Figure 1: Equipment used in the case study, top: HTC Vive, bottom left: Class VR, and bottom right: Google Cardboard.

246x228mm (300 x 300 DPI)

Figure 2: The interfaces users could experience, left: moon walk on the cardboard, top right: exploring inside the tomb of Ramesses VI in the Class VR, and bottom right: VR Fun House as seen in HTC Vive.

244x118mm (300 x 300 DPI)

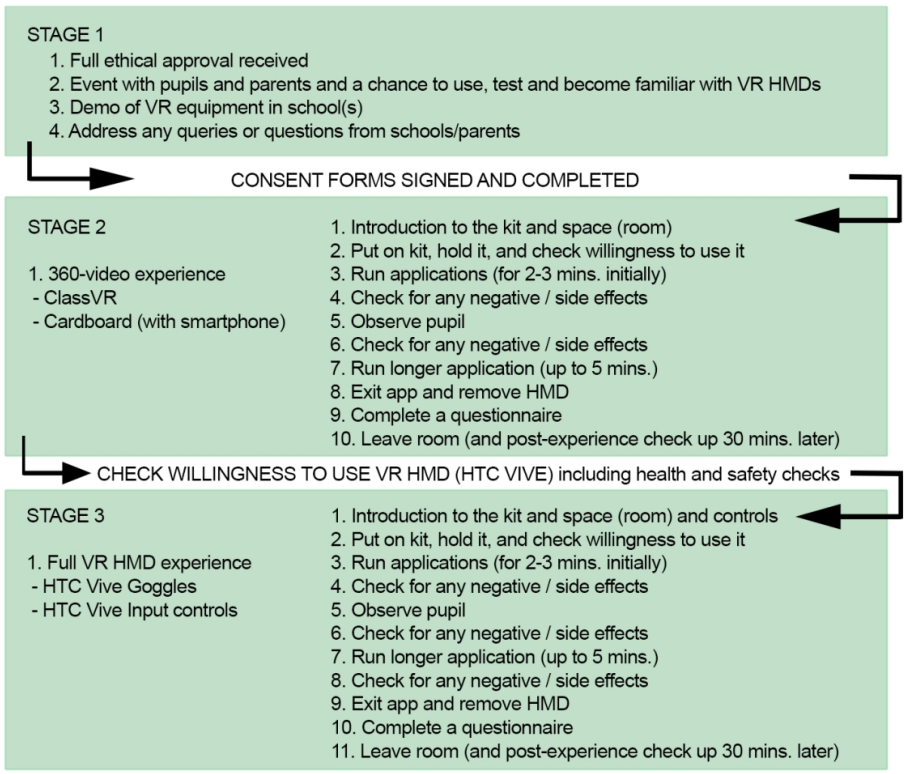

Figure 3. Flow diagram highlighting the approach we took to ensure a safe and ethical outcome for users of the VR HMD.

Thinking about your experience just now, please complete the following questions (ONE tick per question, please):

Q1	**How did you enjoy your VR experience just now?**			
	1 Did not like it at all)	2 Was okay, but felt uncomfortable	3 It was good, I liked it	4 Liked it very much and would do it again
				
Q2	**Did you enjoy the images and graphics that you saw?**			
	1 Did not like it at all)	2 Was okay, but felt uncomfortable	3 It was good, I liked it	4 Liked it very much and would do it again
				

Figure 4: An example of how the questionnaire looked to the participant(s) using the Likert-type scale from 1-4.

246x182mm (300 x 300 DPI)

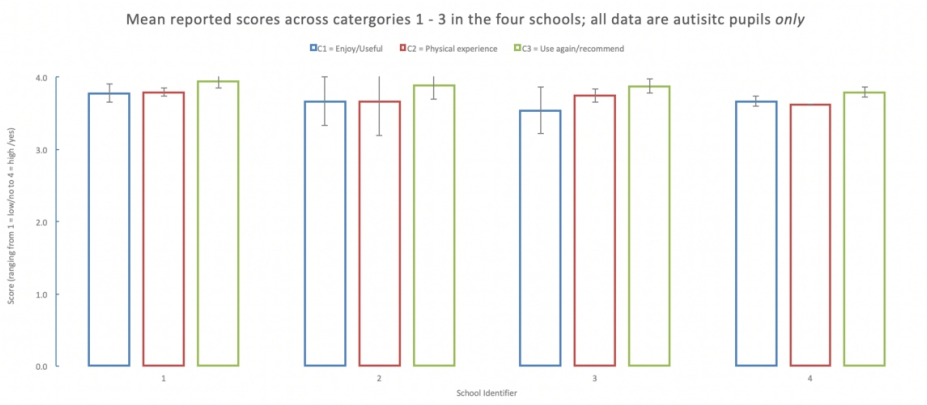

Figure 5: Presentation of data reported across all four schools clustered into categories 1-3 (C1 = usefulness and enjoyment; FC = physical experiences and; C3 = use again/recommend to others). Note: Only data related to autistic children are included.

246x117mm (300 x 300 DPI)

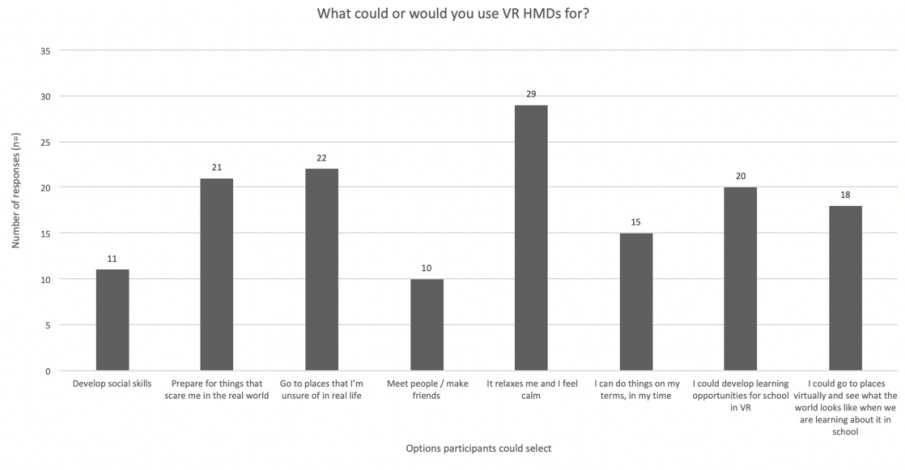

Figure 6: Number of responses to key questions surrounding what the autistic children would like to use HMDs and VR for.

246x131mm (300 x 300 DPI)

Table 1: Descriptions of the four schools participating with brief context related to their provision.

	School A	School B	School C	School D
School Status	Special Educational Needs	Mainstream	Mainstream	Special Educational Needs
School Type	Free School - Special	Voluntary Aided School	Academy - Converter Mainstream	Independent School
Education Phase	Primary, Secondary and 16 to 18	Primary	Secondary	Secondary and 16 to 18
Age Range	4 to 19	5-11	11-16	9-18
Number of pupils in whole school	85	89	550	54
Ofsted Rating	Good	Good	Good	Good
School location	Urban	Urban	Urban	Rural
Free School Eligibility[1]	n=28 (33%)	Not known	n=13 (2.4%)	Not known

In the UK, free school meal eligibility is one way to understand the social-economic area in which the school is based. In primary schools, 14.1% of pupils are known to be eligible for free school meals, whereas in secondary schools, the figure is 12.9% (Department of Education, UK, 2017).

Table 2: Demographics of the pupils who participated across the four schools.

	School A	School B	School C	School D	Total
Total (n=) cohort	12	7	16	8	43
ASD only (n=) cohort	12	3	8	8	31
Age Range	8-16	6-10	11-14	13-16	6-16
Mean Age	12.4	8.7	12.2	14.5	12
Male (n=)	10	4	9	5	28
Male (%)	83%	57%	56%	63%	65%
Female (n=)	2	3	7	3	15
Female (%)	17%	43%	44%	38%	35%
Autistic Children %	100%	43%	50%	100%	72%
Typically Developing Children %	0%	57%	50%	0%	28%

Table 3: Equipment used in the study: Description, pro's and con's, input modes and additional information/context.

Equipment	Cost	Pro's	Con's	Input/control	Additional information
HTC Vive HMD and gaming computer (HP Omen)	£699 + associated PC/laptop £1300	• Superior range of software • Incomparable experience (high quality graphics) • Room-scale tracking • Comfort • Intuitive interface • Full 360 immersive and interactive (input)	• Price (expensive) • Bulky cable (limited range) • Hard on neck and back • Potential tripping hazard	Head can be turned 360 degrees and tilted in all directions. Hand controllers being held by the user appear to be hands in the VR scene. Users can move (walk, crouch) as the yare tracked.	The HTC Vive is considered a 'high-end' HMD and uses graphics and images that are of a high quality. Fully immersive; users can walk, bend down and jump to modify their environment. Users can also control elements and interact moving their hands (when holding a controller). Extensive use of cables and need for power outlets.
Class VR (stand alone device)	£2000 for a pack of 8 (about £250 each)	• Medium quality visuals • No cables • Affordable • Easy to use • Excellent content that is linked to curriculum and lesson plans	• Set up can be tricky (Firewalls) • Limited content • Not entirely interactive • Mainly 360 degree video and images • Users are mainly static in the VR environment	Head can be turned 360 degrees to view material. This HMD also features augmented reality (AV), but was not used for this project. Limited input or control over the VR environments.	Class VR provides a mainly 360 degree video experience. One that enables users to view a 'scene' that is captured using 360 degree cameras. Images are photorealistic. There are also 360 degree video scenes. Considered mid-range experiences and device. Wireless and no need for cables, when being used.
Google Cardboard (stand alone device; with a smart phone)	£4.99 + associated smart phone £599	• Medium quality visuals • Growing and developing content • Easy to set up and use • Ability to use input to move/control the 360 environment	• Set up can be tricky (Firewalls) • Lack of content and low resolution apps • Hardware limitations • Some possible simulation sickness • Restricted to 360 content (with limited	Similar to the above (Class VR) experiences. Cardboard relies on using a smart phone (in this case study an iPhone 7) to deploy content. Input is available using a small button on the top right	Similar to the above description. Content can be loaded onto a smartphone and viewed via the cardboard HMD. Content tends to be 360 video or still images. Some 360 games also available. Wireless and no need for cables, when being used.

			user control/movement)	of the headset or via ‘hotspots’ via the app.	

* All prices correct at time of writing (2018) but are indicative.

Table 4: Procedure and processes that were followed for each of the participants we worked with.

Step	Procedure/process
1	Room was set up with three HMDs, all tested and working.
2	Researcher greeted the participants, working in pairs, along with their teacher/teaching assistant. *It should be noted that participants and teachers all had the project explained to them and pupil and parent carer consent forms had already been completed.*
3	Participants had the project explained to them again for purposes of clarification and for a chance to withdraw for the study.
4	Participants were asked to use / experience the smartphone and cardboard VR HMD using the following protocol: a. They were checked for comfort at intervals. b. They finished after 5 mins. c. Short break was provided with a check to ensure comfort and absence of side effects such as sore eyes, feeling dizzy, etc…
5	Participants were asked to use / experience the ClassVR HMD with the same protocol used with the smartphone and cardboard experience except for the 5 min. timing. a. They are checked for comfort at intervals. b. They finish after 5 mins.
6	Participant was asked to use / experience the HTC Vive experience, again using the same protocol.
7	Questionnaire was administered to participants, in some cases supported by their teacher / teaching assistant for purposes of clarifying questions.
8	The study ended

Table 5: Research questions aligned to data sources.

Research No.	Research Question	Data source (questionnaire)
1	What type of VR HMD device (and experiences therein) are preferred by autistic children?	To address this, we asked the users to select a preference (most enjoyed and least enjoyed). This was the first question we asked on the questionnaire, and we asked it after they had used each device for 5-10 mins.
2	How do autistic children report the physical experience, enjoyment, and potential of VR HMDs in their classrooms?	For this we collated the questions (from the questionnaire) into three factors: (F1) Enjoyment/Usefulness; (F2) Physical experience (wearing the HMD); and (F3) Would they use the technology again or recommend it to others. We asked these questions after they had used the three devices for a total of 25 mins.
3	What would autistic children like to use VR for in schools?	We provided eight options for how VR HMDs could be used (i.e. relaxing, meeting people, feeling calm, prepare for events) and a free text option. We asked these questions after they had used the three devices and when they had some reflection time (2-5 mins.). We also asked the teachers and teaching assistants their views. This was through open-ended questions.

Table 6: Questions that were categorised from1 to 3.

Category Number	Questionnaire Number	Question asked
Category 1	1	How did you enjoy your VR experience just now?
	2	Did you enjoy the images and graphics that you saw?
	8	Might this technology help you in anyway?
Category 2	3	What was it like when you moved your head in the virtual reality experience/game?
	6	What was your physical experience of wearing the headsets for the first few times?
Category 3	4	If you could use the VR head-set again, would you?
	5	Would you use this technology at home, or in other areas away from school?
	7	How likely would you recommend this technology (VR) to your friends?

Table 7: Device preferences; most and least enjoyable (figures are rounded). All data are related to the autistic populations in this study (the data for school's B and C are autistic pupils only).

Device Preference: MOST enjoyed	**A**	**B**	**C**	**D**	**Overall Mean**
Class VR	0%	0%	0%	0%	0%
HTC Vive	100%	95%	100%	100%	99%
Cardboard	0%	5%	0%	0%	1%
Device Preference: LEAST enjoyed	**A**	**B**	**C**	**D**	**Overall Mean**
Class VR	67%	90%	35%	38%	58%
HTC Vive	0%	0%	0%	0%	0%
Cardboard	33%	10%	65%	63%	43%