Feasibility and Acceptance of Virtual Reality Reusable e-Resources Embedded in Healthcare Curricula

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***Abstract*— The use of Virtual Reality in healthcare education is still uncommon. Measuring the feasibility of such resources into formal training is critical for quality, satisfaction, and ultimately improved efficacy over other methods. The Co-creation of Virtual Reality reusable e-Resources for European Healthcare Education (CoViRR) team used a proven development framework to co-create and analyze the feasibility and acceptance of 3 Virtual Reality Reusable e-Resources (VRReRs). The co-created VRReRs have been evaluated on usability, user acceptance and pedagogical acceptability using several formal and ad-hoc instruments. The results demonstrated that co-created VRReRs were on-par with other IT products in terms of usability. Also, users appeared ready to accept reusable VR e-resources as useful skills training instruments. Qualitative evaluation revealed that the user base is ready to accept VRReRs but require high technical fidelity and human-centric interaction schemes, supporting seamless integration of user activities in the virtual world, without technical obstacles. Ultimately, CoViRR analysis on feasibility and acceptance of virtual reality reusable e-resources will act as an example by other higher education institutions and tutors in techniques and topics for effective resource creation.**

Keywords— Virtual Reality; Pedagogy; Healthcare; co-creation; Usability

I. Introduction

A. *Transfer of Information and Digitalization of Content*

Healthcare professionals have demand for high-quality training materials. The healthcare landscape has both increasing amounts of data, information, complex procedures, equipment, and patient needs [1], [2]. Relevant knowledge and skills transfer from expert to learner is a critical point of failure or success in healthcare services. If data from experts is sub optimal then trainees can either learn improper skills and inaccurate information, or a lack thereof. If experts provide excellent knowledge and skills, however it is transferred by a method which is not optimised for the trainees, the same results can also occur [3], [4].

Additionally, adopting mobile learning applications may not necessarily have a positive impact for learners if they are not included in the development process. Research has shown utilization of mobile applications is low [5]. However, low utilization occurs mostly when certain conditions fall into place such as usage in classroom, biases in studies, and outdated smartphones or other devices [6]. Both learners and subject experts need considered and proven methods of inclusion for successful development and integration of digital pedagogical resources.

Furthermore, such common skills transfer opportunities such as lectures, workshops, and hands on experience through shadowing and supervision, are highly dependable on environmental factors allowing them to occur. Most recently, the COVID-19 pandemic has highlighted how disruption to healthcare environments can affect staff, learners, and patients with little time to adapt [7]. The digitalization of content for training has a plethora of benefits which combat such limitations in the current landscape. Changing the way teaching and training is delivered in the digital era is achieved by supporting current curricula and fostering open education [8]. This is where the ERASMUS + European funded project named Co-creation of Virtual Reality reusable e-Resources for European Healthcare Education (COViRR) can positively impact pedagogical processes.

CoViRR aimed to co-create new pedagogical approaches and in particular virtual reality reusable e-resources for European Medical and Nursing schools. CoViRR [9] predicted and expected that learners would adopt this new digital pedagogy and improve their clinical skills and competences through immersive learning. Additionally, the teaching staff are provided the opportunity to enhance their competences in e-learning tool co-creation, and make use of co-creation best practices and recommendation for use[10]. Reformation of the educational process to match current criteria can be achieved by personalised learning opportunities driven by learner focus, as they are the end users and future independent and competent healthcare providers.

Figure 1: VRReR development process based on the ASPIRE framework. Learners are stakeholders from the start when performing collaborative workshops.

CoViRR proposed, and has recently achieved, the integration of immersive technologies in healthcare pedagogy, and this paper presents the design overview and evaluation of two VRReRs. There is focus on feasibility and acceptability of the resources rather than the novelty, however there are novel elements present through the co-creation elements. The resources are reusable learning objects as they are self-contained packages of high-quality information presented to medical learners who were involved in the full development process [11], [12]. Their involvement in the creation of these immersive reality resources is successful from utilising the ASPIRE framework which has a longstanding and continued evidence-based efficacy for development and implementation of resources using cocreation methodology [13].Co-creation and ASPIRE Framework for Healthcare

The ASPIRE framework stands for Aims, Storyboarding, Population, Implementation, Release, and Evaluation. The ASPIRE framework has been refined over decades of implementation to be effective for a large scope through flexibility in modifications of each step [14]–[18]. Recently it has been adapted to be used in Virtual Reality and 360-degree interactive video resources [19], [20], as well as on virtual learning packages that address multiple learning objectives [21], and the rationale for use in this study.

The combination of the co-creation methods within the ASPIRE framework, the exploitation of virtual reality environments, and the quality control of content by subject experts allows for powerful yet efficient and simplistic learning resources. The synergy of these processes form 3 screening checkpoints along the development process to ensure quality and necessity are upheld. In storyboarding workshops, the learners are facilitated by learning technologists and educators to help them verbalize implicit needs that can then be mapped out into clear and defined objectives. Content is checked by content experts before development starts, and another review is performed before the final release. This paper is essentially the 4th and final checkpoint in the process and evaluates the resources, which in turn reflects the efficacy of the entirety of previous actions performed.

B. *Aims and Rationale*

Therefore, the aim of this paper was to evaluate the VRReRs to understand both the strengths and limitations in acceptability and usability. These have been embedded into the resources either during the development processes or identified in the feedback from the learners who test each resource. The evaluation and understanding of strengths and limitations allows both the ASPIRE framework and the VRReRs to develop towards greater efficacious outcomes in future resources created for healthcare students.

Method

C. *Virtual Reality Reusable e-Resources for Evaluation*

Healthcare educators and course leaders helped to determine what subject areas would not only most benefit from VRReRs for students but are most impactful for service users/patients. When Storyboarding collaboration with learners and educators was performed, there were several subject areas that were determined to benefit the most for both learners and service users.

For each of the resources an online storyboard was led by a facilitator and used an online storyboard canvas named Mural which allows multi-user editing of images/text/videos. Internal review of the final content from the VRReRs were performed by subject- matter experts, learning technologists and a facilitator, forming a storyboarding workshop. All resources created could be used in headsets where a mobile phone is added- these are typically plastic and are low costs. For all resources, interaction with the app would involve a gaze dot in the centre of the screen, with participants waiting 3 seconds on an item for it to be triggered.

The first VRReR [22] was produced out of necessity from the pandemic effects on providing learners with communication-based scenarios. Specifically, the context included home visiting of adolescent who are at risk of self-harm [23]. Learners has a great dependency on the communication with the patient and CoViRR has created a VRReR to improve these skills.

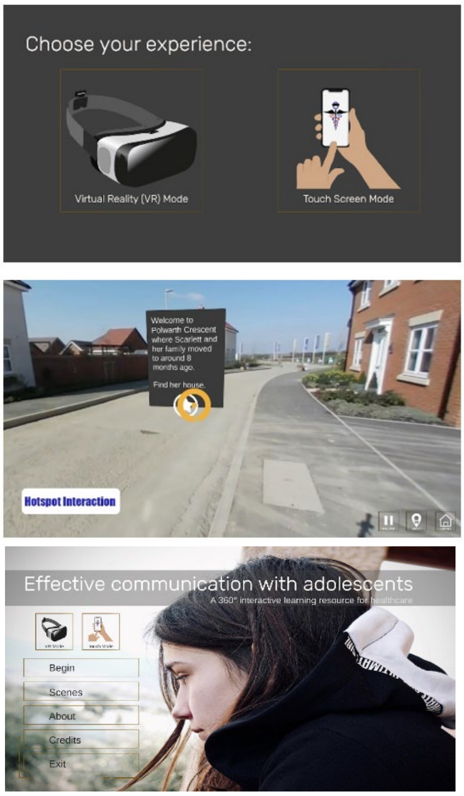

Figure 2: Snapshots of the VRReR to train communication skills with adolescents with home visits.

The second VRReR[24] is a VR mobile resource for a clinical skill course at the CYENS Medical School of the University of Cyprus, with the development process previously presented [25]. The resource provides students with the ability to watch 360° videos that highlight several different scenarios: covering the following areas: sterilizing hands/hands hygiene, surgical gloving technique, excision of skin lesion, glove removal, wound sterilization, and local anaesthetic.

The third VRReR [26] created by Aristotle University of Thessaloniki had 2 sections; one being ECG examination and one being X-ray examination. For the ECG scenario the machine displays single-channel ECG records of various heart diseases like heart arrhythmias and the medical students must identify the disease which the signals correspond to, and choose the correct answer. For the X-ray scenario, alongside the patient, a chest X-Ray is displayed. The user must find the problem based solely on the provided X-Ray and choose among 4 options displayed in a banner next to the X-Ray.

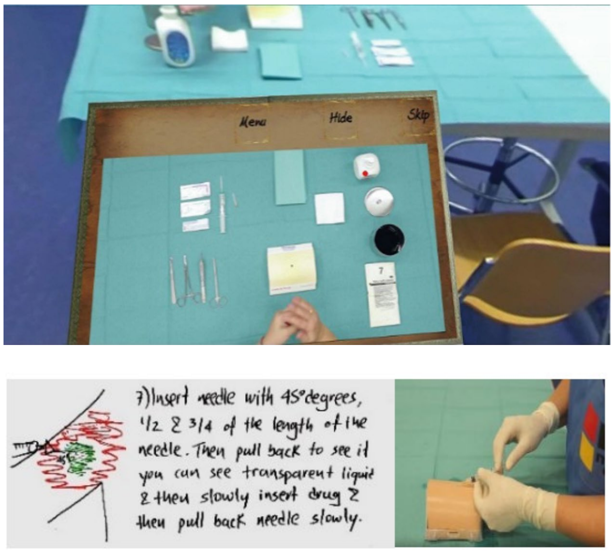

Fig. 3. The 360-degree videos in the background, with the synced close-up videos showing skills

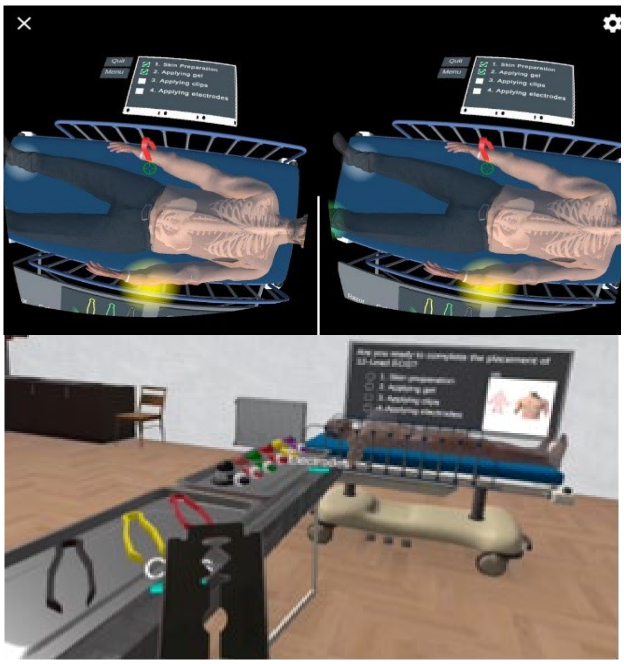

Fig. 4. The 360- environment showing the required tools, and the scenario of procedural steps for x-rays.

D. Experimental Protocol

The convenience sample of 136 participants completed the TAM, SUS, and UTAUT2 surveys before and after use of resources, to understand how the resource may have affected their experiences/perceptions. The participants volunteered to join an online session for the data collection. Descriptive comparisons were made, and inferential results are presented if found between pre-and post- measures along with descriptive summaries.

E. Quantatative Evaluation Measures

There are several evaluation metrics for novel technology in healthcare pedagogy and technology. All participants used the VR options of the resources using mobile VR headsets- this is the context applied to the questions used in the measures. We used the most popular yet relevant, and most established systems of measurement for evaluation and briefly described below:

System Usability Scale

The System Usability Scale (SUS) was used [27] and is a widely used and adopted usability questionnaire. It is popular due to its unbiased and agnostic properties, a nonproprietary, and quick scale of 10 questions. The SUS was developed with a scoring system, in which the result is a score out of 100 and can be compared against a determined average score of 68. Further, 80 or higher is excellent, and 51 or under suggests significant usability problems.

Table 1: Descriptive Stats for SUS questions for participants

Variable	M	SD	Mode
Q7_learn_to_use_system_quickly	3.96	0.93	4.00
Q10_do_not_learn_a_lot_before_use	3.93	1.01	4.00
Q2_system_is_not_complex	3.90	1.14	5.00
Q3_system_easy_to_use	3.81	1.01	4.00
Q4_no_assistance_to_use_system	3.80	1.22	5.00
Q9_confident_using_system	3.75	0.94	4.00
Q1_use_this_system_frequently	3.70	1.00	4.00
Q8_system_not_cumbersome_awkward	3.60	1.16	4.00
Q5_functions_well_integrated	3.51	0.90	4.00
Q6_no_inconsistency_in_system	3.41	1.09	3.00

Slater-Usoh-Steed Presence Questionnaire (SUS-PQ)

The Slater-Usoh-Steed Presence Questionnaire (SUS-PQ) was also used. This consists of 6 questions with a 7-point scale (1-Strongly Disagree, 7-Strongly Agree) and captures user experience of being subjectively present within a virtual environment.

Unified Theory of Acceptance and Use of Technology

The UTAUT2 [28] was developed by taking the advantages of previous constructs from models and theories to develop a more unified form of technology acceptance measure. The theory holds that there are four key constructs: performance expectancy, effort expectancy, social influence, and facilitating conditions.

Technology Acceptance Model (TAM)

The Technology Acceptance Model (TAM) [29] was specifically developed with the primary aim of identifying the determinants involved in computer acceptance in general; secondly, to examine a variety of information technology usage behaviors; and thirdly, to provide a parsimonious theoretical explanatory model. TAM suggests that attitude would be a direct predictor of the intention to use technology, which in turn would predict the actual usage of the technology.

Qualitative Measures

Focus Group Discussions-

A series of short focus group sessions identified the feasibility of CoViRR resources for formal curricular integration. These sessions, spanning no more than 1-1.5 hours and consisting of no more than 5-7 persons each explored all axes of curricular integration such as accessibility in the classroom, use case scenarios, technology requirements for curricular integration etc. These axes were formalized by the research team, in each evaluation site, to consider the curricular details of each institution [7].

II. Results

A. Demographic Data

There were 136 participants in total- 52% (71) males and 48% (65) females. Average age was 21.6 (SD = 4.32, Mode = 20, Mdn = 21). Therefore, participants were Generation Z, described as ‘digital natives’[30]. There were 60 participants who assessed the Aristotle University Thessaloniki VRReR, 38 for CYENS and 38 for The University of Nottingham.

System Usability Scale (SUS) Scores

The SUS score for all data was 68.2, with AUTH receiving a score of 62.5, CYENS a score of 72.3, and UoN a score of 71.6. The collective score is within, and above the median of, 68 – which above the range of average usability. This is a good indicator as the resources were early demos and had reduced beta alpha testing due to time constraints- future updates can improve this metric. There were no significant differences in usability when split by Sex. See Table 1 for descriptive data.

Slater-Usoh-Steed Presence Questionnaire (SUS-PQ)

The 6 SUS-PQ questions showed a moderate to high feeling of presence (mean=4.5, mode=5) when 0–1 is low, 2–3 low/moderate, 4–5 moderate/high, and 6–7 high. This suggested the mobile VR environments facilitated an immersive environment for learners, which is great from the low-fidelity and cost of the equipment. See Figure 4.

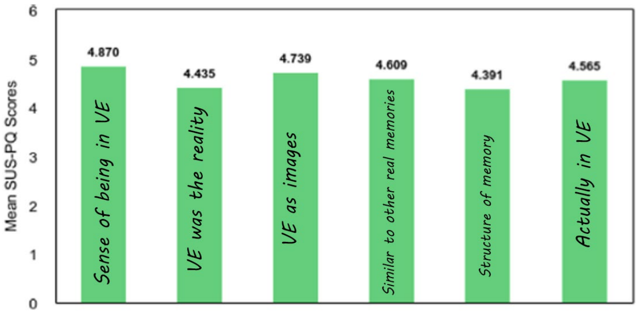

Figure 5: SUS-PQ showing high presence ratings

Technology Acceptance Model

The TAM had 3 sections (Ease of Use, Perceived Usefulness, and Intention of Use). All had positive mean ratings from approximately 90% of participants, therefore approximately less than 10% neutral or disagreeing for each question. Mann Whitney-U tests showed that Ease of Use questions were not significant except perception of low mental effort from before use (m=66) compared to after VRReR use (m=50, P=0.02). This meant the VRReRs were simpler than participants may be used to and/or anticipated-, giving scope to add more information in future updates.

Intention of Use: For users' intentions and predictions of use within their course, the result of the Mann Whitney -U test was not significant (intentions p=.84, predictions p=.93) in their intentions of using the VRReRs, however the direction positively increased which meant learners may

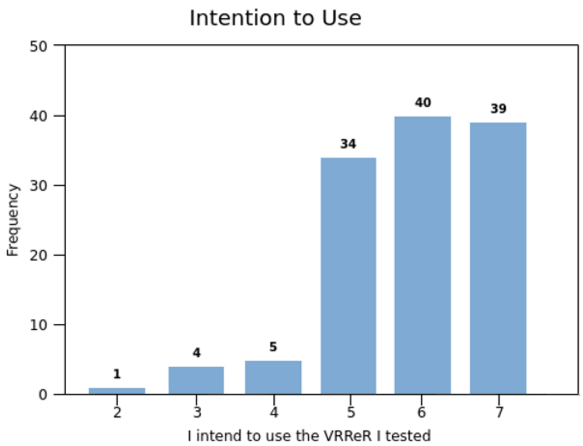

Figure 6: UTAUT2 Intention to use. 7 = strongly agree

intend to use these VRReRs a little more than they expected. Perceived Usefulness: There were no significant findings for the Perceived usefulness of the VRReRs use. This is a positive result. Learners' expectations of the VRReRs were high as they desire useful resources, and fortuitously the post-measures are in range to the pre-measure perceptions therefore showing no great contradiction.

Unified Theory of Acceptance and Use of Technology

There were no significant findings for changes in perceived ease of use from before to after VRReR usage. Again, this suggested they felt the VRReRs fell with the range of what the participants are used to. This is concurred with the 5 Mean Perception of External Control questions as they showed increase ratings after using the VRReR, although again they were not significantly different. For example, 63% of participants stated they perceived they had understanding when using new educational apps, but after VRReR usage 78% stated they had understanding how to use the app.

This links with their abilities as technological users. Before using the VRReRs, participants' anxiety toward computers was measured. After VRReR usage their intention to use was measured. There was a negative Pearson's correlation with these two measures (r-.26, CI=[-.41, -.08] p=.004) indicating a small effect size. The end users were important as this correlation and effect size may strengthen with age or other demographics suggested by research therefore the intended target audience. Overall, participants felt confident in using the VRReR they evaluated (mean=7.7/10, mode=8) and this has been shown a large driver for future reuse [31].

B. Focus-Group-Discussion (FGD)

To supplement these quantitative results and further probe the strengths and limitations found in the data for each VRReR, focus group discussion data were analyzed using thematic analysis.

The majority of comments were regarding technical elements of the resources, and mostly limitations experienced. Within these, the theme of navigation was most common as users experienced a mismatch between what they expected to be navigated to compared to what occurred. For the effective communication VRReR one learner stated, "*it was difficult to go back and choose another example, so I had to refresh*"(p25). Mention and preference of the VR feature was positive when mentioned, for example "*Using the app on touch screen mode was more or less like watching a video"(p37), and "The app functions well in VR mode"(p38).*

There were few mentions of the adaptations for use, however the main issue noted was "*It took me a while to get used to and understand how the 'mouse' worked to navigate and select things"*(p2)- this referred to the visual tracking and selection via a gaze UI dot located at the center of the user's vision. Therefore, referring back to the TAM and SUS there were a portion of participants who gave either neutral or low positive scores. The weaknesses identified in the FGD can lower these occurrences.

III. Discussion

A. Principal Results

The aim of the study was to evaluate the VRReRs based on the users' usability and acceptance with sub- exploration into performance expectancy, facilitating conditions, usage behaviour such as intentions of use, and confidence towards acceptance.

The fact that there is no "one size fits all" evaluation methodology when confronting the 'VR powered educational episode' evaluation as a whole and not as a single novelty is a core issue that emerged during this study. Standardized tools and questionnaires can be used to assess the technology. Also, one can use topical tailored quizzes to assess knowledge retention. However, there is no "one-size-fits-all" tool for assessing the efficacy of a VR-enabled teaching session. This does not rule out the possibility of developing a comprehensive methodology for evaluating immersive instructional episodes. That is the approach that was followed for this evaluation endeavor for the CoViRR project.

Multifaceted measures were used to provide a holistic matrix of the underpinning characteristics which have been shown to be key factors in uptake ,efficacy, and distribution. The results can be summarized to state that all resources hold moderate-to-good Usability, Ease of use, and independence towards self-learning were highly rated; Feedback for improvements on usability were clear, simple to address, and few. Use of resources reduced users' anxieties towards such each VRReR.

Indeed, motivation to use the resources increased after usage and single-session experience results provided ground for stronger effects over several uses. Participants' anxiety toward computers and intention to use the VRReRs showed a negative Pearson's correlation. This was a weak effect size, but it is noteworthy that this may cause issue with end-users who have less use of technology in their educational catalogue. The resources were therefore more suited to the representation of student use in this study from this perspective, such as being 'digitally savvy' participants.

Although we cannot be accurate in predicting the magnitude and speed of distribution, we can state that if participants stated they intended to reuse then they may refer friends to the resource during their course period. Embedding into healthcare curricula is expected to act as further evidence-based proof that such educational advancements can enhance resource access. It was expected they can be used by tutors as evidence for convincing higher education institutions to accept a new pedagogy utilized by VRReRs. It was also expected to contribute to the goal to digitalize the higher education curricula to enhance learners' knowledge on clinical skills and beyond .

It seemed apparent that critical technical features were required in the next cycle of App updates to solve the issues found in the learners' discussions. In addition, we aim to increase usability and efficacy by tweaking of interface as identified by learners as some areas were counter intuitive.

These findings can also help us to modify the ASPIRE process for immersive reality development to perhaps include more control by the learners in the stakeholder workshops on the UI and menus etc. - to a reasonable extent that the goal of the VRReR are still primary focus and simplicity is still maintained.

B. Conclusions

A co-creation approach was followed to create the Virtual Reality Reusable e-Resources. Experts on clinical skills, learners, academics, and healthcare professionals collaborated in participatory workshops to envision and co-create 2 multi-scenario and reusable VRReRs. Both the creation process and the outcome were considered innovative. VR resource development currently is expensive and performed by specialist companies without taking into consideration the learners. Furthermore, learners do not have easily access (e.g., by their mobile phone and cost-effective headsets) to immersive learning experience.

Technology has aided learning since its conception, and VR, in particular, has been seen as a constructivist instrument of instruction. It should come as no surprise, then, that a qualitative-mixed methods approach, the primary choice for evaluating constructivist pedagogical undertakings [32],[33], has been effectively used to provide the holistic framework for its educational evaluation in the CoViRR project. This multifaceted mixed-methods approach demonstrated that there is an audience of learners ready to accept VR reusable e-resources as tools for augmenting their learning capacity towards clinical skills training. Sound usability choices, technical ease of use and adherence to good participatory design choices can make these resources integral supporting parts of contemporary healthcare curricula.

The resources were shared under Creative Commons 2.0 Attribution-Non-Commercial 2.0 UK license allowing to share and adapt the resources as long as appropriate credit is given an indication of changes is evident, and the resources are not used for commercial purposes.

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