

# The Design of Virtual Reality Learning Module in Neurolinguistics: Focus on Aphasia

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**Abstract.** The metaverse, which is essentially a virtual environment parallel to the actual world, is the most recent stage in the evolution of visual immersion technology and is quickly emerging as a testing ground for new social innovations. Since two-dimensional network technology struggles to meet students' demands for immersive learning environments and organic human-computer interactions, meta-universes will change how online education is taught to support students' individualized learning and overall development. In order to push the boundaries of virtual reality technology utilized in various disciplines, this paper will create a virtual reality classroom for neurolinguistics students to learn about aphasia. Different scenarios are built to help students experience communicating with aphasic patients, familiarize themselves with different types of aphasic symptoms and causes, and discuss the rehabilitation program for aphasic patients with peers. Students can complete the whole process of knowledge cognition-experience-construction in a richer and more vivid learning form.

**Keywords:** Virtual reality, learning design, neurolinguistics, aphasia.

## 1. Introduction

The rapid growth of multimedia communication devices and the pervasive usage of digital technology have stimulated research into and the creation of new teaching tools that will transform the education sector. Today, virtual reality technology is seen as a very promising teaching tool since it overcomes the limitation of the teaching style by utilizing other electronic media as the carrier.

A subfield of contemporary linguistics called neurolinguistics investigates the relationship between language and brain activity, particularly how the brain takes in, stores, processes, and extracts linguistic information. The study of aphasia—an acquired language impairment brought on by brain damage—was the inspiration for this particular field of study, and it continues to have as one of its main focus the description and analysis of language abnormalities in aphasia patients [1]. From a standpoint of application, the outcomes of aphasia research can be directly applied to a variety of fields, including language teaching, computer artificial intelligence, and the recovery of language function in aphasic patients. Consequently, there has been an increase in the need for neurolinguistic professionals in recent years.

Neurolinguistics is an interdisciplinary field that incorporates techniques and theories from several different disciplines, including linguistics, neuropsychology, cognitive science, and communication disorders [2]. Due to their lack of knowledge in the biological sciences, neuroscience, and other subjects, many linguistics majors find it challenging to learn neurolinguistics. Therefore, a very exciting development in the field of neurolinguistics education today is the potential for creating more engaging and useful courses that use technical media to aid learners in overcoming disciplinary obstacles. The current literature provides limited insight into designing courses for neurolinguistic learners around the knowledge point of aphasia in conjunction with virtual reality technology, and this paper will frame the design of the learning module based on existing theories to fill the research gap.

## 2. Literature Review

There is a wealth of data to support the idea that the use of media, such as contemporary internet platforms and digital technology, in language acquisition, is very successful. Several recent studies have highlighted the use of open and synthetic virtual environments in aiding language learning made by scholars and practitioners during the past ten years. In remarkable studies such as Lan who developed an immersive *English as a Foreign Language* learning context to go over in-class materials, both qualitative and numerical information from more than a hundred participants was gathered and the outcomes showed positive results of the virtual environment. In particular, the increased number of learning chances for students, the improvement of participants' *English as a Foreign Language* proficiency, and the benefits of a gamified scenario [3]. Another outstanding research was conducted by Chen, who examined how well a platform of 3D virtual reality was used during English class to support the cognitive and linguistic growth of nearly five hundred students at a Taiwanese institution. The primary goal of this virtual environment was the acquisition of vocabulary, which was assessed across the various modules. Results revealed that while using this resource, students gained proficiency in phonology, morphology, grammar, and syntactic structures in addition to vocabulary [4].

However, there is a distinction between linguistics and language learning. Language is a system of customary written or spoken symbols that individuals use to converse with each other and that symbolizes the mentality of a culture, whereas linguistics is an area of study that conducts systematic language research. This is a point that has been easily overlooked or obscured in many previous related studies. Research that clearly defines linguistics and concentrates on the implementation of virtual reality in this subject is limited and even fewer that focus on a specific branch of linguistics (neurolinguistics) or a particular point of knowledge (aphasia). The focus of current research is less on neurolinguistics as a subject of study and more on the application of virtual reality technologies in neuroscience. According to Bohil and Alicea, VR has shed new light on the activity of brain areas responsible for social interaction, multisensory integration of perceptual stimulation, and spatial cognition and navigation, which has significant advantages for basic neuroscience research [5].

The rehabilitation of aphasic individuals has been the subject of research on virtual reality and aphasia. Utilizing virtual reality in recovering from aphasia is primarily an impairment-level intervention, according to Niamh, with only circumstantial evidence of favorable outcomes. The justifications for utilizing virtual reality differ between studies, from freeing up Speech and Language Therapy time to developing ecologically accurate environments [6]. A recent study out of the University of London found that a multi-user online virtual world called *EVA Park* can give aphasia patients an equal opportunity to encourage speech by exploring diverse real-life situations without needing to move from their living room. The latest research reveals that visitors to *EVA Park* regularly laugh and enjoy themselves, which may help to offset some of the negative feelings that are closely linked to stroke (seen as a major cause of aphasia), such as depression, which can affect up to 60% of those who have the illness. These examples of study and practice lack a third-party learner perspective.

## 3. Needs Assessment

### 3.1. Target Population

The learners of this learning module are students majoring in neurolinguistics who have difficulty grasping the knowledge of aphasia only based on textbook contents (higher education). The bulk of the students that enroll in linguistics, a discipline that is taught in colleges and universities, are from the liberal arts. The science information required by neurolinguistics (one of the fields of linguistics, which frequently appears as an elective subject), makes it difficult for students in liberal arts to learn. Many people think that liberal arts students just need to recite information from textbooks, however, this outdated idea seriously underestimates their potential in multidisciplinary subjects. 800 million

jobs will be automated by 2030. *The World Economic Forum* in Davos made it obvious to the working class worldwide that we must return to our human instincts if we don't want to be replaced by computers. This includes teamwork, creativity, empathy, and critical thinking—exactly the traits associated with education in the humanities and arts. The social influences on neurolinguistics and the communication impairments of aphasic patients are crucial components of the pertinent study and liberal arts students have a strong humanistic foundation, improved understanding, and empathy for these issues. For this reason, it is essential to put more effort into linguistics majors' education and create stronger curricula for them.

### 3.2. Learning Objectives

Benjamin Bloom, an educational psychologist at the University of Chicago, established *Bloom's Taxonomy* in 1956 as a module to categorize the various goals and competencies that teachers set for their pupils (learning outcomes). This pyramidal model is divided into six phases, from the bottom to the top: 1. Remember (recognizing and recalling facts); 2. Understand (understanding what the facts mean); 3. Apply (applying the facts, rules, concepts, and ideas); 4. Analyze (breaking down information into component parts); 5. Evaluate (judging the value of information or ideas); 6. Create (combining parts to make a new whole).

History has proven that this well-known, broadly used framework addressed a need and gave educators among the very first comprehensive categories for thinking and learning processes. Six categories comprise the cumulative hierarchy of structures, each requiring mastery of prior expertise or talent before moving on to a greater-level one. Teachers are forced to assess the skills of their students. To do this accurately, a taxonomy of stages of intellectual conduct crucial to learning is required.

The learning objectives of the module are designed based on *Bloom's Taxonomy* and are divided into two main stages. Learners can grasp the classification, signs, and causes of aphasia in the first part of the learning objectives (phases 1&2). In the second level, students have opportunities to learn about certain rehabilitation techniques for aphasia sufferers (phases 3&4).

## 4. Proposed Curriculum Design

The curriculum is designed to index the three learning paradigms throughout the classroom to ensure that learners receive a richer learning experience than they would in a textbook-based classroom so that they can assimilate new knowledge more efficiently (Table 1).

**Table 1.** Teaching Plan

	<b>Step 1</b>	<b>Step 2</b>	<b>Step 3</b>
<b>Learning Paradigms</b>	Cognitivism	Experientialism	Constructivism
<b>Learning Activities</b>	Construct a knowledge framework based on textbook content	Converse with aphasia patients virtually	Enter the virtual seminar room to talk with other learners about how to treat each patient specifically
		Investigate the disease's origin in a virtual medical lab	
<b>Learning Time</b>	10-15 min	20-25 min	10-15 min
<b>Learning Outcomes</b>	Set learning goals and use them as motivation	Effectively facilitate the internalization of knowledge	Produce knowledge based on prior learning experiences

Cognitivism holds that students actively construct knowledge systems from pre-existing prior knowledge frameworks. Because of this, supporters of cognitivism regard learning as a proactive, rewarding, and goal-oriented process that actively assimilates and adapts new knowledge to an existing body of knowledge. Learning is intrinsically motivated; hence it is important for kids to be able to create goals and encourage themselves to study. Based on this idea, during the initial portion of the course, the teacher will guide the students in becoming familiar with the textbook's information on the categorization and symptoms of aphasia as well as their learning objectives, which will help them become motivated to learn. There are seven major types of aphasia, each of which is caused by damage in different tissues within the brain, three of which are the most common, namely Broca's aphasia, Wernicke's aphasia, and Global aphasia. Textbook knowledge is often presented in summarized tables or single-angle brain profiles, which are concise but limited in the richness of the learning material, learners can only deepen their impression by behaviorism in the face of limited textbook knowledge - rote memorization, which is regarded as passive absorption of the knowledge system.

To effectively facilitate the internalization of knowledge, the course implements experientialism in the second session and incorporates virtual reality technology to create a wider learning space for learners. According to experientialism, learning occurs through a cycle of experiential stages, starting with tangible experience, followed by observation and reflection, abstract conceptualization, and testing ideas in novel contexts. The learning module was developed in collaboration with virtual reality technology and leveraged Unity, C# programming, Maya (a graphics software), and an external speech recognition program. The learners first enter a lobby-like starting scene when they put on the virtual reality headset, with several squares in front of them simulating various real-life circumstances, such as parks, schools, restaurants, and so on. People with aphasia are frequently marginalized in society due to their impairment in daily communication, thus real-life neurolinguistic students who want to get close to people with aphasia can only do so in hospitals, rehabilitation centers, or in patient's homes, which is a restriction and brings barriers to advancements in related research. In the virtual world, learners' exposure to aphasic patients becomes diversified and daily, and they can collect more detailed case data through conversations with them, thus deepening their familiarity with the symptoms of a particular aphasic patient. Compared to reciting knowledge directly from a textbook, it is more interesting for learners to explore the virtual world, where each learner may take a different path to absorb new knowledge (the virtual world provides an open communication style and sequence, with no fixed task line), and where unique personal experiences deepen the impression of knowledge in their minds.

Learning in the virtual environment may also break free from the textbook's knowledge structure and reveal fresh ways of looking at things. For instance, it is frequently challenging to observe aphasia patients in high-intensity socializing settings, like a bar. Imagine the scenario of assembling various aphasia patients at a bar in a virtual setting, when the outside world requires more communication and interaction with them through dialogues, learners can observe whether their mental state will change and further affect their language organization system, as well as whether the stimulation of the external environment will worsen the brain injury and thereby aggravate the disease.

After getting familiar with different types of aphasia disorders, learners then enter a virtual medical laboratory to explore the brain tissues corresponding to the damage states of seven aphasia disorders and to get familiar with the knowledge points related to the causes of aphasia. For example, the learner chose a bar scene before and played the role of bartender, then had a conversation with Bob, a patient with Broca's aphasia:

**Learner:** Good evening, Sir. What can I do for you?

**Bob:** Want food.

**Learners:** As well as recommending our delicious cinnamon rolls, here is a unique cocktail for you to try!

**Bob:** Good drink.

After the dialogue, the learner concluded that this type of aphasia is characterized by the patient's inability to speak complete and clear sentences, only individual words or phrases that can come out of the mouth, and the inability to use linking words. The next step is going to the virtual medical laboratory in the second stage, where there is a virtual human anatomy model. Since the learner has just communicated with a patient with Broca's aphasia, the next thing he needs to explore is the Broca region inside the brain. Unlike the picture presented in the textbook, the brain model presented in the virtual lab can be viewed from different angles, and the learner can use the handle to ride through the complex brain structure like a roller coaster. Each time a specific area is locked, an information box will pop up on both sides of the field of vision, detailing the area and its link to aphasia.

The final stage of the course was designed based on constructivism, which involves students coming together in a seminar room after completing their excursions to share their learning experiences and discuss possible rehabilitation options for aphasic patients. In the view of constructivism, learning is an active, positive process in which students actively create their own subjective understandings of reality and information. Although a similar session also takes place in actual classrooms, there are restrictions on the idea collision in the conclusive communication session because students typically stick to a particular learning framework in their textbooks. At this point, learners are producing knowledge based on prior learning experiences rather than just absorbing it. Since each learner's interactions with a person with aphasia in various virtual scenarios are distinct, their ability to communicate as a learning community will be considerably enhanced.

## 5. Media Selection

### 5.1. Affordances of Virtual Reality

The virtual reality that accomplishes the learning model's layout is selected on the basis of the affordances of the medium. An affordance is a relationship between an object or an environment and an organism that permits that organism to act through a series of stimuli. A knob, for example, allows for twisting and possibly pressing, whereas a cable allows for pulling. An affordance, as a relation, demonstrates the prospect of some activity and is not a trait of either an organism or its environment alone.

The most important ones among the affordances of virtual reality are immersion, usability, and motivation. Each user is represented by an "avatar" in many virtual environments, which gives a visual depiction of their true or substitute identity and appearance. There will be a deep sense of psychological immersion in task performance as well as high degrees of establishment of relationships, partnership, and interaction depending on the user's perception that the avatar they are controlling is an image of themselves (or of an alternate self) that they consciously or unconsciously create within the environment [7].

The subjective experience of being somewhere is called presence, and the objective and quantifiable characteristic of a system or environment that fosters presence is called immersion [8]. Learners can engage in immersive communication with aphasia patients in virtual reality, and analyze the brain's internal structure from a first perspective. Virtual reality technology, as a means of creating and experiencing virtual worlds and approach systems, has strong reproduction characteristics and a sense of immersion, so it can create more free interaction and space for the audience, which is very much in line with the humanized development of media technology.

Tasks that would be difficult or impossible to complete in the actual world can be made achievable through the usability of virtual environments for experiential learning [9]. Immersive virtual reality's movement tracking abilities for embodied motion combined with an interactive interface can be beneficial for science education not only because it enables learners to become acquainted with risky or morally constrained procedures such as dealing with hazardous substances or operating on patients with illnesses, but also because it promotes comprehension of abstract concepts by engaging embodied cognition [10]. It is difficult for linguistics students to come into contact with aphasia

patients in real life or experience anatomical scenarios for themselves. Therefore, virtual reality provides them with a convenient way to conduct field studies.

Learning exercises that boost intrinsic motivation and engagement can be facilitated by virtual environments [11]. Assigning clear character roles to learners offers an opportunity for them to execute their roles and become emotionally engaged in the learning tasks. Throughout the learning process, learners will experience the complete process of "communicating with aphasia patients", "understanding and analyzing the reasons for their illness" to "discussing with peers how to help patients with rehabilitation treatment" in the virtual world. In such a situation, they can easily substitute themselves into the role of helpers and are likely to be driven by a sense of responsibility to be more motivated to complete the learning task. There are three components of narrative design features drawn from the module design: having ownership of the task, recognizing the relevance and importance of the task, and acquiring the feeling of accomplishment from completing and challenging manageable tasks.

## 5.2. Competitive Project

The competitive project of this learning module is a 3D simulator of brain structure. In a study of beginners in radiography in South America, training in virtual reality outperformed physical simulation in terms of effectiveness and efficiency. Compared with virtual reality, 3D simulators cannot provide an immersive learning environment for learners. Learners can only control the simulator on the electronic screen by moving the mouse cursor or keyboard, but they can use the VR controller to carry out more specific and diverse activities in the virtual world. The latter will make the learning process more interesting and arouse the motivation of learners [12]. With the help of head and position tracking, immersive virtual reality may generate distinct visualizations for each eye, providing visual signals for depth perception.

## 6. Conclusion

This study incorporates virtual reality technology to design a module focused on aphasia learning for neurolinguistic students, summarizes the research gaps in the past relevant literature, assesses the learning needs in terms of both target group and learning outcomes, and designs a classroom of 45 minutes duration based on learning paradigms. The learning experiences students have in virtual reality help them achieve better academic results and develop vital social and interpersonal skills that they will need in the future, including empathy and teamwork. The paper also describes the reasons for choosing virtual reality technology as an assistive tool in terms of affordances and provides a brief comparison between virtual reality platforms and simulators. An issue that was not addressed in this study was whether learners are tempted to partake in hedonistic activities, which would reduce learning effectiveness. Additionally, as opposed to the majority of virtual reality learning models that include gaming components, this model creates incentives for learners that are more experiential and socioemotional than playable, which calls for a more thorough comparative analysis in the future.

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