Learning About Autism Using VR

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Abstract. This paper describes a project that was carried out at the University of Malta, merging the digital arts and information technologies. The project, 'Living Autism', uses virtual reality (VR) technologies to describe daily classroom events as seen from the eyes of a child diagnosed with autism. The immersive experience is proposed as part of the professional development program for teachers and learning support assistants in the primary classrooms, to aid in the development of empathic skills with the autism disorder. The VR experience for mobile technologies has also been designed in line with user experience (UX) guidelines, to help the user assimilate and associate the projected experiences into newly formed memories of an unfamiliar living experience. Living Autism, is framed within a 4-min audio-visual interactive project, and has been piloted across a number of schools in Malta with 300 participants. The qualitative results collected gave an indication that the project had a positive impact on the participants with 85% of them reporting that they felt they became more aware of the autistic children's needs in the primary classroom.

Keywords: Virtual reality · Continuous professional development · Autism spectrum disorder · Primary education

1 Introduction

Virtual Reality (VR) is the projection of a computer-generated virtual environment that is rendered immersive by its unique affordances of vision, sound, and tracking of user movement. In a VR system, the user would experience an illusion of presence that would aid the user to perceive herself situated in the virtual environment and surrounded with the virtual objects. The sense of presence in addition helps a user experience the events happening in the virtual environment as though these are really happening [21]. The place illusion mechanism in VR allows the users to "be there" [6], and the plausibility illusion mechanism [21] allows players to react to the events happening in the generated environment. The way (VR) makes it possible to induce illusions in which users report and behave as if they have entered into altered situations and identities is through its sensory-coupled stimuli that match the brain's expectations of what should be happening according to the context in which the virtual projections are placed. The effect on the brain can be robust enough for participants to respond realistically to the situations and scenarios in which they are placed, leading to a possible change in behavior in the same way as when the users would have been exposed to the same scenario had this occurred in the physical world.

M. Antona and C. Stephanidis (Eds.): HCII 2019, LNCS 11573, pp. 64–76, 2019.
https://doi.org/10.1007/978-3-030-23563-5_6

The quality and intensity of the VR experience when compared with other simulation technologies employed in education renders this immersive technology more than suitable for teachers' CPD [3]. A number of companies have developed virtual environments in an attempt to replicate and simulate the classroom environment and what a teacher experiences in reality [14]. Yet a combination of animation-like surroundings and cartoon-like avatar characters does not fully equate to the intense experience an educator goes through when facing a real class. The challenge exists in how to provide a more authentic experience that would simulate a realistic classroom environment that would then aid teachers and education professionals to associate their own experiences of the class, to the virtually generated environment.

To overcome the challenge above, the use of real video combined by the natural movement of one's head to inspect the entire classroom and the students around the user embodies an authentic experience that comes as close to the factual thing as possibly can. It provides a visceral sensation that no video on a flat screen can inflict on one's emotional experience. Loewus [14] reports empirical results from a research project managed by a neuro-cognition scientist, Richard Lamb, who analyzed data collected from numerous VR users through heart rate monitors, sphygmomanometers to measure the blood pressure, electrodermal readers to determine the galvanized skin response, and neuroimaging apparatus to picture brain activity. The results were compared to respective data collected when person experience real life situations, and what emerged was that the body in both cases responded in a similar way. His conclusions showed no difference whatsoever between a teacher delivering within a real class and delivering a session through the VR-enabled experience.

Living autism, is a VR experience that uses different film techniques, to transpose the reality a child who is diagnosed with the autism disorder into the virtual classroom with the final aim of then transporting the adult who takes on the experience into a world that he/she may not necessarily be familiar with. Teachers and learning support assistants living through this experience have the possibility to create new associations of what a child in a primary classroom and who is on the autism spectrum might experience. The final scope is that of creating a deeper awareness of actions or stimuli that may have a negative consequence on a child with autism in a way that is not easily explained using any other resource or modality.

By exploring user perceptions, the project described in this paper aims to address three main research questions:

RQ1: How does UX design in VR affect immersion?
RQ2: How is the level immersion related to the manifestation of user behavior?
RQ3: How does immersion relate to empathic behavior in users?

The rest of the paper is structured as follows: Sect. 2 is a review of the literature around VR for continuous professional development (CPD) and user experience (UX) principles for immersive environments. Section 3 gives a deeper insight into the methodology and design of the project 'Living Autism' whilst Sect. 4 presents some of the results obtained during the pilot project. A discussion of the results and an overview of the directions for future work follow in Sects. 5 and 6 of the paper.

2 Literature Review

2.1 Professional Development

One of the attributes of a professional person is a life-long pledge to maintain the highest levels of associated knowledge and skills through education. Continuous Professional Development (CPD) is one systematic way of providing such education, and is essential for any professional who seeks to excel and remain abreast of contemporary information, tools, techniques or methodologies within the field of that same profession. As the field of expertise evolves and rapidly moves ahead, the need and necessity for a professional to follow CPD activities does not cease, in an effort to assist the same professional in diligently perform current duties and enhance career progression opportunities. CPD can take different forms and shapes, be formal or informal, as long as it is relevant to the field of work and focusses on career needs and objectives.

Bosschieter [6] points out that CPD can be a combination of various approaches, ideas and techniques that assist in learning and growing as a professional. She argues that the main focus should be on the end product, namely the benefits yielded in real practical terms. Every professional should be responsible and consciously recognize the need to maintain the highest level of standards in one's vocation to voluntarily seek and feel the need of continuous career development. The use of technologies and digital applications assist and facilitate the CPD process as hand-held devices, apps, and multimedia methodologies allow professionals to access, experience and appreciate such educational materials. Research indicates that the potential of new media plays a crucial part in CPD [7].

The teaching profession is no exception and the need for seasoned educators to pursue their training to ensure they are on their game is always on. Morrison McGill [15] claims that teachers are required to meet the needs of an ever-evolving audience, and thereby they are compelled to regularly practice CPD. However, a variety of factors around educators are continuously changing as Day and Leach [8] list administrative issues like legislation, regulations and teaching conditions, as well as academic matters like curricula, teaching approaches and aids, apart from other broader external factors like environmental, socio-economical, and cultural. The authors identify the development of the system, the educator and the learner as three closely-related purposes why CPD for teachers are instrumental. Yet, if we had to focus specifically on the development of the teacher in isolation then ulterior purposes can emerge, from classroom practical needs to the changing role of the teacher, from evolving school-wide needs to novel government educational policies, apart from personal and professional needs as each educator progresses in life. Jones [10] picks on the first of these purposes as she investigates the challenges teachers encounter when coming in contact with digital and technological tools. She reports that less than 3% of further education institutions in UK had the majority of their academics competent in the use of learning technologies, while 70% of the teacher population confessed that they have a lack of confidence in the use of digital applications. Use of technology should not be done just for the sake of being different, novel or trendy, but educators need to appreciate and comprehend that a particular technology is relevant within the specific contextual circumstances that fit in with the planned lesson and the expected academic objectives and outcomes. Walker et al. [22] conclude in their TEL survey report that teachers will only employ a particular technology only if they envisage it to enhance their current practice as a beneficial academic aid to the educator and student alike.

2.2 Virtual Reality for CPD

To overcome such obstacles and in an attempt to encourage teachers to experiment and experience the benefits of employing different technologies training agencies and CPD providers have reverted to Virtual Reality (VR).

The primary subject of virtual reality is simulating the vision. Every headset aims to perfect an approach to creating an immersive 3D environment. Two screens (one for each eye) are placed in front of the eyes thus, eliminating any interaction with the real world. Two autofocus lenses are generally placed between the screen and the eyes and these adjust based on individual eye movement and positioning. The visuals on the screen are rendered either by using a mobile phone or HDMI cable connected to a PC. To create a truly immersive virtual reality there are certain prerequisites including frame rate and refresh rates, field of view of the headset used. With an inconsistent frame rate and field of view, the user may experience latency with a large time gap between an action and the response from the screen. Apart from the image there are other elements that go into creating an immersive VR experience, making users completely engrossed in the virtual environment and include the impact of sound and eye and head tracking [16].

Researchers at the University at Buffalo in the state of New York have been employing VR to introduce new technologies to educators in an attempt to create a middle-ground safe space whereby educators can freely practice, explore and experiment with what it is like to employ different technologies with non-real kids [1]. The up-and-close experience, that designers compare to a “flight simulator for teachers”, employs images of real students recorded inside a classroom with the help of 360-degree high definition cameras, creating a three-dimensional seamless and immersive environment. Teachers are able to enjoy the full capabilities that VR has to offer in other domains like gaming, medicine, automobile industry, tourism and modelling, whereby users can experience incredible events that would either be impossible in real life. Some examples of popular VR experiences include walking through historical sites and buildings, gender switching and embodiment, Formula 1 car driving, free falling from the sky, diving around the Titanic and many more. The maximization of the senses is exploited through a series of emotional phases that facilitate learning, memory, and emotion while maintaining experimental control [11].

VR technology is still evolving to further enhance the user experience by closing the gap between a real-life occurrences and VR-generated ones. Crosswater Digital Media [6] are adding functionality to their 360/VR experience by enabling VR users to move and interact with individual students as they comprehensively collect video data from within a real classroom. Movements include stepping in any direction, kneeling and verbally addressing persons within the video itself. This will eventually render the VR experience even more realistic and genuinely faithful to classroom settings. Teachers can experience their anxieties, challenges and novel situations through a controlled VR recreation session during their CPD in order to master and muscle memorize their response actions when they come across and experience that same stressful pedagogical event [18].

2.3 UX in VR

User Experience (UX) is the concept that brings together various elements of a system or application such as functionality, usability and appeal to enrich the user's practice whilst increasing the effectiveness and efficiency of the task completion [20]. Having the added value of seamlessly integrating the technology into the daily life practices of the user is also an important aspect of UX [10]. Although each user might experience a new technological practice in different ways, the use of VR for professional development by exploiting its immersive affordances is an example of how emotions can be made use of to stimulate corresponding actions and behavior [2]. Although there may be instances where it is not very clear how the UX is affected by VR technologies, studies indicate that each user interprets the VR experience according to personal background and history [17]. Studies by Shin conclude that rather than the 3D technology per se, what affects the user experience is the narrative surrounding the context of the immersive environment. Therefore the content that is developed needs to be not only engaging, but also targeted specifically towards an audience who can fully associate to the context and the 3D scenario. One of the most important aspects of UX is that of achieving the right flow for the user to engage more deeply with the VR narrative in such a way as to establish the perception of 'being there' inside the story. This may in fact depend not just on personality traits but also on the background and past experiences of the user [21].

Bachen et al. [2] theorise that one of the methods in achieving the right flow in 3D environments is that of helping users identify with the avatar or a non-player character (NPC). Although some personalities may be more disposed towards achieving presence, immersion and character identification than others, by designing the narrative in a way that a user can associate to the context and can readily recognize scenarios within familiar environments can increase the sense of presence and flow [12]. For CPD where simulation of a realistic environment is key, it is important to consider elements based on interaction, and behavioral activities [18].

3 Study Design

3.1 Participants

Participants for this experience were recruited on a voluntary basis, from a number of random Maltese primary schools. Researchers visited the schools, and enlisted teachers and learning support assistants who voluntarily enrolled to take on the experience as part of their CPD sessions. A total of 63 participants were recruited by convenience sampling from teachers' continuous professional development sessions, parental meetings and two educator conferences held across the country. 26.2% of the participants were male, whilst 73.8% of the participants were female. 42.2% of the participants were in the 25–34 age range, whilst 29.7% were in the 35–44 age range. Each participant was asked to go through the VR experience using a head-mounted device for mobile. In addition the participants were asked to report their thoughts, perceptions and ideas in a pre- and post-experience survey, giving a measure of (a) their self-presence in the environment and (b) their perceptions about the issues of autism and migration relating to classroom environment. This was also followed by a more in-depth qualitative analysis of the self-reported perceptions through observation, and the level of self-reported empathy with learners who have needs relating to the autism spectrum disorder.

3.2 Measures

The scope of the pre- and post- experience survey was to give a self-reported measure of personality traits relating to empathy. The surveys were adapted from the empathy measures developed by the Research Collaboration Lab responsible for a number of education and professional development projects with teachers [8].

The surveys developed focus on empathy as a measure of the efforts that any given person would make to understand others, as well as the ability of a person to communicate her understanding of somebody's personal situation. For both pre- and post-VR survey, we used 11 empathy items measured using a 5-point Likert Scale from 1 (strongly disagree) to 5 (strongly agree) (Table 1).

Table 1. Empathy quotient items

Item no.	Item description
T1	I see others' point of view
T2	When I don't understand someone's point of view I ask questions to learn more
T3	When I disagree with someone it's hard for me to see their perspective
T4	I consider people's circumstances when talking with me
T5	I try to imagine how I would feel in someone else's situation
T6	When someone is upset I try to remember a situation when I felt the same way
T7	When I am reading a book or watching a movie I think about how I would react if I were one of the characters
T8	Sometimes I wonder how it would feel like if I were a student in a classroom
T9	When I see one of my students upset I try to talk to them
T10	I easily feel sad when people around me are sad
T11	I get upset when I see someone being treated disrespectfully

In addition to the surveys, researchers used visual observation codes to record and register users' behavior and actions during their VR experience. The codes were used to identify user behavior during the session. These included changes in Facial Expressions (F), Sighing (S), Heavy Breathing (B), Crying (C), Visible Emotion (E), Impassivity (I), and Smiling (Sm). Although the observations only provide a superficial measure of the impact of the 3D immersive experience and are not directly related to the levels of empathy, these give an indication of how the experience affected the users through the manifestation of their behaviour.

3.3 Narrative, Film and Audio

UX was achieved through the use of different sensory modalities such as visuals and audio as well as reality matching, surroundness in the field of view and spatial audio, and a strong plot of the storyline with a dynamic unfolding sequence of events. This experience was brought to the user through a first-person narrative as a child on the autism spectrum at a primary school. The application used real film to provide a first-person account of what happens in a typical day at school as the user is surrounded by a cacophony of sounds and visual stimuli.

The narrative evolves over 6 scenarios typical of a day at school. These include class sessions, lunch breaks in the school yard, and transition across corridors (see Fig. 1). All filming was carried out using a 360 Samsung Gear camera, mounted on a tripod and fitted with a binaural microphone. Scenes were filmed on a low mounted camera to convey to the users an experience from the perspective of a child. Actors were briefed and scenes were staged inside real classroom settings. To aid visual and perception cues and decrease adverse VR effects such as motion sickness, stable visual cues were included in the filming whilst movement was restricted to a linear motion at a constant speed.

Fig. 1. The VR classroom scene

An iterative process has been implemented to progress from the planning to the development phase. The transition to VR development involved work that focused on the user experience, with a degree of constant calibration to minimise motion sickness. Head tracking technology was implemented using the Unity 3D platform and the experience used visual and auditory sensory cues. The VR experience was designed for the Samsung Gear VR Headset. This affected the user interface resolution so particular care and attention needed to be given to the UI elements and how these would appear on the screen. Any use of non-diegetic elements that might distract from the overall narrative of the experience were avoided to impart a more improved realistic experience. Sounds were used to help the user direct her gaze to a specific direction but a voice over was also used to articulate user thoughts and help her associate what was happening on-screen to reactions and behavior to strengthen presence and immersion.

4 Results

The results from the pre- and post- VR experience give an indication of the self-reported measures of user empathy levels.

The table of results (see Table 2) shows the findings after comparing the pre- and post- values following the VR experience. The findings showing a mean above 4, indicate a tendency towards strong agreement with the empathy items. Item 3 shows a lower mean as it is presented in the negative form. The standard deviation values indicate that the values are clustered more towards the mean. The p- values indicate that the only items which register a significant statistical difference between the pre- and the post-VR empathy questionnaires are items T5, 6, 7, 8 and 10.

Table 2. Paired samples T-test for the pre- and post- experience survey

T-test	Pre		Post		Paired samples test			
	Mean	Std. dev.	Mean	Std. dev.	95% confidence interval	Std. dev.	t	Sig. (2-tailed)
T1	4.440	0.562	4.460	0.618	−.2, .168	0.729	−0.173	0.863
T2	4.333	0.539	4.365	0.679	−.23387, .17038	0.803	−0.314	0.755
T3	2.540	0.930	2.810	1.216	−.55666, .01697	1.139	−1.881	0.065
T4	4.267	0.578	4.200	0.819	−.12279, .25612	0.733	0.704	0.484
T5	4.318	0.563	4.587	0.558	−.45194, −.08775	0.723	−2.962	0.004
T6	4.191	0.692	4.492	0.564	−.49154, −.11164	0.754	−3.174	0.002
T7	4.079	0.885	4.365	0.848	−.55112, −.02031	1.054	−2.152	0.035
T8	4.127	0.852	4.635	0.517	−.70958, −.30629	0.801	−5.035	0.000
79	4.254	0.740	4.349	0.765	−.34181, .15133	0.979	−0.772	0.443
T10	4.095	0.756	4.413	0.710	−.56449, −.07043	0.981	−2.569	0.013
Til	4.677	0.696	4.532	0.503	−.05447, .34479	0.786	1.454	0.151

N=63, df=62, p<.05

All the items listed as having had a significant statistical change refer to user perceptions of others in different situations especially those which may be in difficult or unhappy predicaments. Although the survey does not give an empirical measure of the changes in levels of empathy, the results give an indication that the VR experience has in no significant way affected the users' personality but it has impacted the way they think about other human beings in difficult circumstances.

In addition to the questionnaire, users' reactions were also observed during their VR experience and the observations were coded as per the measures shown in Sect. 3.2 above.

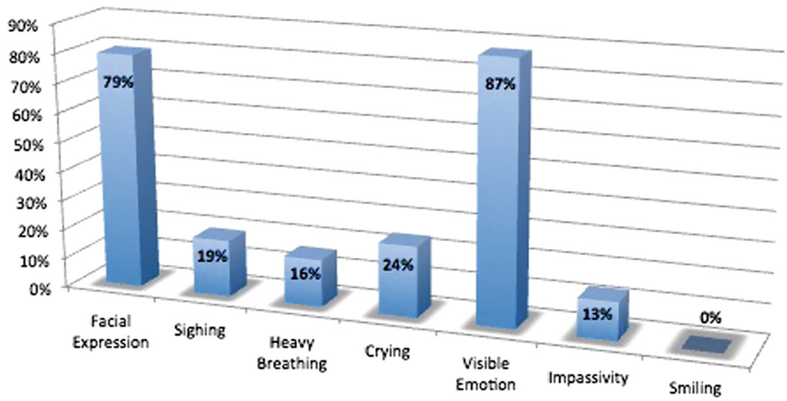

Fig. 2. Observable user behavior during VR experience

The results from Fig. 2 show that 87% of the users going through the 'Living Autism' VR experience showed some visible emotion whilst 79% showed changes in facial expressions. Visible emotion included emotional sounds and signs of some distress and agitation. Changes in facial expressions include observable changes below the head mounted mobile device and therefore concentrate around the mouth area. In addition, a number of users manifested more than one simultaneous behavior.

Following the VR experience participants were also asked to describe their emotional state, and their perception of stimuli effects on autism. All the participants described that the experience made them feel as though they were in another dimension. Even though in the real environment they were used to taking up the central role of the teacher, within the VR environment featuring a familiar class and school setting, they felt they were seeing it and experiencing it from the completely different perspective of a child with autism. The users that showed the most visible emotion reported that they felt the chaos of the class as overwhelming, and they needed to escape to a 'quiet room' without so many stimuli coming at them. Users also reported that now they could really understand what the children who are autistic go through every day as they face the various stimuli, including sounds, and olfactory ones, that are found in the classroom and that their level of understanding was considerably different from that which they had covered in theoretical lessons. All the participants reported that they could associate only too well with what happens in a classroom.

5 Discussion

Overall the results indicate that the VR experience had a degree of impact on the users' perceptions of autism. The qualitative feedback received shows that users could associate and identify with the scenarios presented and the classroom narratives. This association supported self-reported presence and immersion into the VR environment, a concept which tallies with research studies about presence and consciousness in VR [16]. The research questions posed at the start of the project, take into account the UX design of VR experience and how this links together immersion, presence and manifestations of user behavior.

RQ 1 deals with UX design and how this can lead to immersion. Users have reported that they have felt as though they were in another dimension, losing track of time, or place, but having a sense of 'being there' in the virtual world. The mediated sensory experiences have been used to allow users to map their body schema into the contextual framework of the scenarios being presented. The realistic filming, and the spatial audio helped connect pre-existing memory associations to form new ones, thus the illusion of their embodiment in the VR environment extends to the perception of the real world.

Research presented by Banakou et al. [4] had already given similar results that demonstrate that altered body self-representation from an adult to a child, can pose a significant influence on the users' perception of the world and this in turn increases the sense of flow and immersion into the virtual world. UX design principles that have been applied to the VR setting include

- the experience of user comfort: although the experience itself aims to create awareness of adverse effects of audio-visual stimuli on a child with autism, filming and audio were designed and planned to minimize discomfort such as motion sickness, or cyber-tearing;
- the interface design for the start of the mobile application is simple and takes into account usability issues.
- sound: the spatial sound helps users navigate since the interface does not allow for the inclusion of controllers or directions. Sounds direct the users where to look at and also act as a vocal interpretation of thoughts going on inside the child's head.

RQ 2 refers to the manifestation of user behavior and how the level of immersion relates to externalized actions. A relatively high number (87%) of participants displayed visible emotion such as distress and agitation throughout the experience. This also tallies with previous research studies by Kroes et al. [12]. Through the VR experience of 'Living Autism' users were more aware of their own actions and behavior, and their self-reported realization of their own manifestations led them to reflect about the level of immersion into the VR environment.

RQ3 enquires about the relationship between immersion and the empathy. The pre- and post-experience surveys give a measure of the self-reported empathy arising from the experience. The results reported a significant change in the participants' ability to try and imagine how they would feel in another person's situation, or their ability to associate a situation to another person's plight. One of the items on the empathy scale that registered the greatest significant statistical difference for the participants included the ability to understand what it feels like to be a child in a classroom. The results show that following the VR experience the users could report a greater understanding of what it feels like to be a child in a classroom setting. This is interesting more so because all the participants had a direct relationship with the classroom whether these were educators/teachers, or learning support assistants. The inference from this is that there can be instances where teachers and LSAs still do not fully identify with the children as individuals with differing needs, despite the fact that their work environment is the classroom. There may be a number of reasons for this, but one of them could be that the pressures related to the quantity of work that needs to be covered within the academic year, reduces their focus to the academic progress rather than on any other matter. The relation of immersion to empathy also tallies with previous work in the field such as that by [19]. All studies reviewed do not mention changes to the user's inherent personality traits and this is also reflected in the pre- and post-experience survey results presented in this paper.

6 Conclusion

This project stemmed from an identified need about more awareness of how class stimuli can have an adverse effect on a child diagnosed with autism. CPD courses for teachers attempt to bring more awareness about this subject. However, research indicates that when CPD is presented through immersion and simulation, there is deeper engagement which can lead to effective changes in behavior. This paper gave an overview of the results emergent from a VR experience project about 'Living Autism'. The experience designed around UX principles for the design of VR, features daily classroom events for a child diagnosed with autism and presented to an intended audience of teachers and learning support assistants through a first-person narrative. The storyline includes 4 case scenarios that take the users through various learning and socialization instances.

The project enquires into the relationship between UX, immersion and empathy levels in participants taking on the VR experience. Findings from self-reported measures on empathy, as well as qualitative feedback from observation and participant post-experience reflections, indicated that the experience facilitated increased empathy levels with children diagnosed with autism. As a result of this, participants reported more awareness of actions and behavior that might result in a negative reaction of a child with autism.

The project itself had a number of limitations that need to be addressed for future developments. These included the relatively generalised data about autism and how this was integrated in the classroom scenarios. Autism is a complex disorder that manifests itself across a wide spectrum of behavior for different individuals. Individual behavior could not be captured and presented to the users for a variety of reasons including limitations of time and resources. The sample size of the population was another limitation of the project. However, there are sufficient grounds to there is potential for further development. Although this project focused on the context of a classroom, the findings indicate that this can be scaled to the workplace or any other community space, for users to use as part of their CPD. The findings do not give any indication of the long-term effect of the VR experience on the users, or how this will affect their class behavior in the longer term. Future work on this project, may include a longitudinal follow up study to try and understand whether the self-reported changes in empathy would still be significant after a period of time.

Another future direction in this field is the use of neuroscience to understand more about the impact of an immersive experience on the parts of the brain specifically linked to empathy. Results that can empirically link immersion to increased empathic levels would bring great promise to the field of human behavior in VR.

References

1. Anzalone, C.: UB's virtual reality expertise creates simulated classroom environment for aspiring teachers, 28 June 2017. UBNow - Campus News. https://www.buffalo.edu/ubnow/stories/2017/06/vr-teacher-training.html. Accessed 14 Oct 2017
2. Bachen, C.M., Hernández-Ramos, P.F., Raphael, C., Waldron, A.: How do presence, flow, and character identification affect players' empathy and interest in learning from a serious computer game? Comput. Hum. Behav. **64**, 77–87 (2016)
3. Bambury, S.: CPD in VR (2017). VirtualiTeach. https://www.virtualiteach.com/cpd-in-vr. Accessed 15 Oct 2017
4. Banakou, D., Groten, R., Slater, M.: Illusory ownership of a virtual child body causes overestimation of object sizes and implicit attitude changes. Proc. Natl. Acad. Sci. **110**(31), 12846–12851 (2013)
5. Bohil, C., Owen, C., Jeong, E., Alicea, B., Biocca, F.: Virtual Reality and Presence, 21st Century Communication: A Reference Handbook. Sage Publications, Thousand Oaks (2009)
6. Bosschieter, P.: Continuing professional development (CPD) and the potential of new media. Indexer **34**(3), 71–74 (2016)
7. Crosswater: VR/360 (2017). Crosswater Digital Media. https://crosswater.net/. Accessed 15 Oct 2017
8. Day, C., Leach, R.: The continuing professional development of teachers: issues of coherence, cohesion and effectiveness. In: Townsend, T. (ed.) International Handbook of School Effectiveness and Improvement, pp. 707–726. Springer, Dordrecht (2007). https://doi.org/10.1007/978-1-4020-5747-2_38
9. Gaumer, E., Soukup, J., Noonan, P., McGurn, L.: Empathy Questionnaire (2016). Research Collaboration. http://www.researchcollaboration.org/uploads/EmpathyQuestionnaireInfo.pdf
10. Jones, B.: To raise teaching standards we must first improve the use of technology in the classroom, 1 February 2017. The Telegraph Education section. http://www.telegraph.co.uk/education/2017/02/01/raise-teaching-standards-must-first-improve-use-technology-classroom/. Accessed 14 Oct 2017
11. Kim, G.J.: Human-Computer Interaction: Fundamentals and Practice. Auerbach Publications, Boca Raton (2015)
12. Kroes, M., Dunsmoor, J., Mackey, W., McClay, M., Phelps, E.: Context conditioning in humans using commercially available immersive virtual reality. Sci. Rep. **7**(1), 8640 (2017)
13. Kuliga, S.F., Thrash, T., Dalton, R.C., Hölscher, C.: Virtual reality as an empirical research tool—exploring user experience in a real building and a corresponding virtual model. Comput. Environ. Urban Syst. **54**, 363–375 (2015)
14. Loewus, L.: How virtual reality is helping train new teachers. Educ. Week **37**(3), 1–2 (2017)
15. Morrison McGill, R.: Professional development for teachers: how can we take it to the next level? 29 January 2013. The Guardian - Professional Development - Teacher's Blog. https://www.theguardian.com/teacher-network/teacher-blog/2013/jan/29/professional-development-teacher-training-needs. Accessed 13 Oct 2017
16. Rautaray, S.S., Agrawal, A.: Vision based hand gesture recognition for human computer interaction: a survey. Artif. Intell. Rev. **43**(1), 1–54 (2015)
17. Sanchez-Vives, M.V., Slater, M.: From presence to consciousness through virtual reality. Nat. Rev. Neurosci. **6**(4), 332–339 (2005)
18. Shin, D.: The role of affordance in the experience of virtual reality learning: technological and affective affordances in virtual reality. Telematics Inform. **34**(8), 1826–1836 (2017)

19. Shin, D.: Empathy and embodied experience in virtual environment: to what extent can virtual reality stimulate empathy and embodied experience? Comput. Hum. Behav. **78**, 64–73 (2018)
20. Shneiderman, B., Plaisant, C., Cohen, M., Jacobs, S., Elmqvist, N., Diakopoulos, N.: Designing the User Interface: Strategies for Effective Human-Computer Interaction. Pearson, London (2016)
21. Slater, M.: Place illusion and plausibility can lead to realistic behaviour in immersive virtual environments. Philos. Trans. R. Soc. London B: Biol. Sci. **364**(1535), 3549–3557 (2009)
22. Teng, C.: Customization, immersion satisfaction, and online game loyalty. Comput. Hum. Behav. **26**(6), 1547–1554 (2010)
23. Walker, R., Voce, J., Nicholls, J., Swift, E., Ahmed, J., Horrigan, S., Vincent, P.: 2014 Survey of Technology Enhanced Learning for higher education in the UK. UCISA, Oxford (2014)