Encompassing English Language Learners in Virtual Reality

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***Abstract*—Virtual reality (VR) has the potential to drastically alter the future landscape of education. Immersion can be a powerful educational tool, yet it can create isolation issues if user needs are not thoroughly considered. For this reason, designers, educators, and researchers will need to address accessibility issues for the technology to be adopted into mainstream classroom use. English language learners (ELLs) are a relevant user group to study in this regard, as they are largely underserved within the educational technology space, and their usage of these immersive VR tools can highlight both positive and negative aspects of the experience that developers can use to improve their applications.**

***Index Terms*—Virtual Reality, Educational Technology, English Language Learners, Computer Aided Instruction**

Introduction

As each generation becomes more accustomed to rich multimedia experiences, there is an increasing need to develop effective educational content for student engagement and comprehension. Educational practices need to keep pace and supplement live instruction and textbook education with technological alternatives. Interactive multimedia environments will be essential to engage learners and are the only medium to date that can effectively relay the vast amounts of information needed to function in our future societies. Virtual reality (VR) shows remarkable promise for education [2], collaboration [3], and simulation applications. VR has the potential for strong content immersion [1], allowing the user to interact directly with a simulation and focus on the information presented to them, enabling a new educational medium that will change how ideas are expressed by educators and acquired by students. Although the number of educational VR applications are increasing, few are grounded in educational research.

To address this gap, we conducted a study in a public high school, grades 9-12, comparing the effectiveness of three modes of supplemental instruction: 1) a VR learning environment, 2) an instructional video game, and 3) traditional textbook and lecture. The sponsoring school board wished to evaluate VR as a new technology for use in the classroom and was primarily concerned with the fair and accessible use of it for all students. We were tasked with assessing the educational efficacy and accessibility of these technologies for the students and teachers. We were aware of physiological, psychological, sociological, pedagogical, and physical parameters as accessibility factors, but we soon became aware that linguistic and cultural factors are also of high accessibility concern. We found that public school classes will often contain English language learners (ELLs) of varying levels of cultural integration, linguistic integration, and institutional support. This forms the backdrop of the case presented in this paper—VR Human-Computer Interaction (HCI) considerations for ELL students—as it allowed us to recognize and observe a previously under-served user entity for educational VR applications.

As VR begins establishing itself as an educational tool for K-12 education, a variety of educational VR applications are becoming more widespread in their usage. Yet little to no literature explores how ELLs cope with the use of VR when the application targets an educational topic other than foreign language acquisition. This becomes an even more pressing question when the impact of VR on the learning environment is examined and issues of immersion and isolation are factored in. The ELL problem domain is well explored within the education research community, but not to the same extent within the educational technology research community and not at all within the VR HCI research community.

We believe that this is an important user group to consider when designing educational VR applications for a variety of reasons; many of these students will need additional support to succeed academically and VR may be a large part of that solution. Any educational VR application will need to account for ELL users whether or not they are the primary audience to ensure fair access for all users, and potential solutions created for this group may also be beneficial to a wider audience of users. This paper seeks to offer observational insights from our study verified with examinations from the separated research bodies of ELL education and VR HCI for future educational VR HCI research, specifically in regards to ELL education, sheltered instruction, interrupted education, and refugee students. While we plan to formally test our suggestions in future work, the ideas presented here are based on the latest research in both VR and HCI.

Related Works

ELLs are a diverse population that face a variety of issues [5] [10], beyond linguistic and cultural integration. Interrupted formal education [16], lack of literacy skills in native language [14], and active or recent refugee status [17], all put these students behind their peers in academic readiness and achievement. Educational researchers currently agree that effective teaching for second language acquisition should be based on language development instruction combined with opportunities for second language usage [10] [15]. Due to their diverse

situational needs, the exact balance between direct instruction and learning through application is unknown [10].

Since there is no single best method to teach ELLs, there are a variety of different programs implemented in the United States (US) that a VR HCI professional will need to be aware of [5]. Newcomer programs provide intense instruction for 1-3 semesters, familiarizing students with the cultural and educational routines of the country, region, and local community [5]. After this, schools typically place these students in a longer-term ELD program for the remainder of their public education. Developmental Bilingual Education (DBE) programs instruct students in both English and their native language, aiming to integrate students while preserving their culture and language [5]. Transitional Bilingual Education (TBE) programs focus on teaching curriculum in the native language alongside English development, while reducing bilingual support as students develop proficiency in English. TBE is commonly integrated with a Sheltered Instruction (SI) approach where students learn core curriculum subjects via English medium instruction that has been adjusted for their language needs [5] [14]. This latter approach is what we observed during this study.

Educational researchers have studied the use of technology for ELL education from a variety of viewpoints. A 2014 study found that the use of mobile technology by ELLs transitioning from a bilingual to SI approach provided numerous benefits, including helping students: learn content and language, receive individual instructional support, and increase engagement [8]. Similarly another group of researchers investigated interactive white boards as a implementation of a digital learning classroom which demonstrated the ability to raise ELL student achievement to performance parity with the rest of the class [11]. Other researchers have explored the use of virtual worlds such as "Second Life" as immersive tools for second language acquisition in adult ELLs [18]. Another relevant study investigated the effects of avatar embodiment, collaboration, and accordances of a virtual world in a 3D desktop game [7]. The study found virtual environments using minimal amounts of language were better rated by ELL users with diverse language backgrounds. This study validates use of virtual spaces for ELL education, but is limited in its understanding of how that knowledge transitions to VR applications for ELL education.

Perhaps the study most similar to this paper's study is the work of Barbara Freeman, which examined the impact of a digital multimedia math application, HELP Math, on secondary ELL students mathematical capabilities by using an interactive visualization to make associations between words and their meanings [13]. Freeman concluded that "digital student directed learning environments, content, and tools must be purposefully designed and sensitive to diversity, in order to effectively redress academic inequalities and improve ELLs learning outcomes" [13]. Her study highlights the importance of designing educational technologies with an explicit connection between the technology (HELP Math), content (math), educational approach (SI), and context (secondary ELL). Our study extends this work by examining the technological influences of VR on ELL science education within/using the same context and educational approach.

METHOD

This paper describes observations from a VR educational efficacy study that we conducted in a series of public school chemistry classes. Here, we focus on the VR HCI considerations for ELL students; references to the larger study are only included when necessary to describe this case.

Experimental Design

The study took 18 weeks to complete and had three subject groups consisting of 24-27 students per educational medium (traditional textbook, 2D educational game, and VR educational application). Experimental usage of supplemental learning materials occurred twice a week in 20 minute self-contained sessions at the end of the class period. For the textbook, we used a standardized, nationally recognized textbook that was already used in the classroom. For the 2D educational game, we used *Collisions* by Playmada Games. For the educational VR application, we used *MEL Chemistry VR* by MEL Science. The existing teacher designed the use of each of the educational mediums as self-contained modules of chemistry curriculum relating to the current class topic, and these were meant to be used as supplemental learning tools alongside instructor-led lessons. This was meant to provide fair and equal evaluation of all three educational mediums to how their respective educational capabilities were designed. Student participants completed pre and post assessments as voluntary, non-graded classroom assignments.

Environment

The study took place at Dwyer Technical Academy, an urban technology magnet school in Elizabeth, NJ, USA. The school system has seven high schools with 5,500 students. The student population is a diverse mixture of ethnic backgrounds in a lower income urban district with a high percentage of immigrants and ELLs. Dwyer has a total 1,208 students, with approximately 300 students per each of the four grade levels. 70% of the school's student population is Hispanic, with 61.8% stating Spanish as the primary language spoken at home, and 34% ELL students. The study operated in four, third-year high school chemistry classes with alternating meeting days, two in the morning and two in the afternoon.

Participants

The participants represented the overall school population in regards to ethnicity, language, and ELL needs. ELLs were in SI approach of mixed native and ELL classroom, instructed in English. To minimize selection bias, we randomly assigned subjects one of three groups in each of the four chemistry classes. There was only one teacher who taught all the courses to remove confounding variables. Students who opted out or left the study had their class time as normally conducted by their teacher. We designed the study with the teacher to match the educational content of all groups as much as possible. Each medium was expressed in English, and ELL participants had access to their in-class support during the study.

RESULTS

Dwyer Technical Academy approaches ELL education primarily by implementing the TBE program of native language alongside language development classes and classes in an integrated setting. The full bilingual support is limited to those students that represent a population large enough (at least 20) to justify assigning a bilingual instructor to that group. Students that are not given full bilingual instruction are provided with language development classes, as well as content classes via sheltered instruction. Additional in-class support is provided if qualified instructors are available. Instructors also search for learning materials in student's native language and translate them when possible. As in any TBE program, this type of support is gradually withdrawn as students gain English proficiency. Each of the four classes had an population of advanced ELL students without in-class support. Three of the four classes had a beginner ELL student population that did have ELL in-class support, the groups consisted of: five Arabic, four Haitian Creole and six Hispanic students.

Cultural and Social Support

Students are clustered into groups based on their language and grade level when possible. Grouping allows for students to form support structures and makes it practical for instructors to assist them. There does exist ELL populations too small to be clustered and dealt with effectively. In these cases, instructors spend additional time on smaller groups and individual students, often providing support in a language they are not proficient in. Lack of appropriate materials in native languages requires additional time to prepare necessary learning aids. These observations highlights the broader issues of ELL exceeding available resources.

The teachers are trained in working with culturally diverse students, but formal social support is limited and no explicit cultural integration. Instructors are conscious of the need to involve parents, and community in education, and attempt to facilitate that involvement when possible. One approach to providing social support is to place students and teachers into groups know an "families." Issues affecting students are openly discussed at a weekly meeting where teachers collaborate to seek solutions that can be extended to all students.

ELL Participation in VR

Despite the potential limitations of ELLs, we did not observe a decrease in class participation. ELLs demonstrated to be just as engaged in VR as native students, and did not drop out of the study at a different rate from native students. Another significant observation was the general understanding of interactive media by the ELLs. Concepts such as graphical user interfaces, environment interactions, and multi-sensory VR experiences were not an issue to subjects of diverse cultural backgrounds and language proficiencies.

The primary struggle for ELLs was switching between VR and classroom environment. ELLs that were confused by the application were more hesitant to take the headset off and ask for help compared to their native speaking peers. The language barrier also had an effect on training and instruction about the technology. Prior to the actual VR experience, we observed students failing to understand what was expected of them and lacking the self-direction of the native speakers.

DISCUSSION

This school system's high percentage of ELL students provided a good context for a case study on educational VR accessibility factors. HCI professionals will need to address potential isolation issues before the technology can be adopted for mainstream classroom use. This is especially true for ELL users, who may be prone to social interaction and communication issues, and would benefit from technologies explicitly considering these factors in their design.

ELL Considerations in Educational VR

Considering ELL users in educational VR application design will increase its accessibility factors for the entire classroom, and VR has some potential use cases for ELL education. Since this paper is not seeking to solve the larger use cases we are going to look at the potential use cases for ELL education to spur larger conversations about ELL accessibility factors for educational VR application design.

There is a supplementary learning material need in ELL education and VR can be a viable solution. While we have limited evidence on the subject, by analyzing the issues of ELL and the educational frameworks behind them, we can identify specific instances where we think VR can be used effectively. The main benefit of VR is its flexibility and ability to solve multiple issues at ones. For example, limited support situations of isolated ELLs can be enhanced using visual aids to learn a concept, which currently requires: a qualified instructor (in shortage), a translated textbook (not easily available), and the visual aid (one off construction). VR offers a good alternative approach to merge these in an immersive environment as a coherent, accessible experience.

ELL and Educational Technologies

ELLs complicate the already sensitive problem of using technology in the classroom. Educational VR designers will have to address some of this issues before VR can be accepted as a mainstream educational tool. Based on our research in the field and within the literature, it is important to make the VR community aware of this for two reasons.

First, issues of ELL are too complex to be solved by a single method or approach, hence no solution can be expected to be applied to all ELL situations. Technologies attempting to solve this problem will have to carefully consider the many factors involved. Broad solutions attempting to solve problems of all students at the same time are unlikely to make any meaningful impact. Second, some of the intuitive solutions in VR can become counter productive if they are deployed incorrectly, even if these same solutions are verified to be effective in other cases. As an example: language-agnostic interfaces can be a great tool of both students and educators. When used as a supplement in instruction they allow for crossing language

barriers and creating an opportunity for learning. Those same tools can cause language avoidance in students when they are used to circumvent language rather than support language learning [19]. Same tool in different scenarios can be not just ineffective, but actively damaging.

Opportunities in Sheltered Instruction

The variety of ELD programs is a potential problem for developers of educational technologies. This is further complicated by the differences in implementation of such programs not just within different districts, but sometimes within a single school. Educational technology developers in this scenario have to choose between tailoring the application to a very specific environment, or risk developing a product that will not fit within the school's established curricula.

SI is a potential opportunity for educational technologies for three major reason. First, SI is a very common approach which fits well within other ELD programs. Within the educational technology niche for ELL support, SI is a broad area where technologies could be deployed beyond a single school or district. Second, applications which have been successfully deployed in one environment, have more potential for being transfered to other, comparable environments than in non-SI settings. Finally, in SI, the content itself is usually not adjusted beyond language accommodations. SI allows for mixed classroom environment, where ELL and native students learn side by side. Current and future products can accommodate ELL without requiring a separate application for native students.

Study Limitations

Our study did not analyze student perspectives. Without a detailed understanding of the student needs, developing a testable technology is difficult. It is important to recognize that the language barrier inherit to this domain complicates data collection through established methods such as interviews and focus groups. However, we identified a number of significant factors based on our observations. Extensive literature validates our findings but provides inconsistent or contradictory solutions (e.g., removing all language from the interface).

Future Work

We aim to build on this case study by researching and developing educational VR applications that consider ELL users throughout the design and implementation processes with the goals of advising future educational VR applications that: 1) provide a consistent accessible learning experience to all students, regardless of their first language, 2) while supporting ELL education, 3) offering teachers student analysis tools, 4) driven by customization of learning content, 5) and at an affordable cost for school districts.

CONCLUSION

This case study highlights the importance of including an often overlooked group of students that many schools must consider when deploying technology in the classroom. Each population of ELL users will be distinct, consisting of diverse cultures and different language needs. School resources (e.g., knowledgeable teachers of a particular language) are also an important limitation to consider. We believe that ELLs represent an important user group to consider in educational VR design. Whether they are a primary audience or not, ensuring equal access is a necessity as failure to do so may violate school guidelines, and may limit the usability and adoption of future educational VR applications.

ACKNOWLEDGMENT

We thank the Elizabeth School System and Oculus Education for their support of this research. Any opinions, findings, conclusions, or recommendations are those of the authors and may not reflect the views of these parties.

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