Evaluating the Effects of Experiencing a Mixed Reality Simulation of Symptoms of Schizophrenia on Empathy in Medical Students

Master Thesis

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Abstract

This thesis presents a mixed reality application designed to enhance empathy in medical students towards patients with schizophrenia. The application utilizes mixed reality (MR) technology to immerse users in the experiences of individuals with schizophrenia, allowing them to gain a deeper understanding of the challenges faced by these patients. The study involved a user-centered design approach, incorporating feedback from healthcare professionals to ensure the application's effectiveness and relevance. The results indicate that the MR experience .....

Keywords: mixed reality, empathy, schizophrenia, medical education

Acknowledgements

I would like to express my sincere gratitude to...

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1
Introduction

The purpose of a report is to transmit coherent information on a subject to the target readers. Reports are usually technical and should be based on verifiable facts or experiments. It is not a chronological description of your work. Obviously, the requirements of your readers (and tutors especially) must be taken into account: what information is requested, how much does the reader know already, what interests him/her? Write your report in such a way that your fellow students will be able to understand it and can put the contained information to use. Try to use short sentences to explain your work rather than long never-ending sentences.

1.0.1 Project Background

Explain the context of your work. Motivate the relevance of your project within its context.

1.0.2 Scope of Project

Explain the scope of your project.

2
State of the Art

In this section, you should outline the most important academical works revolving around your topic. You may use subsections to structure your work if necessary.

This chapter reviews the current advancements in immersive technologies for schizophrenia simulations and therapy. It examines the use of Virtual Reality (VR), Augmented Reality (AR), and Mixed Reality (MR) in simulating psychotic symptom and through that, fostering empathy. The chapter highlights key studies, their methodologies, and outcomes, while addressing design considerations and limitations for integrating immersive technologies into healthcare and education.

2.1 XR Technologies

Extended Reality (XR) refers to the spectrum of immersive technologies that blend the physical and digital world. This includes Virtual Reality (VR), which fully immerses the user in a computer-generated environment; Augmented Reality (AR), which overlays digital content onto the real world; and Mixed Reality (MR), which combines both, allowing real and virtual elements to interact in real time. In the context of schizophrenia education, VR is often used to simulate intense experiences, such as auditory or visual hallucinations. AR has been applied to embed simulated voices or visual cues into everyday settings, making the experience more relatable. MR, the focus of this thesis, seeks to integrate the strengths of both: allowing users to remain grounded in reality while experiencing interactive, layered symptoms, which may lead to higher engagement and emotional resonance [13, 25, 31].

2.2 Immersive Schizophrenia Simulations

Schizophrenia is a complex mental disorder, characterized by symptoms such as auditory and visual hallucinations [26]. In recent years, immersive technologies have emerged as powerful tools to provide first-person, interactive simulations of schizophrenia symptoms. Important to note is, that out of these three methods listed above, VR is the most popular and most researched tool indicating that there exists a research gap concerning the other two methods [14]. These simulations aim to enhance empathy, reduce stigma, and improve clinical understanding by offering users a direct, experiential perspective. This section explores the background of immersive schizophrenia simulations and their impact on medical education and public awareness.

2.2.1 Virtual Reality in Schizophrenia Education

A major goal of schizophrenia simulation is to recreate symptoms such as hearing voices, visual hallucinations, or experiencing delusions. For example, Skoy et al. (2016) created a simulation where users hear disturbing voices through headphones to better understand the kind of confusion and distraction that people with schizophrenia may deal with [27] . Other studies, like those by Zare-Bidaki et al. (2022) and Chaffin et al. (2013), used VR to create multi-sensory experiences, combining sound, visuals, and interaction to simulate intense delusions and internal voices. These simulations give users a chance to experience how people with psychosis may perceive the world [6, 31].

Silverstein et al. (2021) and van Ommen et al. (2019) looked at how people with schizophrenia might see distorted images, such as unfamiliar faces, strange objects, or warped environments. These insights helped developers create more realistic simulations, showing how visual hallucinations might appear in everyday places. The goal of these simulations is to give users a first-person view of the symptoms. By doing this, they aim to help healthcare professionals, students, and the general public better understand what people with schizophrenia go through [26, 28].

Addtionally, some of these tools have been made specifically for training in medical and nursing education. Yoo et al. (2020) and Lee et al. (2020) developed VR training programs using 360-degree video and actors to recreate clinical situations[15, 30]. These simulations include symptoms like hearing voices, false beliefs, or patients behaving aggressively or withdrawing. They were shown to be realistic and useful for learning, and were delivered through VR headsets.

The majority of studies in this field have focused on using VR to simulate schizophrenia symptoms. For example, Kuhail et al. (2022) used VR to simulate auditory hallucinations for medical students. The students who took part in the simulation showed more empathy and a better understanding of what it's like to live with schizophrenia [14]. Similarly, Silverstein et al. (2021) created a VR experience that simulated visual hallucinations. Participants who went through this simulation showed reduced stigma toward people with schizophrenia [26]. These studies suggest that VR simulations can be helpful for educating people about mental illness and for breaking down stereotypes.

2.2.2 Augmented Reality and Mixed Reality in Schizophrenia Education

An increasing number of studies are exploring the use of AR and MR in schizophrenia education. One early - and for this thesis very relevant - example is by Silva et al. (2017), who created a tool using both VR and AR to simulate psychotic symptoms. This system, developed with input from psychiatric professionals, was designed to help users — especially medical students — better understand schizophrenia and reduce stigma. The AR tool allowed users to interact with simulated symptoms in real time, providing a safe and controlled learning environment [25]. To test the system, 21 medical students used AR glasses to experience the simulation. Afterward, they filled out questionnaires about their attitudes toward schizophrenia, how realistic they found the experience, and whether their views had changed. Students gave high ratings for the audio quality and educational value of the simulation. Many said it helped them better understand what psychotic experiences might feel like. However, some users also reported problems, such as discomfort from the equipment and difficulty focusing in the environment [25].

The simulations impact on empathy and stigma was measured using questionnaires before and after the experience. The results showed that students felt more empathy, expressed more concern for a fictional patient, and were more willing to help. However, there was also a small increase in stigma scores, showing that the results were complex. The study suggests that while AR can help foster empathy, future designs should focus on improving comfort and exploring long-term effects. It also recommends combining simulations with brief educational sessions on schizophrenia to deepen understanding. In this thesis, a similar approach is taken: students will participate in the simulation after they have already been educated on schizophrenia, which should help them better understand and relate to the experience.

A more recent project by Krogmeier et al. (2024) involved the development of *Live-It*, an AR simulation that used the passthrough function of the Meta Quest headset. This system simulated hallucinations and delusions in familiar places like living rooms or pharmacies. The design was based on real-life accounts from individuals with schizophrenia and was reviewed by neuropsychologists to ensure accuracy [13]. Participants in the study —mainly students and professionals in mental health — reported strong emotional reactions and said the simulation helped them better understand schizophrenia symptoms. One of the strengths of *Live-It* was its ability to place symptoms into everyday situations, which made the experience feel more realistic and less overwhelming than fully immersive VR. For example, users heard voices that ranged from critical to supportive, reflecting the variety of hallucinations people might experience. The simulation also ended with hopeful, recovery-focused messages, which helped balance the emotional impact. Overall, the study found that *Live-It* increased empathy and encouraged participants to support individuals with schizophrenia. It showed that AR can be a powerful tool in mental health education, especially when it helps bridge the gap between theory and real-life experience [13].

Some programs are now combining simulations with direct interactions, such as discussions or debriefs with individuals who have lived experience of schizophrenia. For instance, Hsia et al. showed that pharmacy students who took part in a simulation and also heard from a guest speaker diagnosed with schizophrenia showed greater reductions in stigma and increases in empathy [12]. This combined approach helps address one of the main concerns with simulations — that they can unintentionally increase social distance or reinforce stereotypes if not supported by real-life context. Including authentic human interaction can make the experience more meaningful and well-rounded.

2.2.3 Challenges and Considerations

Even though immersive simulations are becoming more popular in mental health education, especially for schizophrenia, they still come with some challenges. One concern is that, if not properly designed and explained, these simulations could unintentionally reinforce negative stereotypes or even increase stigma instead of reducing it [2]. Some users have also reported feeling uncomfortable or distressed during the simulations — especially when the content includes intense symptoms like command hallucinations or feelings of paranoia [6, 31].

Another issue is finding the right balance between realism and ease of use. Creating highly realistic simulations requires detailed sound and visual effects, as well as believable acting. This can be technically complex and time-consuming. In addition, designers must consider the wide variety of ways symptoms can appear in different individuals. Without this, the simulation might not be relevant — or even appropriate — for all users [31].

In summary, immersive technologies like VR, AR, and MR have great potential in mental health education, especially for conditions like schizophrenia. As these technologies continue to improve, they are expected to become more common in medical and nursing training. This could lead to more engaging and effective learning experiences, and ultimately, better care for patients.

2.3 Empathy

Empathy is a key part of good communication and care in healthcare. Many studies have shown that when healthcare professionals show empathy, patients are more satisfied, more likely to follow treatment plans, and often have better mental health outcomes [7, 20, 21]. In medical and nursing education, empathy is no longer seen as just a ”soft skill.” It is now treated as something important that can be taught and developed. Teaching empathy helps improve the way future professionals connect with patients and provide care [7].

Empathy is usually described as having two main parts: *cognitive empathy* and *affective empathy*. Cognitive empathy is the ability to understand what someone else is thinking or feeling. Affective empathy means actually feeling or emotionally connecting with what the other person is going through [17, 29]. In healthcare, both types are important. Understanding a patient’s perspective (cognitive empathy) helps with communication and decision-making, while emotional connection (affective empathy) helps build trust and stronger relationships [7, 21]. Some researchers also talk about a third type, called *clinical empathy*, which is about clearly showing patients that you understand them and care about helping them [10].

Understanding this and training empathy helps doctors and nurses better understand their patients and respond in helpful and compassionate ways [20, 21]. However, research has shown that empathy can decrease during medical training. This might be because students are under pressure, focusing more on technical knowledge, or feeling emotionally drained [18, 21]. This decline in empathy can lead to negative outcomes for both patients and healthcare professionals. Patients may feel misunderstood or neglected, while healthcare providers may experience burnout and job dissatisfaction [7, 18]. Therefore, it is crucial to find effective ways to teach and maintain empathy in medical education.

The immersive tools discussed in this thesis are being tested in medical and nursing schools as a new way to teach empathy by letting students “step into the shoes” of patients [1]. As mentioned earlier, this approach is becoming more popular in education and has shown promising results.

2.3.1 Empathy Enhancement with Virtual Reality

Virtual Reality (VR) has often been called the ”ultimate empathy machine” because it can create powerful first-person experiences in fully immersive environments [19]. Several studies support this idea, showing that VR can have a strong emotional effect on users.

VR is especially useful when it comes to helping people understand the experiences of stigmatized groups, such as individuals with schizophrenia [9, 16, 18]. These systems allow users to go through simulated versions of symptoms like hearing voices or feeling paranoid. By placing users in situations that reflect what it might be like to live with psychosis, these simulations aim to increase empathy and reduce negative attitudes. For example, Formosa et al. found that people who used a VR simulation of schizophrenia symptoms felt more empathy and showed less stigma afterwards compared to those who did not use the simulation [9]. A similar study by Hsia et al. showed that pharmacy students who experienced auditory hallucinations in VR also became more empathetic and less stigmatizing toward people with schizophrenia [12].

2.3.2 Empathy and Schizophrenia Simulations

Marques et al. (2022) ran an experiment to compare how well a VR simulation and a regular 2D video improved empathy, knowledge, and attitudes about schizophrenia. Participants were divided into two groups: one group experienced the symptoms of psychosis in VR, and the other watched the same content in a video format. The study found that the VR group showed greater increases in cognitive empathy and more positive attitudes. However, there were also some challenges. For example,there was no control group with no exposure at all, making it harder to judge the full effect of the simulation. The short length of the simulation may have limited its impact, and some participants struggled to fully engage with the technology due to unfamiliarity with VR. In addition, the study reported some unexpected results in physiological responses and did not measure how immersive the experience felt [16]. In this thesis, we aim to address some of these issues by using Mixed Reality (MR) instead of VR, which may feel more familiar and less overwhelming to users. We will also measure the level of immersion and provide participants with background knowledge before the simulation to improve understanding. *follow up on this*

Another relevant study is by Zare-Bidaki et al. (2022), who looked at how a single VR simulation of psychosis (VRSP) affected medical students' stigma, empathy, and knowledge compared to traditional patient visits. Their results showed that VRSP gave students a more consistent understanding of symptoms, since real patient experiences can vary from case to case. Both the VR and patient visit groups showed reduced stigma and increased empathy, but the VR group had a slightly stronger effect. However, the study noted that VR should not replace direct patient contact - it should be used as a supplement. This real-world context adds human depth, reduces the risk of reinforcing stereotypes, and fosters more lasting empathy. Without this, users might focus solely on the strangeness or severity of symptoms rather than understanding the person behind them. Educational simulations should therefore be seen as tools that complement —n ot replace — personal connection, clinical observation, and comprehensive education [12, 31]. Importantly, while both methods increased empathy, the link between empathy and stigma reduction still needs more research [31].

The study also pointed out some possible downsides of using VR without additional context. If the simulation focuses too much on dramatic or frightening symptoms, it could unintentionally increase stigma rather than reduce it. That is why it is important to pair simulations with educational content that shows the full picture of what it is like to live with schizophrenia — not just the symptoms. In this thesis, this issue will be addressed by ensuring that students receive proper background knowledge on schizophrenia before the simulation, so they can better understand the experience from a cognitive perspective as well [31].

Finally, the study found that the design of the simulation matters. If the environment is too dramatic or scary, it might negatively affect how participants feel about people with schizophrenia. Using calm and neutral environments can help avoid this. The researchers also suggested that Augmented Reality (AR) could be even more effective than VR for building empathy because it allows users to see the real world while experiencing symptoms. This makes the experience feel more realistic and less overwhelming [31]. These ideas also support the decision to use MR in this thesis. Since MR combines real-world elements with simulated symptoms, it has the potential to offer a more balanced and relatable experience. Marques et al. also found that participants who used a VR simulation scored higher on empathy than those who only watched a standard 2D video [16]. This supports the idea that ”embodied perspective-taking” — actually feeling like you're in someone else's position — can be more powerful than just imagining it, especially for people with little prior knowledge about mental illness.

Mattsson et al. studied how nursing students responded to VR simulations and found that many of them not only felt emotionally connected to the experience but also wanted to help the virtual patients [18]. Students said they were better able to recognize emotional cues and understand the patient's perspective compared to traditional learning methods.

In a related study, Olson showed that when nurses expressed empathy in their care, patients experienced less emotional distress [20]. Together, these findings show the importance of empathy in healthcare and suggest that immersive technologies like VR can play a helpful role in training future professionals to connect with patients more deeply.

2.3.3 Limitations of VR in Empathy Training

A meta-analysis by Martingano et al. that looked at 43 studies found that VR tends to improve *affective empathy* — the ability to emotionally connect with others — but has less impact on *cognitive empathy*, which involves understanding another person's perspective on a deeper level [17]. This means that while VR can make people feel emotionally involved, it may not be as good at helping them think through what others are going through unless additional tools, like reflection or discussion, are included. One reason for this might be that VR experiences take away the cognitive ability of the user to imagine themselves in someone else's shoes. The experience already gives you this perspective [17].

Some researchers have raised concerns about relying too much on VR for teaching empathy, especially in moral or educational settings. Rueda and Lara (2020) argue that the emotional reactions produced by

VR can sometimes be shallow or short-lived. They suggest that what's needed is *reason-guided empathy* — where emotional experiences are paired with ethical reflection and a deeper understanding of context [24]. Without this, people might have strong feelings in the moment but not actually change how they think or behave in the long term [17]. *emphasize on the debrief after the testing*

Other important limitations have also been noted. Martingano et al. found that more advanced or immersive VR experiences were not always better than simpler tools, such as 360° video, when it came to increasing empathy [17]. Many VR simulations also focus on dramatic storytelling and emotional intensity, which may reduce the user's ability to make their own decisions during the experience. This can limit the development of perspective-taking and meaningful change in behavior.

Finally, there are ethical concerns. Rueda and Lara warn that if VR simulations are not carefully designed, they might unintentionally reinforce stereotypes or simplify complex experiences in harmful ways [24]. These concerns are especially important in mental health simulations, where realism and responsible storytelling are critical. In this thesis, these risks are taken seriously and addressed by combining immersive experience with structured preparation and post-simulation reflection to ensure a more thoughtful and lasting impact.

2.3.4 Mixed Reality and Empathy in Medical Education

show how everything aligns with MR and how it is the best option for this thesis

While virtual reality (VR) has received the most attention in empathy training, mixed reality (MR) is becoming a promising alternative. MR allows users to stay partly connected to the real world while interacting with digital content. It combines the full immersion of VR with the real-world awareness of augmented reality. This mix can help reduce sensory overload and make the experience feel more familiar and less overwhelming—two common problems with fully immersive VR [31].

Recent research has shown that MR can be effective for building empathy, especially in mental health education. For example, Silva et al. (2017) tested an MR system that simulated symptoms of psychosis. Medical students who used it reported feeling more empathy and better understanding what it's like to live with schizophrenia [25]. The combination of real-world surroundings and simulated symptoms made the experience feel realistic but not too intense. In a similar project, Krogmeier et al. (2024) developed *Live-It*, a passthrough MR experience that showed hallucinations in everyday places like a living room or pharmacy. Participants said the experience felt very emotional and relatable, partly because the simulation included familiar environments and ended with messages about hope and recovery [13].

These studies show that MR can be a valuable tool in medical education, especially for teaching empathy toward people with mental illness. In this thesis, MR is chosen not only for its technological features, but also because it offers a better learning experience. It allows students to experience what psychotic symptoms might feel like, without fully disconnecting from the real world. This balance could help create a deeper and safer understanding of mental illness by combining emotional impact with cognitive clarity.

2.3.5 Measuring Empathy

Various instruments are used to measure these dimensions of empathy, including the Jefferson Scale of Empathy (JSE), which is being widely applied in medical education [1]. This tool allows researchers to assess changes in empathy following interventions and distinguish between shifts in emotional versus cognitive components, which is also what I want to achieve in this thesis. In the context of this thesis, the JSE will be used to measure the impact of the MR simulation on medical students' empathy levels. The JSE is a validated instrument that has been widely used in medical education research and has demonstrated reliability and validity in assessing empathy in healthcare professionals [10]. By employing the JSE, this study aims to provide a comprehensive evaluation of the effectiveness of the MR simulation in enhancing both cognitive and affective empathy among medical students. In chapter 5, we will discuss the results of the JSE and how they relate to the overall objectives of this thesis.

Authors (Year)	Tech.	Target Group	Design	Symptoms Simulated	Main Results	Year	Empathy Type
Skoy et al. (2016)	VR	Pharmacy Students	Pre/Post Exp.	Auditory Hallucinations	Increased empathy	2016	Affective
Zare-Bidaki et al. (2022)	VR	Medical Students	Patient Visit Comparison	Auditory + Delusions	Greater empathy, stigma reduction	2022	Affective
Chaffin et al. (2013)	VR	General Public	Exploratory	Auditory + Visual Halluc.	Understanding, distress	2013	Affective
Silverstein et al. (2021)	VR	General Public	Survey/VR	Visual Hallucinations	Reduced stigma	2021	Affective
Van Ommen et al. (2019)	Survey	Psychosis Patients	Survey Study	Visual Hallucinations	Simulation insights	2019	None
Yoo et al. (2020)	360 VR	Nursing Students	Usability Study	Multiple	Immersive training	2020	Affective
Lee et al. (2020)	360 VR	Nursing Students	Usability Study	Multiple	Awareness, safe tool	2020	Affective
Kuhail et al. (2022)	VR	Medical Students	Controlled Trial	Auditory Hallucinations	Strong engagement	2022	Affective
Marques et al. (2022)	VR	General Public	Controlled Trial	Auditory + Visual + Delusions	High empathy, physio response	2022	Affective
Silva et al. (2017)	AR	Medical Students	Pilot Study	Auditory + Visual	Realism, some discomfort	2017	Affective
Krogmeier et al. (2024)	AR/MR	Healthcare Students	Qualitative Eval.	Auditory + Visual + Delusions	Empathy increased	2024	Affective
Hsia et al. (2022)	VR + Speaker	Pharmacy Students	Mixed-Methods	Auditory + Discussion	Speaker addition effective	2022	Affective
Cunico et al. (2012)	Training	Nursing Students	Longitudinal	N/A	Emotional empathy ↑ (females)	2012	Affective
Ozcan et al. (2018)	Curriculum	Nursing Students	Comparative Longitudinal	N/A	Higher empathy (integrated)	2018	Affective
Ventura et al. (2020)	VR	General Pop.	Meta-analysis	Various	Cognitive empathy ↑	2020	Cognitive
Rueda & Lara (2020)	VR	General	Theory Review	N/S	Affective focus	2020	Affective
Mattsson et al. (2024)	VR	Nursing Students	Qualitative	Pneumonia Sim	Affective empathy elicited	2024	Affective
Alieldin et al. (2024)	VR	Medical Students	Mixed Methods	Social Isolation	JSE ↑, emotional engagement	2024	Affective
Martingano et al. (2021)	VR	General Pop.	Meta-Analysis	Various	Affective ↑, Cognitive —	2021	Affective

Table 2.1: Summary of studies on immersive and training-based empathy interventions, including type of empathy increased.

3
Methodology

In this section, you should present what you intend to do, why you are doing it this way. Outline your research question in regards to the related work you presented. Explain the intended general architecture, design of your system or interfaces. Try to argument your choices with notions from the state of the art.

This chapter outlines the methodological approach taken in this thesis to investigate the impact of Mixed Reality (MR) simulations on empathy toward individuals with schizophrenia. Drawing upon insights from the existing literature on immersive technologies and empathy training, this section details the research question, the rationale behind using MR, the design of the MR simulation system, and the approach to evaluating its effectiveness.

3.1 Research Objective and Question

As identified in the state of the art, immersive technologies have shown significant potential in mental health education, especially in fostering empathy and understanding toward individuals with schizophrenia. However, the majority of research has focused on Virtual Reality (VR), with relatively fewer studies exploring the potential of Mixed Reality (MR) for this purpose. This thesis seeks to fill that gap by investigating:

> ***To what extent can a Mixed Reality (MR) simulation enhance cognitive and affective empathy toward individuals with schizophrenia among medical students?***

This research builds on studies such as those by Silva et al. (2017) and Krogmeier et al. (2024), which demonstrated that MR simulations can evoke empathy without overwhelming users, thanks to their grounding in real-world environments.

3.2 Rationale for Using Mixed Reality

Based on the literature review, Mixed Reality (MR) offers several compelling advantages over Virtual Reality (VR) in the context of schizophrenia simulations, making it a particularly suitable choice for this thesis. One of the most important benefits of MR is its ability to provide emotional safety through real-world grounding. Unlike fully immersive VR, which can sometimes overwhelm users with intense sensory input, MR allows participants to remain anchored in their actual environment. This helps reduce the risk of distress that has been reported in VR-based schizophrenia simulations, especially when simulating severe or frightening symptoms [31].

MR also offers higher relatability and engagement by integrating hallucinations and delusional content into familiar, everyday settings, such as a pharmacy, classroom, or living room. This contextualization can enhance the emotional resonance of the experience, as users are more likely to connect with scenarios that resemble their own daily environments [13]. Rather than experiencing psychotic symptoms in abstract or exaggerated virtual spaces, participants see these symptoms unfold in realistic and meaningful contexts, increasing the perceived authenticity of the simulation.

Furthermore, MR supports a more balanced approach to empathy training by addressing both cognitive and affective components. While VR often elicits strong emotional reactions, MR allows users to emotionally engage with the simulation while still having the cognitive space to process and reflect on what they are experiencing. This dual engagement is particularly valuable in educational settings, where the goal is not only to generate emotional impact but also to foster a deeper understanding of the condition being simulated [17, 24].

From a technical perspective, MR provides a high degree of flexibility through the use of modern headsets equipped with passthrough functionality, such as the Meta Quest Pro. These devices allow for high-resolution video feeds of the user's environment, onto which simulated symptoms can be accurately layered in real time. This technology enables the development of dynamic, responsive simulations that feel both immersive and grounded in reality, offering a unique and effective tool for mental health education.

3.3 Simulation Design

move this to the implementation section (?) The Mixed Reality (MR) simulation system developed in this thesis was designed to recreate auditory and visual hallucinations inspired by first-person accounts of psychosis, with the aim of providing an immersive yet emotionally grounded educational experience. The system runs on a Meta Quest 3 headset equipped with passthrough functionality, which allows digital elements to be overlaid onto the user's real-world environment in real time. This creates a hybrid space in which simulated symptoms blend seamlessly into familiar settings like a classroom or home office.

At the core of the simulation is a orchestrator that delivers hallucinations sometimes even based on user interaction. The experience unfolds in a carefully structured sequence. It begins with auditory hallucinations: users hear unsettling whispers and hostile sentences, designed to evoke feelings of being watched, judged, or threatened—common themes in persecutory delusions. These voices are spatially anchored and vary in tone, emphasizing the sense of psychological intrusion.As the simulation progresses, visual distortions begin to appear. Dark and pulsating stains gradually emerge across the users visual field, disrupting their perception of the environment. The auditory hallucinations continue, now commenting on these visual hallucinations, deepening the immersive experience and creating a multi-sensory representation of psychosis.

In the final stage of the simulation, brightly colored, floating spheres appear above the users head. The voices urge the user to interact with them—repeating instructions until the user does so. Once the user complies, the spheres change color. This simulation draws on phenomenological reports from individuals with schizophrenia. [28]

To support cognitive and ethical processing of this intense experience, the simulation is framed by two educational components. Before the simulation, users receive a short briefing that introduces schizophrenia, explains the diversity of symptoms, and clarifies the pedagogical purpose of the exercise. After the simulation, a guided debrief encourages open reflection, using structured questions to help participants process their emotions, connect the experience to clinical understanding, and critically engage with what they encountered.

The system design draws on established best practices in immersive mental health education, particularly the integration of experiential learning with reflection and context, as recommended by Rueda and Lara (2020) and Zare-Bidaki et al. (2022). This careful balance of sensory immersion, narrative progression, and educational framing aims to foster both empathy and insight while minimizing emotional risk.

3.4 Participants and Procedure

The target group for this study consists of medical students in their preclinical or early clinical training, specifically from the University of Health in Fribourg, Switzerland (Haute école de santé Fribourg, HEdS-FR). This population was selected for two primary reasons. First, students at this stage are actively developing their clinical attitudes, including their capacity for empathy toward patients. Second, previous research has shown that empathy training tends to be particularly effective during this formative period in a healthcare professionals education [12, 14].

Participation in the study is voluntary, and all participants are recruited through internal communication channels within the university. Before taking part, each participant receives comprehensive information about the study's objectives, procedures, and potential risks. They are informed of their rights, including the ability to withdraw at any time, and are asked to sign a written consent form confirming their understanding and agreement.

The study begins with a pre-test phase, during which participants complete the Jefferson Scale of Empathy (JSE) [10] to assess their baseline empathy levels. In addition, they fill out a supplementary questionnaire that includes the Brief Positive and Negative Affect Schedule (B-PANAS) [5], which measures their current emotional state and perceptions regarding individuals with schizophrenia.

Following this, participants undergo the Mixed Reality (MR) simulation, which lasts approximately 4 to 5 minutes. During this time, they are exposed to a carefully designed sequence of auditory and visual hallucinations, situated in a familiar, everyday setting. The aim of the simulation is to offer an immersive experience of psychotic symptoms while maintaining a safe and relatable environment.

After completing the simulation, participants take part in a structured post-simulation debriefing session, moderated by faculty members. This reflection phase provides an opportunity to process emotional responses, share thoughts about the experience, and discuss how it relates to clinical practice. This guided reflection is a crucial element of the methodology, helping to contextualize the simulation and support the development of cognitive empathy.

To conclude the study, participants repeat the JSE and B-PANAS assessments. These post-tests are used to evaluate changes in empathy, emotional state, and attitudes toward individuals with schizophrenia. Participants are also invited to provide qualitative feedback on the simulation, including its perceived realism, emotional impact, and educational value. This mixed-methods approach ensures a comprehensive evaluation of the MR simulation's effectiveness in fostering empathy and insight.

To conclude this chapter, by combining already known MR technology with carefully designed educational framing and post-simulation reflection, this thesis seeks to explore an approach to empathy training in medical education. The methodology builds on known challenges and recommendations from the literature, such as avoiding emotional overload, reinforcing context, and ensuring accurate, respectful depictions of schizophrenia. Through both quantitative and qualitative methods, this study will assess whether MR can provide a safer, more relatable, and more impactful alternative to traditional VR in empathy-focused mental health education.

4
Implementation

In this section, you should present what you have done. How things have been implemented and how they work. Please avoid putting lines and lines of code here. But you can highlight some important elements of your implementations (some important part of the code, if necessary).

4.1 Structure of the Simulation

Explain why you chose this structure and why you chose these hallucinations and sentences

The structure of the simulation was carefully designed to evoke a progressively immersive and unsettling representation of hallucinations associated with schizophrenia. This structure was chosen to reflect both phenomenological research on psychotic symptoms and evidence-based educational strategies for increasing empathy and reducing stigma in health professionals.

The auditory hallucinations used in this simulation draw from documented simulation programs such as Patricia Deegan's "Hearing Voices," which have been shown to significantly impact empathy levels in students and clinicians [12]. In alignment with these findings, the simulation integrates a sequence of whispered voices and confrontational phrases. The sentences were crafted and timed intentionally to gradually escalate in emotional intensity, following research that demonstrates increased affective engagement leads to more powerful learning and emotional responses [27].

Complementing the auditory component are visual hallucination elements, including dynamically spawning colored spheres, spatial distortions through dot placements, and visual darkening of the field of view. These visuals were inspired by clinical descriptions of visual hallucinations in psychotic disorders, such as geometric distortions, flickering lights, and anthropomorphic or symbolic figures [26, 28].

The structural design aims to simulate both simple and complex hallucinations. Early stimuli (whispers, darkness) mimic the subtle onset of perceptual anomalies, while the crescendo of auditory cues and visual manifestations evoke the overwhelming nature of full-blown psychosis. This approach allows users to move from discomfort to disorientation, simulating the lived experience of progressive symptom development.

4.2 Implementation of the Simulation

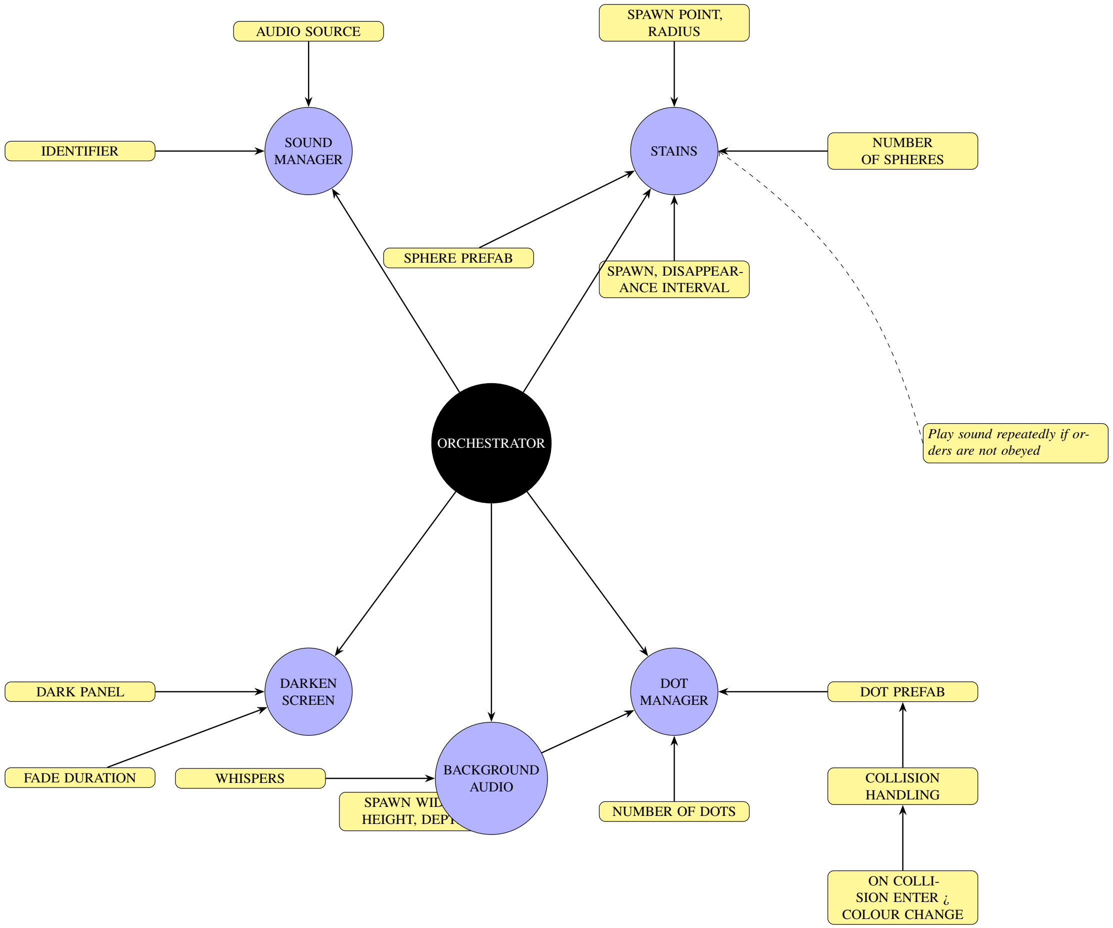
Explain how you implemented the simulation. What are the main components of the simulation? How do they interact with each other? The simulation was implemented in Unity and constructed through modular components that interact in time-dependent sequences coordinated by a central control script.

4.2.1 Orchestration

At the heart of the system lies the *Orchestrator.cs* script. This script sequences the entire simulation, controlling when sounds play, visual hallucinations appear, and environmental effects occur. The timeline was structured using IEnumerator coroutines, allowing asynchronous timed execution of events, ensuring immersive pacing without overwhelming the user too early in the experience.

Synchronization across components ensures the user is not overwhelmed with concurrent stimuli too early. For example, whispers begin before visuals, allowing users to acclimate to auditory disturbances before confronting the more jarring visual phenomena. Visual hallucinations are also paced in relation to emotional escalation in the voice samples, building tension across the timeline.

Figure 4.1: Diagram of the Orchestrator system showing the interaction between auditory, visual, and environmental components.


AUDIO SOURCE
SPAWN POINT, RADIUS
IDENTIFIER
SOUND MANAGER
STAINS
NUMBER OF SPHERES
SPHERE PREFAB
SPAWN, DISAPPEAR-ANCE INTERVAL
ORCHESTRATOR
Play sound repeatedly if or-ders are not obeyed
DARK PANEL
DARKEN SCREEN
DOT MANAGER
DOT PREFAB
FADE DURATION
WHISPERS
BACKGROUND AUDIO
SPAWN WID
HEIGHT, DEPT
COLLISION HANDLING
NUMBER OF DOTS
ON COLLI-SION ENTER ¿ COLOUR CHANGE

4.2.2 Auditory Hallucinations

The auditory effects in the system are handled by the *SoundManager.cs* script. Audio files are grouped by voice type, making it easy to play back different kinds of hallucination samples. These voices include phrases that sound accusatory, confusing, or frightening—reflecting common real-world descriptions of auditory hallucinations.

The voices were generated using ElevenLabs, a text-to-speech AI engine [8]. Each one was created with a specific emotional tone in mind: one voice sounds scared and almost shouting, another is snooty and mean, and the third sounds lost and desperate. These voices are played at key moments to create a stronger sense of fear, confusion, or paranoia. Their timing is matched with visual effects to create a more immersive and realistic experience of multisensory hallucinations.

In addition, the *ObjectCollision.cs* script adds interactive audio that loops until the user physically interacts with an object. This mimics the frustrating and unpredictable nature of hallucinations, as often described by people experiencing psychosis.

4.2.3 Visual Hallucinations

Visual components are diversified to simulate various hallucination types:

- Wave Deformation: *DynamicWaveDeformation.cs* distorts object surfaces using transformations, creating a pulsating geometry that mimics perceptual distortions in psychosis.
- Gradual Screen Darkening: *ScreenDarkener.cs* overlays a semi-transparent black UI panel to simulate the narrowing of visual perception or "tunnel vision," often reported during intense hallucinations.
- Dot Fields: *DotManager.cs* creates random red and blue dots that appear above the user. These dots represent chaotic visual input or visual noise, similar to the floating patterns often described by people experiencing psychosis.
- Pulsating Spheres: The Orchestrator periodically spawns spherical objects, creating a feeling of presence and spatial invasion. Their randomness and impermanence reflect transient hallucinations and visual object anomalies.

Each visual element in the system was designed based on descriptions of how people with schizophrenia may experience their symptoms. These experiences are often grouped into simple, geometric, and complex visual types [26, 28].

The way the system is built makes it easy to expand in the future.

5
User Study

In this section, you should present your user study and its methodology.

5.1 Methodology

This study employed a within-subjects mixed-method design to investigate the impact of a mixed reality (MR) simulation on cognitive and affective empathy in medical students. The experimental component involved participants experiencing a short, immersive simulation of schizophrenia symptoms using a mixed reality headset, while the control aspect involved observation and related tasks by non-headset participants. Empathy levels were measured using standardized questionnaires administered before and after the simulation.

Participants were recruited from the university of health in Fribourg, Switzerland (fr. Haute école de santé Fribourg (HEdS-FR)). Inclusion criteria required participants to be currently enrolled medical students fluent in French or German and able to provide informed consent. All participants signed a consent form that clearly outlined the purpose, procedure, risks, and their rights, including the option to withdraw at any point. Participants were assured of confidentiality and anonymity per Swiss data protection regulations.

The study utilized a mixed reality headset, namely the Meta Quest 3, with a backup unit available in case of technical difficulties. The core of the experimental procedure was a custom-built mixed reality simulation designed to replicate common positive symptoms of schizophrenia, including auditory hallucinations and perceptual disturbances. Each simulation lasted approximately three to five minutes and was rebuilt after every session to ensure consistent functionality.

Data collection was facilitated through Microsoft Forms questionnaires. The pre-questionnaire gathered demographic information and assessed baseline levels of empathy using a validated empathy scale, such as the Jefferson Scale of Empathy or the Interpersonal Reactivity Index. Following the simulation, the post-questionnaire re-administered the empathy assessment and included open-ended items to capture participants' qualitative reflections on the experience.

Additional materials included printed consent forms for each participant, a list documenting participant names and group allocations, and basic administrative supplies such as pens, which were used for signing documents and taking notes when required.

5.2 Preparation

The study environment was prepared prior to participant arrival.

6
Results and Analysis

In this section, you should present the results and their analysis. We recommend using graphics and charts to illustrate your result. Try to highlight the most important results.

7 Discussion

In this section, you should discuss your result and your work. Summarize and discuss your results, discuss your initial choices and compare with other works from the state of the art. How do you compare (if you can) ? Discuss your research questions in the light of your results.

8
Conclusion

This is a very important part of a report. Give all relevant conclusions, even negative. Stress novelty and scientific or industrial impact. Also new insights, outlook and recommendations for improvement should be put here. However, do not introduce results or concepts that belong in the body of the report. Bring structure in your conclusions.

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Erklärung

gemäss Art. 28 Abs. 2 RSL 05

Name/Vorname: ....

Matrikelnummer: ....

Studiengang: ....

Bachelor ☐ Master ☐ Dissertation ☐

Titel der Arbeit: ....

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LeiterIn der Arbeit: ....

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