it is applied to the full data set (Brooks et al. 2015). This resulted in the development of a series of interconnected themes emerging, as detailed in section 5.

- **Participants**: the sample consisted of 8 academics with expertise in fields including child computer interaction and participatory design; IVR/XR content, games, experiences and education; and digital and online implications and policy for children and teenagers. All of the academics had contributed to leading conferences and journals in their fields. The 7 industry experts included technologists and future technologists with VR knowledge and expertise along with experts from regulators and stakeholder organizations supporting the digital experiences of children.
- **Ethical approval:** for the expert interviews was granted by the University of Sunderland Research Ethics Committee. Participants were recruited through existing networks and contacts. Participants were given an information sheet and gave consent for their participation.

2.4 Delphi Study

The REA and expert interviews were used as the basis for creating a Delphi Study to assess the potential for IVR adoption. Delphi Studies have proven to be a reliable measurement instrument in developing new concepts and setting the direction of future-orientated research. They have been used to establish consensus across a range of

subject areas, seeking the opinion of a group of experts to assess the extent of agreement and to resolve disagreement on an issue (Vogel et al., 2019). In a Delphi Study consensus is achieved by delivering multiple rounds of statements or questions to experts. Experts then rate their agreement and the results are analysed to assess the degree of consensus. In each round, the aggregated summary of the last round is presented showing consensus and highlighting unresolved issues.

Based on the REA and the expert interviews, 5 statements about IVR were created for the first round of the Delphi. These sought to gain consensus from the 15 experts in relation to questions that remained unanswered or where there had been a lack of consensus from the interviews. The five statements were:

- Virtual Reality hardware will be mainstream with most homes owning one or more low-cost headsets.
- Virtual Reality experiences aimed at the whole family will offer games and activities to do together and will be a common way to spend a wet Thursday evening with under 12s.
- There will be a significant growth in non-photo-realistic VR games and experiences with low quality VR providing sufficient immersion for users, similar to a VR-equivalent of Minecraft.
- VR experiences will enable users to have presence at live events, concerts, theatres and festivals.
- VR will be used in school and for homework blended with other forms of learning tailored to the domain.

These statements were sent by email to the experts who were individually asked for their view on each statement to identify whether they Disagreed, were Neutral or Agreed, with the results summarized in section 6.

Round 2 of the Delphi sought further consensus in relation to VR adoption to determine if VR would become a more used and adopted technology. We asked a group of 21 experts (12 from the original expert set and an additional 9 experts drawn from academic researchers, school governors and technology teachers). These experts were asked three sets of questions using an online survey about expectations of IVR in 2025:

- What would be the duration (<1 hour to 3+ hours) and frequency (from Rarely/Never to Daily) of VR-headset use in the home for parents, teenagers and 11-13 year olds?
- What would parents, teenagers and 11-13 year olds use VR-headsets in the home for? Activities provided were: Games / Having Fun; Media (e.g. streaming, events, etc.) and Learning and/or Working.
- Experts were asked to rate a range of use cases for IVR in the home that had emerged from the REA and teenager workshop. These included using VR to: Play games; visit places and historic events; meet up with friends; exercising in a virtual gym; going on holiday; watch movies; working and training for work; and learning and doing homework.

The final stage of the Delphi involved gaining consensus on the final report written from the study (Hall, 2020).

- **Participants**: Round 1 involved 15 experts as detailed for the expert interviews. For Round 2, the sample of 21 consisted of 12 of the interviewed experts (6 academics; 6 future technologists / stakeholders) along with an additional 5

academic experts who were researchers interested in future technology and IVR, 2 school governors with knowledge of ICT and 2 school technology teachers. All experts who participated were sent the final report for agreement.

- **Ethical approval:** for the Delphi Study was granted by the University of Sunderland Research Ethics Committee. Participants were recruited through existing networks and contacts. Participants were provided with an information sheet and gave consent prior to engaging in the study. Participants were able to leave the intervention at any time.

2.5 Parent Questionnaires

Within this multiple method approach questionnaires have been used to gather data from teenagers (through the workbook) and experts (through the Delphi questionnaires). Questionnaires were also used with parents in their most typical form as a medium of communication between a remote researcher and subject not requiring direct communication nor presence (Brace 2018). Quantitative questionnaires typically provide standardized responses to the same questions ensuring consistency (Rahi, Alnaser & Ghani, 2019) and offering repeatability and validity within research investigations (Singh, 2017). There are many benefits in using questionnaires all of which apply for their use in this study. These include cost-effectiveness, wide coverage, anonymity, convenience, speed and the opportunity to gather quantitative data that can be used to prove or disprove existing hypotheses. Two questionnaires were used to inform this research, the first before COVID and the second during the first UK lockdown in 2020. Recruitment was via mailing lists and social media. The two questionnaires were separately administered and did not involve the same sample of parents as respondents.

2.5.1 Parent Questionnaire – Pre-COVID

A questionnaire was developed for parents with questions on technology use in the home now and in 2025 including two quantitative and one qualitative question on IVR:

- Are you intending to purchase technology for the home? VR-headsets were one of the technologies provided with parents having the options of: Already have, Bought recently, Thinking of Buying or Not Interested.
- How will we use IVR in the home in 2025? Parents were asked to rate use cases from Very Unlikely to Very Likely. Use cases were using VR to: Play games; visit places and historic events; meet up with friends; exercising in a virtual gym; going on holiday; watch movies; working and training for work; and learning and doing homework.
- What do you think Virtual Reality will be used for at home in 2025? Parents were given the opportunity to add their own comments for this open question.

- **Participants**: 402 parents
- **Ethical approval:** for the parent questionnaire was granted by the University of Sunderland Research Ethics Committee. Participants were recruited through requests to mailing lists, on-line groups, existing networks and contacts. Participants were provided with information sheets with consent assumed if they then went on to complete the questionnaire. Parents were informed that they were able to opt out of the research if necessary.

2.5.2 Parent Questionnaire – In-COVID

During COVID a second parent questionnaire was distributed, to assess the impact of COVID on technology use and future use. It was completed by 232 parents who were asked to respond to two questions on IVR:

- Have you purchased technologies during COVID or do you have intentions to purchase? Responses included VR-headsets as a category aiming to identify if COVID had impacted on adoption with options of Already have, Bought recently, Thinking of Buying or Not Interested.
- Do you agree with the statement "By 2025, Children will be learning, streaming and gaming using VR-headsets" with ratings from strongly disagree to strongly agree.

- **Participants**: 232 parents
- **Ethical approval:** as for the parent questionnaire above.

2.6 Longitudinal Qualitative Interviews

Longitudinal qualitative interviews were used to capture parent perspectives during the first UK lockdown (March-July 2020). The principles of Longitudinal Qualitative Research (LQR) are duration, time and change and considering the transformation that may occur over the course of a study. LQR enables the researcher to better understand the development of perspectives over time, stability of positions or lived experiences. Where change in positioning is pertinent to answering research questions LQR offers insight and adds depth to the research process (Calman, Brunton & Molassiotis, 2013). 13 families participated in a series of longitudinal interviews about technology use in the home and family, with hour long semi-structured interviews via the phone held monthly in April, May and then June. The 13 families included children from babies to adults. The majority of the interviews involved one parent, with some including both parents. Occasionally other members of the family engaged briefly during the interview to give their perspective. The semi-structured qualitative interviews focused on a range of technologies and use in the home, considering how technology use was changing at

home and in the family as a response to lockdown. In their final interview, parents were explicitly asked about VR-headsets and their views on adoption and use. The interviews were recorded, transcribed and thematically analysed to identify themes related to adoption and expected use of VR in the home and family.

- **Participants:** 13 families represented by the parent
- **Ethical approval:** for the longitudinal qualitative interviews was granted by the University of Sunderland Research Ethics Committee. Participants were recruited through existing networks and contacts. Participants were provided with information sheets and consent was given before the study began.

Table 1. *Summary of the Multiple Method Research Design*

Method	**Overview**	**Participants & Ethics**	**Data capture and analysis techniques**
Rapid Evidence Assessment	Review of research, technical & grey literature on IVR adoption in the home and family	n/a	Systematic search and synthesis of identified materials
Teenager Workshops	Teenagers participated in IVR workshops. They experienced IVR and answered questions exploring their	91 teenagers Approval from University of Sunderland Research Ethics	Mixed methods with questionnaire and discussions. Frequencies for quantitative data.

	perspectives and expectations of IVR.	Committee (UoS-REC) Assent from teenagers Consent from parents	Thematic analysis of qualitative data
Expert Interviews	Experts from academia and technology corporates were interviewed to explore their perspectives on IVR as near-future technology in the home.	15 experts Approval from UoS-REC Informed Consent	Qualitative study with semi-structured interviews tailored to participants analysed using template analysis
Delphi Study	Experts (from universities, technology corporates, stakeholder organisations and schools) participated in a consensus gaining approach - considering how VR may be used at home in 2025	21 experts Approval from UoS-REC Informed Consent	Based on the REA and expert interviews, questions were created for a 2-round Delphi study. Agreement assessed through frequencies
Parent Questionnaire	2 quantitative and 1 qualitative question on	402 participants Approval from	Questions analysed with frequencies and

(pre-COVID)	VR use now and in future	UoS-REC Provided with information sheet. Consent assumed if questions completed.	thematic analysis of qualitative response.
Parent Questionnaire (In-COVID)	4 quantitative questions on VR use now and in the future	232 participants Approval from UoS-REC Provided with information sheet. Consent assumed if questions completed.	Questions analysed with frequencies
Longitudinal Qualitative Interviews	3 phone interviews held over a 3 month period to explore technology, the family and home during lockdown. Specific questions on potential of IVR in final interview	13 parents Approval from UoS-REC Informed Consent	Qualitative semi-structured interviews with thematic analysis

3 ASSESSING THE EVIDENCE - CONSIDERATIONS FOR IVR, CHILDREN, FAMILIES AND THE HOME

This section considers existing evidence, presenting a Rapid Evidence Assessment (REA) of Immersive Virtual Reality, children, families and the home. The REA explored the limited adoption of VR-headsets in the home. It aimed to understand why, in a context where IVR could have so much potential in the home that there continues to be little expectation of uptake.

3.1 IVR & Age Restrictions

From the REA, it became apparent that there is a perception that IVR is not for children, as reinforced by currently, commercially available VR-headsets targeting those from age 12 upwards. The PlayStation is for 12+, Samsung Gear 13+, Oculus 14+ and the Vive has no age restriction but explicitly states that it is not designed for children. Although there have been concerns about the physical impact of IVRs on children (Robertson, 2017; Bouckley, 2019) including their vision, brain development and health (Bailey & Bailenson, 2017), there is little evidence to support this view. Findings instead indicate that IVR has little impact on the vision of an 8-12 year-old with reports from Vive studies that eye strain or fatigue in IVR was the same as from a tablet or phone (Skarredghost, 2018). IVR was not found to have a negative impact on visual functions (Tychsen & Foeller, 2018) nor balance (Yamada-Rice et al., 2017) and only low levels of VR motion sickness were seen in children (Aubrey et al., 2019). Although studies identify that IVR has a similar physical impact as other technologies, study numbers have been small and often for one-off experiences rather than regular use, such a one-off 20 minute interaction with VR apps (Lei et al., 2018). While there is a lack of evidence on long-term IVR use, VR-headsets do seem to be appropriate for use, physically, by those who are 7 or older (Aubrey et al., 2019) with the vision of children sufficiently developed and stable by this age.

There have also been concerns about the impact of VR on the mental health of children and teenagers. These range from the impacts of exposure to inappropriate content, people and behaviours in VR to challenges such as addiction. The concerns and mitigation are similar as those for other technologies that support gaming or socialising rather than specific to IVR. Where IVR is unique in relation to age is in providing an immersive separate reality and this does restrict when children can begin to experience it. Younger children have challenges in separating real from virtual. However, by the time they are 6 most children are able to distinguish this. For example, in a study of virtual dinosaurs (Liao et al., 2019) children between 6-8 years old could distinguish between virtual and real. In response, IVR has started to be developed for children in entertainment spaces such as arcade-based immersive VR experiences for children aged 7 or older (Hayden 2018; Garcia-Navarro 2018).

Unsurprisingly, with IVR viewed as being for teenagers and adults most commercial VR content has been developed for the 13+ age range applying the age-rating approaches used by games and films. This assumption of 13+ audiences continues to restrict content development so directly targeting children is a significant barrier for VR adoption (Laurell et al., 2019). The area where content is most likely to be developed is gaming, this being considered the most likely area to benefit from VR technology, given significant investment and development (Fortune Business Insights, 2019a).

3.2 IVR Use - Games, Streaming and Socialising

Games are also the reason for most interest in VR from children (Yamada-Rice et al., 2017; Elliott, 2019). With gaming increasingly popular this provides a considerable market (Clement, 2021). And somewhere, although clearly not at most homes if unit numbers are considered, children are engaging with IVR. 29% of parents reported that

their child had used a VR-headset for gaming in 2019, with 9 years 1 month as the average age they first used it (Internet Matters, 2019).

The most popular games in VR typically involve adventuring, thrill and kill in mainly dystopian spaces, with listings on SteamVR in 2020 seeing little deviation from this trend. IVR provides a more photo-realistic experience, however, for many the difference is the device rather than the game, attracting similar players to an experience with better visuals and audio, but where the play and content remains similar. However, gaming is more than mechanics with social aspects having considerable importance particularly for teenagers. Gaming provides vital social spaces and helps to maintain friendships beyond school by offering important socializing time that may not be replaced if the game is not played (Tomlinson, 2019). Socialising together in game worlds will also be key in VR (Rex, 2017) with a clear need to replicate this experience if IVR begins to replace consoles.

The potential of IVR for socializing is also a key opportunity for VR streaming, which is expected to rise significantly with services such as Amazon, Netflix and YouTube already providing VR channels with features such as Hulu's Social viewing enabling users to remotely stream VR together (Bond, 2018). Streaming sport in VR has already proved popular (Esquire, 2019) with providers such as Fox, Sky and BT. For VR, the playing and streaming of VR esports, video games that require movement in addition to strategy and skill, are also expected to increase significantly with competitions for games such as Space Junkies and Beat Saber being offered. Many children and teenagers are already 'Popcorn gamers' - watching others playing games as much or possibly more than playing themselves (Bosman, 2019). With VR, children and teenagers will be able to stream their favourite games and gamers together, watching, cheering and chatting in the same 'stadium' whilst in their own homes.

VR as entertainment channel has been boosted by the COVID-19 pandemic and there has been a significant rise in VR offerings, including virtual exhibitions (Feinstein, 2020), experimental live concerts with entertainers as avatars (Millman, 2020), virtual festivals (Beaumont-Thomas, 2020) and Fortnite from Travis Scott, providing a new experience for audiences and attracting over 12 million viewers (Frank, 2020). With many cultural institutions having a mandate to engage children with arts and culture, Covid-19 has forced an exploration of alternative digital spaces with online exhibitions and a rise in virtual reality (Feinstein, 2020). However, although VR-headsets provide a new device through which to consume media, sport, culture and games, interactivity and innovation remain fairly limited, with viewers having a similar linear, passive experience to using any device. And of more concern for IVR adoption is that such experiences rarely target children and teenagers. The platform for those groups being tablets for younger children and then mobiles.

3.3 IVR and Learning

The main area where IVR has long been seen to have potential is in providing learning experiences for children in primary and secondary education (Roussos et al., 1999). For over two decades IVR has been shown to be an excellent way to achieve certain types of learning for children including for geography (Minocha, Tilling & Tudor 2018), language learning (McMahon, 2021) understanding history and culture (Yildirim, Elban & Yildirim, 2018). It has been used for exploring challenging social contexts (Ingram 2019) and for learning for the neuro-diverse (Ke, Moon & Sokolikj 2020; Adjorlu & Serafin 2019) and those with disabilities. Although studies of IVR learning are typically small, the overwhelming consensus is that VR could provide a useful additional way to learn. However, until very recently the costly requirement of VR-headsets has been

beyond the practical reality for many schools with already limited technology budgets. The IVR via smartphone did have some adoption, but ultimately was not successful (Robertson, 2019) primarily due to a lack of interactivity.

For IVR education to be adopted, for the cost to be affordable, IVR has to demonstrably add value to education. It has to offer more than non-immersive virtual reality, a significant challenge in that there is a lack of content and experiences beyond games. For educational IVR to become mainstream, not only does it have to be good, interesting, relevant, interactive and engaging. More than this, it appears to have to be better than the screen and to do this it must also be an effective teaching mechanism in the classroom (Kulowiec 2020).

3.4 IVR Data

The final issue that emerged from the REA goes across all the IVR use cases, gaming, streaming, socializing and learning, and relates to VR data. Although many of the issues and thus regulation for VR data are similar to those for other online experiences, some are novel, in particular, the collection and storage of biometrics and biometrically-derived data through VR devices (de Guzman et al., 2020). Micro-movement tracking data can be used to derive basic physical characteristics such as height, to predict or diagnose conditions such as ADHD or autism (Bekele et al., 2013) and to gauge the emotional responses of players. With people exhibiting unique patterns of movement VR tracking data makes them easily identifiable (Pfeuffer et al., 2019), making it almost impossible to provide anonymity. Data collected by VR technologies are largely unregulated, and how they are collected, used and shared is not monitored by any external entity (Outlaw & Persky, 2019). Like other digital products, VR games and experiences use privacy policies to provide transparency around data collection, aimed

at enabling us to understand what is being collected and what this is being used for. However, when VR privacy policies were assessed (Adams et al., 2018), of the HTC Vive only 30% of VR games had the privacy policy posted and although 82% of Oculus experiences had a privacy policy, only 19% of these explicitly mentioned VR or VR data. Most VR games are not yet directly using biometrics, such as heart rate, however, VR privacy policies include clauses that already allow for this (Hosfelt, 2019). The collection, processing and storage of data is to some extent justified as needed for improving and innovating gameplay, however, current messages from the VR sector highlight that this will not be the only use (Cortese, 2019). Almost all VR companies identify in their privacy policies that data will be used for marketing purposes and shared with networks and affiliates. This poses considerable issues with industry concerns that biometric data will be used to create biological maps and keys of users (Adams et al., 2018) used most probably for novel marketing and persuasive techniques. With Oculus being owned by Facebook, this seems inevitable.

3.5 Considerations from the Evidence

Most VR-headset users are male and in the 16 to 34 age group and use their VR-headset for gaming (Newzoo, 2018). With VR seeking to attract such existing markets onto a new device, unsurprisingly there has been a lack of investment in IVR experiences for children and families. Further, there appears to be a lack of interest in what children, teenagers and families could be doing in IVR, with research funders such as UKRI or the EU not focusing on the home context for IVR. This is coupled with commercial ambivalence to the family as consumer, firstly related to the myth of age-restriction; secondly to the rationale for adopting VR in the home, with apparently no clear

challenge nor need for a VR solution; and thirdly the continuing draw of the highly lucrative and expanding adult gaming market.

The main outcome from the REA was the need to envision a future, to explore what it was that could be done with VR and perhaps to identify what could form the basis for a mainstreaming of this technology, and what it might take to enable adoption to happen. In exploring challenges in adoption for children and teenagers at home and to explore what may be emerging that could change this, a multi-method approach was taken engaging with experts, teenagers and parents.

4 RESULTS: TEENAGER VIEWS

4.1 Teenager views on learning in IVR

Teenagers were not entirely convinced about learning in VR by 2025, with 43% of teenagers neutral about whether VR would be used in most of their lessons, 34% thinking that VR would be used a lot with 23% hardly or not at all. Teenagers were somewhat positive about the impacts of learning with VR, see *Figure 4*. Just under 60% thought learning in VR will be more interesting and 57% that it will make learning more fun. 43% thought it would be easier and 40% that it would make remembering easier. However, around 30% of teenagers thought that VR would make learning harder, less fun, less interesting and harder to remember.

Teenagers were asked about the subjects they might study in VR, see *Figure 5*. Teenagers thought they would use VR for learning to fly and for learning physical skills such as building a wall, learning to cook or studying Art and Design. They also thought VR could be used to study history. IVR was not viewed as positive for studying maths nor for language learning.

4.2 Spaces, places and experiences that teenagers would like to use in VR and who with

Teenagers were somewhat doubtful and had relatively limited hopes of what VR might bring beyond games or movies. Teenagers did not believe that they will be using VR in the workplace, with only 29% believing that they would use VR regularly in their work lives and 38% believing they would not be using it much if at all. This contrasted with the jobs they thought they might hold, even for roles such as engineer, games developer, architect and so on most doubting they would be using VR regularly in work.

48% of teenagers had visited a place in Virtual Reality that had made them want to visit it in real life. These were often cities and frequently places that would be difficult including regions such as Antarctica, Everest, the bottom of the sea and outer space. Around half of the teenagers believed that they could use VR to convince their parents to visit a destination. Teenagers were more likely to think that they could convince their family to visit if it was a city. However, if teenagers did go on a VR holiday, they would prefer to do so either with their friends (49%), or alone (34%), with the family in last place (17%).

Teenagers were not at all convinced by virtual tourism and did not believe that an experience in VR would be as good as the real thing, with only 27% of teenagers thinking that VR could be a substitute for real life and 49% firmly believing that it could not. Where teenagers did see a use case was exercise, with 50% of teenagers expected to exercise in the home with only 24% of teenagers intending to go to the gym by 2025.

4.3 Usability and Authenticity

Teenagers found the VR headset the least comfortable of the devices they used to interact with VR. The most comfortable device is the games console, with 63% of

teenagers finding this comfortable for 2 hours or more in comparison to only 46% finding the headset comfortable. Teenagers doubted that adults will be able to adapt to VR. Although, most teenagers thought that their Granny would probably have a go in Virtual Reality, only 32% thought 'Granny' would really enjoy it, with 59% believing that their 'Granny' would find the VR "impossible to use" with only 1 teenager thinking that 'Granny' would be able to use it straight away.

All teenagers agreed that immersive VR had elements of realism, however, only 55% found it totally realistic. VR is least realistic on handheld devices such as Nintendo. Whilst Minecraft is non-realistic, for 19% of teenagers a pixelated environment has elements of real life, with 6% believing that Minecraft was exactly the same as real life, as in *Figure 6*.

4.4 Use Cases

Teenagers were asked about several use cases (e.g. learning in VR, tourism in VR, IVR games and experiences, etc.) and to suggest their own. The use cases that were suggested by the teenagers already exist or have been prototyped in the literature. There was a lack of novel, unique or unusual ideas for interactions and experiences suggested. When asked "what else" the focus was mainly on better games. The use cases suggested by the teenagers were included as a question in the second round of the Delphi and in the questionnaire to parents, with the use cases provided in *Figure 10*.

5 RESULTS: EXPERT INTERVIEWS

The interviews with the 15 experts were analysed using Template Analysis (Brooks et al. 2015) with five themes emerging, as outlined in *Table 2* and further discussed below.

Table 2. Themes from Expert Interview Analysis

Themes	Summary of Comments
VR Adoption	Significant workplace adoption Adoption in home will be mainly by teenagers / children Limited adoption anticipated by parents with few potential applications identified Age not a barrier - lack of content is Little awareness of VR data issues
User Experience	Light weight; easy to use; service available to everyone; seamless VR; more affordable; great content but mainly games. Main use cases: games, education, streaming, visits, tourism, exercise/gym, attending events, social spaces Limited innovation for experiences and lack of products targeted at home/family.
Gaming Utility	Main way children and teenagers will play games at home Similar to current games – same audience and similar approaches Expectations of improved immersion and performance Lower visual realism offers potential for children
Educational Utility	Potential for wide range of subjects (history, languages, geography, STEM, arts, culture, etc.). Seen as being used primarily in the classroom. Opportunities for disability/neuro-diverse
Social Utility	Friends – games as social as well as playing spaces with social VR spaces such as streaming, watching esport, etc. Social VR spaces for connecting such as events, exercise, with family

	possible but little provision VR-headsets likely to reinforce, but improve, the solitary life of tweens and teenagers within the family.

Experts predicted a continued rise in using VR in many sectors and jobs, that VR will be: "*Stretching into work more than in the home environment*." Experts thought that it was unlikely that VR headsets would be adopted, seeing limited use by adults in the home: *"… not at all clear what use it has in the home beyond entertainment or for working from home*" with the "*Majority of VR users are from business, education and gaming sectors, not much else to be seen*." However, although experts saw limited utility of VR for adults in the home (beyond remote working), they did expect to see a continuing and increasing purchase of VR-headsets for use at home by teenagers and children with "*VR headsets offering access to incredible, engaging and often communal and social experiences from the comfort of the bedroom*."

Experts agreed that the IVR user experience was much improved "*the days of staggering as you put a big clunky headset on are long gone… but it is the wires going that will have the most impact on experience*." Another key factor for adoption was mentioned by most experts was the increasing affordability of IVR: "*VR-headsets, like Oculus, they now cost less than a gaming PC or a tablet*." Technical experts highlighted changing distribution mechanisms that would increase availability: *"…we don't have to connect the VR headset to the server or any machine at home… linking to the cloud platform to deliver the VR content*."

Most experts were uncertain about age restrictions and IVR. In general, experts concurred with the view of headset providers that VR-headsets were currently for

teenagers and adults rather than children. No experts were aware of studies highlighting negative impacts from VR on children and teenagers. All the experts were aware that data was likely to be retained by VR companies, but only 2 of the experts were aware of the extent of data capture or the uniqueness of user interactions. All had awareness of IVR experiences for children and expected more experiences to emerge, anticipating that the market would grow significantly: "*sales keep growing… Oculus Quest is out of stock. There would be more players if there was more hardware available. And sure, they'll be getting younger*."

The general view was that VR games would be mainly similar to what we have now on other platforms, and of course, engaging, excellent and fun. Experts thought that VR-headsets would become the main way that children and teenagers engage in games in the next decade. Experts identified the ongoing challenge of children accessing content for older age groups and that this was already occurring, partially as a result of a lack of content for younger gamers. However, the challenges and issues related to IVR gaming were viewed as being similar to those for other formats. Expectations were of better immersion, more ways to interact and realistic IVR in games. Those experts involved in designing with children, suggested an alternative: "*the emergence of a killer-app for VR-games using low-resolution Virtual Reality that will run on reasonably priced hardware and provide new interactions and approaches, just as Minecraft did for the screen*."

After games, the main use case that experts discussed for IVR for children and teenagers was education. Experts emphasised the potential for IVR to offer a different educational experience "*you're going to be going places that you can't visit, a nuclear power station, a volcano erupting, we're going to get that kind of content in VR you know like documentaries and full-on experiences that will be fun*." IVR was considered to have

significant educational utility: "*you can give the virtual experience to the students in the classroom or even at home for some subjects then it is a lot more interactive and can develop their understanding much better*." In this role of learning technology, IVR was seen as a useful additional way to engage children: "*VR is a quick and easy way to keep your children amused and you sort of feel like you might be doing something good because they happen to be playing on something that is teaching them something, and you can get on with your day*." IVR was seen as relevant to almost all subjects, with examples from history: *"…rather than visiting the site itself you can give the virtual experience to the students in the classroom or even at home…*" to engineering: "*develop [student] understanding remotely using virtual reality and when they are comfortable then you can take them to the real world*." Several experts identified the potential of IVR education for children and teenagers with disabilities and neuro-diverse populations, yet that there was still a lack of experiences: "*so many projects, so many great ideas but hardly any make it into use even though results say that VR could make a difference*."

Even though many educational uses were identified for IVR, experts were not convinced that IVR would become a significant part of learning: *"[pupils] can really get much closer to the actual experience of the archaeological dig using VR so I think these sorts of specialized and important applications are going to continue to show up and they'll find their place in education but I don't see them in maths or in certain parts of science*." Most experts were of the view that VR learning would be a part of a larger blended learning experience rather than the main approach: *"…VR-driven educational future, like Ready Player One… no one wants that*." Although IVR would exist for younger age groups, the general view was that schools engaging in VR would be focusing on teenagers. There was almost no consideration of IVR for informal and self-selected

learning, with IVR seen as an adjunct to formal school subjects. Experts who had been researching in IVR for some-time were still waiting for IVR to become well-used: "*using IVR for education was compelling in the 90s, and although the technology is better and affordable, it still isn't used in schools. Which makes you wonder if it ever will be.*"

In addition to gaming and education, experts identified a range of use cases for VR in the home, including, as an exercise space: "*connected classes, we'll join with people to exercise together in VR,*" however, there was doubt that this would be immersive: "*headsets are not meant for exercise… just don't fit the brief.*" Some of the experts had visited destinations in VR, however, VR-visits and tourism were not expected to gain popularity: "*all these places, they are a bit empty and well, somehow the essence of a visit is lost, if it is just sight and sound*." Some experts mentioned the growing availability of streaming services and eSports: "*they watch them, they can compete in them and even win them, what's not to like, it is a viable career option if you're a great gamer*." Experts identified that VR would have growth as a way to attend sporting events, concerts and festivals. However, again this was as individuals, rather than as families attending communal events. Experts highlighted the potential of VR as a social space "*there are lot of possible applications for VR…our extension to the digital world…the digital version of yourself in that virtual environment, in that virtual world and where families and friends can collaborate and socialize.*" However, even with examples such as VR Party, the togetherness is generally of friends with applications for families engaging together in VR is one that experts had not seen.

The main issue seen as limiting IVR was the lack of interactivity including the need to add additional channels, such as haptic technologies: "*more than headsets, at least haptic gloves … letting you feel and touch the unreal and interact with a game world more naturally*" and "*For instance, one should be able to pick up things. So, you know,*

you don't just show them pictures of the Pyramids or the Elgin Marbles but actually have 3D models so that you can pick them up and make the most of them." This improvement of immersion was the key technical development that experts discussed for the future of IVR "*games are emerging where you really can interact with objects, feel them, touch them and the sense of presence is so strong it feels, well, real.*" There was the continuing view that this realness was a key advance, such as with additional interfaces for smell, taste and touch: "*of course you are not rowing in the lake, but the VR content is as great as if you are rowing in the lake, so you are incentivized to use it.*"

Experts were generally positive about Virtual Reality, seeing it as a useful technology, yet some of the experts were somewhat jaded. Virtual Reality has had a significant impact in the workplace and for specific sectors, however, quite how to use it as a family, by children and teenagers and in the home, was less clear, and experts recognised a lack of work in this area. Some experts felt they had been waiting a long time to see what VR would provide beyond the workplace. And although experts provided many examples of how VR might be used beyond gaming and streaming in the home, they identified that prototypes and concepts were very rarely scaled up into products.

6 RESULTS: DELPHI STUDY

From the results of this first round of the Delphi, experts achieved agreement that IVR would not become mainstream. There was a lack of agreement for use cases in the home, without consensus on families engaging together in IVR nor for the use of IVR for education, although the use of IVR for events beyond the home was seen as highly likely. Also expected, was that a child-centred approach for IVR such as a VR-equivalent of Minecraft would emerge (see *Table 3*).

Table 3. Round 1 - Delphi statements and consensus

Statement	**-ve**	**Neutral**	**+ve**	**Consensus**
Virtual Reality hardware will be mainstream with most homes owning one or more low-cost headsets.	10	2	2	-ve
Virtual Reality experiences aimed at the whole family will offer games and activities to do together and will be a common way to spend a wet Thursday evening with under 12s.	5	3	6	No consensus
There will be a significant growth in non-photo-realistic VR games and experiences with low quality VR providing sufficient immersion for users, similar to a VR-equivalent of Minecraft.	1	3	10	+ve
VR experiences will enable users to have presence at live events, concerts, theatres and festivals.	1	2	11	+ve
VR will be used in school and for homework blended with other forms of learning tailored to the domain.	3	4	7	Towards +ve

In the second round of the Delphi study, experts were asked to estimate usage. As detailed in *Figures 7* and *8*, experts expected that parents would only use IVR occasionally, if ever, and when they did for relatively short time periods.
Experts anticipated that parents would have limited use across the three most anticipated uses of IVR for games, streaming and learning and/or working as in *Figure*

9. Far greater use was expected for teenagers, and notably for tweens, where regular interactions with VR were anticipated of longer duration. Streaming was the main use expected for teenagers, with 11-13 year olds seen as likely to use VR for games and learning.

Experts were also asked about a variety of use cases as being likely for VR. These use cases, see *Figure 10*, were developed from those suggested by the teenagers as detailed above. There was some consensus amongst experts about what VR would be used for by 2025, with games still the most likely use case, with meeting friends and streaming also seen as more likely. The use case least favoured by experts was virtual tourism. As can be seen from the figure, experts were neutral, or perhaps unconvinced by most use cases or at best ambivalent.

7 PARENTS - QUESTIONNAIRES & INTERVIEWS

7.1 Pre-COVID Parent Questionnaire - Results

In the first questionnaire, undertaken before COVID, 16% of the respondents already had a VR-headset, 3% intended to buy soon, 28% someday and 53% of parents had no interest in purchasing a Virtual Reality headset. Parents thought that VR would be used at home mainly for playing games, learning and watching movies. Whilst 54% of parents did think we would have VR experiences allowing us to visit the past, 78% did not think we would use VR for going on holiday. However, just under half of parents did think they would be using VR at home for work and training related to work, see *Figure 11*.

Parents were also asked to suggest potential uses for VR at home as an open question. This was analysed into categories, with the most common responses being respectively: games, learning (including self-learning via tutorials), streaming, exercise, socializing and connecting with family, cultural exhibitions / events and visiting universities, hotels

and places where someone might be making a choice about visiting. There were no use cases presented of novel experiences, with no suggestions beyond VR experiences that already exist.

7.2 In-COVID Parent Questionnaire - Results

In the second questionnaire, distributed during the first UK lockdown in April-May 2020, parents were asked if they had purchased any technology since February. As can be seen from the following *Figure 12*, the least popular technology for adoption was VR-headsets with parents less likely to already have a VR-headset and most likely not to be interested in purchasing one, with 73% of respondents having this view.

In response to the statement, by 2025, Children will be learning, streaming and gaming using VR-headsets, 19% of parents strongly agreed, 41% agreed, 21% were neutral, 13% disagreed and 5% strongly disagreed.

7.3 Results: Parent Interviews

In the parent interviews, there was no mention of VR and its use within the home, except for in the final interview when parents were explicitly asked about VR-adoption. VR was not seen as a technology for the home and family and although parents talked broadly about many technologies, such as Voice Assistants, games consoles, smartphones and screens, VR was not mentioned. Nor did parents see themselves using VR at home, "*maybe, if work provided it and we had to use it*" and "*it just doesn't look a comfortable way to watch a film*." They could see few uses for VR beyond gaming, "*it's just the new console really*."

Considering how challenging many parents had found lockdown and home schooling, the potential for VR as a learning environment was suggested by the interviewer, again no parents raised the idea of VR for learning without prompting. And once again,

parents were not keen: "*it might work well for some lessons, but I think the live teaching they do via screens is probably better*." And "*seems very OTT and a bit unnecessary … not sure it would be a good way to learn, classrooms would be better*." There was some concern about the impact of such devices on family dynamics "*he'd [12 year old] love one but then it would cause fights as only one of them could use it*" and from another parent: " *… would seem odd to have them sitting in the front room like a mannequin and really somewhere else escaping from the family in every way*." The potential for VR to provide social spaces was suggested, but by June, all of the participants were using Zoom or similar and found that sufficient, with the challenge of how VR could be used in a multi-person family seen as significant: "*it would be much harder to do that sort of thing in VR, we'd all have to have headsets, now when I'm talking to mum, the children [9 and 12] can join in. If I was wearing a headset it would just be me*."

8 LIMITATIONS & RESPONSES

The study had several limitations. With the teenage workshops, 73% of the sample were male. The workshop focused on Computer Science, IVR and the future of technology. As the teenage participants had self-selected attending the workshop this gender imbalance of participants was to be expected. It reflects other studies, with teenage boys identified as having a greater preference for engaging in VR technologies (Newzoo, 2018). Additional workshops have been held including some targeting girls particularly in relation to virtual tourism. However, similar to the results reported here there were no innovative use cases proposed. Future work aims to focus on using design thinking with teenagers to explore new use cases.

Limitations lie in the data that was captured from teenagers. Workbook questions asked for predictions, with for example 50% of respondents expecting to exercise in a virtual gym at home. However, the questionnaire did not capture whether IVR would change what teenagers were already doing, such as whether they were already exercising at home and did not intend to use a gym regardless of IVR. How IVR could disrupt and alter their lives was not explicitly considered during the workshop, with future studies intended to further explore potential IVR impacts.

The expert interviews and Delphi Study were limited in that similar to many qualitative studies numbers were small. Further, there may be experts with more knowledge and awareness of current and future trends in IVR than those that were interviewed or participated in the Delphi Study. However, it is possible to suggest this limitation is minimal, as the experts' view tallied with that of the REA again highlighting limited expectations and use cases for IVR in the home.

The focus of the parent surveys and interviews were technologies, the family and the home with IVR one of the technologies considered. This approach incorporating multiple technologies could be a limitation, however, parents had little interest in VR or intention to purchase and thus this limited focus on IVR in both the questionnaires and interviews was appropriate. Future work includes exploring why parents have such a negative viewpoint of IVR, with qualitative interviews, focus groups and IVR experiences planned with parents of children and young teenagers.

A limitation that deserves consideration is that different samples were used for the two parent questionnaires and the parent interviews. The decision to undertake an additional questionnaire and to interview parents had not been made when the first questionnaire was developed. The additional questionnaire and longitudinal qualitative interviews were a spontaneous response to the unprecedented COVID situation. In

summer 2022, we intend to update and re-administer the study to identify whether parent views of IVR are changing.

9 DISCUSSION

As seen in the presented results, adoption of VR by the family and home looks unlikely beyond gaming and streaming:

- Experts agreed that VR headsets would NOT become mainstream.
- Parents identified no interest in purchasing a VR-headset, either before (53%) or during COVID (73%), making VR-headsets significantly less likely to be purchased than all of the other home technologies
- Teenagers see IVR for gaming and are doubtful that Virtual Reality could be a substitute for real life and somewhat ambivalent towards using it for learning or at work.
- VR does not present as a solution to current problems in the home leading to a lack of use cases for VR

VR will continue to be used significantly in industry yet still have limited use in the home, yet to find the domestic challenges it can solve and the added value it can bring to family life, with homes apparently lacking requirements that need a VR solution. Parents and experts agree with this view, with VR-headsets unlikely to become a typical device in the home in the near future. Their main function will be for gaming both by teenagers and the younger market, encroaching on the market space currently occupied by games consoles. Although teenagers are positive about VR for games and entertainment, they are less certain about its use for learning and working. Limited experiences, hardware cost and stretched budgets prohibit VR-adoption for most

schools. Without uptake at school or of its use by teachers, VR adoption for learning is an unlikely user case for the next decade.

The results from experts, teenagers and parents highlighted a lack of consideration of what IVR could be used for. No new ways to exist and experience IVR were proposed, coupled with the view that traditional, games-style content and interactions would dominate. Nor was there the belief that an experience in VR would be as good as the real thing, although the solution as ever was technology advances, such as supporting additional senses. However, it seems doubtful that it is touch, taste or smell that will drive adoption. Yes, the experience would be better, be more realistic. But, for children and teenagers the 'set' is not so important, it is what we will do in it. And this will need to be more than just experience realistic surroundings. IVR must also focus on the interactivity, fun and play with others that children and teenagers are seeking.

Teenagers respond cognitively and behaviourally to sensory salient and immersive media like IVR in ways that differ from adults (Bailey & Bailenson 2017). For instance, Sharar et al. (2007), using a VR-headset, found children of 6–18 years of age reported higher levels of presence and "realness" of a virtual environment compared with adults 19–65 years of age. If children and teenagers experience IVR as more real than adults, they may be more likely to be influenced by the content in both positive (e.g., prosocial education) and negative ways (e.g., increased materialism). Reduced visual quality has been seen as a barrier to the adoption of more affordable VR-headsets (Elliott, 2019), however, for children and teenagers low resolution will be enough, with realism not essential for engagement and fun. For example, 25% of teenagers at the workshop found the non-realistic, pixelated environment of Minecraft to have elements of real life. Our imaginations fill in the gaps of imperfect virtual spaces and children and teenagers are engaged and immersed irrespective of the lack of realism (Flint et al., 2018). There is

clear potential for a low-resolution VR equivalent running on reasonably priced hardware providing new interactions and approaches. Currently, there are few consumer level software products for creating virtual worlds. As an equivalence, Super Mario was released in the early eighties yet Mario Maker, the consumer level Mario development tool was not released until 2015. This needs to happen more rapidly for VR, with the market needing to be proved over time with developers and consumers still waiting for that "killer app."

VR as a space for children and teenagers has significant privacy and data-related issues. Legislated and regulated as other entertainment experiences and devices, Virtual reality not only brings a new dimension for play and entertainment, but also a new dimension for quantifiable data. Current practices indicate that VR companies would retain permanent record of all physiological, interactive, verbal and interpersonal virtual activities. Following current trends, most parents - through clicking Agree to Terms & Conditions – will readily give the privacy of such intimate data away. If, as suggested by this and other studies, the main users of VR in the home are older children and teenagers, then the technology corporates will have extensive biological, physical, social and emotional data about them as they progress into adulthood. Along with a lack of understanding of the potential for the use of VR there is a real lack of understanding of the data issues, particularly the type, quantity and quality of data being retained.

There is no rationale for children not to be using IVR, in fact quite the opposite, with recognisable physical, emotional, social and developmental benefits for children using Virtual Reality headsets. The cumbersome, uncomfortable glitchy experience of the past is gone, now Immersive Virtual Reality really does offer a virtuality that complements and undoubtedly should be extending realities of childhood. Yet as this paper has

demonstrated, Immersive Virtual Reality is not viewed as becoming mainstream, it is seen as just another gaming platform.

This research explored VR adoption in homes and families, with the goal to discover ***"Why isn't IVR viewed as the way forward for education, collaborative entertainment and social engagement for children? Especially in a post-COVID world? Or perhaps more simply the question of why isn't IVR being positioned more for use by children and teenagers in the home?"*** With the right investment, VR-headsets could provide an everyday way for children and teenagers to experience life, learn with virtual classmates and for friends to feel that they are together by removing the physical boundary of the home offering children and teenagers a new, different way to connect and be. There are several reasons for this lack of adoption, including lack of content, affordability and as we have highlighted a lack of VR use cases. However undoubtedly, the most significant barrier to adoption in the home and family is parental resistance. Parents are not positive towards VR; they do not see headsets as devices for them. The use of VR-headsets strikes a dissonant chord, demanding a truly family-unfriendly context of use requiring hardware-bound solitary confinement – the ensuing isolation from children and family in a place that is not the home. Whilst this may be the goal of the teenager, for parents they are constantly 'keeping an eye out' with their attention and engagement partially on the family. Similarly, whilst the teenager seeks to escape to the virtual world and their friends, parents implicitly perceive of that as withdrawing from the home and family. The solitary nature of IVR obfuscates the collaborative engagement with peers, of a social experience together. And with a lack of family experiences in VR, particularly co-located experiences, this is likely to continue.

10 CONCLUSIONS

The multi-method approach outlined in this paper garnered a significant amount of data, representing very different voices for the adoption of VR. The results of our multi-methods - gathering review, evidence and data from the literature, experts, teenagers and parents confirmed that, on the face of it, IVR adoption in the home looks unlikely. Or does it? Experts did not see VR becoming mainstream, that is a technology owned and used by most, and parents appear increasingly unconvinced to purchase (even when in a prime use case, such as lockdown). However, in almost direct opposition, the consensus for parents and experts was that most 11+ children would be using VR-headsets by 2025. And most of the teenagers at the workshop would be interested in having their own VR-headset. And if that is so, then these devices will be mainstream for a significant number of households and adoption thus actually happening, but probably not for adults.

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Appendix 1 – Workshop Workbook (questionnaire)

List of Figures & Captions

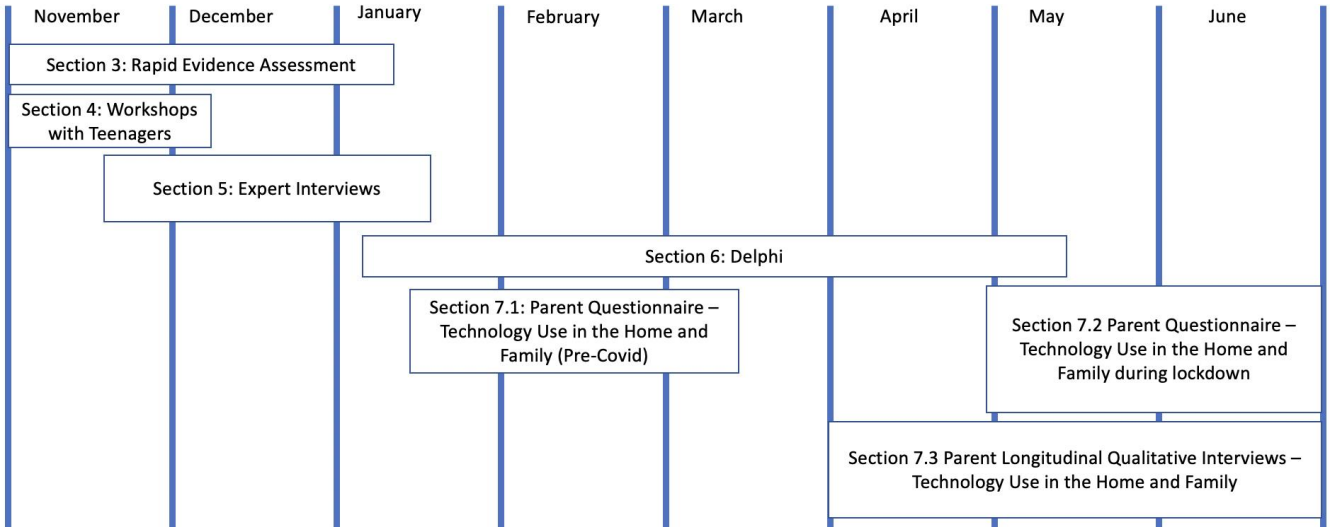

Figure 1. Multiple Method Research Intervention Schedule (November 2019 – June 2020)

Figure 2. Inside the Technology Truck

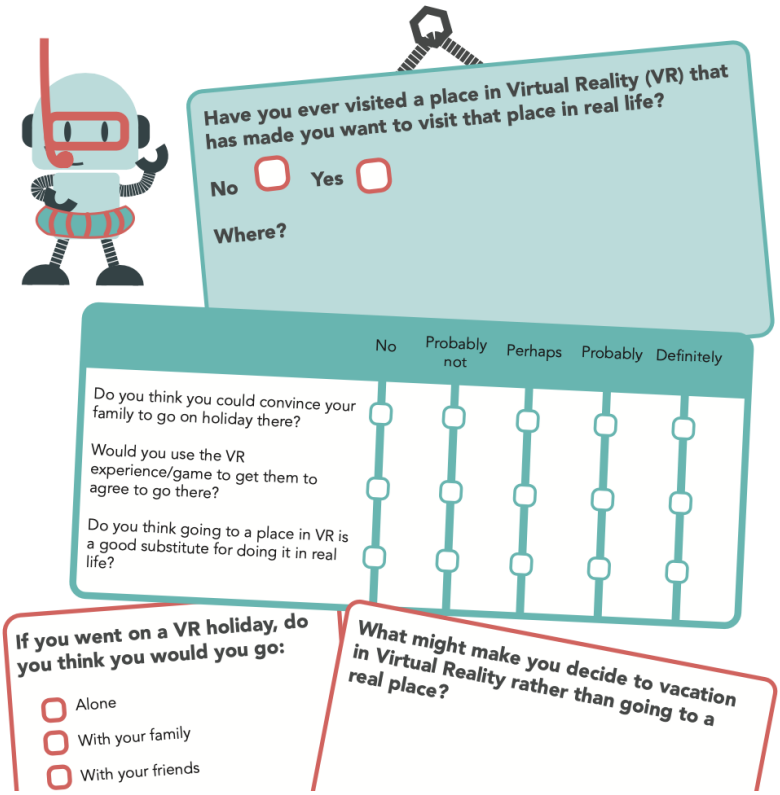

Figure 3. Fragment from the Workbook

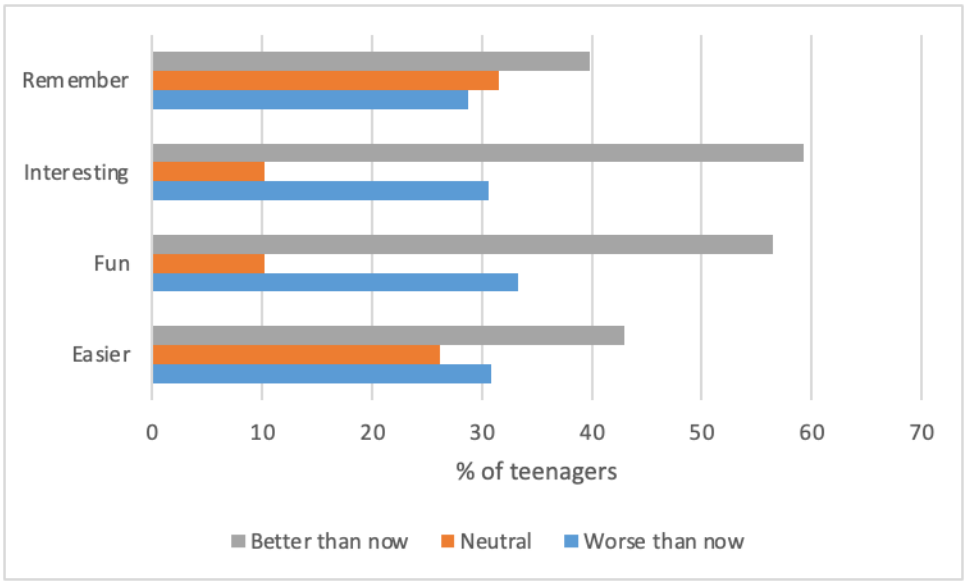

Figure 4. Teenagers' views of learning in VR as compared to how we learn now

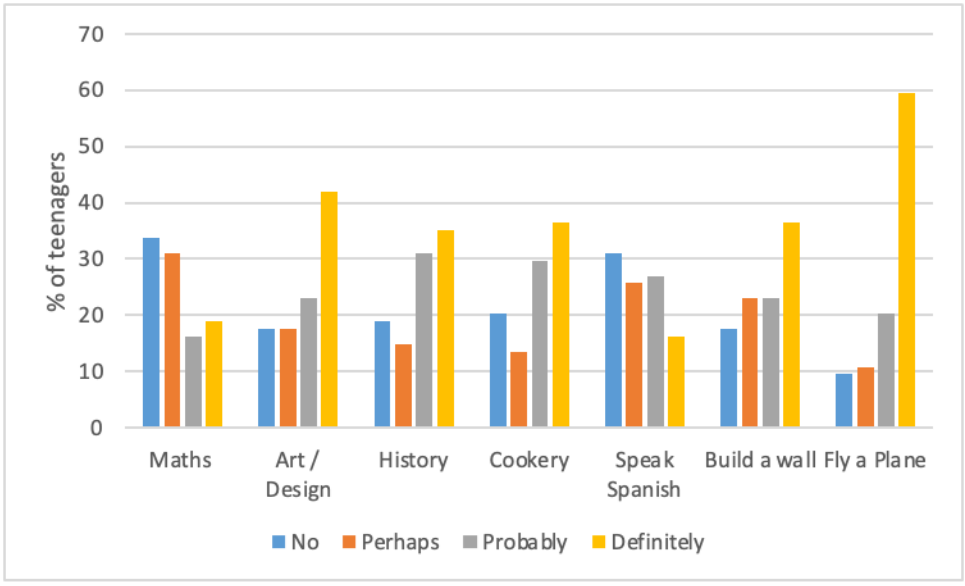

Figure 5. Teenager views of which subjects they would learn in VR

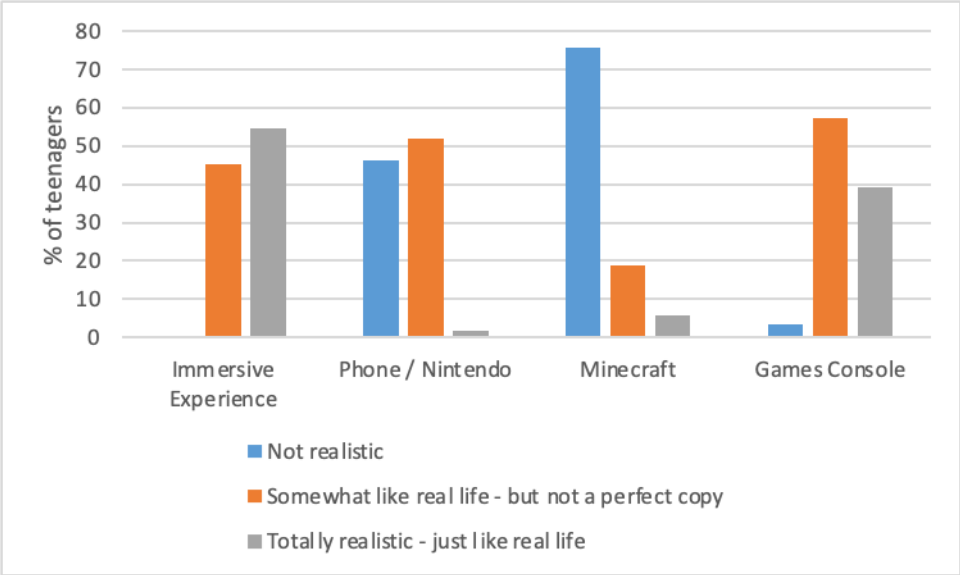

Figure 6. Teenager perceptions of realism in virtual environments

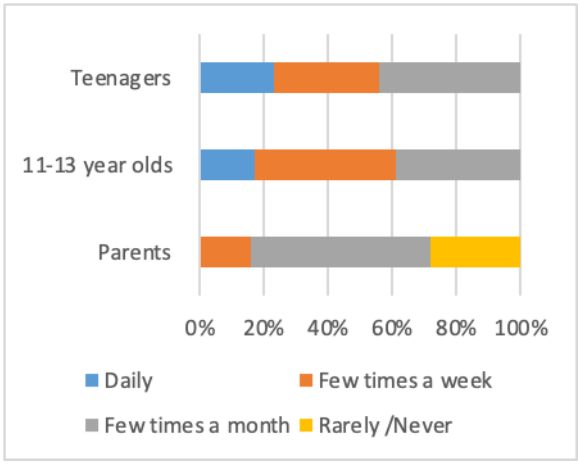

Figure 7. Experts' expected frequency of VR Use in 2025

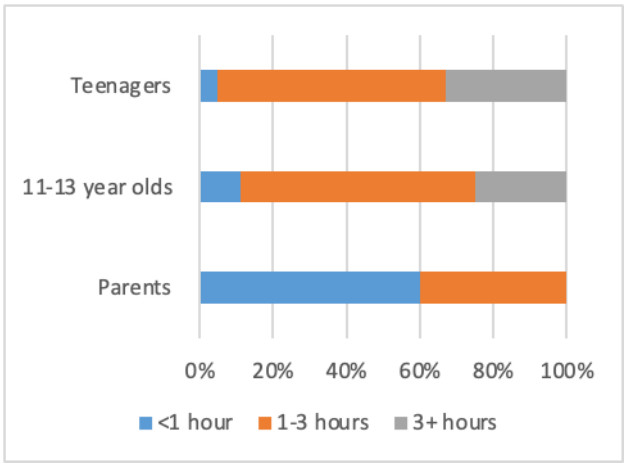

Figure 8. Experts' expected duration of VR Use in 2025

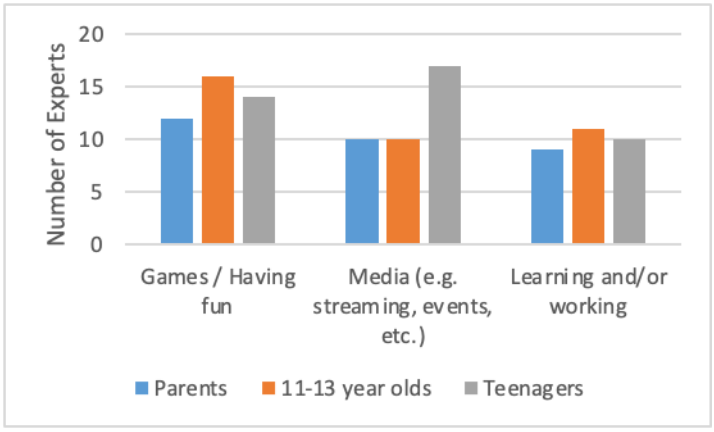

Figure 9. Experts' expectation of VR Use in the Home by Use Cases and Age

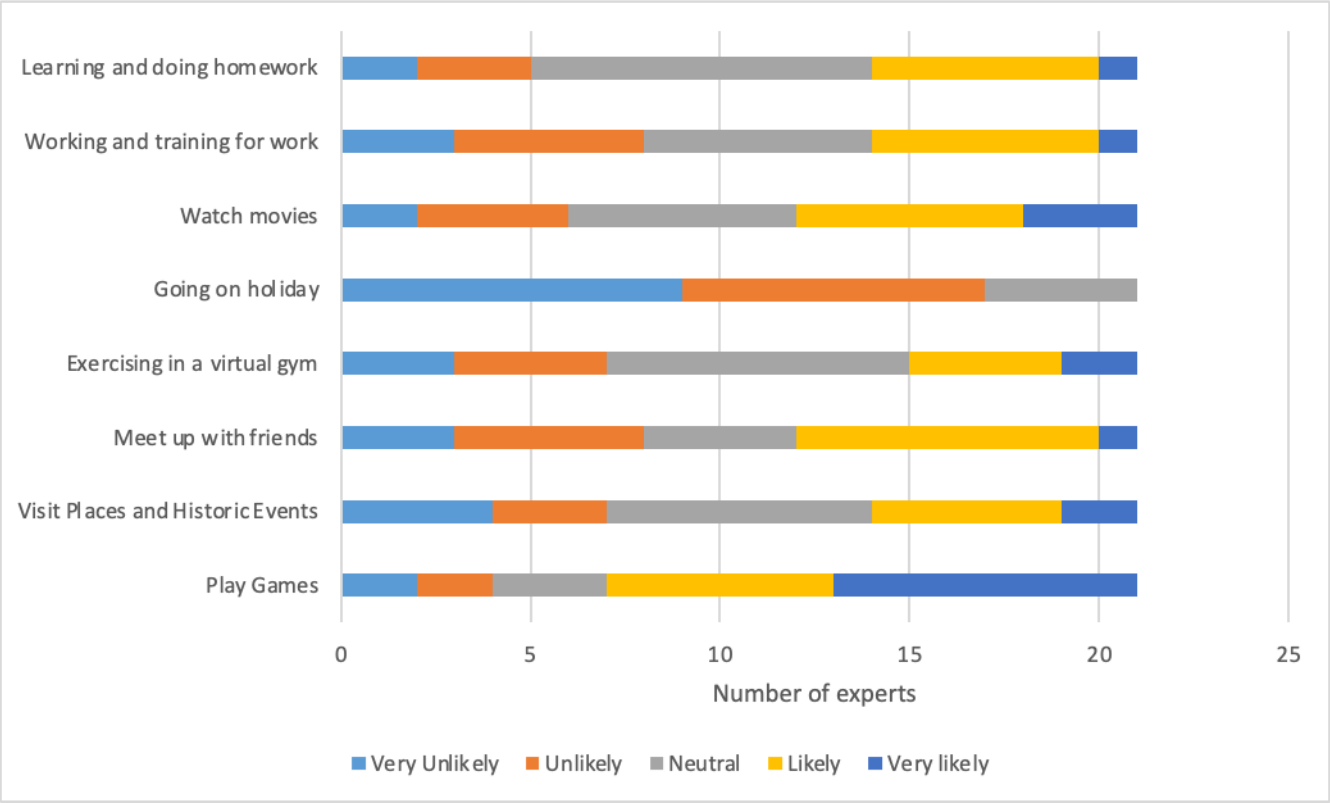

Figure 10. Experts' Expectations of Use Cases

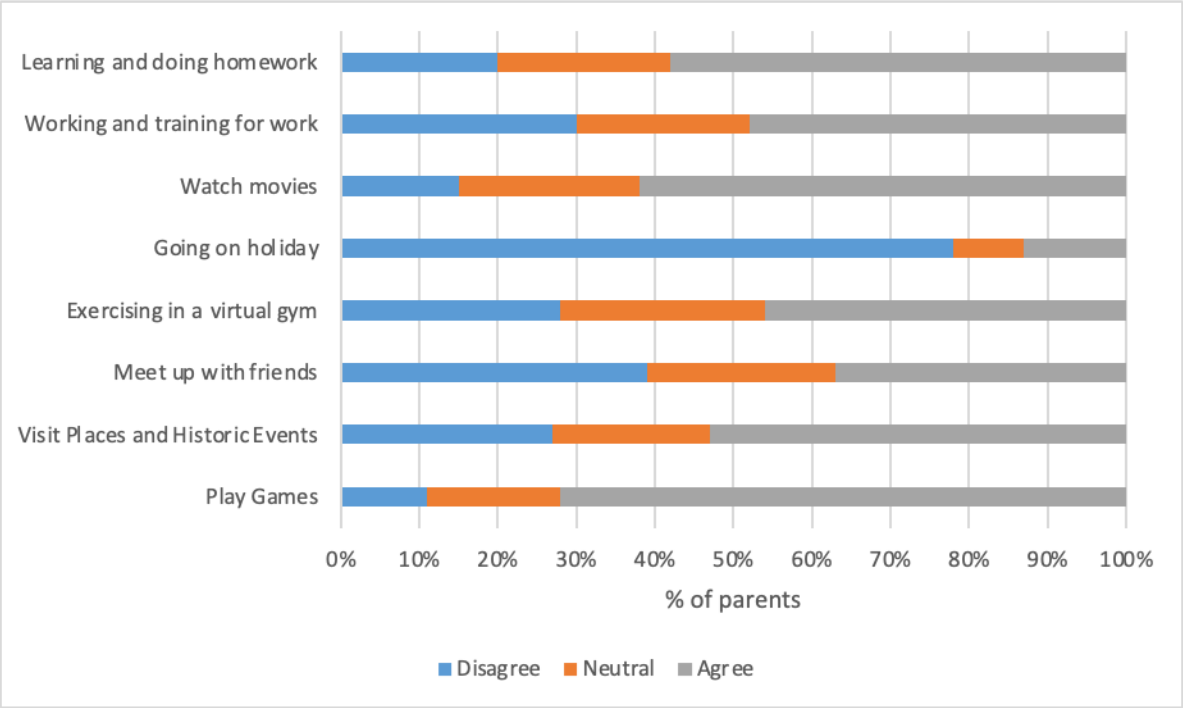

Figure 11. Parents' Views of Proposed Use Cases

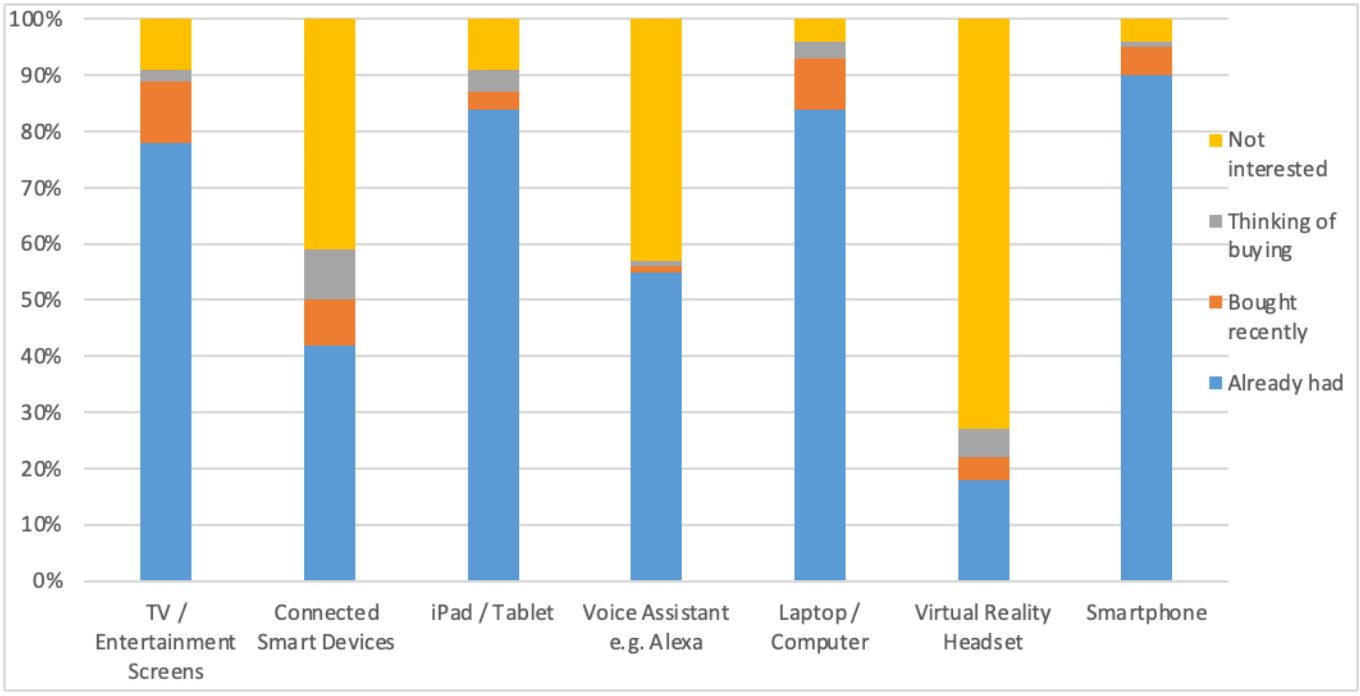

Figure 12. Parents' Technology Adoption and Intention to Adopt

Figure 13. 1st page of the VR section of the Workbook

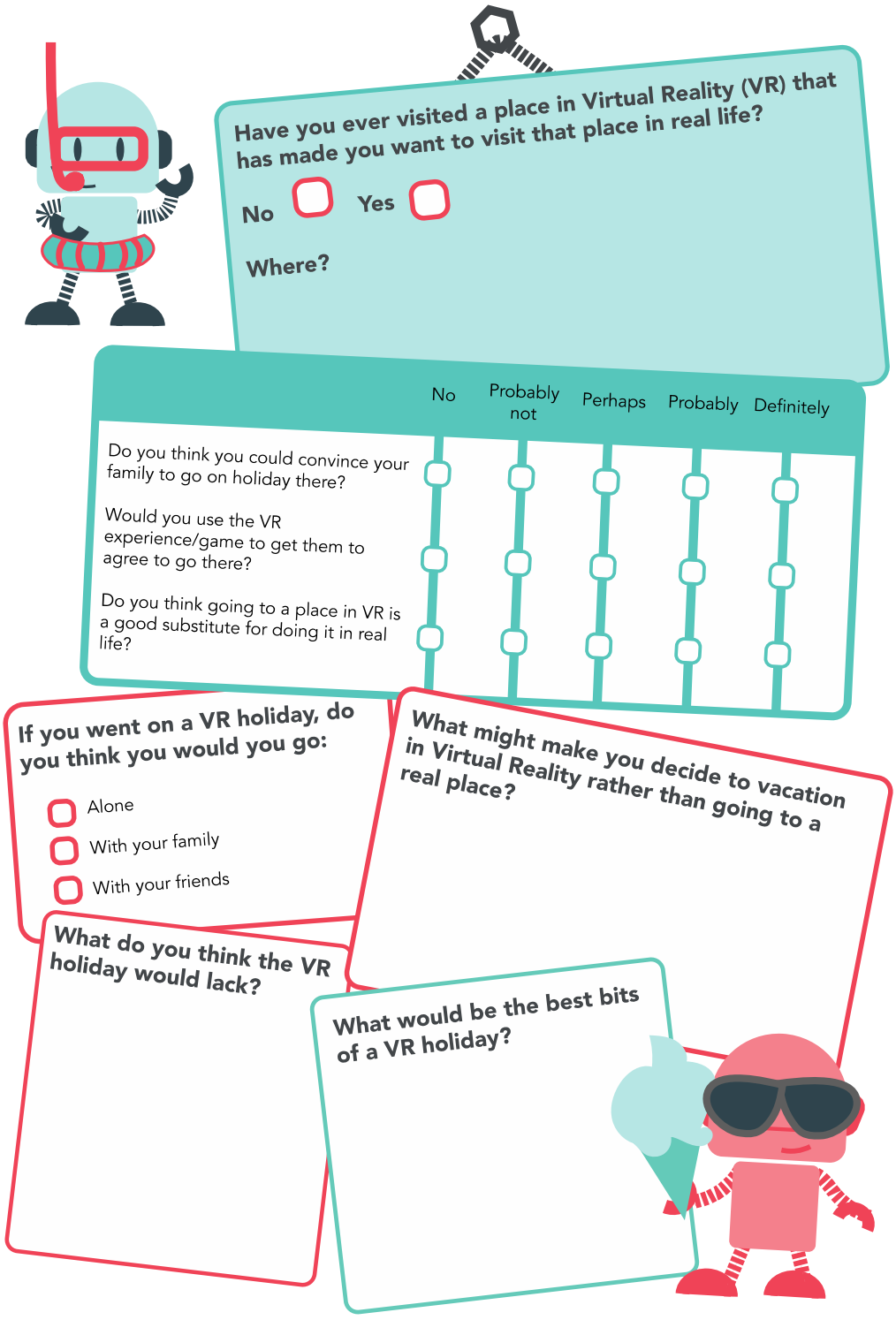

Figure 14. 2nd page of the VR section of the Workbook

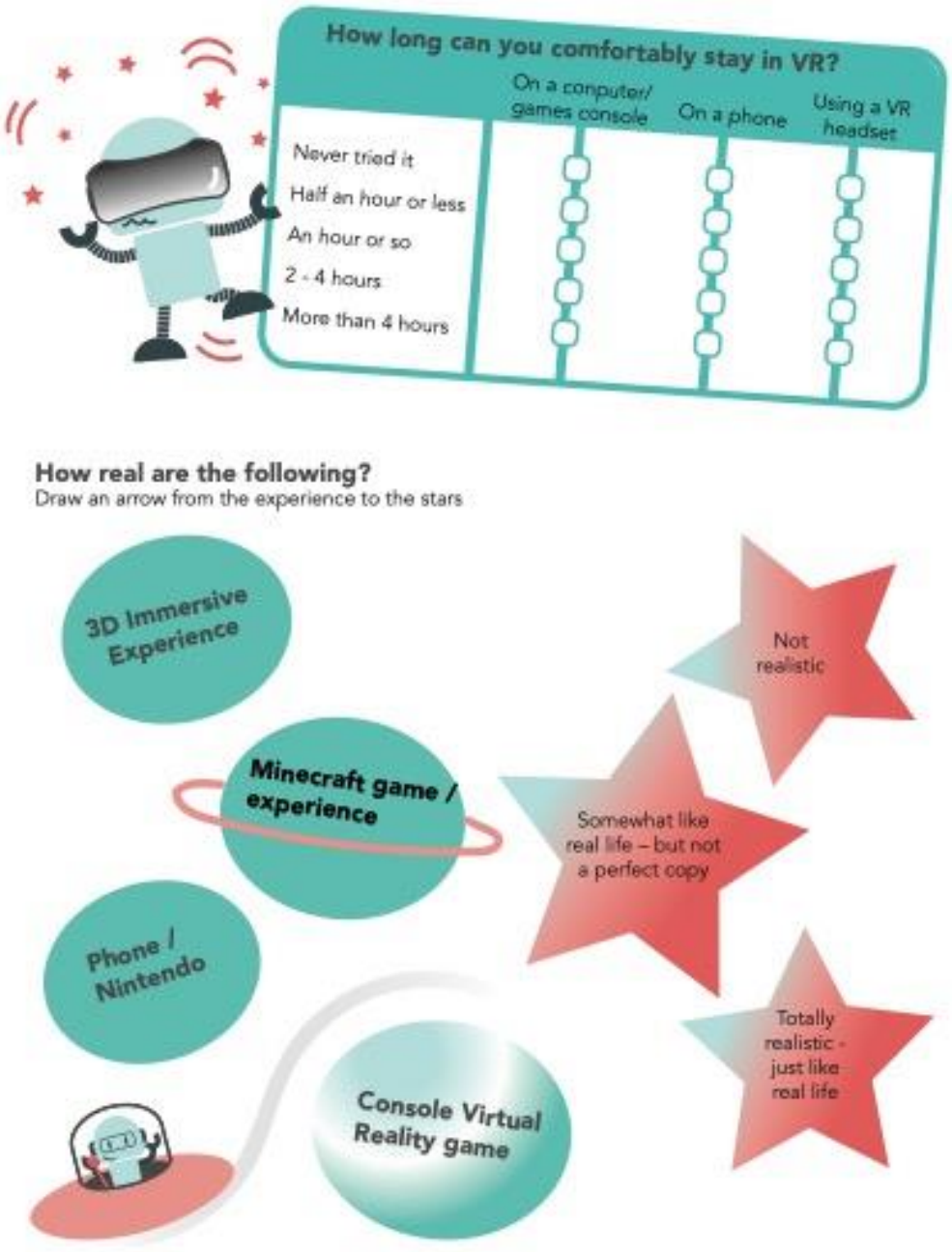

Figure 15. 3rd page of the VR section of the Workbook

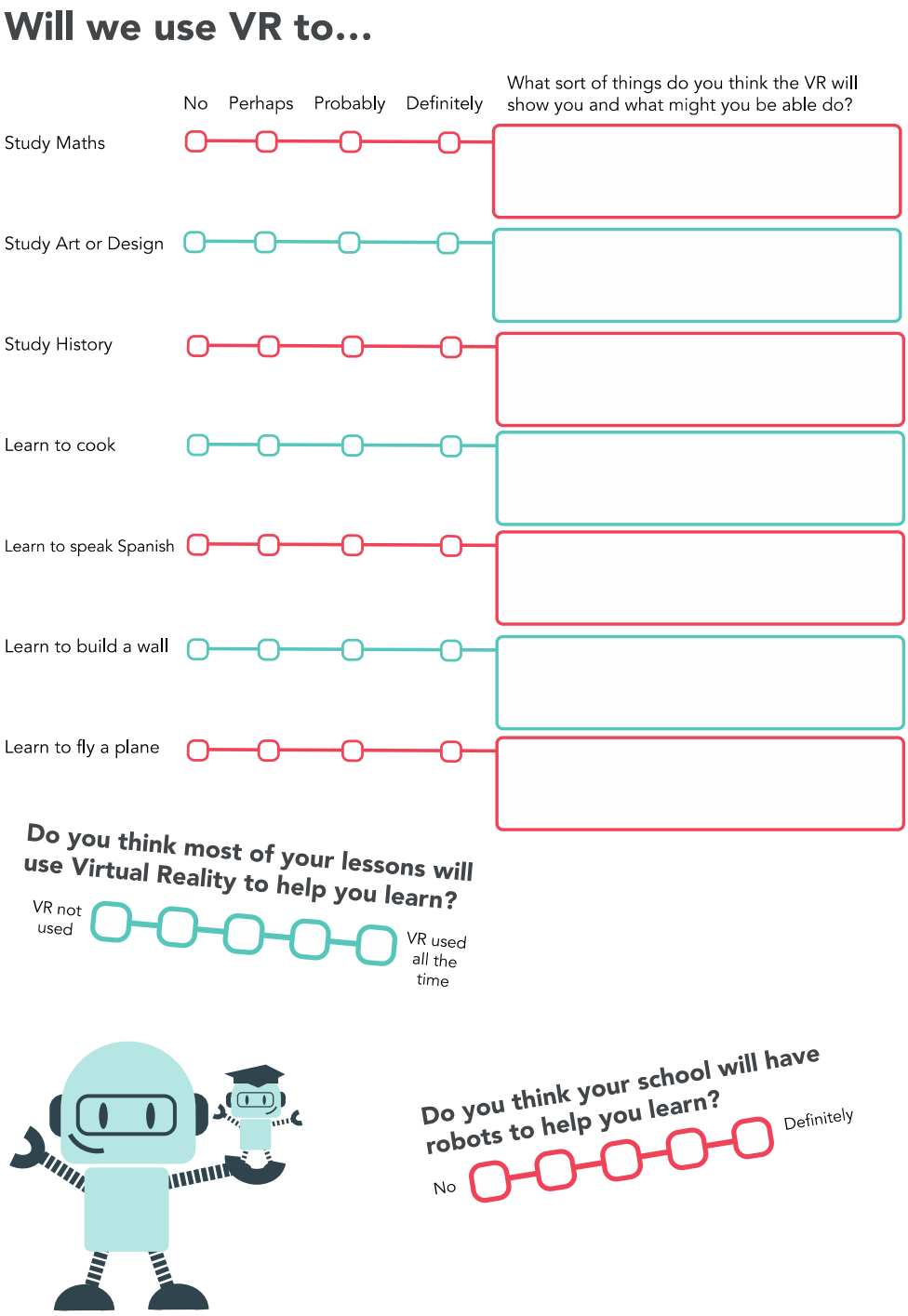

Figure 16. 4th page of the VR section of the Workbook

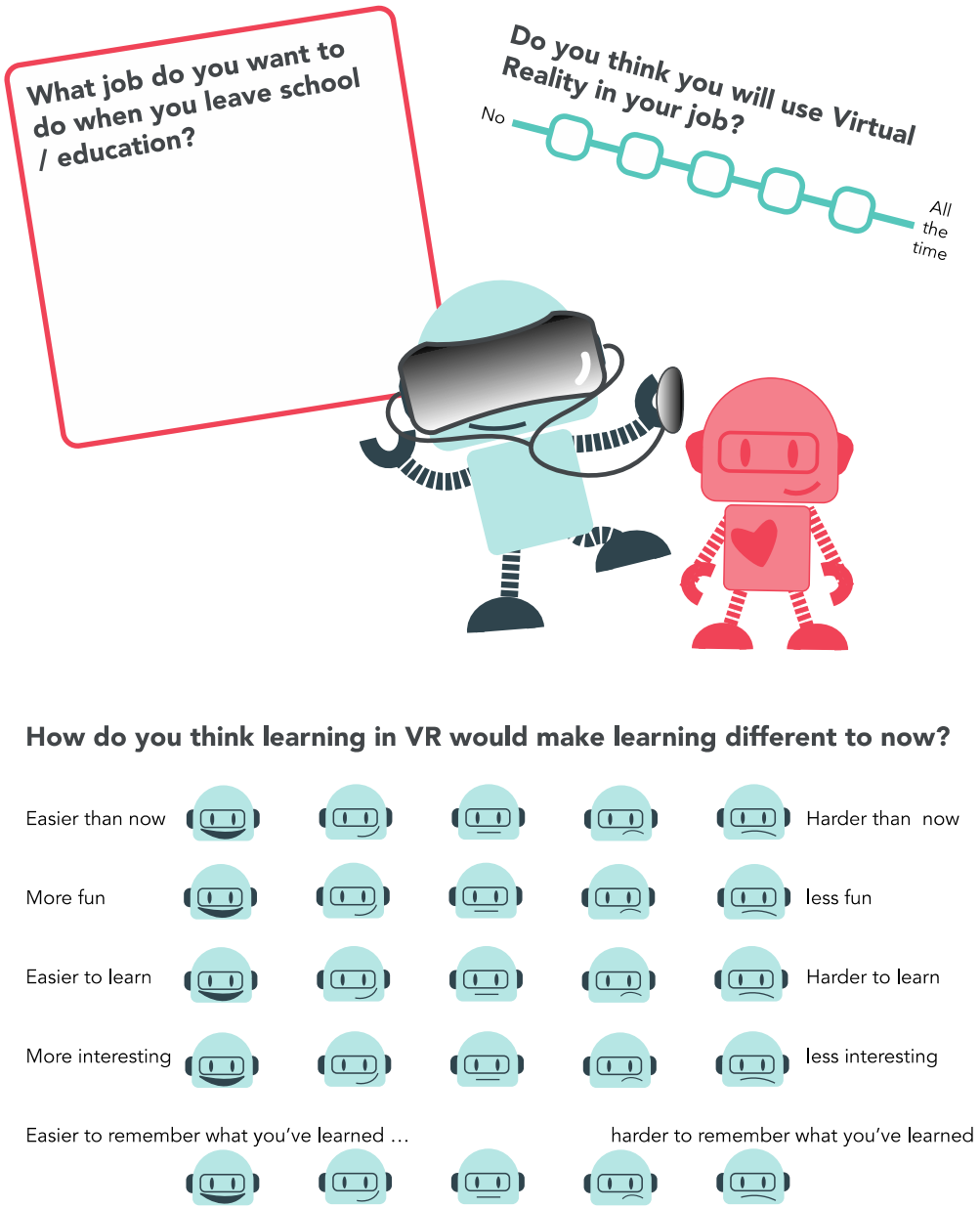

Figure 17. Final page of the VR section of the Workbook