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Cardiopulmonary Resuscitation (CPR) training in schools in Wales: Emerging opportunities for improvement through Virtual Reality and gamification.

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Cardiopulmonary Resuscitation (CPR) training in schools in Wales: Emerging opportunities for improvement through Virtual Reality and gamification.

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Abstract

Cardiopulmonary Resuscitation (CPR) training in schools in Wales: Emerging opportunities for improvement through Virtual Reality and gamification.

UK average survival from Out of Hospital Cardiac Arrest (OHCA) survival is around 8.6%, which is significantly lower than other high performing countries with survival rates of over 20%. A cardiac arrest victim is 2–4 times more likely to survive OHCA with bystander CPR provision. Mandatory Teaching CPR to children in school is acknowledged to be the most effective way to reach the entire population and improving the bystander CPR rate and is endorsed by the World Health Organization (WHO) "*Kids Save Lives*" statement. Despite this, Wales is yet to follow other home nations by including CPR training as a mandatory within the school's curriculum.

In this paper, we explore the role of teaching CPR to schoolchildren and report on the development by Computer scientists at the University of Chester and the Welsh Ambulance Services NHS Trust (WAST) of VCPR, a virtual environment to help teach the procedure. VCPR was developed in three stages: identifying requirements and specifications; development of a prototype; and management—development of software, further funding and exploring opportunities for commercialisation. We describe the opportunities in Wales to skill up the whole population over time in CPR and present our Virtual reality (VR) technology is emerging as a powerful for teaching CPR in schools

Keywords:

- OHCA
- CPR
- Virtual Reality
- Cardiac Arrest
- School Children

Key points:

- Significant improvements in survival from OHCA can be gained through improving Basic Life Support (BLS) training.
- Mandatory Teaching CPR to children in school is acknowledged to be the most effective way to reach the entire population and improving the bystander CPR, but this has not happened yet in Wales
- Challenges have been identified in divorcing CPR training in schools from cost, time and effort involved in implementation of teaching programs and in sustaining delivery
- In an online survey conducted in collaboration with European Resuscitation Council 72.8% (n = 180) believed VR could play a role in future CPR training, 63.9% (n = 158) indicated that it could work better in kids yet only 2.4% (n = 6) reported use of serious games and 1.6% (n = 4) VR devices.
- We describe the opportunities in Wales to skill up the whole population over time in CPR and present our Virtual reality (VR) technology is emerging as a powerful for teaching CPR in schools
- We report on the development of VCPR, a virtual environment to help teach the procedure.

Introduction:

Out-of-hospital cardiac arrest (OHCA) is the third leading cause of death in industrialised nations [1]. The EuReCa TWO study [2] receives data from 28 countries in Europe, covering a total population of 178,879,118 and 37,054 OHCA, and between 1st October 2017 to 31st December 2017 they reported a total of 37,054 confirmed OHCA's where with CPR was started in 25,171 cases [2]. Despite significant advances in interventions provided by Emergency Medical Services (EMS), OHCA survival rates have not improved significantly in 30 years, and range from 8.6%-20% [3-5]. OHCA survival in the UK is around 8.6% [3], this is much lower than other developed countries, who achieve survival rates of over 20% [4, 5, 6]. Such high survival rates can be gained through improvements in Basic Life Support (BLS) training, public education and access to Automatic External Defibrillators (AED's) as reflected in the Chain of Survival, which includes actions to be taken to improve chances of survival from OHCA.

The EuReCa TWO study [2] found that the bystander CPR rate ranged from 13% to 82% between countries (average: 58%), and survival to hospital discharge was higher in patients when a bystander performed CPR with ventilations, compared to compression-only CPR (14% vs. 8% respectively). Barriers interfering with bystanders engaging in CPR have included lack of knowledge or training, skills, and confidence to initiate CPR and use of an AED (Dobbie et al., 2018). Hawkes et al (2017) [7] recently conducted a survey exploring of adults' attitudes to CPR and Defibrillator use in the UK. This study included the Welsh population in their sample of 2084 participants using YouGov's methods. Hawkes et al (2017) [7] found that 19% of participants had witnessed an OHCA and approximately 60% had undertaken some form of CPR training. These figures however fell to 17% to 27% for those trained within the past 5 years. Whilst the workplace was the most frequently reported place of training (55%), 27% were trained at school or in a youth organization. Hawkes et al

(2017) [7] also found that such training makes a difference in people's willingness to act in the event of OHCA.

The Resuscitation Council (UK) Guidelines [8] recognize the importance of early defibrillation, and if it is delivered within 5 minutes of OHCA survival rates of 50–70% can be achieved [9, 10, 11, 12]. However, for every minute of delay to defibrillation the probability of survival reduces by 10%, yet in the UK, fewer than 2% of victims have an AED deployed before the ambulance arrives [13]. A victim of OHCA is 2–4 times more likely to survive OHCA with bystander CPR provision [14], and up to 70% of OHCA are witnessed by family members, friends and other bystanders [15]. Therefore immediate CPR given by bystanders can increase the number of people who are given a chance of surviving.

CPR teaching in schools in Wales:

Teaching CPR to children in school is acknowledged to be the most effective way to reach the entire population. Mandatory CPR training of school children has been identified as having the highest potential impact for improving the bystander CPR rate [16]. Subsequently, the highest bystander CPR rates are in Scandinavia, where CPR training in schools has been mandatory for decades [17]. In support, the World Health Organization (WHO) has endorsed the "*Kids Save Lives*" Statement, a joint statement from the European Resuscitation Council (ERC), European Patient Safety Foundation (EPSF), International Liaison Committee on Resuscitation (ILCOR) and World Federation of Societies of Anesthesiologists (WFSA) [18]. This statement recommends two hours of CPR training annually from the age of 12 years in all schools worldwide.

Wales has led the way in many policy areas relating to the younger generation; for example, the *Well-being of Future Generations* (Wales) Act 2015 [19], reflects a society in which people's health is maximised through an understanding of the choices and behaviours that benefit future health. This act also advocates an inclusive approach to achieving well-being goals by involving children and young people [19]. Many initiatives have been introduced in Wales to improve learning of CPR, including Save a Life Cymru which is a partnership between a wide range of organizations offering CPR and defibrillation support and advice [20]. WAST lead the Defibruary initiative which aims to raise awareness of Defibrillators across Wales and arranged events where we educated people on how to use them, and Wales participates in Restart a Heart (RSAH), one of the largest UK initiatives to improve CPR skills is Restart a Heart [21]. Despite this, such a progressive vision may however not have extended to the policy position in Wales on learning CPR in Schools? In a letter to the Emergency Medical Journal, Phillips & Chapman (2019) [22] highlighted how Wales was at risk of being left behind the rest of the UK as CPR training is now a mandatory part of the secondary school curriculum in England and Scotland's 32 local authorities have all committed to teach CPR to every schoolchild.

All secondary schools in Wales can access a free British Heart Foundation (BHF) 'Call, Push, Rescue' kit, lesson plans, and training videos. However, challenges elsewhere have been identified in divorcing CPR training in schools from cost, time and effort involved in implementation of teaching programs and in sustaining delivery [16]. The Welsh OHCA Survival plan [20] have adopted elements of the Chain of Survival which represents a series of sequential actions to be taken to improve chances of survival from OHCA Figure 1.]. The Welsh OHCA Survival plan [20] recognises that CPR is an important component of health education of all the population, and all schools, further and higher education students should be provided with opportunities to learn CPR techniques. This proposal recognises how technology may provide solutions to achieve high rates of CPR learning in schools.

Fig 1. Save a Life Cymru Chain of Survival Out of Hospital Cardiac Arrest Plan for Wales (2018) [20]

Phillips & Chapman (2019) [22] highlighted the approach of gamification of CPR teaching which Otero-Agraet (2020) [23] suggests is also a very effective way of teaching and engaging schoolchildren. Such innovations in CPR teaching they suggest have removed the barriers to teaching it in schools and leave little excuse for its absence in the curriculum in Wales.

Our team includes paramedics, ambulance service and third sector leaders, researchers, academics and computer scientists whom have published widely in this area. We aimed to explore the development and adoption of VR for teaching CPR in schools.

Methods

Following review against the Health Research Authority [24] guidance the project was not classed as research at this stage, but rather service improvement, as research has previously demonstrated benefits of VR in teaching CPR to school children. However, WAST maintains oversight and future development and validation of the technology will be required before its adoption.

Our team of VR developers, researchers, paramedics and trainers from the University of Chester (UC) and the Welsh Ambulance Services NHS Trust (WAST) engaged in the development of VCPR in the stages below:

Task 1: Requirements Specification

Chester University, WAST and BHF worked with schools representatives to specify the requirements for VR from the perspective of CPR training in schools. These were documented by the University of Chester and used to drove the development of the prototype system. During this stage we secured Health and Care research Wales Pathway to Portfolio funding to develop and deliver the project.

Task 2: Development VCPR Prototype

An initial implementation of a VR environment was produced for training CPR. This was demonstrated to key stakeholders and feedback gathered. The Oculus Quest VR technology was used, a tetherless device that does not require connection to a PC. We envisaged using tangible haptics so that the user would press down on a suitably deformable block of material. They would however see a realistic person that needs CPR. We plan to recreate different scenarios with variation in patient outcome.

A. The VR Scene

The simulator contained a physical model of a human torso (manikin). This is used for training palpation during the CPR procedure. The user wore the head-mounted display (HMD) shown in Fig. 2 and placed their hands onto the physical torso. In the virtual world, a model of a human male (lying on the ground following a heart attack) was also shown in 3D stereo. These had to be accurately registered so that they are co-located in the real and virtual worlds – as illustrated in Fig. 3. To achieve this one of the hand controllers was mounted in a retort stand (Fig. 2) at a carefully measured distance from the manikin. The Oculus Quest supports positional tracking with six degrees of freedom using internal sensors and an array of cameras in the front of the headset. The position of the hand controllers in relation to the headset is therefore always known. We used this information to overlay the virtual avatar on top of the physical location of the manikin.

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B. Performing CPR

The second hand controller was worn around the wrist like a bracelet (Fig. 2). This is useful because both hands are required to be used together to compress the chest wall during the CPR. As the user performed a chest compression, the up and down motion of the hands was captured by the hand controller. We can therefore determine the rate (beats per minute) that was being used and provide hints to the user as to whether they were going too fast or too slow. This information was displayed on the pop-up panel that can be seen in Fig 3.

We enhanced the virtual scene with ambient sound effects appropriate to the environment that the user was immersed in. The key to successfully performing CPR is to find and maintain the correct rhythm for the chest compressions. When being taught the procedure, it is often recommended that the user sings to themselves a classic song such as "Stayin' Alive" by the Bee Gees, which helps to achieve the 100-120 beats per minute needed. In the virtual environment we therefore also enabled the user to select an appropriate song that was played to them as they carried out CPR.

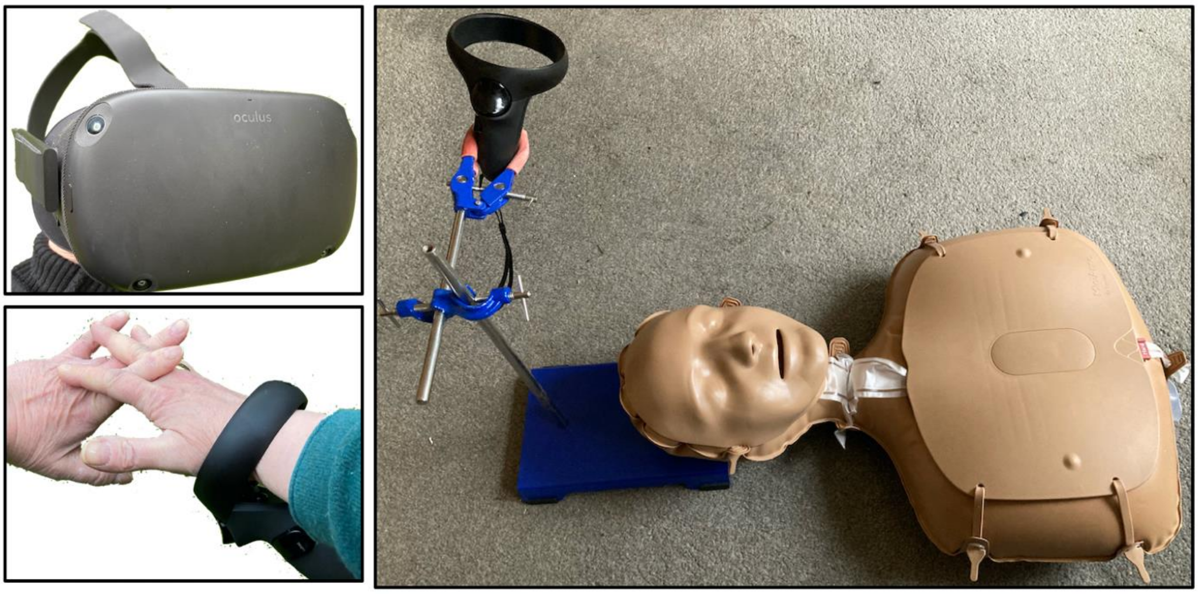

Figure 2. The Oculus Quest and Hand Controllers as used in the VCPR application. In the right-hand image the controller is clamped at a known distance from the manikin.

Figure 3. The VCPR training environment in use. The real and virtual worlds have been superimposed for illustration purposes.

C. Virtual environment 3D software development

The virtual environment for the CPR simulator was designed to reflect the spontaneous nature of CPR which could occur in unpredictable locations such as at the scene of a car accident at the roadside or in a town square (Fig. 3). The environment was developed using a 3D Games Engine called Unity. Unity includes realistic physics modelling and allows us to import the assets for any 3D scene that we wanted to build. It also had excellent support for the latest VR devices such as the Oculus Quest. The functionality for calculating the beats per minute was implemented in a custom script that is integrated into the scene.

III. EVALUATION AND TESTING

A. Feedback from Paramedics

A range of individuals, groups and organisations provided feedback. This included the study team which included paramedics, trainers, the WAST cardiac lead and BHF Cymru. We also demonstrated and received input from schools and children during a mass CPR training event. Presentations and question-and-answer sessions were conducted at a WAST, Bevan Commission Innovators event at the Senedd Cymru/Welsh Parliament Bevan Commission, 2020 [25] and Cyberworlds Japan 2020 [26]. These events included a wide range of paramedics, trainers, political and policy makers, academics, researchers, industry, and senior operational and clinical staff. The authors continue to work closely with these groups and to demonstrate our developed system and gather feedback. We continue to monitor the literature and gather critical evidence and evaluation which will further demonstrate the applicability, clinical and commercial potential of the developed technology for teaching CPR to schoolchildren in Wales and ultimately to improve survival from OHCA.

We continue to complete further in-depth clinical evaluation, which is being strengthened by having support from political and policy processes, other organisations and sectors and industry collaborators.

Task 3: Management

Simultaneous to the software development, a collaboration agreement will be finalised. We will also start investigating options for further funding and the eventual commercialisation of PARAVR junior for schools, and the prototype developed during this project will leverage further grant monies and investment for this project.

Discussion

We started this project in 2018, and during this time Virtual Reality CPR training has been further developed and evaluated by a small number of investigators who conclude that it can be an acceptable tool for training programs addressing general populations, schoolchildren and healthcare professionals with a gamification approach [27,28]. The positive feedback experienced within our project is consistent with this growing evidence base for the role of VR in CPR learning. In an online survey conducted in collaboration with European Resuscitation Council and the Research NET community, Böttiger et al (2017) [29] sought to evaluate and test attitudes on VR from the CPR instructor community. Whilst only 2.4% (n = 6) reported use of serious games and 1.6% (n = 4) VR devices, 72.8% (n = 180) believed that VR could play a role in future training and 63.9% (n = 158) indicated that it that could work better in kids.

Technological developments in VR teaching of CPR have also evolved from early studies before and during our study. Boada et al (2015) [30] developed and evaluated LISSA, which is a serious game designed to complement CPR teaching and also to refresh CPR skills in an enjoyable way. They performed a randomized controlled trial with a population of 109 nursing undergraduate students to compare the classical CPR teaching involving mannequin practice. They found that LISSA students using LISSA gave significantly better learning acquisition scores than those following traditional classes, they also found significant improvement in student performance of main steps of CPR protocol with LISSA.

Semeraro et al (2009, 2017) [27,32] and the Italian Resuscitation Council (IRC) has led the way in using VR to raise awareness and teach CPR to children through its Virtual Reality Enhanced Mannequin (VREM) experience. Semeraro et al (2017) [31] evaluated acceptance of a virtual reality enhanced mannequin (VREM), in a sample of 39 possible users who reported that the system was very positive, as was the feeling of immersion and realism of the environment and simulation, with 84.6% of the participants judged the virtual reality experience as interesting and believed that its development could be very useful for healthcare training.

Resuscitation Council UK developed Lifesaver VR for cardiac arrest awareness aimed at schoolchildren and the general population. Yeung et al (2017) [32] conducted a Randomised controlled trial of 3 UK schools comparing Lifesaver, face-to-face (F2F) training, and a combination of both. They found that use of Lifesaver by school children, compared to F2F training alone, can lead to comparable learning outcomes for several key elements of successful CPR. They also concluded that its use can be considered where resources or time do not permit formal F2F training sessions, but that the true benefits may be realised if paired with F2F training.

Learning approaches which aim to merge traditional training with quality CPR feedback mannequins and Virtual Reality environment have been developed by the Italian Resuscitation Council (IRC) through their course "Basic Life Support and Defibrillation, Quality CPR and Virtual Reality (BLS-D VRQ 2019). Semeraro et al (2009, 2017) [27,31] evaluated two different CPR feedback mannequins and two different VR devices with the same self-directed learning program and found that unanimously, the Virtual Reality Experience was considered very immersive, with a very high sense of presence and with an effective feedback on participant skill performance. They concluded that the new BLS-D

VRQ course may be considered as an effective and acceptable alternative to traditional training courses. However, costs, equipment and initial instructor training must be acknowledged.

Within our project we employed the Quest Hand Controller in a novel manner during the VCPR simulation. Semeraro et al (2019) [33] also employed motion detection technology, to accurately estimate chest compressions quality CPR parameters. They evaluated correct chest compression rate (CCR) and depth (CCD) compared to a standard mannequin. And this comparison of measurements between VR CPR and RA showed equivalent results.

Leary et al (2019) [28] examined whether using a VR mobile application (mApp) for CPR training would improve bystander response compared with a standard mApp CPR training. 105 participants were enrolled: Bystander response was significantly higher in the VR mApp arm: called 911 (82% vs 58%, p = 0.007) and asked for an AED (57% vs 28%, p = 0.003). However there was no difference in CPR performed (98% vs 98%, p = NS) and the application of the AED (90% vs 93%, p = NS). When comparing the VR mApp to the mApp, mean CC rate was 104 _ 42 cpm vs 112 _ 30 cpm (p = NS), and mean CC depth was 38 _ 15 mm vs 44 _ 13 mm (p = 0.05). The authors concluded that use of the VR mApp significantly increased the likelihood of calling 911 and asking for an AED, however, CC depth was decreased. This highlight the need for rigorous development and evaluation to avoid any unintended, harmful consequences of the VR applications.

Our development of VCPR along with several other groups have therefore worked in parallel to develop the body of knowledge and present opportunities to improve teaching of CPR in schools. As this body of knowledge, evidence base and technology continues to develop and mature, so to is the need for the commercial, policy and political discussion on the vital role of teaching CPR in schools to improving survival from OHCA and utilisation of VR in this process.

Limitations

Our project has explored the development of VR for teaching CPR in schools in Wales through VCPR. Despite recommendations that schoolchildren receive two hours of CPR training annually, as with many countries across the world, this is not mandatory in Wales. Our experiences may not then transfer into other contexts. We have however drawn on a growing international evidence base pointing to the role of VR in supporting teaching of CPR in schools. Our study on VR should not limit the central message around the importance of mandatory CPR training in schools, but rather, should serve to highlight the need to maintain the focus on this important issue for Wales. Before adoption of VR, further technological development of VCPR will be required and whilst other VR versions may be available, VCPR presents opportunities to tailor to the local setting including requirements such as a Welsh language version and may benefit from the flexibility of VR, as large-scale, inexpensive tailored software upgrades may be introduced in response to such emerging changes in practice in a way that expensive physical models cannot.

Conclusion

Survival of around 8% from OHCA in the UK is significantly lower than high performing regions where survival exceeds 20%. Survival from OHCA is significantly higher when a bystander performs CPR and yet there is wide variation in delivery of these lifesaving skills, ranged from 13% to 82% between countries. Barriers interfering with bystanders engaging in CPR have included lack of knowledge or training, skills, and confidence to initiate CPR and use of an AED. The World Health Organization (WHO) has endorsed the "*Kids Save Lives*" which calls for mandatory Teaching of CPR to children in school, which is acknowledged to be the most effective way to reach the entire population and improving the bystander CPR rate. Wales may be at risk of being left behind the rest of the UK and other developed nations where CPR learing is increasingly becoming a compulsory part of the curriculum.

In an attempt to raise the profile of CPR learning in schools and utilise technology to address some of the challenges, we developed a Virtual Reality (VR) training simulator for the CPR training in schools. Building on work we had previously conducted utilising VR for infrequently used paramedic skills (ParaVR) [34] we designed VCPR in partnership with researchers, computer scientists, paramedics, policy makers, teachers and school children. This simulator incorporates that latest VR technologies including the Oculus Quest. Some of these technologies have also been utilised by other investigators and have found them to effective and accepted well by users.

We have gained input from NHS paramedics and several related organisation to design the system and provide feedback and evaluation of the preliminary working prototype. We have also monitored the literature which continues to build the body of knowledge to support VR use in teaching CPR to school children. Whist there is an urgent need to deploy such technology to teach CPR to school children, we continue to further develop the simulator, and are aiming to produce more advanced versions incorporating Artificial Intelligence technology ready for formal evaluation, clinical testing and future commercialisation. In the meantime, we call for continued pressure on policy and political processes to ensure that all children receive mandatory CPR training in schools.

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References

1. Taniguchi, D. Baernstein, A. Nichol, G. (2012) Cardiac arrest: a public health perspective. *Emerg Med Clin North Am* 2012;30:1–12
2. Gräsner JT, Wnent J, Herlitz J, Perkins GD, Lefering R, Tjelmeland I, Koster RW, Masterson S, Rossell-Ortiz F, Maurer H, Böttiger BW, Moertl M, Mols P, Alihodžić H, Hadžibegović I, Ioannides M, Truhlář A, Wissenberg M, Salo A, Escutnaire J, Nikolaou N, Nagy E, Jonsson BS, Wright P, Semeraro F, Clarens C, Beesems S, Cebula G, Correia VH, Cimpoesu D, Raffay V, Trenkler S, Markota A, Strömsöe A, Burkart R, Booth S, Bossaert L. Survival after out-of-hospital cardiac arrest in Europe - Results of the EuReCa TWO study. Resuscitation. 2020 Mar 1;148:218-226. doi: 10.1016/j.resuscitation.2019.12.042. Epub 2020 Feb 3. PMID: 32027980.
3. NHS England (2015) *Ambulance-quality-indicators*. Available from: www.england.nhs.uk/statistics/stasistical-work-areas/ambulance-quality-indicators/. [Accessed on 13/09/2016]
4. Lindner, T.W. Soreide, E. Nilsen, O.B. Torunn, M.W. Lossius, H.M. (2011) Good outcome in every fourth resuscitation attempt is achievable-An Utstein template report from the Stavanger region. Resuscitation 2011; 82:1508-13.
5. Grasner, J.T. Herlitz, J. Koster, R.W. Rosell-Ortiz, F. Stamatakis, L. Bossaert, L. (2011) Quality management in resuscitation--towards a European cardiac arrest registry (eureca). Resuscitation 2011; 82:989-94.
6. Division of Medical Services Public Health - Seattle & King County 2013 Annual Report to the King County Council. Available from: http://www.kingcounty.gov/healthservices/health/ems/reports.aspx. [accessed on

7. Hawkes, C.A et al (2017) Attitudes to CPR and public access defibrillation: A survey of the UK public. Resuscitation 118:-39 · September 2017 DOI:10.1016/j.resuscitation.2017.08.101

8. Perkins GD, Handley AJ, Koster RW, et al., Adult basic life support and automated external defibrillation section Collaborators. European Resuscitation Council Guidelines for Resuscitation 2015: Section 2. Adult basic life support and automated external defibrillation. Resuscitation 2015;95:81–99.

9. Valenzuela TD, Roe DJ, Cretin S, Spaite DW, Larsen MP. Estimating effectiveness of cardiac arrest interventions: a logistic regression survival model. Circulation. 1997; 96:3308 –3313.
10. Berdowski J, Blom MT, Bardai A, Tan HL, Tijssen JG, Koster RW. Impact of onsite or dispatched automated external defibrillator use on survival after out-of-hospital cardiac arrest. Circulation 2011;124:2225-32.
11. Ringh M, Rosenqvist M, Hollenberg J, et al. Mobile-phone dispatch of laypersons for CPR in out-of-hospital cardiac arrest. N Engl J Med 2015;372:2316-25.
12. Blom MT, Beesems SG, Homma PC, et al. (2014) Improved survival after out-of-hospital cardiac arrest and use of automated external defibrillators. Circulation 2014; 130:1868-75.
13. Deakin CD, Shewry E, Gray H, (2014) Public access defibrillation remains out of reach for most victims of out-of-hospital sudden cardiac arrest. Heart 2014; 100:619-623.
14. Van Hoeyweghen RJ, Bossaert LL, Mullie A, et al. Quality and efficiency of bystander CPR. Resuscitation 1993;26:47–52.

15. Breckwoldt J, Schloesser S, Arntz HR. Perceptions of collapse and assessment of cardiac arrest by bystanders of out-of-hospital cardiac arrest (OOHCA). Resuscitation 2009;80:1108–13
16. Plant, N. Taylor, K. (2015) How best to teach CPR to schoolchildren: A systematic review_ Resuscitation 84 (2013) 415– 421

.

17. Wissenberg M, Lippert FK, Folke F, et al. Association of national initiatives to improve cardiac arrest management with rates of bystander intervention and patient survival after out-of-hospital cardiac arrest. JAMA 2013;310: 1377–84

18. B.W. Böttiger, H. Van AkenTraining children in cardiopulmonary resuscitation worldwide Lancet, 385 (2015), p. 2353
19. Well-being of Future Generations (Wales) Act 2015. Available from: www.legislation.gov.uk/anaw/2015/2/contents [accessed on 24/01/2019]
20. Out of Hospital Cardiac Arrest Plan for Wales. Available from: https://gov.wales/about/cabinet/cabinetstatements/2017/outofhospitalcardiacplan/?lang=en [Accessed on 24/01/2019]
21. RCUK (2021) Resuscitation Council UK: Restart A Heart Day. Available from: https://www.resus.org.uk/get-involved/restart-heart-day [Accessed on 17/02/2021]
22. Phillips, E.J. Chapman, C.G. (2020) Mandatory CPR teaching in Welsh schools: missed opportunity? Emerg Med J 2020;0:1. doi:10.1136/ emermed-2020-210045
23. Otero-Agr, M. Barcala-Furelos, R. Besada-Saavedra, I. et al. (2019) Let the kids play: gamification as a CPR training methodology in secondary school students. A quasi-experimental manikin simulation study. Emerg Med J 2019;36:653–9.

24. NHS Health Research Authority, Medical Research Council. Is my study research? http://www.hra-decisiontools.org.uk/ research/ (accessed 23 November 2020)
25. Bevan Commission. EVENT: Bevan Commission's Innovators Showcase - Bevan Exemplar Exhibition. 2020. https:// business.senedd.wales/mgCalendarEvent.
26. Vaughan, N. John, N. Rees, N. (2019) CPR Virtual Reality Training Simulator for Schools. Cyberworlds Japan 2020. Page(s):25 - 28 2020. Available from: https://ieeexplore.ieee.org/document/8919055
27. Semeraro F, Frisoli A, Bergamasco M, Cerchiari EL. Virtual reality enhanced man-nequin (VREM) that is well received by resuscitation experts. Resuscitation2009;80(April (4)):489–92.[2].
28. Leary, M. McGovern, S.K. Chaudhary, Z. Patel, J. Abella, B.S. Blewer, A.L. (2019) Comparing bystander response to a sudden cardiac arrest using a virtual reality CPR training mobile app versus a standard CPR training mobile app. Resuscitation, Volume 139, 167 - 173
29. Böttiger BW. ERC Research NET-The network for sudden cardiac arrest andresuscitation research in Europe. Resuscitation 2017;117(August):e21–2, mem-bers of the ERC Research NET.

30. Boada I, Rodriguez-Benitez A, Garcia-Gonzalez JM, Olivet J, Carreras V, Sbert M. Using a serious game to complement CPR instruction in a nurse faculty. Comput Methods Programs Biomed. 2015 Nov;122(2):282-91. doi: 10.1016/j.cmpb.2015.08.006. Epub 2015 Aug 21. PMID: 26319184.
31. Semeraro F, Frisoli A, Loconsole C, Mastronicola N, Stroppa F, Ristagno G, et al.Kids (learn how to) save lives in the school with the serious game Relive. Resus-citation 2017;116(July):27–32.[3]. Lifesaver VR at www.resus.org.uk/apps/

32. Yeung, J. Kovic, I. Vidacic, M. Skilton, E. Higgins, D. Melody, T. Lockey, A. (2017) The school Lifesavers study—A randomised controlled trial comparing the impact of Lifesaver only, face-to-face training only, and Lifesaver with face-to-face training on CPR knowledge, skills and attitudes in UK school children. Resuscitation. Volume 120: Pages 138-145,

33. Semeraro F, Ristagno G, Giulini G, Kayal JS, Cavallo P, Farabegoli L, Tucci R, Scelsi S, Grieco NB, Scapigliati A. Back to reality: A new blended pilot course of Basic Life Support with Virtual Reality. Resuscitation. 2019 May;138:18-19. doi: 10.1016/j.resuscitation.2019.02.034. Epub 2019 Mar 5. PMID: 30844415.

34. Rees, N. Vaughan, N. Day, T.W. Rees, L. John, N.W. (2020) ParaVR: a virtual reality training simulator for paramedic skills maintenance. *Journal of Paramedic Practice*. 12(12):478. DOI: 10.12968/jpar.2020.12.12.478

Figure (i.e. diagram, illustration, photo)

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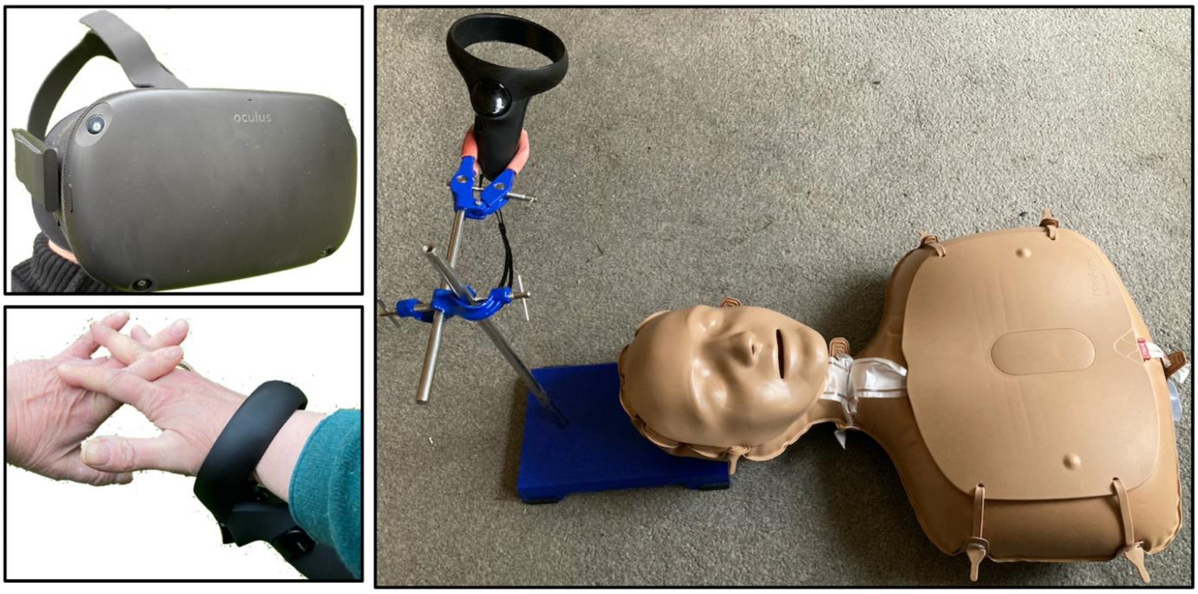
oculus


VCPR Feedback
Hand Position: Down
Total Beats: 76
BPM: 14
Average BPM: 47
Too Slow!!