# A Portable Multi-User Cross-Platform Virtual Reality Platform for School Teaching

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***Abstract*—This paper discusses and evaluates a self-contained portable multi-user cross-platform Virtual Reality (VR) setup that was devised and configured using off the shelf technologies and devices. This paper exemplifies how some fundamental challenges like those faced in Malawi in relation to technology use, can be addressed, to allow for the use of VR technology as a potential solution to improving the quality of secondary school education in situations where the challenges in question are faced. This paper explains how the proposed VR setup was evaluated, in which the results of that evaluation indicate that the proposed portable multi-user cross-platform VR setup is a potentially viable VR setup that can potentially be used for secondary school teaching. This is a follow-up to a previous work that explained a VR software application that was implemented to showcase the capabilities and functionality of this "Synchronous Multi-User Cross-Platform Virtual Reality for School Teachers". Whilst the challenges addressed are those that are faced in Malawi, the platform has more general applicability to a range of teaching contexts.**

***Keywords—virtual reality, education, technology, Malawi***

## I. INTRODUCTION

Virtual Reality is seen to eventually become an important part of education (Kumar et al., 2021). However, at present VR is not widely prevalent in education [CITATION NEEDED] but VR is gradually gaining traction in education (McGovern et al., 2020). VR is perceived to be beneficial to education. For instance, according to Kumar et al. (2021), when applied to practical based subjects in education, VR has potential benefits such as allowing for repeated learning for students (Kumar et al., 2021). In this regard, Kwon (2019) suggests that VR allows for students to engage in experiences that would otherwise not be possible for them.

The work presented in this paper is a follow-up to our previous work in which the implementation of a VR software application which was developed to showcase the functionality and capabilities of a multi-user cross-platform VR setup, was discussed (Kambili-Mzembe and Gordon, 2022). The previous work in question highlighted a cross-platform VR setup which consisted of a Head Mounted Display (HMD) VR device and desktop VR devices (Kambili-Mzembe and Gordon, 2022). In this regard, this paper discusses the configuration and evaluation of the VR setup that was highlighted in our previous work. The Malawi Government (2018) has indicated that there is a need for "improved quality of secondary school education" (Malawi Government, 2018, p. 39) in Malawi. Therefore, as discussed in our previous work, taking into account the perceived benefits of VR, VR was proposed as a potential solution to improving the quality of secondary school education in Malawi (Kambili-Mzembe and Gordon, 2022). However, as highlighted in our previous work, information regarding the use of VR technology within education in Malawi, could not found (Kambili-Mzembe and Gordon, 2022). Therefore, the VR setup discussed in this paper was devised to showcase how the technologies highlighted in our previous work can be configured into a VR platform that can potentially be used by VR application developers, researchers and possibly educators in Malawi, in the process of assessing the feasibility and benefits of applying VR for secondary school teaching in Malawi.

## II. RELATED WORK

A multi-user VR application developed for the purpose of aiding surgeons in collaboratively planning for surgeries, is presented by Chheang et al. (2021). According to Chheang et al. (2021), their application was developed using Unity game engine and it utilise the HTC Vive HMD VR device (Chheang et al., 2021). Furthermore, multi-user functionality is enabled via a network (Chheang et al., 2021), in which both "asynchronous and synchronous" (Chheang et al., 2021) functionality between users is supported. According Chheang et al. (2021), experts who evaluated their VR application considered the application helpful for training purposes. Marks and White (2020) discuss a multi-user mixed reality system that utilises both VR and Augmented Reality (AR) (Marks and White, 2020). According to Marks and White (2020), this system utilises an HMD VR device and a tablet, enabling a user on each device to collaborate within the same virtual environment (Marks and White, 2020). In this regard, the user on the HMD VR device is responsible for navigation within the virtual environment, while the user on the tablet, which serves as the AR device, is responsible user interface functionality (Marks and White, 2020). Furthermore, Marks and White (2020) state that their mixed reality application utilises a network for multi-user functionality. In addition Marks and White (2020) state their application has been used within an education setting, and that feedback from learners suggested that the learners considered the system beneficial (Marks and White, 2020).

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## III. CONSIDERATIONS

The choice of technologies and devices comprised in the proposed VR setup considered some the technology usage related challenges faced in Malawi, as well as the fact that the proposed VR setup is intended for a classroom setting.

### *A. Technology Usage Related Challenges Faced in Malawi*

As discussed in our previous work (Kambili-Mzembe and Gordon, 2022), Malawi is a very underdeveloped country (Malawi Government, 2018), which is echoed by the National Planning Commission in Malawi (2021), which states that "poverty" (2021, p. 7) is the biggest challenge faced in Malawi, where according to the Malawi Government (2018), "the majority" (2018, p. 66) of the population in Malawi resides in poverty stricken areas. Furthermore, the National Planning Commission (2021) states that one of the challenges faced is costly Information Communication Technology (ICT) services, which according to the National Planning Commission (2021), negatively affects "technology adoption" (2021, p. 40) in Malawi. This is echoed by Hettinger et al. (2021) who indicate that the cost of services such as the internet is a challenge in Malawi. In addition, adequate availability of and access to electricity is also a challenge for many in Malawi (Malawi Government, 2018; Pankomera and Van Greunen, 2016), including schools where for instance "18%" (Malawi Ministry of Education, 2022, p. 171) of secondary schools in Malawi have no access to electricity.

### *B. The Education Context*

Hmelo-Silver (2004) suggest that collaboration is an important component of education, and in this regard, Cooper et al. (2019) who state that the "collaborative potential" (2019, p. 8) of VR should be accounted for when considering VR for educational purposes. Furthermore, Garcia-Bonete et al (2019) state that if educational VR applications can only be utilized on a "specific device" (2019, p. 18), this can result limiting the number of people that can use then applications, thereby potentially introducing accessibility and inclusion challenges, where in this regard accessibility would refer to how the VR applications in question, are "accessible by as many people as possible" (Sharp et al., 2019, p. 17), and inclusion would refer to how accommodating the VR applications in question are to "the widest possible number of people" (Sharp et al., 2019, p. 17).

## IV. THE PROPOSED VR SETUP

The technologies and devices utilised to configure the proposed VR setup consider for the context of Malawi as well as the educational context in which these technologies are being proposed for. Therefore, as shown in Figure 1, to account for accessibility and inclusion, the proposed VR setup was devised as a cross-platform setup consisting of an Oculus Quest VR device, which is an HMD VR platform, as well as a Windows tablet, and an Android tablet, both of which are utilised as desktop VR platforms. In this regard, Garcia-Bonete et al. (2019) suggest that "cross-platform technologies" (2019, p. 18) should be preferred to ensure accessibility of VR content used for educational purposes. As detailed in Table 1, each of the devices utilises different input and output functionalities. In this regard, Sharp et al. (2019) state that allowing for different ways of interaction for users enables those that might otherwise difficulties with a specific way interacting with the product, an alternative means of interaction. Therefore, by providing support for different VR platforms with different methods of input and out, the proposed VR setup not only accounts for accessibility, but also considers inclusion. Furthermore, to account for cost related issues, the proposed VR setup was devised to flexible in that if specific type of VR devices were not available (for instance HMDs), then it can still be utilised with the devices that are available.

To account for synchronous multi-user functionality, which enables collaborative VR experiences, the proposed VR setup utilised Wireless Local Area Network (WLAN) technology. According to Yadav et al. (2018), WLAN technology is appropriate in situations where network infrastructure is a challenge. In addition, WLAN technology is thought to be simple to use and cost effective (Yadav et al., 2018). Therefore, as detailed in Table 1, the proposed VR setup utilises a WiFi capable off the shelf network router for multi-user functionality, of which WiFi is WLAN based "network communication" (Zhang et al., 2019, p. 394) technology. In this regard, an existing network infrastructure, or the internet, is not required. Therefore, all network communication between the VR devices is facilitated by the router, on which a local network is configured and utilised.

To account for electricity access challenges, all the devices utilised in the proposed VR setup do not rely on a persistent supply of electricity for power. Therefore, the VR devices that were utilised are all battery powered mobile devices. Furthermore, as shown in Figure 2, for power, the WiFi router uses an off the shelf portable rechargeable power bank, which is a device that is usually utilised as a portable charger for mobile devices like a phone (Zheng et al., 2021). Utilising battery powered devices ensures that even areas with no access to electricity can utilise the VR proposed VR setup.

## V. EVALUATION OF THE VR SETUP

Evaluation can be carried out for the purpose of determining the suitability of a given design of a product (Sharp et al., 2019). In this regard, the proposed VR setup was evaluated using heuristic evaluation, which is an established and commonly employed evaluation method [CITATIONS NEEDED].

### *A. Heuristic Evaluation*

Heuristic evaluation belongs to a category of evaluation methods referred to as "inspection methods" (Sharp et al., 2019, p. 505), of inspection methods can be employed to identify "usability problems" (Sharp et al., 2019, p. 505) without the involvement of intended users (Sharp et al., 2019). In this regard, heuristic evaluation involves experts carrying out an evaluation by utilising a set of guidelines known as "heuristics" (Sharp et al., 2019, p. 550). Between three and five evaluators is regarded as appropriate for heuristic evaluation (Sharp et al., 2019), and between five and items in regard to heuristics, is considered adequate for heuristic evaluation (Sharp et al., 2019).

Although there is an established set of heuristics referred to as "Neilsen's heuristics" (Quiñones and Rusu, 2017, p. 90), Neilsen's heuristics are not always adequate for the evaluation of domain specific aspects (Quiñones and Rusu, 2017) due to

the notion domain specific factors could be overlooked (Quiñones et al., 2018). Therefore, a number of heuristics have been developed to cater to specific domains (Quiñones et al., 2018; Quiñones and Rusu, 2017), some of which were developed by adapting Neilsen's heuristic (Quiñones and Rusu, 2017). In this regard, this study adopted without modification, usability heuristics proposed by

## VI. DISCUSSION AND CONCLUSION

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