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“It’s Like I’m Really There”: Using VR Experiences for STEM Career Development

Yang Jiang[1] · Vitaliy Popov[2] · Yaoran Li[1] · Perla L. Myers[3] · Odesma Dalrymple[4] · Joi A. Spencer[5]

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Abstract

Research suggests that the likelihood of students entering into science, technology, engineering, and mathematics (STEM) careers can be increased by promoting and maintaining students’ interest in STEM during middle school years, a critical developmental stage when students’ interests begin to solidify. One way to attract students to STEM is through technology-enhanced learning environments and experiences, which can spark and cultivate the long-term interest needed to pursue STEM careers. Virtual reality (VR) can potentially increase access to such STEM-related experiences for all students due to its educational and technological affordances. Currently, there has been little exploration of the intersection between VR and career development for K-12 students. This study, therefore, aims to address this gap by exploring the use of VR 360 videos for STEM career exploration. Data were collected using focus group interviews with 39 primarily Latinx middle school students who participated in the summer enrichment program. These interviews were conducted immediately after a VR 360 video activity that featured female characters and/or characters from racial minorities in order to best support students who are underrepresented in STEM fields. The findings support the potential of VR as a tool for career development as long as content, possible physical side effects, and scaffolding are considered. The implications for research and practice are discussed.

Keywords STEM · Virtual reality · Possible selves · Career development · Latinx · K-12 · Informal learning

Introduction

“Wow, it’s like I am really there!” exclaims a middle school student as she presses a pair of Google Cardboard glasses to her face. As a student from a school district with limited resources, the chances of her touring Google’s data center or a spaceship were slim—that is, until she was able to experience them through a virtual reality (VR) experience. Today, she is following a day in the life of Tierra Fletcher, an African-American aerospace engineer. Though the students have read about engineers in class, seeing Tierra’s work environment and daily tasks has brought the job to life.

Exposure to experiences like these can be critical for developing a robust STEM pipeline. Research suggests that promoting and maintaining interest in science, technology, engineering, and mathematics (STEM) can increase the likelihood of students entering into a STEM career (Dabney et al., 2012; Maltese & Tai, 2010; Sadler et al., 2012; Uitto et al., 2006). Interest in a particular career can be formed through exposure to relevant information and opportunities (Bergin, 2016; Maltese & Tai, 2010; Renninger et al., 2015). One way to spark interest is exposing students to hands-on activities as well as self- and career-exploration experiences (Barnes, 2010). For instance, STEM interest can be stimulated by puzzles, team projects, and repeated exposure to material (Barnes, 2010; Bergin, 1999; Harackiewicz et al., 2000; Mitchell, 1993; Renninger et al., 2015).

✉ Yang Jiang
yjiang9888@gmail.com

1 Jacobs Institute for Innovation in Education, School of Leadership and Education Sciences, University of San Diego, San Diego, USA

2 Learning Health Sciences, University of Michigan, Ann Arbor, USA

3 Mathematics and Computer Science Department, College of Arts and Sciences, University of San Diego, San Diego, USA

4 Department of Industrial Engineering, Shiley-Marcos School of Engineering, University of San Diego, San Diego, USA

5 School of Leadership and Education Sciences, University of San Diego, San Diego, USA

Unfortunately, students with limited or inaccurate information about STEM careers can be discouraged from pursuing them (Auger et al., 2005; Cleaves, 2005). Research shows that many students have misconceptions about engineers (Fralick et al., 2009; Knight & Cunningham, 2004). Thus, it is crucial to debunk stereotypes about STEM professions by providing accurate information (Wyss et al., 2012) and implementing STEM materials in the curriculum (DeJarnette, 2012). Dorssen et al. (2006) found that informal STEM activities are one of the most promising ways to help young people reconsider career pathways they previously disregarded due to faulty beliefs. Therefore, students benefit from being exposed to informal opportunities that contribute to the formation of accurate perceptions of STEM careers (Blotnicky et al., 2018).

Black, Latinx, and Native American students, in particular, need exposure to STEM-related experiences as they continue to be underrepresented in STEM in the USA (National Science Foundation, 2017). As early as middle school, minority students' interest in STEM begins to diverge from their White peers (Oakes, 1990; Zhu, 2018). A significant number of minorities who select a STEM major in college or university either drop out or switch to a non-STEM major prior to graduation (Chang et al., 2014; McGee, 2016; National Academy of Engineering & Committee on Understanding the Engineering Education-Workforce Continuum, 2019; Snyder et., 2019; Xu, 2013, 2015). According to the US Census Bureau and the National Academy of Sciences, underrepresented minorities earned only 18% of the Bachelor degrees in science and engineering fields (Bianchini, 2013; Institute of Medicine, 2011; Landivar, 2013). Latinx students, especially, need support as the Latinx population is the youngest and fastest growing major racial group in the USA (Pew Research Center, 2017). Although the percentage of Latinx employees in the general workforce increased from 3 to 15% from 1970 to 2011; they still comprise only 7% of the STEM workforce (Landivar, 2013).

Virtual reality (VR) has the potential to increase access and exposure to STEM-related experiences for all students due to several educational and technological affordances (Cecil et al., 2013; Haluck & Krummel, 2000; Liu et al., 2017; Moreno & Mayer, 2002). These emerging technologies can help students learn complex concepts that may be difficult to understand without visualization (Popov et al., 2019; Potkonjak et al., 2016) and create access to resources from any place and time by transcending geographic and other boundaries (Cecil et al., 2013). Immersive technologies can also be a cost-effective and accessible way to deliver career-related services and information, especially for training or situations that would be expensive, dangerous, or too complex to physically replicate (Bimrose et al., 2015; Hughes, 2012). However, to our knowledge, no studies have been conducted on the use of VR for career exploration in K-12 settings. Therefore, this study addresses this gap by investigating the use of VR experiences for STEM career exploration within a STEM summer enrichment program. In order to address the issue of diversity within STEM, the study focuses on Latinx middle school students.

The following questions guided this study:

1. What are the students' perceived affordances of using VR experiences to explore STEM careers in a STEM summer enrichment program?
2. What are the students' perceived challenges of using VR experiences to explore STEM careers in a STEM summer enrichment program?

The Need for Exposure to Learning Experiences

At an early age, through exposure to certain situations, places, and people, children use their experiences to understand themselves and the world around them. As they construct a picture of the world, they also construct a picture of themselves in that world (Blustein & Noumair, 1996). One of the ways children begin to think about themselves is through the jobs they might hold in the future, or their occupational identities (Super, 1953). Thus, it is important that at an early age, students are exposed to diverse development opportunities so they can learn about the possibilities of work and their own interests, abilities, and values (Magnuson & Starr, 2000). The following theories clarify the role of exposure to learning experiences on career development.

Social Cognitive Career Theory

Social cognitive career theory (SCCT) states that an individual's *vocational interests*, or "the pattern of likes, dislikes, and indifferences regarding various occupations and career-relevant activities" (Lent et al., 2006, p. 264), will determine their career choices (Betsworth & Fouad, 1997). An individual's vocational interests are influenced by their *self-efficacy*, or an individual's beliefs about his or her ability "to organize and execute courses of action required to attain designated types of performances" (Bandura, 1986, p. 391), and *outcome expectations*, or "personal beliefs about the consequences or outcomes of performing particular behaviors" (Lent et al., 2006, p. 262), in relation to a specific career. In other words, people will form a long-lasting interest in a particular career or related activity if they see themselves as competent at it and that pursuing it will lead to positive outcomes (Bandura, 1986; Lent et al., 2006).

One way to influence self-efficacy and outcome expectations is through *vicarious learning*, or *modeling*, which occurs when individuals learn from observing others

(Ireland & Lent, 2018; Usher & Pajares, 2008). Traditionally, individuals find models in the people within their immediate and direct environment, such as parents or peers (Bandura, 2001). Now, however, *mass media* (defined as television, radio, films, music, newspapers, magazines and books, VR/AR and the Internet, Dong, 2012) can serve as significant sources of modeling, especially for experiences, people, and situations that individuals are not able to have direct contact with (Bandura, 2001). The media, therefore, can allow people to "transcend the bounds of their immediate environment" and access a much wider range of vicarious learning experiences (Bandura, 2001, p. 271).

Despite the reality of media as an increasingly important and common source of modeling, research on modeling has tended to focus on an individual's vicarious learning experiences with people that they come into direct contact with. For students, studies tend to ask about vicarious learning experiences with peers (Klassen, 2004), adults (e.g. teachers, parents) (Usher & Pajares, 2006), or both (Lent et al., 1996; Lopez & Lent, 1992). Understanding how media serves as a source of modeling could contribute to the development of resources and programs that do not rely on direct contact for vicarious learning and take advantage of media's ubiquitous presence.

Now that we have pointed out how media may provide access to a range of vicarious learning experiences, we turn to a specification of possible selves theory in order to integrate what is known about occupational possible selves with VR's educational affordance for exposure to STEM career pathways.

Possible Selves Theory

Possible selves are "representations of the self in the future" (Markus & Nurius, 1986; Meara et al., 1995, p. 954). These images capture our hopes, fears, and dreams and can be a source of motivation (Markus & Nurius, 1986; Meara et al., 1995; Packard & Nguyen, 2003; Ruvolo & Markus, 1992; Strauss et al., 2012). For instance, the image of graduating can motivate a student to study more. Possible selves also act as a frame for evaluating the meaning of current actions and situations (Markus & Nurius, 1986). A student who hopes to be a doctor, for example, may evaluate a bad grade on a biology test differently from a student who hopes to be an artist. Individuals can also experiment with their future careers through imagining different possible selves (Strauss et al., 2012).

Individuals' social contexts can limit the development of possible selves (Oyserman et al., 2006). If an environment cannot provide relevant role models or experiences, an individual may struggle to form a particular possible self. For instance, Shepard (2003) found that rural adolescent girls, who grew up in environments that exposed them to a limited range of occupations, reported few occupational and educational selves. Contextual restrictions can also affect the possible selves of minorities and low socioeconomic status youth (Oyserman et al., 2006). Thus, research on ways to develop possible selves beyond direct interactions is necessary.

One promising solution is the use of media. The media is often an important source of socialization and information about possible selves for youth (Behm-Morawitz & Mastro, 2008; Dong, 2012; Larson, 1995; Packard & Conway, 2006). Through media, youth can interact with contexts and people that are not available to them in their immediate environment (Bandura, 2001). For instance, though many children have never met a scientist, they can describe one based off of media representations (Stinke et al., 2009; Scherz & Oren, 2006). Exploration through media is also a low-cost and low-risk way to experiment with possible selves (Green et al., 2004). Thus, exposure to media can potentially transcend environmental limitations on youths' possible selves. Currently, however, the relationship between media and possible selves is under-researched (Stinke et al., 2009).

Using VR for Exposure to STEM Career Development

The past few decades have seen increased exploration of technology as a tool to support learning (Huang & Liaw, 2018). In particular, there is strong interest in the potential of virtual reality (VR) to transform education. In *Computers & Education*, for instance, 25 articles about VR had been published by 2000, and by 2019, there were 500. Within literature on the educational use of VR, several technological *affordances*, or "characteristic[s] of the environment that… provid[e] an opportunity for some action" (Shin, 2017, p. 1828), have been distinguished. As Dalgarno and Lee (2010) argue, while these affordances may not directly stimulate learning, they can provide users with the opportunity to experience or perform certain tasks that may then *lead* to learning.

Several VR educational affordances may be relevant for STEM career development (as illustrated in Fig. 1). First, while media, in general, can increase access for students to situations and places that they cannot access otherwise, VR offers the most immersive and realistic experience out of all currently available media formats (Dalgarno & Lee, 2010). Especially when designed with high quality and fidelity of representation, VR can offer users the sense of "being there" (Dalgarno & Lee, 2010). This means students can be exposed to high fidelity (i.e., accurate) representations of career environments, such as a space station or chemistry lab, making it more likely that they can learn specific and

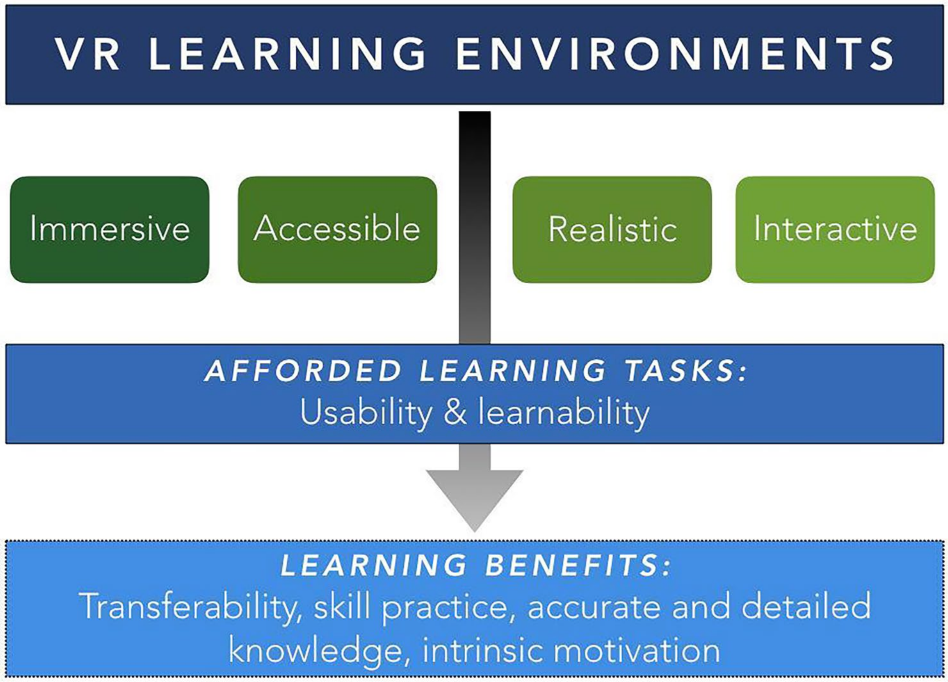

Fig. 1 An affordance model of VR learning environments adapted from Shin (2017)

accurate information about what it is like to have a particular job.

VR also offers users the ability to interact with a simulated environment, allowing users to learn about the qualities of objects in it and gain experience through active participation, or knowing by doing (Shin, 2017). Through VR simulations, learners can repeatedly practice a specific skill or task (Andersen et al., 2016), which is particularly useful for tasks that would be "expensive, risky, or dangerous to undertake in the real world" (Dalgarno & Lee, 2010, p. 19). The ability to replay and review one's performance makes VR even more conducive to honing career-related skills (Vaughan et al., 2016). For instance, VR simulations have been used to train orthopedic surgeons (Aïm et al., 2016; Vaughan et al., 2016), those who are looking to gain oral presentation skills (van Ginkel et al., 2019), medical professionals in the military (Linde & Kunkler, 2016), power electric system operators (Cardoso et al., 2016), and nuclear power plant workers on how to handle emergency situations (Jorge et al., 2010). VR, therefore, can give students embodied learning experiences with actual tasks and skills they would need to perform in certain careers.

Since VR is highly immersive, students may also potentially experience greater motivation and engagement during these learning experiences. As Shin (2017) found, VR users described their experience with words like "absorption," "concentration," and "engrossment" (p. 1830), and said that they felt an enhanced sense of "deep involvement" with their environment. These descriptions sound similar to what Csikszentmihalyi (1990) termed *flow*, or when we become so engaged that our attention is completely immersed in and focused on the task at hand. Flow has been linked to increased intrinsic motivation, engagement, and positive emotions toward learning (Faiola et al., 2013; Hektner & Csikszentmihalyi, 1996). Rueda et al. (2018) describe this as "ludic immersion," where absorption in a task in VR leads to enjoyment, and vice versa. Thus, a potential learning benefit of VR is its ability to provide a learning experience that is intrinsically motivating and engaging (Dalgarno & Lee, 2010).

Furthermore, the VR experience may contribute to students more easily transferring their knowledge into a real-world context (Dalgarno & Lee, 2010). Since the VR environment is highly contextualized and aims to be realistic, students can learn in environments that are consistent with reality. As a result, when they are in a real-world situation, they may more easily recall what they learned and be able to apply it. Chittaro and Buttussi (2015), for instance, found that people recalled significantly more knowledge when learning about safety procedures through a VR game than a traditional education method.

Currently, though scholars have argued for the integration of technology into career-related services and information delivery due to its cost-effectiveness and accessibility (Bimrose et al., 2015; Hughes, 2012; Organization for Economic Co-operation & Development, 2004), little research exists on the use of VR for STEM career exploration and development. This study, therefore, aims to address this gap by exploring what middle-school students learn about careers through VR experiences, specifically using Google cardboard, and the educational affordances that contribute to or challenge this learning.

Methods

Participants

We recruited the participants from a 2-week STEM summer enrichment program funded by the National Science Foundation. The students participated in this program were recruited from a public school district in the Chula Vista region of San Diego near the Mexican border, a school district composed of the following demographics: 54% economically disadvantaged students, 6% students with disabilities, 81% Hispanic, 10% White, 8% Asian Pacific Islander, and 1% other. The focus group interviews described in this study were conducted with 39 sixth grade students (59% female).

Setting

The summer program curriculum included (a) STEM hands-on activities focused on mathematics and engineering (including mathematical visualization, engineering design process through towers and chain reaction machines, and explorations with Arduinos and circuits) and (b) career development activities that centered on self- and career-exploration experiences (including career cards, games, virtual reality experiences, conversations with and presentations from STEM professionals). The VR experiences were a part of the career development activities that took place during the first week of the program (see below detailed description).

Procedure of the VR Experience Activity

Six 360 videos related to STEM careers on YouTube were chosen and compiled into a playlist. Given that greater similarity between people within media and the viewer has been found to support learning (e.g., Andsager et al., 2006; Ito et al., 2008), the research team prioritized videos featuring female characters and/or characters from racial minorities in order to best support students who are underrepresented in STEM. The topic/content of the 6 videos is as follows (see Appendix for hyperlinks):

> Follow multiple women as they describe their STEM careers, such as studying how the corrosion of marine plants and animals affects offshore wind turbines, and using math and physics to build sturdy skyscrapers and bridges.
> Tour a Google data center and learn about how it is taken care of, especially in a green and efficient manner.
> Explore three of the Lawrence Livermore National Laboratory's additive manufacturing research labs.
> Learn about Inna Braverman's career as a green energy entrepreneur harnessing the power of waves to deal with pollution.
> Travel alongside astronauts as they go about their day in space.
> Discover the story of Tiera Fletcher, an African-American female Boeing aerospace engineer who works at NASA to design rockets.

For the activity, students were divided into groups of 10. During each group's time with the activity, half of the students were given Google Cardboards and iPhones, and the other half were given iPads. This was due to the limited amount of iPhones available. Students with iPhones were given about 15 min to view the videos using their Google Cardboards. The other students viewed the same videos with their iPad. After about 15 min, the students switched technologies, so that all students experienced the videos with Google Cardboard glasses for about 15 min. Viewing the videos with the Google Cardboard glasses and the iPhone was considered the full VR experience (Fig. 2).

Data Collection and Analysis

Due to the exploratory nature of this study, a qualitative approach was taken to gather detailed data on students' perspectives and experiences. In following Grounded Theory methodology (Charmaz, 2006), which allows researchers to study how participants construct meaning and actions from their experiences, we chose to use a semi-structured interview protocol. The protocol was designed to ascertain participants' reflections on how the VR experiences influenced their conceptualizations of STEM careers and their occupational possible selves. The core questions were (see Appendix 2 for full interview protocol) as follows: *What thoughts and feelings did you have during the VR experience? What did you learn about jobs from the VR experience? How did the VR experience teach you this? Did the VR experience influence the kind of job you want to have? Why or why not? Did the VR experience help you imagine yourself in a particular job? Why or why not?* Interviews were conducted immediately after the activity in focus groups. Five student groups, with 5–8 students each, were interviewed for 25–30 min. Responses were recorded on a digital audio recorder and transcribed. We chose to use focus groups because they allow participants to "comment, explain, disagree, and share their views," which can "generate more ideas about, and yield deeper insights into, the problem under investigation" (Tausch & Menold, 2016, p. 1).

Fig. 2 Pictures of the study participants during the VR experiences

Data management and analysis were performed using Dedoose 8.2.12 and Excel. The first two authors coded and analyzed the data following an inductive coding approach to qualitative research (Erlingsson & Brysiewicz, 2017; Saldaña, 2015). To begin analyzing the interview data, an open coding approach was used to identify shared meaningful themes among all transcribed interview. After this step, selections of text addressing the same issue were grouped together in analytic categories and given tentative definitions. An instance of a theme usually consisted of a sentence. Codes were assigned to a text chunk of any size (e.g. "At first, it got me dizzy, but then I got used to it"), as long as that chunk represented an issue of relevance. The same unit of text could be included in more than one code. Finally, the data were systematically reviewed to refine the coding scheme.

The initial coding scheme was reviewed and refined through conversations among the authors. The inductive thematic analysis resulted in 12 categories (e.g. sensations, visualization, motivation), which were afterward grouped into 2 overarching themes (see Table 1 for the full list of categories and themes). We applied Patton's (1990) dual criteria for judging categories in terms of internal homogeneity and external heterogeneity, i.e., data pertaining to a theme must cohere together meaningfully, while the themes should be distinct from each other.

Using the final coding scheme, all transcripts were coded a second time by both coders to ensure the coherence and replicability of the themes. To assess inter-rater reliability, Cohen's kappa was calculated for each of the 12 categories, resulting in good or very good agreement between the two coders (see Landis & Koch, 1977), ranging from 0.82 to 0.90.

Results and Discussion

This study explored how exposure to VR experiences about different STEM careers could influence, or inhibit, Latinx middle school students' knowledge of, interest in, and motivation to pursue STEM careers. The representative examples obtained from the data analysis focus on the salient themes that were descriptive of the whole dataset. The data excerpts show similarities present across groups and provide a more descriptive interpretation of the data. Table 1 summarizes the distribution of excerpts across each of the themes and categories from the inductive thematic analysis.

RQ1: Perceived Affordances of Using VR Experiences for STEM Career Development

Students commented on how "realistic" the images in the videos were, as well as the level of detail involved. For instance, one student said that the NASA video showed the "inside of a spaceship" in such detail that "you could actually analyze it." A few students mentioned the "first-person perspective" as an important part of the visuals. For example, one student said, "It seems that you're actually there, as if you were the person that was recording."

The immersive nature of the 360 videos was also noted, with phrases like, "full body experience" and "you feel like it's real." For several students, the immersion was connected to their physical sensations. One student, for instance, said, "When I was stepping on glass, it looked like I was going to fall." Another student liked the ability to control where the 360 video was looking, adding more interactivity than the usual learning experience: "The cool thing was that you could actually move and not just have to learn it…it was like a real experience."

Several students also compared their experience with the 360 videos to books, stating:

Interviewer: Was it better than reading a book?
Student: Yeah.
Student Yes, because you could actually see it.
Student: It was so much better.
Student: Because in books they describe it to you.
Student: But for virtual reality, you can actually see it.

Table 1 Distribution of excerpts from the interviews

Theme	Category	No. of excerpts	Sample excerpts
Perceived VR affordances and challenges	Visualization (the visual/representation aspects of the VR experience)	25	But for virtual reality, you can actually see it, but you can feel it
	Sensations (physical feelings during and in response to the VR experience)	15	At first, [the VR experience] got me dizzy, but then I got used to it
	Immersion (the experience of being "there"/ inside the experience)	17	You can—you can kind of like get a full body experience and see more than you would in the movie…
	First-person perspective (the video occurring from the perspective of the main character)	3	And it seems that you're actually there if you were the person that was recording
	Movement (the viewer's ability to control movement in the VR experience)	9	The cool thing was that you could actually move and not just have to learn it like it was like real like what you're learning, it was like a real experience
	Comparative (comparisons between different modalities)	6	Well, I was—I felt like [the VR experience] was a lot better than the iPad
Perceived learning outcomes	Possible self (self-concept of a potential future self)	6	Yeah, I think it was good for us to visualize like what we can do in the future
	Motivation (desire to pursue future goals)	10	[After seeing the VR experience] when I grow up, I want to scuba dive…
	Self-efficacy (confidence in one's ability to achieve a goal)	4	I feel like [the job shown in the VR experience is] going to be too challenging…
	Career knowledge (information learned about careers)	22	It kind of explains how the technology works and…how to keep the computer systems…
	Interests (information learned about students' potential interests)	6	[After seeing the VR experience] you know what you want to do for a living…
	Limited video choices (the limited nature of the content of the VR experiences)	6	I didn't really find videos of the job there that I wanted…
Total		129	

They also stated that the visualizations were better in the 360 videos compared to iPads: "With the iPad, there was a lot of glare coming off the screen, so you can barely see it." One student also preferred the immersive nature of the Google Cardboard because it completely blocked off external visuals, whereas "in the iPad…it wasn't real because you can see the trees [outside]."

Exposure to the 360 videos benefitted students' career development in multiple ways according to them. First, students reported gaining more knowledge about different careers. As one student said, "I noticed that a lot of the jobs that I watched were hands on. Like the Mars one, it looked like they were testing out some stuff." Another student said that the videos showed him/her how valuable the roles were in their field: "I noticed that most of them are quite important to their company or line of work." For some students, the videos corrected previously held perceptions. For instance, one student said that the NASA video corrected his/her perception of what it means to be an astronaut:

Some people think that being an astronaut is just being in space onboard. Well, then when you see it, it's not [just being] onboard—you have to go connect different things and use lots of computers and lots of different things.

The videos also helped students consider and explore their future careers. One student said, "It helped me learn about new jobs I'm interested in." A few students also reported the visualization aspect of the videos being important because, as one student said, "I can imagine myself in there because I can see what they do." Having concrete images appeared to be useful for students by giving them imagery they could use to visualize themselves in a future career.

Some students mentioned feeling more excited about and motivated to pursue certain careers because of the videos. Several students reported feeling more interested in the careers after watching the videos. One student, for instance, said, "[The careers are] more interesting than what you think, even if they're already really interesting." This spurred one student to want to pursue his/her imagined career even more: "It made me more determined because you see [the job] as pretty interesting [so] you work more hard for it, like you dream more about it and got more determined about doing that job."

Overall, this study strengthens the idea that VR can offer a high-quality representation that gives users a sense of "being there" (Dalgarno & Lee, 2010). This immersive and high fidelity experience led to students feeling more knowledgeable about specific STEM careers, creating a more detailed and accurate perception. The vivid and concrete visualizations also made it easier for students to imagine themselves in a particular job in the future. Students enjoyed learning about these careers through VR compared to reading about them because the students did not need to try to conjure up images in their head or rely on their own assumptions and existing knowledge.

RQ2: Perceived Challenges of Using VR Experiences for STEM Career Development

At the same time, there were challenges to learning through VR. Several students experienced physical difficulties with the VR experiences. They noted being "really nauseous" or "dizzy" and that their "neck…and back hurts…[from] trying to look at the sky." Two students also commented on the Google Cardboards being unsafe because you cannot see where you are walking, making it possible that you could "bump into a rock and tree." A few students commented that they preferred the iPad to the Google Cardboard because it did not make them nauseous or worried about bumping into things:

> Student: So, I was really nauseous.
> Student: We have to be careful.
> Student: You're going to bump into rock and into a tree.
> Interviewer: Did the nauseousness go down after a little bit or did it stay with you for the whole time?
> Student: No, it stayed with me.
> Student: Well, I was – I felt like it was a lot better than the iPad.
> Student: But I like the iPad because I didn't feel so nauseous.

These difficulties have been previously described in the literature; Sharples et al. (2008), for instance, title them "virtual reality induced symptoms and effects (VRISE)" (p. 58), while others have called it "simulator sickness" (e.g., Bouchard et al., 2009; Mourant & Thattacherry, 2000). The students reported that this made it difficult for them to enjoy the experience, and some said they preferred using iPads instead because it did not cause the same issues.

Several students also expressed a desire to have full mobility in the videos, so they could move around, rather than just turn their heads. For instance, one student said "It's cooler when you walk," while another said being able to move forward would allow for better learning because you can look at the environment up close. For several students, this inability to move clearly distinguished these videos from what they considered virtual reality. As one student said, "Normal VR, from what I've experienced, is you'll have to walk around sometimes."

A few students expressed diminished self-efficacy after watching the videos. One student, who watched the Google data center video, said:

> I realized running the servers, storage, and their personal stuff…it's really hard to maintain it because there's too many to maintain and all those servers, like there were at least a hundred, maybe thousands of servers because that was only one level. You also had to cool all those servers down, make sure they don't overheat, and then you had to also get into technical difficulties and then they also had to shred and make sure no one gets a hold of your information.

Other students said the video showed them how "complicated" and "too challenging" the jobs could be. Therefore, they did not feel capable of doing the jobs successfully and did not want to pursue them. This finding adds a consideration to the usual view that realism is a useful affordance of VR (Dalgarno & Lee, 2010). While realism should not be avoided, the finding implies that without a proper sense of self-efficacy, students can feel overwhelmed by the information. They may struggle to connect with a sense of confidence, especially if they are unaware of how they may develop into an older adult that has the necessary capabilities and skills and instead are projecting their current skill level and self-image onto the job they are learning about. As SCCT claims, self-efficacy is necessary to motivate an individual to pursue a career; without it, the individual may be less likely to see him or herself as competent and therefore decide not to pursue that career (Bandura, 1986; Lent et al., 2006).

Students also reported that the jobs in the videos were simply not the jobs they wanted. One student, for instance, said, "I don't feel like doing those types of careers." Another said, "I mean, [the jobs] looked cool but it's not something that I would do…I don't want to go to space." Instead, students would have liked to see videos about jobs like "video game designer."

In sum, the study results suggest the potential of VR for fostering STEM-related career development when the content is relevant. Students did report learning specific information about STEM careers from the videos. Some students also found the careers shown irrelevant to them, as in they were not interested in pursuing them, and so the videos were not as helpful or interesting to them. Therefore, while VR has the potential to be more intrinsically motivating and enjoyable to interact with (Dalgarno & Lee, 2010; Rueda et al., 2018; Shin, 2017), the content still needs to be geared toward students' interests. This reflects research within media studies, which finds that viewers pay more attention to media when the person featured seems similar to themselves (Ansager et al., 2006).

Limitations

We acknowledge that this study has several limitations. Firstly, as an exploratory study, we relied purely on focus group data. Although this approach may provide us with rich insights into students' perceptions, we are not able to quantify the impacts of the VR career-related experiences on students' outcomes. Future research may include the design of an experimental study to further explore the impact of VR-related interventions on students' career interest and self-efficacy. Second, we chose to deliver the VR experiences using Google Cardboards and iPhones but did not specifically ask the students to compare the immersive VR experience versus the 360 video experience. Therefore, although we received some students' comments about immersive VR experience being better spontaneously, we cannot generalize these comments. Lastly, because of the nature of the study design and the small size, we are not able to systematically investigate the individual differences in students' perceptions. Future studies can build upon the findings resulting from this study to select quantitative measures to assess the role of students' gender, prior STEM career knowledge, and prior experience with VR in their perceived usefulness of VR-related career exploration activities.

Implications for Research and Practice

The results of this study have implications for both research and practice. Further studies could be done on how to utilize the benefits of VR for delivering STEM career development as well as minimize the difficulties of using VR. For instance, it would be worthwhile to quantitatively measure the effects of exposure to STEM career-related VR experiences on students' STEM career identities, self-efficacy, and motivation, especially over time. Do these effects vary based on different types of content (e.g., showing the day-to-day life versus major events and highlights; showing multiple responsibilities versus a specific task; showing professionals with similar backgrounds to the viewer; showing a person who is leading the viewer through the experience versus first-person perspective with no main character)? Another question to explore is the transferability of skills: how, if at all, does exposure to VR experiences lead to real-life skills as well as education and career choices?

Studies could also investigate methods to minimize simulator sickness or understand who tends to be more likely to experience it. Regan (1995), for instance, found that nausea decreased, and even disappeared, for VR users by the third or fourth usage. Munafo et al. (2017) found that women at times experience greater incidences of motion sickness using Oculus Rift due to differences in body movement. These studies, however, tend to be with adults; studies are needed with children.

Lastly, future studies could investigate the interaction between VR content, students' prior knowledge about careers, and students' self-efficacy. Studies could pull on SCCT's concept of sources of self-efficacy (Ireland & Lent, 2018). Perhaps students need to see younger adults who are just beginning to acquire the training necessary to perform certain job skills, such as a college student, rather than seeing accomplished professionals such as NASA astronauts. This would allow them to have the process of developing into a particular career modeled, which could provide them with self-efficacy around their ability to work toward a career. Exploring such questions would help provide educators with information as to how to effectively integrate such career-related experiences into their classroom. An experimental design study with the learning outcomes measured can further investigate the value-added impacts of using VR on STEM career development compared with other approaches.

In terms of practice, the findings suggest that teachers consider the following points when using VR to deliver STEM-related career development. First, find videos that exhibit relevant careers to create engagement and interest; taking a survey of students' career interests before selecting content could be helpful. Second, provide different options for content delivery to students (e.g., iPads), given that immersive media experiences like VR can create physical side effects that inhibit learning. In addition, add experiences and information, or select videos, that account for students' current level of self-efficacy and career development, so as to avoid students feeling overwhelmed by particular careers.

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Declarations

Ethics Approval and Consent to Participate All procedures performed in this research, involving human participants, were in accordance with the ethical standards of the institutional and/or national research committee (Review Board of Social Sciences at University of San Diego, IRB approval number IRB-2018–468). An informed consent was obtained from all individual participants or anonymous data collection was used.

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Appendix 1

- Follow multiple women as they describe their different STEM careers (https://www.youtube.com/watch?v=X3Dakpctg3o&list=PLtXjQYxZuoesRs_lbyzMYutd-ojU2PQrJ&index=1);
- Tour a Google data center and learn about how it is taken care of (https://www.youtube.com/watch?v=zDAYZU4A3w0&list=PLtXjQYxZuoesRs_lbyzMYutd-ojU2PQrJ&index=2);
- Explore three additive manufacturing research labs (https://www.youtube.com/watch?v=AnqOFmC2n8s&list=PLtXjQYxZuoesRs_lbyzMYutd-ojU2PQrJ&index=3);
- Learn about Inna Braverman's career as a green energy entrepreneur (https://www.youtube.com/watch?v=uRtzWu5pfpQ&list=PLtXjQYxZuoesRs_lbyzMYutd-ojU2PQrJ&index=4);
- Travel alongside astronauts as they go about their day in space (https://www.youtube.com/watch?v=dwHBpykTloY&list=PLtXjQYxZuoesRs_lbyzMYutd-ojU2PQrJ&index=5);
- Discover the story of Tiera Fletcher, an African-American Boeing aerospace engineer (https://www.youtube.com/watch?v=wrtFLhwu168&list=PLtXjQYxZuoesRs_lbyzMYutd-ojU2PQrJ&index=6)

Appendix 2

Interview question	Theoretical link
1) What thoughts and feelings did you have during the VR experience?	Social cognitive career theory (SCCT): learning experiences and outcomes expectations
2) What did you learn about jobs from the VR experience? (a) How did the VR experiences teach you this? (b) Did this make you want to go into this job more?	SCCT: self-efficacy and outcome expectations through vicarious learning
3) What kind of job do you want to have? (a) Did you want this job before you saw the VR experience? Why? (b) Did the VR experience make you want this job even more?	SCCT: self-efficacy, outcome expectations interests, choice goals, choice actions Possible selves: hoped-for occupational and educational selves
4) Can you imagine yourself in this job? (a) YES i) Please describe how you imagine yourself in this job i) Did the VR experience help you imagine yourself in the job? (1) If so, why? (2) If not, why not? (b) NO i) Why can't you imagine yourself in this job?	SCCT and possible selves

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