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Article

Integrating and Assessing the Use of a "Makerspace" in a Russian Cultural Studies Course: Utilizing Immersive Virtual Reality and 3D Printing for Project-Based Learning

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Abstract

This article discusses the development of an immersive virtual reality (VR)-infused Makerspace for experiential learning. Students in an advanced-level Russian course used a Makerspace to complete a three-part project aimed at language and cultural learning through art and presentational speaking. Participants completed a survey about their experience at the end of the project, thus providing some data by which to assess its success. Students used Oculus Rift headsets to view 360-degree target-culture images and engaged in a hands-on sculpting activity that resulted in printing 3D models. Learners also used iPads for a painting activity, which was then compared with the VR sculpting task. The survey results showed that the Makerspace, and using VR in particular, was a success. Positive outcomes included facilitating task motivation, fostering speaking and artistic creativity, enabling deeper learning and focus on the task, assisting with cultural development, and enjoying learning by doing/making. Suggestions for future Makerspace projects in language labs are discussed.

KEYWORDS: immersive virtual reality, Makerspace, project-based learning, computer-assisted language learning.

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Introduction

Unlike desktop virtual reality (Merchant, Goetz, Cifuentes, Keeney-Kennicutt, & Davis, 2014; see Chun, Kern, & Smith, 2016 for a discussion of desktop virtual environments such as Second Life for language teaching), research on immersive virtual reality in educational contexts is only just beginning (Jensen & Konradsen, 2018). Immersive virtual reality, which we abbreviate throughout as VR, refers to virtual reality that uses a head-mounted display (HMD) device. Educators have suggested that VR can assist with student engagement, collaboration, and discovery learning (Alfalah, 2018), and can also create an environment that is more memorable, and that leads to better recall as compared to learning from traditional/desktop platforms (Krokos, Plaisant, & Varshney, 2019). Indeed, promising results for VR have been shown for various educational domains, such as in science education (e.g., Markowitz, Laha, Perone, Pea, & Bailenson, 2018), although research in the humanities-based disciplines, and particularly for languages, remains very limited.

The particular characteristics of VR are able to provide significant opportunities for experiential learning (e.g., Schott & Marshall, 2018), due to the sense of immersion and presence it provides (Freina & Ott, 2015; Ryan, 2015). Users of VR find themselves in a completely different world, complete with sights and sounds, and they experience the feeling of actually "being there" (Heeter, 1992). In light of this unique quality, Lloyd, Rogerson, and Stead (2017) discuss various affordances of VR for language teaching, which include enhanced learner engagement with content, placement of students in contextualized and real-life/target-culture environments, and the ability to verbally interact with others via "social VR" platforms. Indeed, engaging with content through virtual field trips (i.e., being immersed in 3D 360-degree videos and/or images) has been a topic discussed in recent language learning literature (e.g., Pilgrim & Pilgrim, 2016; Xie, Ryder, & Chen, 2019). For example, Xie and colleagues (2019) qualitatively examined Chinese language learning with Google Cardboard HMDs by asking students to act as virtual tour guides for one another while using Google Expeditions (360-degree images). Findings indicated several advantages of VR: it increased interest in learning, facilitated exploration of cultural topics and use of sophisticated vocabulary, and helped to ease nervousness related to presentational speaking.

Unlike the Google Cardboard viewers, higher-end HMDs feature more immersive qualities; they include hand controllers that can mimic the act of touching or grabbing, and they can rotationally and positionally track one's head and hands, thereby increasing the range of movement from three degrees of freedom to six degrees of freedom. These HMDs (e.g., Oculus Rift, HTC Vive, and Oculus Quest) are becoming increasingly more affordable

(Radianti, Majchrzak, Fromm, & Wohlgenannt, 2020). Some studies in language teaching and learning have used these six degrees of freedom systems, with important results. For example, Legault and co-workers (Legault, Zhao, Chi, Chen, Klippel, & Li, 2019) found that specifically for less successful learners, learning Chinese vocabulary through VR led to better word recognition as compared to learning through word-word associations. Similarly, Cheng, Yang, and Andersen (2017) found that physically being able to move in a game geared toward Japanese language learning heightened the sense of presence and learners' ability to express cultural awareness, while Vázquez and associates (Vázquez, Xia, Aikawa, & Maes, 2018) illustrated how the platform Words in Motion can enable learners to encode vocabulary items through physical actions, with their study showing that kinesthetic movement in VR (as compared to traditional/2D learning and learning in non-kinesthetic-based VR) yielded significant gains on a delayed post-test—that is, even after the novelty of VR had worn off. Finally, Enkin (under review) looked at the integration of social VR activities in an advanced-level Spanish course, and found that, as compared to face-to-face dialogues, social VR conversations led to fewer feelings of self-consciousness, were perceived as more fun, and enhanced learners' speaking experiences through various interactive environments.

Given VR's affordances of immersion and presence, the use of VR also has important pedagogical implications for project-based language learning activities. These activities include presentation-style, visual, real-world, and cultural-based projects (Chao, 2013). A "Makerspace," which can be defined as a space dedicated to collaboration and product creation through both digital technologies and handicraft (Andersson, 2014), can take these projects a step further by facilitating student-centered learning through hands-on creation that supports creativity, innovation, and interdisciplinary connections. Makerspaces can therefore allow learners to combine language skills and digital tools, in order to make artifacts, such as creating an animatronic diorama with a digital story (e.g., Bull, Schmidt-Crawford, McKenna, & Cohoon, 2017). By building communities of practice around the creative process of making, Makerspaces foster the sharing of knowledge and are a product of "Maker culture," a movement that caters to hobbyists and encourages do-it-yourself projects, as well as the integration of new technological applications (Kuznetsov & Paulos, 2010). Although Makerspaces come in various forms and are often seen in community areas (see Sheridan et al., 2014), their role in formal education continues to be explored (Halverson & Sheridan, 2014). By engaging learners' senses in ways that are different from traditional classrooms, and therefore afford new cognitive processes, Makerspaces can open new learning pathways that may otherwise be unavailable, and the act of making can also help learners bring their own personal identities to schoolwork (Kafai, Fields, & Searle, 2014). We therefore hypothesized that a Makerspace could be successful in the context of a university-level language course, which prompted the project we discuss in this article.

"Russian Through Art": A Makerspace Course Project

We set out to create and explore the benefits of a VR-infused Makerspace in our language lab for an advanced (third year) level Russian course titled "Russian cultural studies." The class, which is taught in Russian and intended for Russian majors and minors, focuses on contextualizing the study of language and culture through art. It therefore enables students to examine a wide variety of Russian art masterpieces, different genres and their characteristics, various artists and artistic movements, and the historical context in which artists lived and worked. One of the course's overarching goals is vocabulary acquisition for productive/functional target-language communication.

We created a Makerspace for the project-based learning approach to the course's three-part final project, which was carried out over the course of the semester through visits to the language lab. The project activities were primarily narration- or storytelling-based and were designed to encourage vocabulary acquisition, to advance students' communicative skills and cultural competence, and to promote authentic engagement with the target language. Presentational speaking seemed to be the most natural communicative mode to target in this project, not only because we wanted to incorporate oral presentations into a final project (as is frequently done), but also because of the nature of our activities. That is, students would be in VR HMDs individually (the apps we chose for our project's needs were single-user experiences), and we also developed two hands-on art activities that were innately solitary in nature (painting and sculpting). Thus, we believed that individual oral presentations directly following these activities would be most natural. The project therefore aimed to facilitate active learning strategies that foster critical thinking skills and a deep learning experience of the content, as well as enhancing learner motivation (see Grunert O'Brien, Millis, & Cohen, 2008; Nilson, 2016).

The project was grounded in experiential language learning (see Mollaei & Rahnama, 2012), which has been shown to be potentially more beneficial than traditional language teaching (see, e.g., Sharifi & Shariati, 2017). In experiential learning, learners directly engage with, and then reflect on, an experience (Kolb, 1984). Thus, the frequent involvement of hands-on work within an experience (see Wurdinger & Carlson, 2010) makes a Makerspace particularly conducive to facilitating experiential language learning opportunities and enhancing student engagement (see Alley, 2018). Because the project was carried out over the course of the semester in our Makerspace, it enabled an experience–reflection cycle in the lab, where students informally reflected on experiences after their activities. Reflection was further facilitated in the two hands-on activities described above, where students were asked to create and then explain their own artwork in the target language. In addition, students reflected on their experience as a whole in an end-of-project survey, which also served as our project assessment tool.

A VR-Infused Makerspace: Activity Space Layout and Procedures

Given the presence and immersion levels that are possible with VR, as discussed earlier, we used an Oculus Rift headset (a six degrees of freedom VR HMD system) to support experiential learning. Within the project's activities, students could therefore be transported to target-culture locations to discuss artwork they viewed, and they could also engage in learning by doing as they created and explained their own artwork. This use of VR was intended to further promote language learner motivation (see Fransson, Holmberg, & Westelius, 2020; Kessler, 2018), which could enhance creativity both in students' artwork and in their speaking.

As mentioned above, we utilized the language lab to create a VR-infused Makerspace for our Russian learners. The lab consists of three rooms—a lounge, a classroom outfitted with video conferencing technology, and a room that has been named the "innovation workroom." The innovation workroom is devoted to project-based language learning activities and was utilized for each VR/lab session. Before the project began, students attended a lab orientation session (by individual appointment) that involved completing the Oculus First Contact tutorial, which oriented them to the VR HMD and hand controllers. Each part of the project thereafter was held during a one- to two-day span (depending on the stage of the project), taking the place of one class day each week.

More specifically, the VR activities were conducted in a space located within the innovation workroom that had been allocated as an "XR (extended reality) space." This area is approximately 3 meters × 3 meters and houses a VR-capable PC, a large screen, an Oculus Rift HMD, and easily movable furniture so that students can participate in seated, standing, and room-scale VR experiences and apps. Figure 1 illustrates the XR space and showcases the use of the Oculus Rift headset.

Because each phase of the project was different, the procedure varied slightly with each lab session. For the first activity, students used an online poll to sign up for a one-hour time slot in small groups (three students per time slot). Once in the lab, they took turns individually using the VR HMD in the

Figure 1. A demonstration of using the Oculus Rift HMD in the XR space. The user is utilizing the Oculus Medium app (the VR sculpting app used in this project), and the computer screen behind them is displaying the HMD view.

XR space. While students waited to use the equipment, they remained in the lounge where they could prepare for or talk about the activity together, and they could also discuss their experience afterwards. For the second activity, which did not utilize VR, students signed up for a 15-minute time slot (up to two students per time slot). They completed the "Making" component of the activity in the lounge during these 15 minutes, and then they individually used the XR space for their presentations. During this time, another pair of students could get started on the "Making" part in the lounge. Finally, for the third activity, which utilized VR again, each student reserved the XR space for 30 minutes (one student per time slot). In instances where there was overlap between appointments (if students ran over their allotted time), students would wait in the lounge until the XR space became available. Because this part of the project took the most amount of time, it was spread across two days.

Project Activities

As noted above, there were three parts to the final project. Each part concluded with a student oral presentation that was filmed and shared with the instructor of record for grading purposes. In order that each part should run smoothly for students, we needed to implement particular workflows at our end. These workflows also showcase our own involvement in the Makerspace community that we aimed to create. Specifically, the workflows were developed by the language lab manager, who has an IT background. Relatedly, Enkin and Kirschling (forthcoming) discuss the changing role of the language lab manager in light of emerging technology and its place in language programs. They explain that a generalized IT background as well as knowledge of web app development is key expertise that may be helpful for a lab manager to possess. By detailing the steps of our workflows below, we hope that those with and without an IT background may be able to find this information useful for future Makerspace projects.

Part I: VR 360-Degree Museum Experiences

The first part of the project consisted of an introductory stage, which would ultimately lead to the "Making" parts of the project. This preparatory stage involved both prepared and spontaneous speech. For prepared speech, students would use VR to view the Large Italian Skylight Room in the Hermitage Museum in St. Petersburg, Russia. To prepare for their virtual experience, students explored the room on their own by visiting the 360Cities website on a desktop/laptop or mobile device (www.360cities.net/image/the-state-hermitage-museum-st-petersburg), which offers a view of the room, and is the same image as that used in the VR HMD. This was done so that students could familiarize themselves with the art pieces in the room in their own time, and so they could then choose two paintings (or one sculpture and one painting) to focus on in more detail for their presentation. Additionally, they had to locate their selected artwork on the official Hermitage website, which offers detailed descriptions of the works in Russian (https://pano.hermitagemuseum.org/3d/html/pwoa/main/#node28). When they were in VR, students described what they saw in the room and discussed their selected pieces in Russian for four to five minutes. For spontaneous speech, students entered a different room in a different Russian art gallery in VR, and narrated their experiences, including what they saw and how the art pieces made them feel, for three minutes.

In the spirit of Maker culture, we decided to use our own footage and open educational resources for the spontaneous speech component. Thus, the image that students viewed was a room in the Sampilov Museum of Fine Arts in Ulan-Ude, Russia, which had been extracted as a still frame image from a 360-degree video recorded by a graduate student with the lab's 360-degree camera. A workflow was designed to extract the still frame image from the video and make it viewable using the Oculus Rift headset. It consisted of blending the stitch lines from the 360-degree recorded video, changing the video projection format, adding a stabilization effect in order to counteract shakiness from the footage, and exporting one still frame as a viewable image. Finally, the exported image was viewed within the Rift using the Oculus 360 Photos app.

Part II: iPad-Based "Making"

Part two of the project was the first of two "Making" activities. The activity focused on 20th-century art. Students were asked to produce their own artwork in line with the movements they had studied in class. To prepare, students chose one of the following movements: Abstract art (represented by Kandinsky), Rayonism (represented by Larionov), Constructivism (represented by Tatlin), and Suprematism (represented by Malevich). They were also asked to research the movement, the artists representing it, and their artwork. During the lab session, each student used one of the iPads and styluses available in the Makerspace to create their own artwork using the iOS Notes app, in line with their selected movement. When ready, they described their paintings in Russian. They were instructed to include the following elements in their descriptions: discussion of the movement and other background information that inspired the piece; the meaning and symbolism behind their creations; and links to personal experience. Students' paintings were saved digitally and were also printed out in color at the end of the session. The paintings were then given to the instructor for incorporation into a subsequent follow-up communicative activity in a later class session.

Part III: VR-Based "Making"

Part three involved the final "Making" activity. Students used the Oculus Medium digital sculpting VR app (which is now Adobe Medium) to create/sculpt their own artwork in a manner that was in line with any artistic movement or a combination of several movements discussed in class. Since there was only enough time in the curriculum for one sculpting session, we thought it might be easier if students worked on a blank Russian nesting doll 3D model that was imported into the Oculus Medium app at the beginning of each sculpting session (although two students decided to start from scratch). Students were then free to sculpt and decorate the blank model as they liked, or to recreate the shape completely, as many did. Note that there was fundamentally no difference between starting from scratch and recreating the shape; however, due to the novelty of the project, we believed that students might be less overwhelmed if they were able to start with a template. As with the iPad activity, students came prepared to describe in detail in Russian the various elements of their sculptures, the movement(s) and other background information that inspired their work, the meaning of their piece and symbolism behind it, and links to personal experience.

Students' artwork models were 3D printed by the lab manager (outside of class time) in the lab, so that students could have souvenirs of their work. Once again, a workflow was developed to accomplish this. It consisted of exporting each student's sculpture from the Oculus Medium app as a 3D model file, prepping the file for printing (e.g., adjusting size and position of the model, adding support structures to ensure a successful print), saving the printing preparation settings into an accompanying file, and transferring both files to the 3D printer. The average print time was about three to four hours per model. When the models were printed, students came to the lab in their own time to pick them up.

Project Assessment: Design

Guiding Assessment Topics

Given the novelty of creating a VR-infused Makerspace that also resulted in 3D printed models for a language course, our assessment topics were broad. Based on the results of an end-of-project student survey, we examined how well our Makerspace worked according to (1) self-reported ratings of VR activities, including overall perceptions of activities, as well as differences in ratings with respect to motivation and creativity for VR and non-VR/iPad "Making" activities; and (2) main themes that emerged from the open-ended responses regarding VR-related learning experiences.

During the last two weeks of the semester, after the project was completed, participants completed the end-of-project survey online (through Qualtrics). The anonymous survey was optional, but seven students (age range, 19–28; average age, 22; four Russian majors and three Russian minors, all native English speakers) completed it. The survey questions collected some background information, and asked participants for their perceptions of the Makerspace project via two quantitative Likert-scale questions and eight qualitative open-ended questions.

Student Participants

Six students were graduating during the academic year of the project, while one was graduating the following year. Prior VR experiences (i.e., before the course) were mixed: two students had never used VR, three had experienced low-end mobile (i.e., smartphone/tablet) VR apps with only three degrees of freedom (and one student specifically indicated very little usage of this type of VR), and two had used six degrees of freedom VR (one had used a painting app, and the other was currently using VR for a computer science senior project). Although one student noted liking VR the same before and after the project, the remaining six participants all noted positive changes in their attitudes (which were due to the experience with the project and not to any negative perceptions based on previous experience); they now thought VR was impressive, intuitive, interesting, fun, that it contributed to their learning, and that more people should have access to it.

Survey: Design

The first quantitative question contained six statements regarding the participants' overall perceptions of VR activities (discussed below and in Table 1), and the second contained three statement pairs (six statements in total) asking participants to compare their iPad painting and VR sculpting experiences in terms of motivation and creativity (discussed below and in Table 2).

The open-ended questions asked participants to discuss their favorite and least favorite aspects of using and being in VR (as compared to more regular types of course activities); the specific VR activity that was their favorite; thoughts on viewing paintings in VR and any differences in prepared and spontaneous speaking tasks; thoughts on the VR sculpting activity and if/how it facilitated speaking practice and learning by doing, and how it compared with the iPad painting activity; difference in interest levels when it came to printing out iPad paintings versus 3D printing VR sculptures; overall thoughts on whether using VR can be a successful platform for developing language skills and cultural knowledge; any suggestions for VR activities, and for incorporating them into the current class and future courses; and any additional comments.

For the first guiding topic, we examined the results of the quantitative questions. To ensure internal reliability, Cronbach's alpha was also calculated for the first quantitative question asking about overall perceptions of VR activities. For the second guiding topic, the open-ended responses were analyzed for pertinent themes that emerged.

Project Assessment: Findings and Discussion

Student Ratings: VR Activities in a Makerspace

The quantitative findings illustrate the overall success of experiential learning through the VR Makerspace activities, as reported by students. Tables 1 and 2 show percentages of responses for each of the Likert categories (rounded to the nearest whole number) and mean ratings. In Table 1, ratings were mostly at the 4—agree and 5—strongly agree levels, with mean ratings for all statements ranging from 4.29 to 4.86 (average: 4.55); a Cronbach's alpha analysis indicated internal reliability ($\alpha = .84$). While the high ratings point to an overall

Table 1
Overall Perceptions of VR Makerspace Activities

Statements	1 Strongly disagree	2 Disagree	3 Neutral	4 Agree	5 Strongly agree	Mean ratings
I enjoyed experiencing museums in virtual reality as part of a Russian course.	0%	0%	14%	14%	71%	4.57
Viewing paintings in virtual reality was useful for my ability to speak about cultural (art) topics.	0%	0%	0%	43%	57%	4.57
I enjoyed using the Oculus Medium app to sculpt in virtual reality as part of a Russian course.	0%	0%	0%	14%	86%	4.86
Creating artwork (a sculpture) in virtual reality was a helpful way to express course concepts.	0%	0%	0%	71%	29%	4.29
I enjoyed practicing my Russian when discussing my sculpture in virtual reality.	0%	0%	14%	29%	57%	4.43
Including various virtual reality activities in Russian courses would act as a motivator to continue learning.	0%	0%	0%	43%	57%	4.57

positive and helpful experience, the highest rated statement shows enjoyment experienced with VR "Making" specifically.

When looking at the "Making" (sculpting) component in Table 1 more closely, the discrepancy between levels of enjoyment (statement 3) and usefulness (statement 4) is an interesting point to highlight. That is, although most students strongly agreed that they enjoyed sculpting, most of them agreed—but

Table 2
Comparisons of VR and iPad "Making"

Statements	1 Not at all	2 Slightly	3 Somewhat	4 Moderately	5 Extremely	Mean ratings	Mean rating differences
(1a) I was motivated to create a piece of artwork (a painting) on an iPad.	0%	0%	14%	43%	43%	4.29	0.57
(1b) I was motivated to create a piece of artwork (a sculpture) in virtual reality.	0%	0%	0%	14%	86%	4.86	
(2a) I was motivated to speak about culture (art) when creating a painting on an iPad.	0%	0%	14%	43%	43%	4.29	0
(2b) I was motivated to speak about culture (art) when creating a sculpture in virtual reality.	0%	0%	14%	43%	43%	4.29	
(3a) Painting on an iPad facilitated a feeling of creativity for the task.	0%	0%	29%	29%	43%	4.14	0.72
(3b) Sculpting in virtual reality facilitated a feeling of creativity for the task.	0%	0%	0%	14%	86%	4.86	

not strongly—that it was a helpful way to express course concepts. This discrepancy may in fact indicate the novelty of making itself, and of experiential learning as a whole. Students may not be accustomed to this type of learning, causing them to be more cautious in how they approach its usefulness (although its usefulness was still rated quite high). Indeed, one student explicitly noted the "different" nature of experiential learning with VR in an open-ended comment (see the next section). As teachers develop more types of Makerspace projects, student perceptions regarding their usefulness may become even stronger.

Table 2 further showcases the VR sculpting activity's success as compared to the iPad painting activity. While these activities were rated the same (both relatively high), when it came to motivation to speak about art, there was a numerical preference for VR sculpting over iPad painting with respect to facilitating creativity and motivation for the task. It is therefore important to underscore the beneficial nature of combining both "Making" and VR together when creating experiential learning opportunities for students. That is, being fully immersed in a 3D environment where one can use six degrees of freedom to freely create artwork is likely one of the critical factors driving creativity and motivation for the task. In fact, the primary reason behind our choice to use such a comprehensive VR sculpting app for our project was to maximize task creativity. Indeed, several of the open-ended comments point to full immersion being able to assist with increasing focus on task and self-expression; for example, one student's comment adds further context to the powerful nature of sculpting in a 3D space, saying that "it gives you a chance to really work and zoom and edit and fix things the way you want it to be." Further student reactions will be discussed in more detail in the next section.

Student Voices: Learning Experiences in a VR-Infused Makerspace

Five themes emerged from the participants' open-ended responses: (1) VR sculpting facilitates experiential learning; (2) VR assists with vocabulary recall and speaking improvisation; (3) viewing museums in VR assists with cultural development; (4) VR sculpting is highly enjoyable and the resulting 3D printed model is exciting; and (5) VR activities may also need to incorporate interpersonal communication. Each theme is discussed below.

The first theme indicated that VR sculpting successfully facilitated experiential learning. It was particularly effective in enabling deeper learning of content and focus on the task, and in fostering creativity in speaking and artistic expression. Representative examples of student opinions from different participants about each of these facets include the following.

> "We would talk about [content] in class, but actually doing it helped me retain more and understand it better."
>
> "Being in VR completely removed distractions and I was able to more completely focus on the activity."
>
> "It definitely facilitated my speaking practice by letting me talk as I worked."
>
> "I liked being creative and trying to tie vocab to my art."
>
> "It was great to see students sculpt things besides a matryoshka and be able to express themselves."

An interesting point can be made about the third comment above, because it suggests that the immersive quality of VR, and the focus on the task it facilitates, may also support "private speech" or self-talk in the target language, which is a component of sociocultural theory that refers to talking out loud to oneself for self-regulation purposes. Private speech, in the first or target language, can be instrumental in helping to mediate thinking and learning (Lantolf, Thorne, & Poehner, 2015). Lastly, and taken all together, this theme also highlights that sculpting made way for freedom of expression, which is an affordance of an educational Makerspace (e.g., Halverson & Sheridan, 2014). Figures 2–5 show several examples of the different sculptures that students

Figure 2. The sculpture "Russian girl with a toy and a bear" was created as an ironic depiction of Socialist realism. It features black, gray, yellow, red, and blue colors.

Figure 3. The sculpture "Karl Marx" was inspired by the art movement of Rayonism. It features blue, pink, green, and black colors.

Figure 4. The sculpture "Vase" represents the art movement of Expressionism. It features white, yellow, green, and black colors.

made (both the VR version in color and the 3D printed model counterpart, which was printed using a neutral color filament so that students could paint their sculptures if they liked).

Figure 5. The sculpture "Orange cat" was inspired by Russian Abstract art. It features orange and black colors.

The second theme showed that VR was instrumental in vocabulary recall and speaking improvisation. For example, one student stated that the sculpting activity made "consulting [paper] notes impossible," thereby "forcing [them] to speak using only vocabulary [they] know." Thus, speaking in this type of immersive environment may be helpful in supporting learners to more confidently employ communicative strategies such as circumlocution and rephrasing when limitations in vocabulary are present, which is a goal for advanced speakers according to the proficiency guidelines for speaking outlined by the American Council on the Teaching of Foreign Languages (ACTFL, 2012). Another student added, "I do think that the act of sculpting takes long enough and has enough changed that the pre-prepared scripts can be flexible and require you to think on your feet before finally presenting." Interestingly, this result of needing to be flexible illustrates the varied nature of outcomes that participation in an experiential learning project can produce (e.g., Wurdinger, 2005).

Further supporting the second theme, another student's comment also showcased that being in VR encouraged taking more chances and being more flexible with speaking and vocabulary choices, while also causing less stress when speaking:

> In a weird way, having the headset on your face made it less intimidating. You know you're being recorded and talking about things but, when you're in VR it doesn't

> feel like it and it makes it less nerve-racking. Yeah, there is that handicap you can't look at your notes if you forget a word but it lets you improvise.

Indeed, Enkin (under review) also found that language learners can be less nervous when speaking in VR through an avatar as compared to in real life, and Xie and associates (2019) found that presenting while viewing 360-degree images in VR alleviated language learner nervousness as well. This is an important finding, given that language students often experience anxiety regarding the skill of speaking (e.g., Horwitz, Horwitz, & Cope, 1986; Phillips, 1991; Price, 1991; Young, 1990; Zheng & Cheng, 2018), while language majors and teachers have also identified that language programs' preparation in speaking specifically is very important but is the most lacking of the four skills (Enkin & Correa, 2018). Interestingly, and on a related note, the spontaneous speaking task for the VR museum activity (a task that relied on improvisation and may have generated a higher stress level) did not create much stress either (only one student noted it was more stressful than the prepared speaking counterpart task). Students explained that they were "less stressed … because [they] just had to wing it," and that they "enjoyed exploring speaking [their] mind."

The third theme illustrated how the experience of viewing museums in VR assisted with students' cultural development. As one participant noted, "I enjoyed viewing paintings in VR as it felt as though I was really there as opposed to looking at the 2D image in a book." Another student also explained:

> Using virtual reality to visit museums is perfect for a class about art in another culture. We don't have access to Russian art here, and getting to virtually visit a Russian museum is a great way to engage students. The prepared speaking is nice because it allows us to comfortably talk about a painting. The unprepared [spontaneous] speaking in virtual reality not only tested our speaking ability, but gave us the chance to explore the museum and think critically about the paintings we saw.

This result echoes the finding of Xie and co-workers (2019), where viewing images in VR caused learners to experience enhanced interest and passion for target locations and cultures.

The fourth theme showcased the high level of enjoyment associated with the VR sculpting activity. Students noted that it was "exciting" and "fun," and that it was their favorite part of the project, thereby highlighting an emotional connection with the activity, which has been shown to facilitate a lasting learning experience (Nilson, 2016). This result supports findings by Enkin (under review), where the six degrees of freedom VR environment added a fun element to target-language speaking experiences. It also echoes research showing that in comparison with more traditional teaching conditions, VR can enhance positive emotions (Allcoat & von Mühlenen, 2018). One illustrative comment explains enjoyment experienced from the task, and how enjoyment might also affect motivation level:

> I think the VR sculpting was also extremely effective at garnering motivation for the project, as a lot of students wanted to do the project because it was fun and something different and exciting. It was easier to talk and prepare for a project when students were looking forward to it.

The 3D model that resulted from sculpting was also viewed as exciting, as is demonstrated by the following representative student comment: "The sculpting was amazing and fun and I am beyond excited to have a 3D doll of my own creation."

The fifth theme illustrated an area of project improvement, namely, that VR activities could incorporate more interpersonal (rather than presentational) speaking opportunities. One participant's comment is representative: "I think [VR] might be more useful for language, if there were … spaces where we could interact with other Russian speakers." This suggestion therefore might highlight why in the quantitative results, there was no numerical difference between motivation to speak for the iPad and VR "Making" activities. In order to broaden communicative goals and strengthen the experiential learning aspect (see, e.g., Mollaei & Rahnama, 2012; Schott & Marshall, 2018), one revision to the current project could therefore be to use an app such as SculptrVR, where pairs/groups can sculpt together and talk; students' artwork could also be 3D printed.

Conclusion and Pedagogical Implications

Our VR-infused Makerspace pedagogy proved to be a success for learners, facilitating student engagement, creativity, and excitement for a project that integrated making, critical thinking, culture, and presentational speaking within an experiential learning frame. One student noted this success by describing the project as follows: "Super interesting! I think the whole project was a success in terms of getting students excited and motivated, and providing new ways to help students learn." Presence in VR also increased enjoyability for the "Making" activity, brought a deeper learning experience to students while enhancing focus on task, and improved cultural development. Importantly, the immersive setting also liberated students from relying as much on notes or flashcards when speaking and recalling vocabulary, while also encouraging creative use of the target language and lessening stress around presentational speaking. Learners truly became artists and used the target language and cultural knowledge for self-expression through six degrees of freedom VR sculpting and through being placed into authentic target-culture environments, both of which are difficult, if not impossible, to recreate in traditional classroom settings. This project therefore has significant pedagogical implications, as it removed certain limitations found in traditional instruction.

Incorporating more "Making-type" projects into language programs may have a profound impact on both students and the curriculum, as they can enable the use of language skills in various art or animation story-making/storytelling activities (see Bull et al., 2017; Reinders, 2011), which can connect to cultural content. Indeed, Makerspace projects can connect well to the primary goal of both language and cultural learning by placing students in learner-centered environments where both language and culture can come together in meaningful, authentic, and personalized ways. In other words, learners are able to take ownership of their language and cultural understanding by actively interpreting and forming a deep understanding of cultural knowledge, and then being able to express this understanding in the target language through the power of experience and creation.

Moreover, a Makerspace can offer students the advantage of a designated area for projects that encourage learning through making, creative play, and VR (see Yamada-Rice, Rodrigues, & Zubrycka, 2020). It is therefore important to begin exploring and examining various VR apps and activities that can be used within Makerspaces, especially because different pedagogical approaches will require different VR educational content (Jensen & Konradsen, 2018). Future larger-scale studies can thus go beyond this small-scale pedagogical report, where number of participants is an inherent limitation, by creating and testing various VR activities in lab-type Makerspaces. Assessment should go beyond project perceptions to measures of other learning outcomes. Educators should also be cautious when choosing VR apps, as it is important to avoid any cognitive overload that might interfere with learning (see, e.g., Makransky, Terkildsen, & Mayer, 2019). Likewise, there are additional challenges associated with VR, such as cybersickness, and others related to curricular, pedagogical, and administrative integration (see Fransson et al., 2020 for discussion). This includes monetary barriers as well as technological issues related to ease of use, the need for technical support, and opportunities for professional development. It also encompasses concerns centering around organizational and practical issues, such as class size and activity design, space accommodations, and the appropriate integration of activities into the larger frame of curricular content and goals, expected learning outcomes, and assessment.

By detailing our process and findings, as well as the tools used, we therefore hope to inspire ideas for new as well as pre-existing Makerspaces. The suggestion regarding implementing interpersonal communication activities in VR-infused Makerspaces can also point others to new directions. Additionally, creating and assessing "come-and-go" or drop-in autonomous learning Makerspaces that cater to more collaborative tasks, or to larger, longer, and more self-paced projects (e.g., senior-type capstone projects) may also be explored. Indeed, one student's suggestion regarding time in our Makerspace (i.e., wanting "longer times to work" in VR) further highlights the potential need for a more flexible working arrangement.

Thinking beyond the activities discussed in this article, we have several suggestions for VR-infused Makerspace projects, which other instructors might want to consider. For example, Makerspaces with video production equipment (360-degree cameras, green screens, studio lighting) can be used by students to film and produce in-lab or target-culture location-based group drama activities. These 360-degree videos could then be viewed in 3D using a VR HMD or in 2D on a screen. Additionally, teachers may want to use Quill, which is an immersive VR app that enables students to illustrate and animate scenes, for an individual or group storytelling-based class project. The project could be done throughout a semester (or could even be expanded into a capstone project), and could be instrumental in targeting cultural understanding of specific course content such as popular culture. Another idea, which might work especially well for language for specific purposes courses, is for an instructor to design a simple making tutorial/guide in the target language (tailored to the appropriate proficiency level), and ask students to work individually or in groups to follow each step. Their creation (which could be in either digital form or a physical 3D model) could be used to assess how well they understood the directions, and additional language components such as storytelling could also be incorporated into the assignment. Lastly, another activity could be as simple as asking students to create and print 3D props or cultural artifacts for a class activity such as a role play. Students could even 3D scan a cultural artifact, and then import and modify it within a 3D modeling app.

Given the rapid advancement of technology, it is important to provide students with valuable digital literacy skills in the form of hands-on experience with tools such as VR and 3D printing. This type of technological integration into language programs can assist students in learning how to use these new technologies, and it can also aid with the language learning process itself. In fact, Enkin and Kirschling (forthcoming) review how language labs can play a new and critical role in bringing emerging technology to language students, and how the technology can be used to develop the three communication modes in novel ways. Kessler (2018) also discusses how newer technology can enable students to be placed in truly contextualized/authentic, meaningful, compelling, and motivational contexts that optimize language learning within project-based frames, and how technology-enhanced activities can facilitate individualized and robust learner-centered experiences as well.

Not only can emerging technology keep students focused and interested in tasks, but it can also help to build transferable technological literacy skills (see Blikstein & Krannich, 2013). These are important for students' futures, given that Makerspaces themselves are expanding into career and professional domains (Hui & Gerber, 2017). Indeed, Makerspaces can assist learners in developing critical professional skills, such as project management and development, team collaboration, and innovative and flexible thinking, and can serve as platforms to create connections with companies for internships and career opportunities (dos Santos & Benneworth, 2019). Thus, Makerspaces not only lead to strong interpersonal skills and interdisciplinary connections, but also to shared experiences where active learning strategies rather than traditional instruction is the norm.

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