MAKING VIRTUAL REALITY ACCESSIBLE FOR LANGUAGE LEARNING: APPLYING THE VR APPLICATION ANALYSIS FRAMEWORK

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Abstract

Virtual Reality (VR) is a valuable tool for learning, however, there is a lack of education-focused content for language learning needs. This article introduces the *VR Application Analysis Framework* (Lege, Bonner, Frazier, & Pascucci, 2020) to assist educators in scaffolding existing commercial off-the-shelf (COTS) applications for use in classroom activities through four key lenses: *immersive capacity*, *cognitive load*, *purpose*, and *communicative capability*. The framework is then used to analyze the strengths and weaknesses of an example COTS VR application, *Tilt Brush*. This analysis, completed using the framework, is followed by three lesson plans for *Tilt Brush* that demonstrate how VR could be used in the language classroom.

Keywords: virtual reality; VR Application Analysis Framework; immersive capacity; communicative capability; CALL; *Tilt Brush*

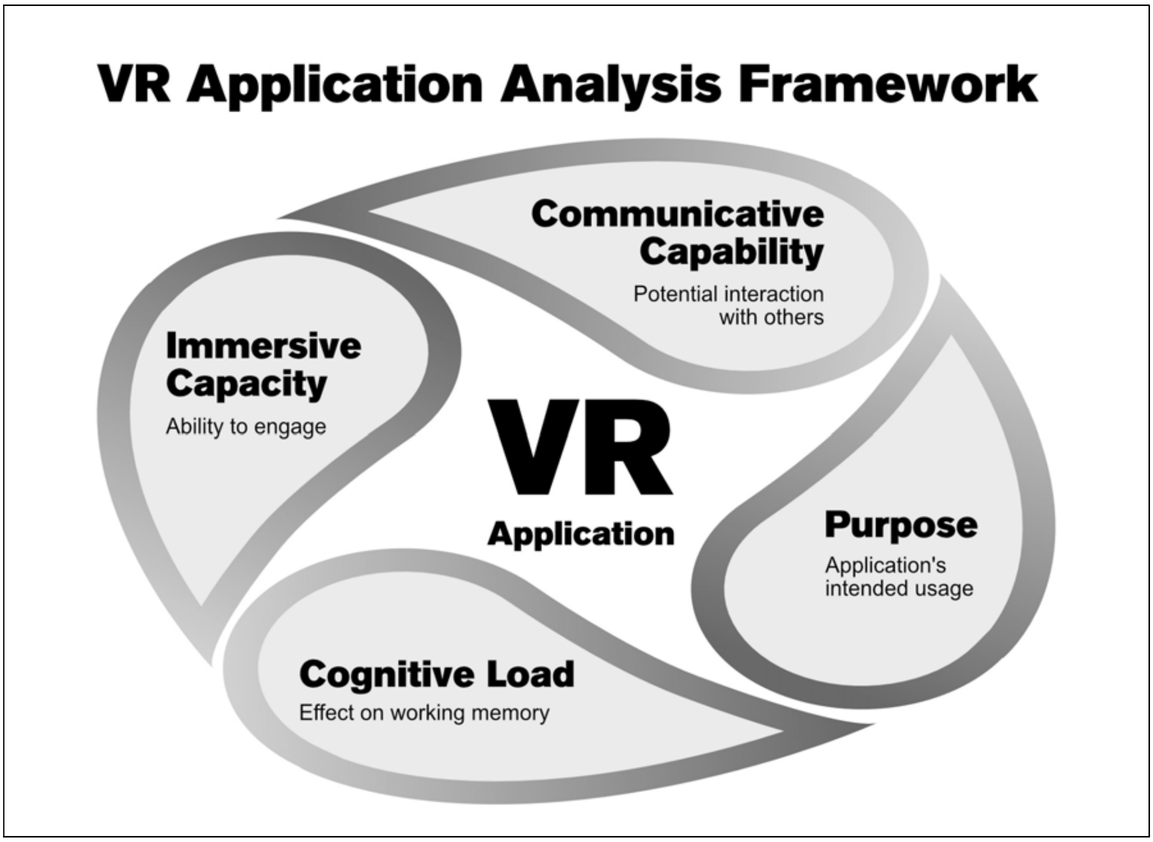
1. Introduction

Virtual reality (VR) has rapidly become more affordable and easier to use in recent years, making it both accessible and obtainable for average consumers. VR can also be found in increasingly varied contexts, including educational fields such as science, engineering, and even language learning. Particularly for language teaching, it is difficult to employ novel technologies effectively while also meeting the pedagogical needs of the classroom. To use VR successfully to meet language learning outcomes, there are many aspects related to hardware, software, and task design that need to be carefully considered. While there is an abundance of commercial off-the-shelf (COTS) VR experiences, there is a lack of purpose-built educational applications. To use these COTS applications effectively, the *VR Application Analysis Framework* (Lege, Bonner, Frazier, & Pascucci, 2020) was devised to analyze them for language classroom activity use. This article reviews the four key aspects of the framework: *immersive capacity*, *cognitive load*, *purpose*, and *communicative capability*. The framework is then applied to an example COTS VR application, detailing how the application was analyzed. Finally, a focused activity will be suggested that aims to successfully apply a VR application to the needs of the language classroom.

2. Framework: Four Lenses

Scaffolding VR technology is necessary for its implementation into classroom tasks while meeting pedagogical outcomes. As Mercado (2017) notes, "technology is but a means to an end and should be chosen and used carefully if it is to truly help our learners reach their fullest potential in learning a second language" (p. 20). VR applications are no exception to this rule and must be carefully considered before classroom use. Bearing that in mind, the *VR Application Analysis Framework* is based on foundational literature from different disciplines within language teaching, including gaming for language learning, technology-assisted language learning, task design, cognitive load, media literacy, and more. The framework needs to not only look at the unique aspects of the technology, but also consider language learners' experiences both in VR and for parts of instruction not using VR. Ultimately, the framework is divided into four distinct methods of inspecting VR applications to ensure that proper analysis is completed before introducing VR into a language learning environment. Hereafter, these methods are referred to as lenses, as they allow instructors to view specific aspects of the applications for analysis. These lenses are *immersive capacity, cognitive load, purpose,* and *communicative capability*.

Figure 1: The *VR Application Analysis Framework* (Lege, Bonner, Frazier, & Pascucci, 2020, p. 28)



Note: The *VR Application Analysis Framework*. Reprinted from *New Technological Applications for Foreign and Second Language Learning and Teaching* (p. 28), by M. Kruk & M. Peterson, 2020. IGI Global. Copyright 2020 by IGI Global. Reprinted with permission.

2.1. *Immersive Capacity*

One of the most unique features of VR is the ability to create a sense of presence, "the (psychological) sense of being in the virtual environment" (Slater & Wilbur, 1997, p. 604). This means that learners may experience mental and physical immersion leading to engrossing experiences that makes them feel as if they are in a different physical environment. The framework divides *immersive capacity* into three categories: high, medium, and low. VR experiences with high immersive capacity allow users to move about freely within defined boundaries while mirroring their movements in the virtual world through hand and head tracking systems. Highly immersive applications do not necessarily have to be photorealistic to be immersive. Some of the most popular and immersive VR applications use a consistent and well thought-out application of low-polygon or cartoon-like environments. The nature of the experience is the most important factor in determining its immersive quality. Passive VR experiences do not allow for locomotion or interaction in the environment, so they tend to have low immersive capacity. These experiences often consist of 360-degree videos or applications that only allow interaction through tracking gaze and head rotation. If an application contains elements of both high and low capacity then it would be classified as having medium immersive capacity.

Key questions about immersive capacity:

- How does the user experience and interact with the virtual environment? Can they move freely within the space using their own body, or are they limited to using head movements and controllers to navigate?
- Are there elements of the virtual environment that pull the user out of the experience?
- Can the user naturally manipulate objects within the virtual environment or is the environment static?

2.2. *Cognitive Load*

Immersive VR can be a very sensory-rich experience. The combination of detailed 3D environments, spatial audio, and realistic environmental navigation and interaction can create some unique challenges for users. Parong and Mayer (2018) note that "immersive VR may create so much extraneous cognitive processing that the learner does not have sufficient cognitive resources left to learn the essential material in the lesson" (p. 795). For language learners this may be further compounded, as language processing is added to the already lengthy list of factors that use mental resources. Hence, while working with VR for language education, it is important to consider the degree to which mental resources are being allocated for a VR learning activity. Cognitive Load Theory (Sweller, 1988; Sweller, 1994) suggests that when designing a learning experience, the limits of working memory are both recognized and designed for. Cognitive load can be categorized into three distinct types: *intrinsic*, *extraneous*, and *germane* (Chandler & Sweller, 1991). Intrinsic load refers to the embedded difficulty of the content itself, which may be either linguistic, subject-related, or concerned with how the user interacts with the virtual world. The other types, extraneous and germane, deal with task design and the integration of background knowledge into activities, which can be handled with careful effort on the part of the teacher.

The framework divides cognitive load into three categories: high, medium, and low. High cognitive load applications are normally classified by time constraints placed on the user. Often applications present users with instructions quickly and without a chance to review them. This can lead to failure if the user did not understand the instructions quickly enough. This can overwhelm working memory, especially for second language learners if the content is unfamiliar and the language is too difficult. Additionally, if the application interface is not intuitively designed, this can put extra stress on the user's working memory. Furthermore, applications with multiplayer capability often can be characterized as having high cognitive load as interaction between players can be unpredictable. Applications with low cognitive load are generally self-paced, passive experiences with little to no pressure or constraints from the VR application or other users. A user of these applications effectively determines how much working memory they will apply to each experience. VR applications that fall into the medium cognitive load category possess elements from both high and low cognitive load.

Key questions about cognitive load:

- What cognitive burden is the VR application placing on learners? To what degree are cognitive resources being used by the interactional methods, linguistic components, or audio-visual elements?
- What can be done to lessen the load on students? How can educators scaffold the activity or provide better instructions?
- What can be done to help students build schema and automate processes before engaging in the VR learning experience?

2.3. *Purpose*

Purpose, as defined by the framework, refers to the genre of the VR application. Each genre has the ability to address certain aspects of the real world and is limited by the restrictions of the genre itself (Feez, Iedema, & White, 2008, p. 52). Applications are designed with a purpose in mind and an intended use case that is the basis for how the application will be used. The utilization of the application may differ from the developers' initial intent. For example, physical therapists have used the popular rhythm game, *Beat Saber* (*Beat Games*), designed for entertainment, to help patients do exercise outside clinical settings (Torres, 2017). Accordingly, the framework identifies four overarching purposes: *entertain*, *inform*, *communicate*, and *design*. These are not rigid classifications and may be mixed or combined. VR applications with the purpose to *entertain* are the most widely available COTS VR applications. These range from video consumption platforms to a wide variety of games and may require differing degrees of mental and physical agility. VR applications designed for learning would fall within the purpose of *inform*. These applications allow users to discover new knowledge and often consist of experiences in museums or different geographical locations that learners would not have the opportunity to visit otherwise. Online social experiences and chat applications are clear examples of applications designed for the purpose of *communicate*. Finally, applications with the purpose of *design* grant users creative freedom without pressure; these could be used for not only making art, but other creative activities such as mind mapping, visually organizing linked ideas or information.

Key questions about purpose:

- What was the intended purpose of the VR application?
- How can the identified purpose of the VR application be adapted for language learning?

2.4. *Communicative Capability*

Communicative capability refers to the ability to communicate and interact with other users using built-in application features. Built-in features include but are not limited to synchronous voice chat, text messages, emotes, and gesture-based communication. Additionally, there may be some aspects of the application design that VR users can use to communicate with people in their immediate, real-world environments. Elements of the application, including pacing and linguistic complexity, may either permit or discourage communication with others in the immediate environment. Considering both the built-in features and the ability to communicate directly; the framework divides the communicative capability into three categories: high, medium, and low. Most often, applications with high communicative capability feature multiple modes of communication such as synchronous voice chat, emotes, or gesture-based movements. Applications with low communicative capability lack the ability to communicate with other players and are often designed as single-user experiences. Applications with a mix of high and low communicative capability would be considered as medium.

Key questions about communicative capability:

- What built-in features does the application have to aid communication?
- Apart from the application's built-in communicative features, what opportunities does the application provide for people who share the same real-world space to communicate?

3. Applying the framework: *Tilt Brush*

Tilt Brush (*Google*, 2016. Found at https://www.tiltbrush.com/) is a VR artistic design application available on all current VR platforms including *Oculus*, *SteamVR,* and *Windows Mixed Reality*. *Tilt Brush* is a 3D-painting experience wherein users access a plethora of shapes, colors and tools via a virtual palette accessible in one hand and paint with a virtual brush in the other. By walking physically around a space painting brush strokes into the air, artists can create 3D art of any scope and scale. These creations can be shared online then downloaded and edited by anyone in their own Tilt Brush environments.

Through the four lenses of the *VR Application Analysis Framework*, it is possible to see how Tilt Brush can be applied in language learning classroom activities (see Figure 2).

Figure 2: Analysis of Tilt Brush through the four lenses of the *VR Application Analysis Framework*

Purpose				**Immersive Capacity**		
Entertain	Inform	Comm.	Design	Low	Mid	High
Cognitive Load				**Communication Capability**		
Low	Mid	High		Low	Mid	High

Applications with a *purpose* of design usually do not have any extrinsic goals or overt objectives and instead focus on giving users the freedom to create with the provided tools. *Tilt Brush* clearly falls into this category, as users simply select a brush style, a color, and start painting into the space. This is achieved without any instructions or limits concerning what the user creates or how they go about creating it.

For its *immersive capacity*, *Tilt Brush* features a high level of immersion. The user's dominant hand holds the brush, while the other holds the virtual palette. The palette contains access to all tools and menu options, providing a control scheme that closely mimics the same creation process of a real-world artist, despite the lack of an overt user interface. This allows users to quickly become accustomed to painting in a natural and intuitive fashion. Movement within the space is achieved through natural body movements rather than through joystick controls, reducing the likelihood of causing discomfort and lowering immersion.

The *cognitive load* would be considered *low* as *Tilt Brush* focuses on providing a simple, intuitive interface and environment. A low germane load is achieved through the recognition of natural hand movements and gestures to paint within the space. The application also does not impose any time constraints, instructions, goals, or other limitations on the user and allows them to commit as many or as few cognitive resources to the creative experience as they desire.

Finally, *Tilt Brush* also has a low *communicative capability* as it is a single player experience with no real-time communicative features. The only communication possible between users is through the sharing of their creations via an online repository of submitted art works. Users cannot meet, talk, and work together within the space at the same time, but they can modify the works of others and resubmit them to the repository as a reinterpretation of their work.

4. Example classroom activities using *Tilt Brush*

There are many practical ways that a creative application such as *Tilt Brush* (see Figure 3) can be used in a classroom activity. The following examples demonstrate some activities involving high school or college students in a typical second-language acquisition course. For activities involving VR equipment, it is vital to provide orientation for students prior to the activity so that they are already familiar with the equipment and requirements for the safe use of VR in a classroom setting. This includes demonstrating safe navigation of virtual spaces, VR equipment sanitation between uses, and personal space awareness. Some of these activities can be undertaken with only one VR headset, while others would benefit from one VR headset per group.

Figure 3: Image taken from Google's *Tilt Brush* promotional video
(https://www.youtube.com/watch?v=TckqNdrdbgk)

Tilt Brush Activity One: Presenting Visual Summaries of Narrative Fables

Target Level: Intermediate/upper-intermediate (A2-B2)

Time: Two 90-minute sessions

Aims: Students will practice analyzing and summarizing written narratives, creating a visual summary, and developing presentation skills

Resources/materials: Short narrative story, paper for storyboarding, VR headset, *Tilt Brush* app, projector for streaming

Possible problems: Activity is possible with only one headset, but more VR headsets are recommended to reduce activity length, difficulty streaming the VR content to the projector if WiFi signal is weak

Procedure: This example is a reading and writing activity analyzing a fable and creating a summary of its narrative structure visually. The activity focuses on providing students with an opportunity to demonstrate their understanding of the topic through construction of their own visual summaries and providing verbal tours to their classmates.

Stages:

1. Students are given a fable to read, highlighting the most important narrative moments of the story.
2. Students write down the key points of the story and summarize its contents.
3. Students are divided into small groups and assigned a part of the fable. They are asked to sketch a storyboard on paper, describing visually what happens during their assigned part.
4. Based on their storyboard, students discuss what kind of artistic 3D creation they wish to create and divide up the work.
5. Students take a turn entering the VR *Tilt Brush* environment and recreate their scene from the fable.
6. Once the class has finished their creations, each group presents their scenes to the class with one member in VR streaming their art to a screen for the class to view, while the other members explain their scene and design choices.
7. During each presentation, the class is encouraged to take notes on each scene and a quiz can be administered later to check student recollection of the key moments of the fable studied in class.

Tilt Brush Activity Two: Descriptive Language Practice via Virtual Dioramas

Target Level: Intermediate/upper-intermediate (A2-B2)

Time: 90 minutes

Aims: Students practice using descriptive language such as adverbs of place, prepositional phrases, and adjective phrases

Resources/materials: List of descriptive language / prepositional phrases, 3D model, printed imagines of detailed scene, VR headset, *Tilt Brush app*

Possible problems: Limited number of headsets available for groups, finding a detailed model for use in the activity

Procedure: The following example is an activity to improve students' ability to utilize prepositional phrases and descriptive language. The activity is split into two 45-minute sections.

Stages:

Part 1 (45 minutes)

1. Teacher distributes paper handouts with a picture of a room with many objects.
2. Students practice describing the picture and the objects depicted therein.
3. Teacher reviews prepositional phrases and adverbs of place used for describing the picture by displaying the picture on a projector and asking students to describe the location of specific objects. Teacher writes elicited responses with prepositional phrases on the board.
4. Teacher divides the students into pairs or small groups of 3-4 and distributes one VR headset to each group.
5. One student from each group puts on the headset and opens *Tilt Brush*. The student opens the prepared 3D model.
6. The student describes the position of objects in the model using the phrases and language discussed previously. At the same time, members of the non-VR group write down the phrases.
7. Students change roles and add more phrases to their list until they have the target total (for example, 10).
8. Teacher monitors and assists the students with the correctness of the phrases

Part 2 (45 minutes)

1. Students remove the VR headsets, and set them aside.
2. Teacher demonstrates how to make a change to a scene in VR or shows a screenshot showing the process of editing existing 3D creations.

3. One member of each group puts on the VR headset and makes 5 additions or changes to the model.
4. After this is complete, the student takes off the headset and passes it to other members of the group. The students then search for and describe the 5 changes that have been made.
5. This process can be repeated as many times as necessary.

Tilt Brush Activity Three: Using Virtual Memory Palaces to Memorize Vocabulary

Target Level: Intermediate/upper-intermediate (A2-B2)

Time: 90 minutes

Aims: Students use VR to help visualize challenging vocabulary to aid with comprehension and retention

Resources/materials: List phrases/vocabulary, one VR headset per group, *Tilt Brush* app

Possible problems: One headset per group is required for this activity, vocabulary needs to be in some way represented visually.

Procedure: VR has been proven effective for improving spatial memory (see Pollard et al., 2020). This activity leverages this strength of VR by having students create virtual *memory palaces* to aid in vocabulary recall.

Stages:

1. Students are placed into groups and assigned a list of 10 vocabulary words.
2. Students take a few moments to check the definitions of the words and brainstorm ideas for how they can be visually represented.
3. One student enters VR, opens the *Tilt Brush* app and creates a new empty art scene. They then create a floorplan of the classroom in *Tilt Brush*. The students should be encouraged to add some objects to the room so that it mimics the real classroom as much as possible.

   It's important for the floorplan to be based on a space that every student knows the layout of. Refer to Krokos, Plaisant, & Varshney (2019) for more detail.
4. Once the space has been created, and ideas brainstormed for visual representations of the vocabulary, students enter VR one by one and add their creations to the room, remembering to write the vocabulary word under each creation. Other students can provide advice via streaming the VR experience on a smartphone or tablet.

   E.g., if the class is studying advertising, then the following objects could be used to represent key vocabulary visually in VR:

i. Brand - A *McDonald's* logo
ii. Catchy - A baseball mitt and a musical symbol
iii. Endorsement - A thumbs up at *Starbucks* logo with money next to it
iv. Viral - Many *Twitter* logos grouped together

5. After the memory palace is complete, each student reenters *Tilt Brush* to remember each vocabulary representation and its location within the virtual classroom.
6. Students take off the VR headset and then attempt to recall all the vocabulary words.
7. Teachers can then quiz students on the vocabulary in the following lesson to check retention.

5. Conclusion

VR is a powerful tool that can be used to enhance language learning experiences. However, there still remains a distinct need for more education-focused VR applications. Despite the lack of purpose-built applications, there is a wealth of commercial off-the-shelf experiences that can be taken advantage of until more specific educational content becomes available. Identifying and adapting these applications to fit the pedagogical needs of educators can be tedious and difficult.

With this in mind, by applying the *VR Application Analysis Framework* to existing applications it is possible to determine which aspects of an application need to be scaffolded for the language classroom. By analyzing an application through the four lenses, *immersive capacity, cognitive load, purpose,* and *communicative capability,* it is possible to create materials and activities to make VR accessible to any classroom. With this framework, teachers can have the confidence to apply VR to their classroom rather than continue to wait for relevant educational content to be created. As more teachers look to VR to redefine their language learning classroom activities, this framework will contribute to the body of research that aids in positioning VR as a commonplace tool for language learning.

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Other commercial off-the-shelf applications for classroom activities

The following are a list of other commercial off-the-shelf VR applications that have the potential to be applied successfully in classroom activities:

- *Anne Frank House VR* (Force Field, 2018, https://forcefieldxr.com/project/anne-frank/)
- *Job Simulator* (Owlchemy Labs, 2016, https://jobsimulatorgame.com/)
- *National Geographic Explore VR* (Force Field, 2019, https://forcefieldxr.com/project/natgeoexplorevr/)
- *Notes on Blindness* (Novelab, 2016, https://www.arte.tv/sites/webproductions/en/notes-on-blindness/)
- *Puppet Fever* (Coastalbyte Games, 2019, https://www.puppetfever.com/)
- *Rec Room* (Rec Room Inc, 2016, https://recroom.com/)
- *Spotlight Stories* (Google, 2016, https://atap.google.com/spotlight-stories/)
- *Traveling While Black* (Felix & Paul Studios, 2019, https://www.felixandpaul.com/?travelingwhileblack)