# Virtual Reality for Students with Special Needs

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**Keywords:** intellectual and developmental disabilities, autism spectrum disorders, virtual reality, special education, classrooms, design thinking, accessibility, inclusive education

## 1 Introduction

While virtual reality technology is already widely used in business and culture for immersion in new worlds of experience, virtual reality (VR) in the field of special and inclusive education is still not widespread. Students with intellectual and developmental disabilities (IDD) are often externally determined to various degrees in their lives. To cope with everyday life independently, practicing action skills is necessary. In a real-world physical environment, this is not always easy. Virtual reality offers a possibility to acquire skills without restrictive conditions.

Within the project "Virtual Reality for Children with Special Needs" the potentials of virtual reality for students with IDD are explored. This research and development (R&D) project is a collaborative effort of the University of Applied Sciences (ZHAW Winterthur), the University of Teacher Education in Special Needs (HfH Zürich), and Vivala as the Foundation which supports persons with intellectual and developmental disabilities.

## 2 The Aims of the Project

The aim of this mixed method study is to work out a connection between the degree of immersion and the degree of action competence imparted. To this end, we can draw on about 20 students as testers, who will test out three use cases and their variants. Two of the three use cases use special peripheral hardware to enhance the immersive experience. The exemplary and participatory testing, evaluation, and individualization of virtual reality applications for students with disabilities to promote their participation and self-determination in mobility, education and everyday culture is the focus of the research project.

The aims of the research and development project are:

1. Exemplary testing, evaluation, and individual adaption of three VR uses cases in the areas of 1st mobility, 2nd safe leisure activities, and 3rd communication and cognition.
2. Empowerment of students with IDD in the definition and implementation of their needs for individualized VR solutions
3. Transferring the design thinking approach to another technological field of application.
4. A possible quantification of the goal formulated above could be how many of the participants would like to repeat the VR experiences they have had.

The research questions are:

RQ1. Which drivers and barriers support and hinder the use of immersive VR for students with disabilities? A special focus is on the use of a treadmill and a motion simulator.
RQ2. Which use case do the students mostly use? And why?
RQ3. How can the experiences of Vivala as the future competence center for VR for students with IDD be transferred to other institutions?

We want to explore, how do students report the physical experience, enjoyment and potential and of three different VR devices and uses cases. How do individual adaptions can lead to strengthen action skills in the areas of mobility, safe leisure activities for students with IDD and around communication and cognition for students with autism spectrum disorders. We have designed three use cases that are characterized by the fact that they teach action skills. These support the goal of strengthening self-determination and participation.

In iterative cycles three use cases are successively tested by students with disabilities.

1. *Mobility training* for electric wheelchair users by a physical motion simulator: practice using the joystick safely, visit and experience any places.


**Fig. 1.** The used Yaw VR Chair[15]

2. *Safety training:* Safely dealing with routine daily tasks involving walking: exploring places on one's own and solving adapted tasks, safe exploration of water bodies.

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**Fig. 2.** The used Kat VR Treadmill[11]

3. *Recognition and communication training*: Practicing recognizing emotions on humanoid avatars to facilitate communication for students with autism spectrum disorders.

Gamification as a means to enhance motivation is meaningful and is applied for all the three uses cases.

The CRPD assigns a key role to information and communication technology (ICT) in achieving social participation. In addition to Article 9 – "Accessibility and usability" Article 28 – "Adequate Standard of Living and Social Protection" - is of relevance for the project: "To ensure disabled persons access to affordable ... equipment and other assistance for needs related to their disability." [14, p. 21]. At its core, this is about empowerment to support the overwhelming aims of the project: self-determination and participation.

## 3 State of the Art

VR as a technology and applications of immersive VR in various domains have reached a stable stage of development. This project is not about developing technologies further. Rather, it is about the effect of VR on the user. There are three core matters of the project.

### 3.1 Drivers and Barriers for the Use of VR by Students with IDD

First, it is about the effect of immersion on the teaching of action skills. In the literature as well as in practice, this connection has already been addressed and investigated [4, 7]. We have already conducted field experiments on this topic with students in the upper school [8]. However, with students from mainstream schools, it is easy to assume that motor and cognitive skills are to be expected, which facilitates the design of VR apps.

[11] https://miro.medium.com/max/1400/1*ZMqCHXREbZ3Ntf_XSbVPHw.png

For our application context, this is not the case. Newbutt et al. [7] reported that head-mounted displays are enjoyable, physically and visually comfortable, easy to use, and exciting for students at the autistic spectrum.

Although many experiments are available as scientific articles, no generally valid rules can be derived from them [e.g. 7, 4, 13]. Therefore, from a scientific point of view, the main question is how the immersion (and thus the sensory stimuli) must be adapted and aligned to the individual abilities so that the positive effect of immersion on the teaching of action competencies is achieved. We want to address this question on the basis of the above-mentioned use cases by conducting a long-term field study with Vivala.

In a preliminary research project an immersive VR app was developed simulating a large train station including moving trains and walking passengers. The aim of this virtual train station was the training of a standard situation for students with disabilities. The students were confronted with several tasks within this immersive virtual world including interacting with virtual objects, finding places, e.g., toilets, within the train station and walking to the platform to enter the correct train leaving for a specific destination [1].

### 3.2 VR in Classrooms

The recent state of the art shows that there is value to the use of VR regarding increased student motivation, interest levels, and collaborative learning opportunities [13]. Holly et al. [6] emphasise the overall advantage of a hazard-free and repeatable environment in which learners can safely learn through trial and error. An additional aspect is the option to visualise unseen phenomena and virtually added hints [6 p. 114] which bear potential support elements in creating VR environments for students with intellectual or physical disabilities.

As Hellriegel & Čubela [5] state the presumed potential of VR media for positive learning outcomes for young learners needs to be promoted (p. 1). The same applies for special education issues as Lipinski et al. [9] state as well. Accordingly, VR can serve as a medium to stimulate an inclusive attitude [9. p. 18]. And it can facilitate the establishment of barrier-free and safe learning experiences for students with disabilities.

### 3.3 Individualized VR Solutions: Empowerment by Design Thinking

The importance of participatory design of VR solutions for students is already broadly discussed and tested. But so far there is little experience in participatory design and evaluation processes with students with disabilities. There are some results for students with autism spectrum disorders [e.g. 10] but just a few studies with participatory research approaches involving students with IDD [13]. Within the broader field of special education Lipinski et al. [9] describe how a prolific teaching scenario with VR as a low-threshold entrance to a self-contained approach with VR, based on experiences in psychomotricity education programs can be established. This serves our project as an example of how the implementation in a special school might work. Furthermore, the first author already showed how participatory research with persons with IDD can be successfully installed in technical engineering processes [2]. Likewise, the developed participatory design thinking approach for 3D-printing with persons with IDD shall be adopted for VR.

## 4 Methodology

Regarding the methodology the prototype development is based on an iterative research- and development cycle, often used in the context of social innovation, and adapted for people in the project SELFMADE by the first author [2, 3]. The methodological findings generated in the context of a project on the self-determined production of aids using 3D printing "SELFMADE" can be transferred to "Virtual Reality for Children with Special Needs". Thus, the method is also oriented towards self-determination and participation of persons with disabilities [2, 3].

Each of the uses cases is identified on the basis of a needs analysis. In the needs analysis the project uses a User Centered Design approach, which is linked with a Design Thinking process. This allows to identify, test and adapt the uses cases in a Co-Creation process by students with disabilities for students with disabilities. During the process experiences, gained while developing each prototype, are considered in the design of the derived prototype. Overall 20 students test the three use cases and their variants. The prototypes are developed in an iterative cycle, based on the principles of Design Thinking.

In order to address individualization and adaption of VR artifacts, the following steps of design thinking can be used:

- Understanding: The first step focuses on the understanding of the problem, this leads to an appropriate question, which defines the needs and challenges of the project. Data sources: photo documentation and written collection, composed from workshops.
- Observation: To gain important insights and to define the status quo an intensive search and field observation follows. Data sources: field notes and written collection, composed from workshops.
- Point-of-view: the individual needs are clearly defined in one question: Data source: documentation of the brainstorming question.
- Brainstorming to develop and visualize different concepts. Data source: think aloud.
- Prototyping: To test and to demonstrate the ideas, first adapted virtual reality. Data source: individualized products and think aloud.
- Refinement: Based on the insights gained from the prototype, the concept is further improved and refined until an optimal, user-centered product is developed. This iteration step can be applied on all previous steps. Data sources: individualized products [12].

This approach is particularly attractive for virtual reality companies because it has the potential to reach new target groups by making it as accessible and usable as possible.

Design methods are already well established in co-creation contexts. Among other benefits, some of them improve development processes by bringing in a user-centered perspective. This specific approach is a good entry point for an inclusive development process. A user-centered approach makes it possible to take into account the perspective and thus the needs and abilities of the target group of a solution.

In the first stage, all stakeholders are introduced to the design thinking process, which is adapted to the needs and abilities of students with IDD or austism spectrum disorders.

Technically the design thinking process represents a prototyping approach. Each iteration in the design thinking process is accompanied by an iteration in the prototyping of the use cases. The evolving experimental prototype is then used as an input for the next iteration in the design thinking process.

From a technological point of view, we use Unity as game engine and development environment. We have evaluated the Oculus Quest 2 as VR goggles. YawVR and KatVR are used as further peripheral devices. The product includes one VR app per use case for the Quest 2.

## 5 Prototyping Environment

The prototyping environment is based on the Unity Development Environment (version 2020.3). Key design constraints are platform independence and multi-device deployment. The interaction concept aims at using hand and finger tracking by visual means. The use of controllers is discouraged because it is not intuitive and to various degrees complex depending on the functionality of the joystick and the additional available buttons. Both main head mounted display manufacturers, i.e., Vive and Oculus, support visual hand tracking but to various degrees. A rather practical design constraint concerns the avoidance of cabling. Again, headsets from both Vive and Oculus support wireless connections. However, this constraint conflicts with the additional peripheral hardware used for two of the three use cases. Both the treadmill (KatVR) as well as the motion simulator (YawVR) need to be connected by cable to the gaming Laptop and the network, respectively.

## 6 Preliminary Results

Due to the fact, that the project started in February 2022 and runs until the end of April 2023 it is not yet possible to present results. At the conference we will present preliminary results. The focus will be placed on the first experiences with the tested VR prototypes and on the development and adaption of the design thinking process.

The prototyping process foresees up to four iterations with students in the Mixed Reality Lab at the ZHAW where all the equipment is available for testing. At the time of writing three iterations have been completed. The enthusiasm, interest and joy of the involved students was very impressive. In short, the following main challenges during the first iteration have been identified by the students:

- The walking on the treadmill is different from the natural walking on ground. The difference is mainly in the body posture and the walking is rather a shuffling. This

posed a challenge to various degrees for the students. Hence, they proposed to start with a simple exercise to just learn the walking without any head mounted display.
- The virtual room was perceived as too versatile and deviated the focus of the students. Hence, a simpler virtual world was suggested.

The above suggestions have been implemented for the second iteration. Again, in short, the following perceptions were made by the students:

- The quality of the visualization was criticized. The problem was caused by the used air link communication which was disturbed and caused a low frame rate.
- The newly developed walking exercise was perceived as very helpful but nevertheless still considered as demanding.
- As part of the walking exercise a very simple game was implemented consisting of collecting points. This feature was considered as very motivating and fun.

Furthermore, the first steps for the development of a competence center for Virtual Reality for students at the Vivala Foundation will be presented at ICCHP-AAATE with the focus if the use of VR can "push" the inclusive education of Vivala through a special attractiveness.

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