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A Virtual Bridge to Cultural Access: Culturally Relevant Virtual Reality and Its Impact on Science Students

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Abstract

This mixed-methods study examines the implications of using the tenets of culturally relevant pedagogy (CRP) to design an elementary science lesson grounded in four virtual reality (VR) videos. Given the need for additional understandings of how elementary science educators can infuse cultural relevance alongside content development, this study illuminates how designing for CRP can utilize VR as a pedagogical platform to bridge science instruction and students' lived experiences. Using pre- and post-attitudinal surveys (n=145) and post interviews (n=48), we examined students' perceptions of a single virtual reality lesson about energy and food chains. The data suggest that learning through a CRP-based VR design (CRP-VR) enhanced students' perception of the connection between the science content and its socio-political application to social justice issues. Implications highlight the potential of leveraging VR technology as a means to provide science instruction that explicitly affords students the opportunity to connect content learning and social action.

Introduction

A growing body of research has shown the benefits of teaching science by focusing on the science that exists in students' own experiences. In elementary science, culturally relevant science instruction has shown promise in its impact on students' learning and capacities to apply what they learned (Djonko-Moore, Leonard, Holifield, Bailey, & Almughyrah, 2018; González-Espada, Llerandi-Román, Fortis-Santiago, Guerrero-Medina, Ortiz-Vega, Feliú-Mójer, & Colón-Ramos, 2015; Upadhyay, Maruyama, & Albrecht, 2017). As scholars develop a deeper understanding of the relationship between student motivation cultural relevance (i.e., Kumar, Zusho, & Bondie, 2018), the role of culturally relevant design in educational technologies offers a new frontier for further research.

Currently, virtual reality (VR) is being explored as a potential means for improving students' interest in science (Jones, 2017). However, many of the available VR resources bring students to far away locations or provide virtual depictions of the past (Barbour & Reeves, 2009; Friena & Ott, 2015). While these applications are useful, they reinforce the idea that science is far removed from students' lives. We argue that, as no technology or multimedia environment is acultural (Lee, 2003), the virtual environments of these technologies will inherently send students messages about who they are in relation to science. Thus, building on scholarship that calls for a critical review of culturally-centered STEM learning environments (Lim & Barton, 2006), we take the stance that research into students' application of the messaging of virtual environments requires the same careful attention. As new educational technologies emerge, researchers must carefully consider how to incorporate these potential resources in a way that both improves teaching and learning and draws on the demonstrated affordances of cultural relevance. Thus, a critical question emerges: How might using VR alongside the pedagogical tenets of culturally relevant pedagogy (CRP) influence the ways these students learn and apply science concepts?

Background Literature

Early research on the impact of VR in education highlights its potential value in classrooms (Dickey, 2003) by providing indications that teaching using VR may enhance student learning (Merchant, Goetz, Cifuentes, Keeney-Kennicutt, & Davis, 2014). This research also raises the importance of improving teaching practices related to the use of technology (Jones, 2017; Kleiman, 2004). These studies stress the potential of VR but call for a better understanding of how to integrate excellent teaching within the benefits of this technology (Barbour & Reeves, 2009). An additional line of early VR research emphasized the technology's intellectual value via the potential for realistic experiences (Cruz-Neira, Sandin, & DeFanti, 1993).

More recently, Markowitz, Laha, Perone, Pea, & Bailenson (2018) found that engaging in what they termed *virtual reality field trips* led to positive learning outcomes and an increased interest in the topic. In this study, the authors argue that the immersive nature of VR headsets enabled students to internalize the effects of ocean acidification. However, they also noted the practical challenges of having a few students at a time experience the field trip while the rest of the class watched (p. 17). Lower cost options have also emerged. Vishwanath, Kam, and Kumar (2017) used Google Cardboard headsets and recycled cell phones to employ VR field trips in a low-resource environment in India, demonstrating the potential broad application of such technology. In both cases, students used VR to learn about distant locations, suggesting that there is a need for work that investigates if VR could also be used to help students see local issues and environments from a new perspective. In sum, these studies show the potential of VR as a pedagogical tool, as well as identify some potential limitations.

Although these studies indicate the possibilities of learning science concepts through VR, their focus remains on a traditional learning paradigm of science content aligned with the goal to succeed academically on measures such as standardized test items that decontextualize the content from students' sense-making. Aronson & Laughter (2016) argue that while such measures do have value, assessing student outcomes "requires an expansion of 'achievement' beyond only test scores to include other qualitative measures of academic skills and concepts" (p. 197). In our study, we consider the possibility that newly designed VR environments could be used to address local scientific issues affecting students' lives and communities, embracing and embodying a socio-political agenda of disciplinary learning. Thus, this study contributes to existing scholarship on VR by exploring how culturally relevant pedagogy situated within VR can impact elementary students' learning of science.

Theoretical Framework

Research on the interaction of culture and learning, stemming from culturally relevant pedagogy (CRP), has illuminated the importance of cultural relevance in relation to how students make sense, retain, and apply content knowledge across disciplines (Buckley, Kershner, Schindler, Alphonse, & Braswell, 2004; Villegas & Lucas, 2002) including science (i.e. Carlone & Johnson, 2012). The CRP framework, as originally articulated by Gloria Ladson-Billings (1995), calls for educators to rethink the possibilities of pedagogy by reframing teaching as an opportunity to promote students' cultural competence, academic success, and socio-political consciousness. According to CRP principles, instruction should teach disciplinary content while simultaneously helping students conceive of themselves as change agents who can apply the content within their lived realities. This call has been taken up and extended by numerous education researchers (Emdin, 2016; Paris & Alim, 2017). In developing a VR lesson using principles of culturally relevant pedagogy (CRP-VR), we posited that current classroom applications of VR science videos do not consider the breadth of environments in which science occurs. In contrast, we sought to leverage the deep connections between science content, the culture of the students, and localized applications within a carefully designed lesson.

While science education research was initially slow to explore the impact of CRP on student learning, several recent studies outline how culture impacts science teaching and learning (Adams, 2016; Calabrese-Barton & Tan, 2018; Emdin, 2010). In turn, these researchers challenge educators to use students' culture as a resource to improve pedagogy and problem-solving in specific content area related tasks. These studies also highlight the potential benefits of incorporating cultural relevance within science instruction and, we argue, could be utilized by designing VR learning environments for science education that emphasize the tenets of CRP. To this end, in lieu of assuming cultural neutrality, we designed a single VR elementary science lesson leveraging the tenets of CRP, with specific attention paid to providing content learning that was contextualized within the students' specific communities while also integrating a socio-political lens to the application of the content in those locales. Importantly, we draw from a definition of culture articulated by Rogoff and Gutierrez (2003), who define culture as a collection of "repertoires of practice" (p. 19) that arise within community interaction, rather than as a static collection of individual traits. Therefore, in our work, we consider culture to be interactionally constituted, as well as geographically and temporally located in the classroom contexts of our study. From this stance, we argue that students could use their science content knowledge to actively engage with social issues within their localized contexts – a claim supported by prior research that showcases such a lens (Braaten & Sheth, 2016; Mensah, Brown, Titu, Rozowa, Sivaraj, & Heydari, 2018).

Given this theoretical base, we considered what VR learning environments that incorporate tenets of CRP could contribute to contemporary science education research. Principally, lessons designed in this approach could enable students to draw immediate connections from school science content to their local context. Additionally,

students could make greater connections between their local community, their perceptions of school science content, and their identities as capable science students and scholars. Finally, integrating a CRP-VR framework could potentially afford opportunities for students to engage with socio-political applications of science in ways that are authentically connected to their lived experience. To examine how using VR software and CRP may impact students' learning of science, we explored two research questions:

1. How did students connect science to their lived experiences following a culturally relevant virtual reality lesson?
2. How did students describe their experience using a culturally relevant virtual reality approach to teaching science?

Methods

Project Overview

The design of our CRP-VR lesson intentionally embedded cues of cultural relevance to send students a message of belonging – to elicit familiar responses from the cognitive schemas they use outside of the classroom and connect them to the science content. These elements included four VR360 videos playing locally popular music, such as Kendrick Lamar, as they displayed science concepts. We also integrated voice overs that were recorded by children and people of color. The virtual reality videos introduced a driving question (should you grab flaming hot Cheetos or fruit for a snack?), offered a formative assessment, described a calorimetry lab procedure, and framed a summative assessment in which students were asked to apply their science knowledge. The videos were embedded within a Nearpod platform that allowed students to watch the videos, read or listen to additional information, and respond to questions about the material. To further emphasize socio-political consciousness as a tenet of CRP, we infused a purposeful application of the content within the fourth video, which set up the summative assessment task. This video took students through a shopping area located near their schools to connect the application of the science content (energy transfer in food chains) to a socio-political frame (observing the food options available in their localized community).

In each classroom of approximately 30 students, all participants engaged in the lesson simultaneously using cell phones and Google cardboard headsets provided by researchers. Each classroom teacher led the lesson for their own students, following a scripted lesson sequence. Although most of the instruction was delivered via the digital content, students also observed a real-life calorimeter demonstration to see the difference in calories between fruit, Cheetos, and crackers. Figure 1 below displays how the lesson incorporated elements of CRP and Table 1 highlights selected screenshots from the CRP-VR lesson in the Nearpod platform.

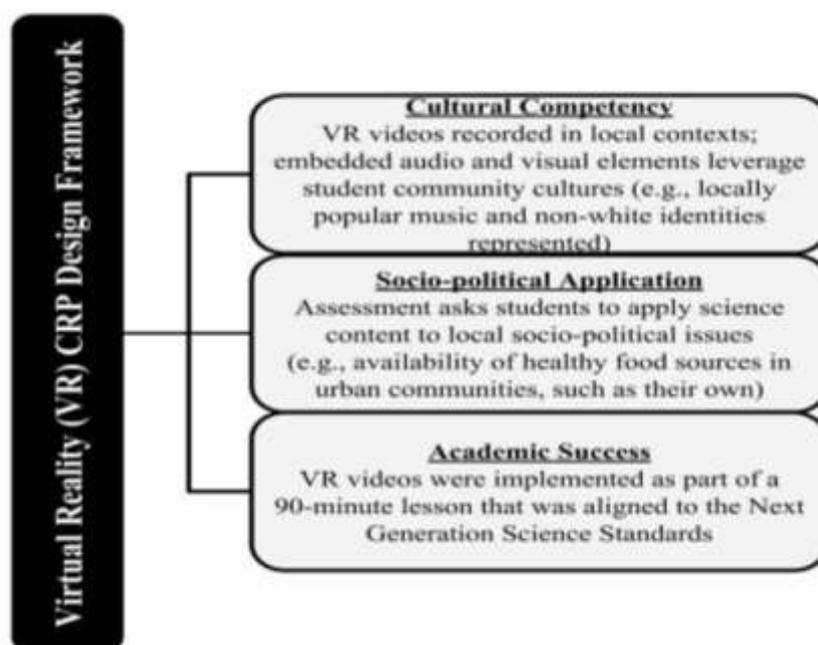
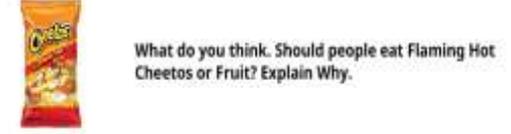
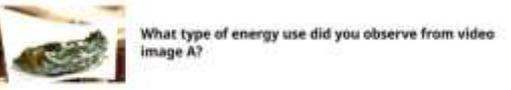


Figure 1. Elements of CRP Embedded within the VR lesson design

The design elements of the CRP-VR lesson incorporated the flexibility of the VR platform with CRP tenets that purposefully catered to the ways in which students experience the world outside-of-school (i.e., visual, audio, and linguistic cues), thus bringing their culture inside the science classroom in a lesson aligned to the Next Generation Science Standards. These design elements contextualized the content in students’ local communities and leveraged the opportunity to have students apply their learning within the VR lesson to these locales in ways that emphasize the fostering of a socio-political consciousness.

Table 1. Selected Screenshots from the Nearpod Lesson

SLIDE PURPOSE AND DESCRIPTION	IMAGES OF THE SLIDES
<p><u>1ST VR Video</u> <u>(Guiding Purpose):</u> This acts as a way to introduce the topic to prime students to think about the purpose of the lesson. In this case the priming takes the form of a discussion in a barbershop filled with people of color over the following question with overlays that act as moving images of people discussing but not their actual speech: Do you think Flaming Hot Cheetos or Fruit are healthier to eat?</p>	
<p><u>Eliciting Students’ Thoughts:</u> This slide acts as a way for students to express their thoughts about the guiding topic. This starts to get students engaged with the discussion rather than being separate from the discussion that was just presented in the VR video.</p>	 <p>Please enter your answer here.</p>
<p><u>2nd VR Video</u> <u>(Formative Assessment):</u> This VR video serves as a formative assessment of students’ acquisition of the previous content. It presents three 2-D videos overlaid in a VR 360 video of a science laboratory; these videos show science phenomena, but no explanations are provided. Students will use these observations in the next slides.</p>	
<p><u>‘Quiz’ Slides</u> <u>(From VR Video):</u> These three sequential slides show snapshots of each of the videos the students just observed within the VR 360 video above. They ask the students to match the phenomena they observed (e.g., molding food; marine mammals eating fish; and plants sprouting in soil, respectively) with the scientific vocabulary.</p>	 <p>Producer Consumer Decomposer</p>
<p><u>3rd VR Video</u> <u>(Laboratory Primer):</u> In this VR video, students are immersed within one of our sites’ schoolyards. Former students from that school explain the procedure to conduct a calorimetry lab while 2-D video overlay gives additional information.</p>	
<p><u>4th VR Video</u> <u>(Investigating the Local Community):</u> In this final VR video, students are taken through their local community (via having the VR 360 camera mounted on a car driving through their community) and asked guiding questions such as: ‘How many fast food restaurants do you see?’ Students also enter a local convenience store, similar to those they frequent, and are asked to look for healthy foods, with some overlaid nutritional tags of specific foods.</p>	

Study Context

Working with seven 4th and 5th grade teachers, we implemented our CRP-VR lesson in three partner schools (two district and one charter) located within ten miles of each other in Northern California. The schools share similar demographic and academic profiles. Across the three schools, the students' self-identified racial backgrounds were approximately 60% Hispanic/Latino, 18% African-American, 12 % Filipino/Asian, 5% White, 2% Pacific Islander, and 1% American Indian. We assessed the impact of this lesson in two ways: (1) A pre-/post-lesson attitudinal survey, and (2) post-lesson interviews. In total, 145 students completed the survey and 48 students were interviewed after the lesson. This mixed-methods design (Creswell & Creswell, 2017) provided an opportunity to assess the impact of the lesson approach on students' perceptions of science and its relevance to their local context. Figure 2 below summarizes our research design.

Data Collection

On our first visit to each classroom, we offered students a 30-minute software training in which they learned how to open and navigate VR360 videos. This introductory lesson served to limit the potential impact of students' different levels of prior experience using VR affecting how and in what ways familiarity with the technology may influence our results. Next, we engaged in a two-day data collection process. On day 1, students engaged with the CRP-VR lesson in their classrooms and, on day 2, the research team interviewed a sample of students about their experience. The interview protocol included questions that probed the experience of using virtual reality in a classroom setting (such as "If someone new came to your classroom, how would you explain to them how to use VR for a lesson?"), prompts about the science content ("Think about the images you saw in the VR goggles and talk about the science you see"), questions about the images and sounds in the video ("What did you see or hear that was new to you? What did you see or hear that was familiar to you?"), and questions about community connections ("The lessons you were learning were about things you might experience in your neighborhood. How did these lessons relate to your community?"). The researchers used prompts such as "can you tell me more about what you meant?" to follow up on students' initial responses.

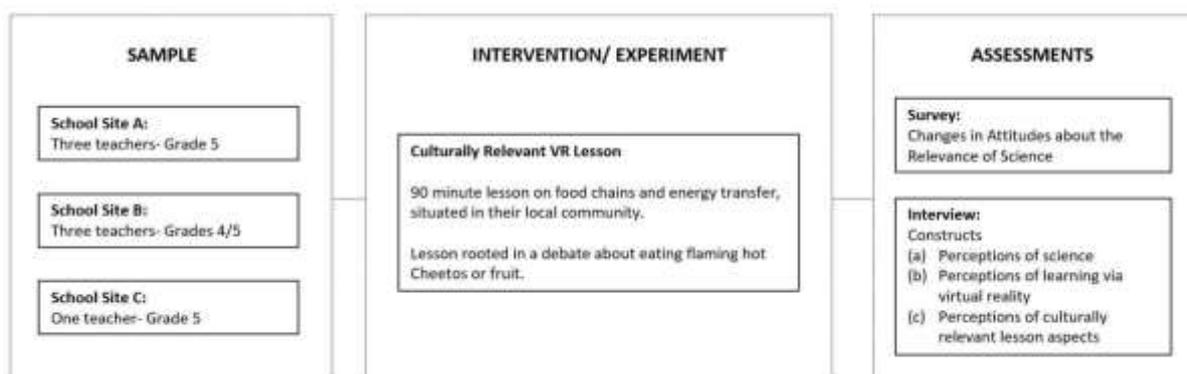


Figure 2. Representation of the Study Design

To assess student attitudes about science before and after the lesson, we implemented a modified version of the Changes in Attitudes about the Relevance of Science (CARS) 5-point Likert survey developed by Siegel & Ranney (2003). We altered the instruments to ensure a 4th grade reading level and added additional statements about science and community ("I can help my community by learning science"). After modification, the instrument still held similar reliability as previous reported estimates (Cronbach's Alpha > .80), indicating that the modifications did not affect the reliability of the survey. We also interviewed a representative sample of students that matched the gender and ethnic demographics of the overall student population. Students were asked to explain their thoughts about learning using VR, their understandings of the disciplinary phenomena, and their perceptions of the value of what they learned to their local community.

Data Analysis

After collecting the survey and interview data, all interviews were transcribed by an online service and reviewed by the research team to ensure accuracy. We then engaged in an iterative coding process with the verbatim interview transcripts. The research team met to discuss emergent patterns in the interviews and outlined macro

level themes, a precursor of the Level 1 codes presented in the Findings section below. This process was repeated until we were able to identify a primary codebook, which contained the final Level 1 codes. Once we created our codebook, a primary coder coded each transcript to identify instances of each theme in the interview transcript. A secondary coder then reviewed that transcript. The primary and secondary coders met to identify and resolve any discrepancies in their coding until all coding reached 100% agreement. The team repeated this process to create Level 2 codes, identifying appropriate codes from the Level 1 codes that broke the larger themes into smaller units of analysis.

To triangulate the data, we used a simultaneous analysis (qualitative and quantitative) procedure to identify patterns that emerged concurrently (Creswell & Creswell, 2017). In our quantitative analysis, we conducted paired t-tests to compare the pre-and post-survey results on the overall survey score. In order to assess whether students with differing initial attitudes showed a different response to the lesson, we also conducted a median split of the data based on pre-survey score. Then, we conducted paired t-tests of pre- and post- survey scores for students in each half of the dataset (designated as “high relevancy starters” and “low relevancy starters”). Concurrently, we engaged in the above qualitative analysis to understand the ways that students thought about their experience our CRP-VR science lesson.

Findings

The results of our analysis highlighted a relationship between the use of culturally relevant VR and students’ perceptions of how understanding science may influence their community. In investigating research question 1, *How did students connect science to their lived experiences following a culturally relevant virtual reality lesson?*, we began with an analysis of the pre- and post- CARS survey responses (see Table 2).

Table 2. Descriptive Statistics: Pre-/post-Intervention

	Pre-Mean	STDDEV	Post-Mean	STDDEV	Effect Size
All Students (N = 145)	3.72	.488	3.74	.570	.05
High Relevancy Starters (n = 73)	4.12 ^a	.552	3.94 ^{**a}	.238	.41
Low Relevancy Starters (n = 72)	3.33 ^a	.524	3.55 ^{***a}	.330	.52

Paired t-test: ^{**} $p < 0.01$, ^{***} $p < 0.001$; ^a indicates significant differences from independent t-tests

When examining the total pre- and post-survey mean results, we identified a slight but not significant increase in students’ scores from pre-/post-survey scores [3.72 to 3.74, $p=0.34$]. Students who had a high assessment of the relevance of science before the lesson (“high relevancy starters”) showed a significant decrease in attitude after the lesson [4.12 to 3.94, $p=0.003$]. Students who had a low assessment of the relevance of science on the initial questionnaire (“low relevancy starters”) showed a significant increase in attitude after the lesson [3.33 to 3.55, $p=0.0004$]. Although the overall survey mean results did not demonstrate a significant shift on the broad measures of student attitudes about science captured by the survey, the intriguing pattern of the median split data (Figure 3) suggests that this intervention may be especially effective for students who have not had previous opportunities to engage with science as something that is relevant to their lives. On the other hand, it may be less effective for students who already view science as interesting and relevant to their lives.

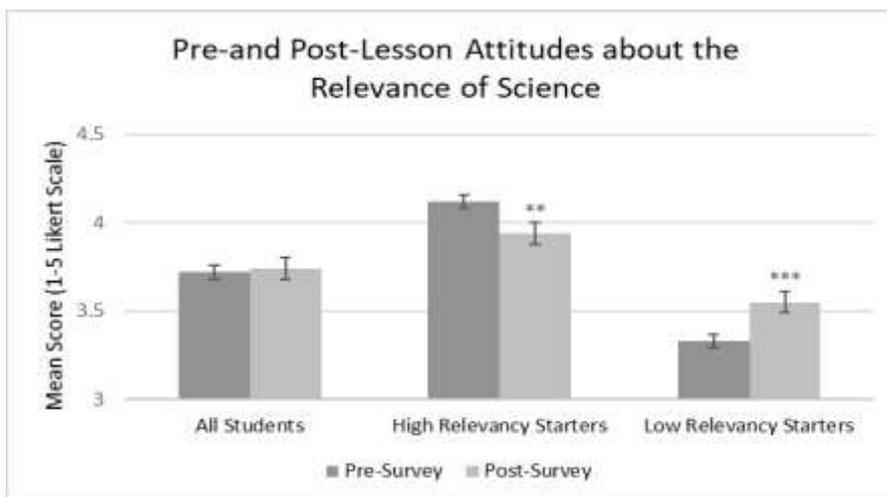


Figure 3. Pre- and Post- lesson Survey Data. ^{**} $p < 0.01$, ^{***} $p < 0.001$

Our detailed analysis of student interviews to investigate research question 2 (*How did students describe their experience using a culturally relevant virtual reality approach to teaching science?*) indicated that students exhibited an ongoing engagement with the sociopolitical framing of the lesson. Our qualitative analysis provided an opportunity to examine student reflections on learning through a CRP-VR lesson. In our initial analysis, we documented 5 Level 1 macro categories of responses. For brevity, the first 3 (*VR Experience*, *Science Learning*, and *Images and Sounds*) are not discussed here. However, since the last 2 macro categories illuminated goals specific to our micro-analysis, we will describe them in more detail. These two categories, *Cultural Relevance* and *Social Justice*, describe distinct connections made by students.

In talk coded as *Cultural Relevance*, students described how aspects of the lessons involved content and experiences that were familiar to the students. Importantly, *cultural relevance* was not defined by a specific race or ethnicity; rather, it refers to connections to local, familiar, cultural characteristics. For example, Michael (all student names are pseudonyms) explained, “Because [the people in the video] kind of sounded like some people, kind of like grown up people that I know, like it could be around the school or in my neighborhood.” In this instance, Michael explained how he identified a connection with the speakers in the videos because they used discourse patterns that he found similar to the “kind of grown up people I know.” This insight highlights how students like Michael were attuned to the subtleties embedded in the sounds and images of the lesson.

In instances coded as *Social Justice*, students discussed how the content taught could be used to address social injustice. In most cases, this involved students making connections beyond those explicitly named in the lesson. An example is found in Ronaldo’s comments about how the availability unhealthy food and dialysis centers in their community might be rooted in economic injustice. Ronaldo explained, “The advantages for the store is that they make the money or the government so they can make [more] money” (Ronaldo). The ideas expressed by Ronaldo reflected a pattern of student responses where the young people in the study shared thoughts about a perceived relationship between the science of food chains and economic and health injustice in their community. Collectively, the diversity of responses and the depth of thought expressed by students highlighted the impact of CRP-VR on students’ ideas about justice.

In our Level 2 analysis of instances of talk coded with *Social Justice*, which occurred among students across all three partner schools, we found three primary types of responses: *Health Justice*, *Economic Justice*, & *Environmental Justice* (Table 3). While the interview questions did not ask students about social justice applications of science, we found that students referred to social justice without prompt in 16 of our 48 interviews (33%). This finding suggests that several of the students were independently making connections between the science lesson and their communities through our lesson. Table 3 below summarizes these codes.

Table 3. Level 2 Code Names, Descriptions, and Exemplars

Code Name	Code Description	Example
Health Justice	Instances of talk where students describe how lessons learned from VR and/or previous lived experiences shape their thoughts and feelings about justice regarding health disparities as it pertains to their community. May include calls to action – both individual and collective	“This lesson was connected to my community because there are a lot of people in my community that eat unhealthily. I kind of want help them so that they can eat healthier.” (Brenda, INT 2017)
Economic Justice	Instances of talk where students describe how lessons learned from VR and/or previous lived experiences shape their thoughts and feelings about justice regarding economic inequality as it pertains to their community. May include calls to action – both individual and collective	“Advantages for the store is the money or the government for the money.” (Ronaldo, INT 2017)
Environmental Justice	Instances of talk where students describe how lessons learned from VR and/or previous lived experiences shape their thoughts and feelings about justice regarding environmental inequality as it pertains to their community. May include calls to action – both individual and collective	“Well, if people keep buying the plastic from junk foods, they could throw it into the sea and damage the birds.” (Aaron, INT 2017)

Health Justice

In multiple instances, students discussed how their lesson on food chains held implications for issues of health justice. Rather than simply identifying the types of food that they should eat, these fourth and fifth graders were applying a sociopolitical consciousness to identify the structural features that might influence the availability of healthy food choices. For example, Ariana explained, “So these lessons relate [to me], because we should have more grocery stores and be more healthy and we should think about what we're doing.” In Ariana’s analysis, she drew an explicit connection between the lesson on food chains and the lack of grocery stores in her geographical area. We also found that after participating in this VR lesson, where students learned about energy transfer and then virtually toured their own neighborhood to examine the food options available, students expressed frustration that focused on the abundance of unhealthy options as compared to healthy options in their local stores and neighborhoods. Some students explicitly referred to the virtual neighborhood tour video where they recognized how many fast food restaurants there were as opposed to healthy options. Joe connected his review of healthy options in his neighborhood to local stores and lamented:

It was when we were going through the [tour] to spot as many fast food places, that is, there’s a lot of fast food places in this area. We were looking for the healthy food inside the store; there wasn’t that much. It’s sort of like how stores are now.

His suggestion that not having healthy options in his neighborhood was “like how stores are now,” offers an example of the pattern we observed in which students made connections about their neighborhood and the need to improve community health options.

Other students noted that when engaged in the VR activity that took them into the local convenience store, they looked around but were unable to find healthy options to eat. This video also allowed students to zoom in on several of the nutrition labels and analyze the nutritional content of the available food. We discovered that students applied their understanding of energy transfer to health justice. Students offered critiques of the availability of healthy foods. Kermit explained, “The type of food is like junk food and mostly – and some fruits and vegetables. But in that junk food is fruit and vegetables only like this much, [*gestures to demonstrate a small amount*] this much percent.”

Kermit was not the only student who used his newly gained knowledge of food chains to highlight that junk food offered minimal nutritional value. Joe explained, “It was pretty hard to look for healthy things, because obviously it was junk and soda and we looked through the caption of coke. There was a lot of sugar, a lot of sodium.” Tyler also adopted this position as he explained, “Do you see how many fast-food restaurants and all the unhealthy stuff that’s around, they should change that.” These students’ conceptions of food, energy, and the need for better community health highlighted a keen awareness of the lacking availability of healthy food in their local communities and their discontent with this reality.

Economic Justice

Students noted that, although they wanted to help people eat healthier, it could be costly. While financial costs of different food options were not a component of the lesson, students independently made connections between food consumption and economic justice. They identified a disconnect between what they wanted people to eat and what people could actually afford to eat. Although these students wanted their community to eat healthily, they acknowledged the barriers that exist that often keep that from happening, regardless of intention.

Kermit expanded on his earlier observation of the disparities in availability of food options by making a connection to cost. He said, “So like the stuff in like stores costs like – sometimes if you buy like all the stuff that you want it adds up to like hundreds of hundreds of dollars, which like is unfair to the community because they just want to eat and it’s like one of the key roles to survival.” His suggestion that awareness of healthy food options was secondary to affordability issues highlighted a set of ideas shared by other students as well. Jazmine shared a similar sentiment as she explained “In high class housing and all that stuff, like there’s usually a Trader Joe’s, a Whole Foods, a Sprouts, and all those expensive stores are healthy for you. What I see in my neighborhood are liquor stores and places that sell unhealthy food.” The students’ awareness of the relationship between economic realities and food options demonstrated that students, through the CRP-VR lesson, were integrating the science lesson with the issues of economic injustice that they observed in their lived experiences.

Finally, some students argued that there is no incentive for business owners to change the types of food available for those in low-income areas, as many people benefit from the sales of unhealthy foods as well as the

medicine (such as insulin) that people end up needing after many years of unhealthy eating habits. Ronaldo explained this point succinctly:

Because all the fast foods that they have and all the unhealthy foods that they have are being sold more than healthy foods, so since they're being sold more there's more money and then it's basically like a drug. They get addicted to it and then do it over and over.

Ayinde shared this perspective, but offered a more cynical explanation, “people give you bad food and then they trick you into getting sick and then you have to buy medicine.” Zendaya, analyzing why she thought there were disparities in food availability in local convenience stores, referred to what she perceived as a difference in how people’s needs were prioritized based on their wealth. In her interview, she stated that “I didn't really like it, because people with more money, they want their kids to be healthy and stuff. People with less money, they have to buy whatever is necessary.” Here, Zendaya is recognizing the shared goals of parents, regardless of economic status, but arguing that parents with less money have to settle for buying what they can afford in their local stores. This sophisticated connection between the content being taught and issues of economic injustice emerged as an interesting outcome to the CRP-VR lessons.

Environmental Justice

In the instances coded as *environmental justice*, students identified a connection between the lesson and where they live; they expressed a desire to use the knowledge they had acquired to act to improve the physical environment of their community. Some students focused on the junk food wrappers from the unhealthy foods, and the litter that it leaves in their communities. Joe described this issue, saying: “There is so much trash laying around and I always see kids eating unhealthy foods... It makes me feel like of sad or scared because like I don't know what's going to happen with all the trash.” Elizabeth not only raised concerns about littering, but she also gave active suggestions of what might be done to address this problem, which she saw as a side effect of the abundance of junk food in their neighborhood: “[*I want to make people*] stop littering 'cause people, when they get out of the store, like open whatever they got and throw it on the ground... You can put up signs or posters everywhere and say, ‘Stop littering. It makes our community look bad.’”

Rather than simply describing the injustices that they observe in their daily lives, these students talked about why addressing them is important, and expressed a desire to help the community eat more healthily and keep their community clean. Their explanations demonstrated an awareness of an interconnection between themselves, their community, and the negative outcomes associated with unhealthy eating. However, it is important to note that not all students’ proposed actions were at the community level. Some were individual, such as Ramon, who explained, “It made me think that I should stop eating junk food.” Shannon offered, “I think I will start eating a little bit healthier, 'cause like now I know there's so many calories in them I'll be a little more careful.” Together, students demonstrated a dynamic set of ideas about how the science content impacts personal and community issues of health, economic, and environmental justice.

Discussion and Implications

The results of this study offer insight into the potential of using VR in conjunction with culturally relevant pedagogy to teach elementary science in ways that emphasize understanding how that content can be applied to local contexts to address socio-political issues. We began this project asking two questions:

1. How did students connect science to their lived experiences following a culturally relevant virtual reality lesson?
2. How did students describe their experience using a culturally relevant virtual reality approach to teaching science?

In answering the first question, we found that students who did not initially see science as relevant to their lives had significantly more positive attitudes toward the relevancy of science to their lives after completing the CRP-VR lesson. Additionally, our interview data indicated that learning science through CRP-VR helped students draw deep connections between science and their community. This supports Lee’s (2003) assertion of the importance of designing for culture in multimedia environments, as students made connections to their own lived experiences based on the cultural cues embedded in the CRP-VR lesson. The results of this analysis suggest a need for deeper exploration of VR not just as a tool to take students to faraway places but as a tool to help students see science as valuable to their local community contexts. When students, especially those who

did not initially see science as relevant to their lives, entered into a familiar environment from an unaccustomed perspective, they identified new connections that they had not previously recognized.

In answering the second question, we discovered that students provided dynamic explanations of issues of health justice, economic justice, and environmental justice. Previous work has shown that elementary students are capable of making sociopolitical connections to classroom science learning (Upadhyay, Maruyama, & Albrecht, 2017), and this study demonstrates that such connections can be made through a CRP-VR lesson as well. Although the VR lesson used local convenience stores and fast food restaurants to highlight local food sources, the lesson made no explicit mention of issues of economic, health, or environmental justice. The students' consistent and thoughtful discussions of these issues provided an indication that the CRP-VR lesson enabled students to transition from discussing the science of food consumption to analyzing how food justice impacted their local community. This result highlights a need for deeper exploration of how this might emerge in other contexts.

Subtle messaging with cultural cues embedded in CRP-VR instructional materials has the potential to be beneficial to schools for several reasons. First, the customizable nature of these resources and their design for whole-class implementation mean that such resources can be easily taken up and adapted by elementary educators. Our attention to the classroom experience in design and implementation of this pilot study serves to address existing concerns about a lack of pedagogical focus in designing virtual learning environments (Fowler, 2015). Most importantly, these materials leverage the research on culturally relevant pedagogy (Ladson-Billings, 1995) to consider the application of each tenet to technology such as VR. We argue here that these designs impacted students' perceptions and applications of science in ways that embraced the socio-politicality of the content while also embedding a cultural competence component related to agency and identity through the representation of audio, visual, and linguistic design elements familiar to students that participated within this study. As science is taught through new technologies, understanding how to leverage those technologies to embed tenets of CRP represents a potentially powerful mechanism in urban science education. In developing the next generation of content-specific hardware and software, it is important to understand how race, language, and culture inform how students experience science in their local communities. We argue that research into new instructional technologies should not be premised on an assumption of cultural neutrality; rather, the cultural cues and tasks embedded within technological spaces should be researched as carefully as those within physical classroom spaces.

Conclusion

This paper provides an initial glimpse into the possibilities of CRP-VR in science classrooms, but additional research is needed to better understand the impacts of CRP-VR on content knowledge acquisition and the development of a personal science identity. This study suggests an important opportunity for research on how teachers might be able to customize and apply these lessons in areas outside of the specific locale of this study. We encourage researchers to consider how the cultural nuances students bring to the classroom might serve as assets to enhance science learning in an era of rapidly advancing technology.

Limitations

This study is not without its limitations. First, working with three different schools and seven different teachers, issues of teacher fidelity may have impacted the results of this study. While the lessons themselves were scripted, teachers' comments to students before and during the lesson are difficult to account for and may have influenced students' interpretation or application of the content. Finally, although all three partner schools are within the same geographical region, the comfort with social justice conversations at each school varied. At one school, social justice conversations are a standard part of the curriculum, while in other contexts this was not the case. Nonetheless, our findings, which drew from students across all three schools, represent substantial contributions to our understandings of how to use and design culturally relevant learning environments within technology such as VR.

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