Virtual Reality for Many Kinds of Learning

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Abstract
In this paper, we present the main takeaways from our experiences co-designing low-cost Virtual Reality-augmented learning experiences with and for an after-school learning center in Mumbai, India that caters to low-income children from neighboring communities. We draw on our data to highlight the agency of our participants, the adaptability of the content used, and the feasibility of the VR platform. We found that VR's unique representational fidelity appeared to arouse students' curiosity, leading them to ask more questions that reflected deeper engagement with the topic. In this paper, we propose to explore VR content creation in diverse HCIxB domains, looking across geographic and disciplinary borders.

Author Keywords
Virtual Reality; Learning; HCI4D, India

ACM Classification Keywords
H.5.m [Information interfaces and presentation (e.g., HCI)]: Miscellaneous

Introduction
Highly immersive virtual environments accessed using specialized Virtual Reality (VR) hardware like Head Mounted Displays have shown improved learning outcomes [4, 5, 6], increased confidence [8, 9], and positive behavior change

[1]. Most prior research has taken place in experimental conditions and controlled laboratory settings that generally involve expensive VR equipment and room facilities. At the same time, the consumer market is being increasingly flooded by affordable VR technologies such as low-cost cardboard viewers [2].

These developments mean that VR can potentially be used in everyday educational settings, both formal and informal, such as the classroom. Given the reality of limited budgets for public education in U.S. as well as the Global South, for instance, VR could be used to take students on virtual tours around the world of educational significance without leaving the classroom. This could be even more impactful for students from low-income households who already have limited educational opportunities. In order to realize this opportunity, however, more contextual research is necessary in order to understand the users' contexts – especially what happens once VR is introduced into these low-resource contexts – as a first step in replicating the above outcomes.

Our research proposes to examine the feasibility of integrating low-cost VR technologies for supporting learning in low-resource settings, using a field study we conducted at Pragati [1], an NGO-operated after-school center in Powai, Mumbai (India) in June-July 2016. In this proposal, we first provide details on our fieldwork so far and then discuss the key takeaways of our study. Highlighting the potential of VR-based learning from a student and teacher perspective, we offer implications for integration of VR into learning environments. The results of this study have been published in [7]. In this paper, we outline ways in which this work can be taken forward.

[1] Names have all been anonymized.

Fieldwork So Far

We conducted our field research at Pragati, which is inhabited by migrants from all over India. The center was founded 10 years ago by a doctor whose clinic was in the community, with the goal of providing free basic education to children from disadvantaged backgrounds. Classes take place in the morning (and afternoon) to cater to students attending public schools in the afternoon (and morning). These schools follow the state curriculum. Students receive lessons on topics covered in school, supplementary topics not in the state curriculum, and basic computer literacy.

At the time of our study, the center had 7 administrative staff, 12 teachers, 5 volunteers and 125 students (grades 4 to 12). Teachers were full-time employees who taught and managed entire classes. They were paid hourly based on their qualifications (high school diploma to a Bachelor of Education) and teaching experience (1 to 10 years). Volunteers were students from a nearby college who helped by providing one-to-one tutoring to students needing academic support. The center's facilities included 4 classrooms, one lab with 5 desktop computers and 1 printer, a Wi-Fi network, and 5 tablets. Two classrooms each contained a wall-mounted television and a desktop whose screen is projected onto the TV.

Study participants were a teacher called Meera (pseudonym), as well as all 6th-graders (8 girls and 1 boy) and 7th-graders (5 girls and 2 boys). Meera was responsible for teaching 6th- and 7th-graders General Knowledge, Geography, History and Science. She has a high school diploma and has been a teacher for 5 years. We worked with her upon the founder's recommendation, who commended Meera for her commitment to innovating on her teaching approaches. All fieldwork was conducted by the first author, a native speaker of Hindi, which was the medium of instruction at the center. The data was examined by all authors and analyzed inductively to iterate on key themes. Fieldwork took place as follows:

Phase 1: Formative work over 2 weeks in December 2015 and 2 weeks in June 2016. The goals were to gain a deep, situated understanding of the center's learning activities, as well as establish the level of trust and rapport with stakeholders such that they see value in committing an adequate amount of time to co-designing and piloting VR-augmented lessons with us.

Phase 2: Co-designing the VR-augmented lessons lasted 1 week in June 2016, during which we worked intensively with Meera to co-design lessons that incorporated VR. The VR technology that we chose was Google Expeditions [3]. At the time of our study, it was the most inexpensive off-the-shelf option, worked under low bandwidth, and had a comprehensive suite of educational content (250 VR tours of landforms, natural ecosystems, landmarks, museums and cities, with more being developed). Expeditions runs on tablets and smartphones over a Wi-Fi access point that does not need connection to the Internet.

Phase 3: Piloting the VR-augmented lessons with Meera over 2 weeks in July 2016 in 15 class sessions (6 with 6th-graders only, 6 with 7th-graders, and 3 with both). After every lesson, we iterated with Meera on her VR plans for subsequent classes. The Expeditions virtual tours were accessed using a Nexus 9 tablet (teacher), 12 Cardboard viewers (students), and 12 Nexus 4 smartphones (students). The phones were salvaged from recycling centers across Mumbai.

Discussion

We now identify the takeaways from our work for researchers and practitioners keen to deploy VR tools for learning. While

Figure 1: Students using the Cardboard viewers in class.

assessing learning outcomes would require a longer study, our research offers support for the 'appropriability' of VR in contexts such as those we examine. Given the enthusiastic response of both teachers and learners, we contend that it would be worthwhile to further investigate the potential of VR for learning in low-resource settings.

While significant effort was required initially to integrate VR, this process became easier over time. Students and teachers possessed a strong desire (possibly due to popular hype) to use VR. However, the appropriation of the toolkit needed external support. This support came from staff members and students who ensured the cleanliness and safety of the Cardboard kit, battery power in the phones, as well as storage and distribution of the devices to the students at the start of class. A single class teacher could not simultaneously distribute 15 viewers and phones to each student, open the desired field trip, and ensure synchronization of all devices over the local network. Two staff members were required to remain in the classroom to help students with connectivity, battery, and miscellaneous issues regarding their viewers and/or phones. Their presence and support ensured that the class progressed without too many logistical kinks. Moreover, Meera had to develop familiarity with the Expeditions user interface, and this took her two days. Mobile phones, in comparison, have an easier learning curve because of greater exposure and wider applicability. We also note that the core of the VR kit is still a mobile phone platform - this feature facilitated versatility in terms of the use-cases for the system. The smartphones could also be used for regular 2D display when not used for VR.

The original Google content had a high degree of adaptability to the Science and Social Science topics and was easily navigable. Meera developed workarounds to integrate the content found the experience of using this new content to be very informative to her students and herself. While some workarounds might be acceptable, too much divergence could be problematic. Furthermore, adaptability was facilitated further since the Cardboard viewer and the Expeditions application supported a wide variety of smart phones available in the Indian consumer market. Local brands and manufactured phones could also host Expeditions and the Cardboard supported most screen sizes and resolutions. This played a major role in driving adoption of the toolkit and integrating content.

With regards to the feasibility of VR in this environment, we found that creation of content is a challenge. Unlike content creation for mobile/tablet environments, VR content creation requires more than a simple phone camera. All students and teachers did not own a phone capable of recording VR content and the teacher also struggled with locating relevant content online. Moreover, VR content was suited to only specific subjects in this school - namely, Science and Social Science. Teachers and staff members found it difficult to locate and adapt VR content for Math, English, and the local Indian languages. Mobile platforms can support a wider range of content and even allow for easy content generation and sharing.

Besides content, we note that the Expeditions VR system was easily replicated in this context. While content creation and sharing was hard due to limited hardware constraints, the VR system in itself could easily expand from one classroom to many classrooms in the same school. With adequate initial support and minor sustained manpower support, the VR system was adopted very fast by other classrooms and also by other members of the community outside Pragati. Through our findings described in [7], we articulate the VR infrastructures needed to deploy and evaluate a VR system in disparate contexts, i.e. settings similar to our field site. We describe that there are challenges and benefits of integrating VR into a classroom in a low-resource context, and we discuss the challenges and infrastructure requirements to integrate VR systems into school settings. These recommendations may be helpful beyond the VR case to other technologies as well.

Proposed Research

In the last month, we have signed up 6 partner organizations - five in Georgia and one in India - and are communicating with other partners. We plan to identify not more than 10 partners so we can foster a deeper relationship with them. Our primary goal for the next year is to complete one full iteration of the design cycle with our initial phase of partners and launch the first batch of VR content on the online platform. All this field work will inform future iterations of the content development cycle.

So far, we have only evaluated the impact of VR in a classroom environment. Highly immersive virtual environments accessed using specialized Virtual Reality (VR) hardware like Head Mounted Displays have shown improved learning outcomes [4, 5, 6], increased confidence [8, 9], and positive behavior change [1]. This, coupled with the recent flooding of the consumer market with affordable VR technologies such as low-cost viewers [2], motivates us to explore content development opportunities in diverse HCI4D domains across different contexts around the world. Broadly speaking, we see VR functioning as a platform for hosting new (and possibly user-generated) content relevant to the problem, and this VR platform will function as a more feasible alternative to traditional two-dimensional displays and videos.

Within the education domain, we are conducting VR field deployments in three schools in Atlanta, USA and we would like to compare and contrast the integration process in these schools with each other, and also with our integration experience in Mumbai. We are seeking cross-border collaboration for deploying VR learning platforms in diverse socioeconomic communities. We are also hoping to explore cross-domain collaboration within the HCI4D community – and take VR content creation to new environments such as healthcare centers and maternity wards. Collaborating with ICTD experts in diverse fields will allow us to explore VR content creation for tackling issues like crisis response, women's safety, gender and caste barriers, and other socioeconomic challenges.

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