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UNIVERSITY OF CALIFORNIA
SANTA CRUZ

**Designing and Evaluating a Serious Virtual Reality Game for the
Psychosocial Support of Preadolescents with Orofacial Cleft Lip
and/or Palate**

A dissertation submitted in partial satisfaction of the
requirements for the degree of

DOCTOR OF PHILOSOPHY

in

COMPUTATIONAL MEDIA

by

Tiffany Thang

June 2023

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2023

Table of Contents

List of Figures	v
List of Tables	vii
Abstract	viii
Acknowledgments	x
1 Introduction	1
1.1 Orofacial Cleft Lip and/or Palate (CLP)	5
1.1.1 Psychosocial Skills	7
1.1.2 Existing Methods of Psychosocial Support for Individuals with CLP and Limitations	10
1.2 VR Technologies	12
1.2.1 VR and AR Technologies for Psychosocial Support	14
1.2.2 VR for the Psychosocial Support of People with Psychosocial Dis- abilities	18
1.2.3 VR for the Psychosocial Support of Individuals with ASD	21
1.2.4 VR, AR and Non-immersive VR Technologies for Individuals with CLP	24
1.2.5 Developing VR for the Psychosocial Support of Individuals with CLP	27
2 Designing a Serious VR Game for Psychosocial Support	31
2.1 Expert and User Interviews	32
2.1.1 Psychologist Interview Data: Colombia	33
2.1.2 Psychologist Interview Data: Brazil	34
2.1.3 Psychologist Interview Data: Philippines	35
2.1.4 Patient Interview Data	37
2.2 Game Design	40
2.2.1 Journey Mapping Psychosocial Support Sessions	40
2.2.2 Storyboarding Game Modules and Storyline	44

2.2.3	Iterative Design and UCD for VREs	47
3	Game Development	52
3.1	Game Format	53
3.1.1	Introduction Module	54
3.1.2	Module A: Social Soccer	55
3.1.3	Module B: Cafeteria Calculations	57
3.1.4	Module C: Cyberbully Bugs	60
3.1.5	Game Conclusion	64
3.2	Multiplayer Capabilities	64
3.2.1	Implementation of Multiplayer Capabilities	65
3.2.2	Synchronization of Scenes, Dialogue and Objects	67
4	Case Study and Results	72
4.1	Study Design	72
4.1.1	Case Study Procedure	75
4.2	Results and Data Analysis	79
4.2.1	Quantitative Data	80
4.2.2	Qualitative Data	84
5	Discussion	90
5.1	Analyzing the Impact of Designing with Psychologists and Individuals with CLP	91
5.2	Analyzing the Impact of Providing Psychosocial Support Through VR Games	98
5.3	Directions for Future Work	101
6	Conclusion	105
	Bibliography	110

List of Figures

2.1	Journey map produced from journey mapping exercise conducted with Smile Train partnering psychologists from Colombia, outlining psychosocial support in 1-on-1 and group sessions based on severity of psychosocial needs.	41
2.2	The initial storyboard for the Introduction module created with the psychologists from Colombia is shown here. Images drawn from collaborative discussions and comments from the psychologists and development team are included on the storyboard.	44
2.3	Diagram demonstrating how the VR game would be incorporated into 1-on-1 psychosocial support sessions with preadolescent patients with CLP	47
3.1	A screenshot of Module A: Social Soccer, where the Psychologist UI is active. The psychologist or clinician must decide whether the patient's response progresses the game or prompts the characters to ask them to repeat themselves.	56
3.2	SuperPup is helping supervise the patient who must figure out the correct combination of food items to match the payment total of the student.	58
3.3	In Module C: Cyberbully Bugs, the patient is inside of Angelina's computer that is infested with bugs. The Psychologist UI is shown, where they can delete the bug that the patient has clicked once they have decided an appropriate way of reframing it	61
3.4	A system diagram depicting the use of Photon PUN 2's regional servers to connect the MasterClient (Psychologist) and Client (Patient) in a game room is shown.	65
3.5	In this image the Psychologist UI is active. The button directly underneath the dialogue box allows the Psychologist player to switch the Master Client, allowing for proper synchronization of scenes and in-game actions.	66
3.6	Screenshot of DialogueManager.cs script that enables the dialogue to synchronize across all players in the game (left) with the dialogue objects shown in Unity (right).	68

3.7	Code from Module C: Cyberbully Bugs, using a RPC to synchronize the deletion of spiders from the game scene.	70
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List of Tables

4.1	BASC Factor Definitions	76
4.2	BASC Factor Definitions (Continued)	77
4.3	Participant User Testing Schedule	78
4.4	BASC Scale Results	81
4.5	Median Module Feedback Questionnaire Quantitative Responses	83

Abstract

Designing and Evaluating a Serious Virtual Reality Game for the Psychosocial
Support of Preadolescents with Orofacial Cleft Lip and/or Palate

by

Tiffany Thang

Preadolescents with orofacial cleft lip and/or palate (CLP) will often require support in developing and strengthening psychosocial skills. As instances of peer rejection, bullying and low self-esteem are prevalent during this age, preadolescents with CLP may require psychosocial support in learning to accept their condition and effectively deal with difficult social situations. Accessing this type of support can be challenging, as clinicians and healthcare professionals may lack the experience and training necessary to provide adequate psychosocial support to preadolescents with CLP. Licensed psychologists with experience working with this population may be available, however it is noted that the costs associated with their support may cause increased financial strain on families and individuals with CLP. In this dissertation work, I aim to address some of these challenges through the design, development and evaluation of a serious virtual reality (VR) game in providing psychosocial support to preadolescents with CLP. In collaboration with global cleft organization, Smile Train, I designed this game with psychologists and patients from their partnering clinics and hospitals across the globe, and evaluated the use of the game as a supplement to existing psychosocial support sessions with a psychologist. Through this work, I examine the impact of co-designing a VR game for

psychosocial support and the feasibility of VR games for providing psychosocial support to this population, discussing the implications of the findings towards future work in this field.

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Chapter 1

Introduction

Orofacial cleft lip and/or palate (CLP) is a congenital condition that occurs when the lip and/or palate is not joined or completely formed before birth [1]. This condition is often associated with a visible facial cleft, but also with various physiological health issues, including speech disorders, hearing deficits, chronic ear infections, and dental and palatal deformities [2, 3, 4]. Psychosocial issues, such as low self-esteem and bullying, have also been identified as a common experience among individuals with CLP, and may lead to symptoms of anxiety and depression [5, 2, 6, 7].

While individuals with CLP may elect to receive surgeries to address their clefts, these may often result in scarring and may not completely remedy health and psychosocial concerns associated with the condition [4]. Individuals with CLP will often receive resources and support to address physiological health issues, such as speech therapy for speech disorders, but access to resources and support for psychosocial issues is often lacking. Healthcare professionals acknowledge that children with CLP are at

risk for poor psychosocial adjustment [8, 9], but are often unable to provide effective support due to lack of time, experience and education in psychosocial care for this population [5]. Access to a licensed psychologist with experience providing psychosocial support to individuals with CLP can also be limited, with 57% of US families with a child with CLP reporting that they live over an hour away from their CLP care clinics [10]. Additionally, the cost of accessing care to address physiological and psychosocial symptoms of CLP can cause increased financial strain on individuals and their families, which is the most commonly reported stressor of accessing CLP care in the US [10]. The US Department of Health and Human Services estimates that the lifetime cost of treating CLP is \$697 million [4], and even with health insurance coverage, out-of-pocket expenses and cost sharing for patients with CLP has increased for beneficiaries in the US by 6-17% over the past decade [11].

Without appropriate psychosocial support, individuals with CLP are at risk of experiencing difficulty with psychosocial adjustment in childhood and adolescence, especially when faced with teasing, peer rejection and bullying [5, 12, 13]. Healthcare professionals have identified that 30-60% of their patients with CLP have experienced psychosocial challenges [5], with parents of children with CLP as young as 4 reporting that their child has experienced anxiety regarding their physical appearance and faced social rejection by their peers [2]. Lack of support in dealing with these psychosocial challenges often results in the adaptation of avoidant coping strategies, leading to the development of low self-esteem and negative self-concept [14, 15, 16]. The impact of these psychosocial challenges may often continue into adulthood, where lack of psychosocial

adjustment and the presence of psychosocial challenges in adolescence is shown to be significantly associated with lack of education, employment or training as a young adult [17].

Research has demonstrated the importance of psychosocial support for individuals with CLP, but the inaccessibility of this care suggests that there is great need for more accessible forms of support. Virtual reality (VR) technologies have emerged as a potential solution to increasing access to psychosocial support for various populations, with many studies evaluating the impact of these technologies on self-esteem [18], social anxiety disorder [19, 20, 21, 22] and depression [23]. Children and adolescents in particular have been shown to benefit from the use of VR interventions in treatment for social anxiety disorders [20, 21]. While research on the use of VR technologies to help provide psychosocial support to people with developmental, intellectual and other disabilities is prevalent [19, 21, 24], there is a dearth of research surrounding its use to provide psychosocial support to individuals with CLP. However, similar non-immersive and AR technologies regarding care for people with CLP typically focus on providing support to surgeons performing cleft surgeries [25, 26] or focus on educating parents and patients on how to manage living with the condition [27].

In this dissertation, I address the gap in the literature surrounding the use of VR technologies in providing psychosocial support to individuals with CLP through the following contributions:

1. Working with psychologists, clinicians, and individuals with CLP in the design of a serious VR game for psychosocial support to understand the needs of these

populations and its impact on the game

2. Developing a serious multiplayer VR game for the psychosocial support of pre-adolescents with CLP
3. Evaluating the use of this game as a supplement to psychosocial support for pre-adolescents with CLP with a psychologist
4. Examining the impact of the game on promoting psychosocial skill development in pre-adolescents and adolescents with CLP

This work is done in collaboration with Smile Train, a global organization providing support to individuals with CLP, where their network of psychologists, clinicians and patients have assisted in the design, development and testing of this VR game. Through this work the following research questions are addressed:

1. How does the inclusion of psychologists, clinicians, and individuals with CLP in the design of serious VR games for psychosocial support impact its efficacy and integration into existing practices?
2. Can a serious VR game be a feasible method of providing psychosocial support to preadolescents with CLP?

The methods used in this dissertation include user-centered design methods. These methods will be further described in Chapter 2, where the design of the VR game will be discussed.

The dissertation is outlined as follows: 1) Chapter 1 will provide background information on CLP, psychosocial skills, methods commonly used by psychologists and clinicians to address psychosocial skill development, and VR as a psychosocial and CLP-care support tool; 2) Chapter 2 will discuss the process of designing the VR game to include psychologists, clinicians and individuals with CLP and their parents in the process; 3) Chapter 3 will describe the development of the VR game; 4) Chapter 4 will describe the evaluation of the game through a case study and go over using the game as a part of the psychologist's practice, including discussion on the results of the case study and its impact on psychosocial skill development for pre-adolescents with CLP; 5) Chapter 5 will discuss the findings of the study in relation to the research questions presented above, along with some insight on the broader impact of the work and directions for future work, and Chapter 6 will conclude this dissertation with a summary of the work conducted, overview of the work's impact on preadolescents with CLP and psychosocial support and the overall impact of this work on the field.

1.1 Orofacial Cleft Lip and/or Palate (CLP)

CLP has impacted children around the globe, with recent figures showing that this condition affects 1 in 730 children across low- and middle- income countries [28]. The condition is primarily defined by a physical orofacial cleft, where the lip and/or palate are not fully developed before birth [1]. CLP can occur where the cleft is affecting the lip only, the palate only, or where the cleft affects the palate and the lip. For the

purposes of this dissertation, CLP will be used to collectively refer to and include these 3 distinctions of CLP. While the physical orofacial cleft is the main symptom of this condition, it is also commonly associated with speech disorders, hearing deficits, chronic ear infections and psychosocial issues [2].

Psychosocial challenges for individuals with CLP will often manifest as peer rejection, bullying, shame, social anxiety and low self-esteem [4, 2, 7, 13, 29]. Research has attributed these psychosocial difficulties to the individuals' experiences with bullying, teasing and peer rejection around their physical appearance and speech differences, resulting in social isolation, social anxiety, shame and low self-esteem [12, 15]. In particular, studies have highlighted the occurrence of these experiences during childhood, around the age of preadolescence and adolescence, where one's self-esteem and self-concept are thought to be most vulnerable due to the physical and social changes that occur during this age, along with increased awareness around social belonging and comparison [30, 31]. Unfortunately, the impact of these psychosocial difficulties may persist into adulthood if not adequately addressed, leading to negative effects on social, educational and vocational outcomes [17, 32].

In the following sections, existing methods of psychosocial support for preadolescents and adolescents with CLP will be discussed. In these sections, psychosocial skills will be defined and specific methods for psychosocial skill development will be described in detail. Methods used to provide psychosocial support to children and adolescents with CLP will also be described in this section, where the benefits and limitations of existing methods will be discussed.

1.1.1 Psychosocial Skills

In this dissertation the term psychosocial skills will be broadly used to refer to social skills that play a role in the development of psychological well-being and adjustment, as defined in Riggio et al. [33] and Cnaan et al. [34]. Through this definition, the impact of social skills on factors of psychological well-being are understood through the attainment of mental health and social skill goals [33, 34]. In this section, the relationship between social skills and psychological well-being will be further illustrated through elaboration on the development of self-esteem in preadolescents. Additionally, this section will include common methods used to address psychosocial development for preadolescents with CLP, with a focus on understanding its benefits and limitations.

1.1.1.1 Developing Self-Esteem

Rosenberg defined self-esteem through 2 dimensions: competence and worth, which describe an individual's ability to see themselves as capable, and the degree to which they feel valuable as a person, respectively [35]. Based on these dimensions, self-esteem is defined as someone's overall evaluation of themselves as a worthy and capable person [35, 36]. As competency and worth contribute to an individual's levels of self-esteem, research has suggested that an individual's social interactions and relationships have a meaningful impact on these two dimensions. To assist with understanding this impact, research has suggested that self-esteem can be conceptualized as an outcome, a self-motive, and a buffer for the self [35]. As an outcome, self-esteem is decreased or increased through an individual's experiences, and similarly as a self-motive, encourages

someone to behave in ways that maintain or increase their self-esteem [35]. As a buffer for the self, self-esteem also serves to protect an individual from experiences that may be harmful to their competence and worth [35]. In all of these conceptualizations, self-esteem is seen to be influenced by and moderates social interactions, behaviors and relationships.

Cast and Burke [35] go on to relate self-esteem to identity theory, which suggests that an individual's idea of themselves, including their worth and competency, is composed of multiple identities which reflect their position in a given social structure. Identity theory is then related to self-verification, which occurs when an individual's identity is validated through their experiences in a given social situation [35]. Through identity-verification, where an individual makes an attempt towards self-verification, an individual may experience dissonance between their identity and their social experiences, leading to distress and potentially negative emotional responses, such as anxiety and depression [35]. If an individual is met with constant failure in the identity-verification process, they are likely to avoid these social experiences or situations altogether, with the goal of avoiding distress and negative emotional responses. However, if an individual avoids social experiences and is unable to achieve identity-verification, they are then unable to further develop their self-esteem and may continue to be burdened by distress, depression and anxiety.

These ideas contribute to the understanding that self-esteem is the most challenging during preadolescence [37, 29], where exposure to new social situations, increased agency and judgment from peers can result in difficulty with identity-verification, lead-

ing to socially avoidant behavior, anxiety and depression [30, 31]. It is suggested that low self-esteem in preadolescents results in a higher likelihood that they will respond to problems in an avoidant or depressive manner, and that those with higher levels of anxiety in addition to low self-esteem may be less motivated to actively address these problems [31]. This effect is also demonstrated in preadolescents with disabilities, where their experiences with bullying and negative responses to psychosocial challenges have led to difficulty with developing self-esteem and broader psychosocial skills [38, 39]. It is also noted that preadolescents with disabilities are more likely to exhibit symptoms of psychosocial distress than their peers without disabilities, often due to victimization by their peers, leading to greater levels of depression and low mental well-being [40].

For preadolescents with CLP in particular, psychosocial distress is often heightened due to feelings of shame surrounding their cleft or surgical scarring [2, 15, 12] and experiences involving peer rejection, teasing and bullying [2, 5, 13, 12]. A study found that 69% of individuals with CLP reported being teased due to their cleft during preadolescence, with 42% of these individuals reporting that was a daily occurrence for them, leading to increased feelings of sadness and depression [13]. Similar studies have also suggested that these negative psychosocial experiences have led to difficulties in developing interpersonal skills, where children with CLP report being cautious about developing friendships with peers due to concerns about being teased [15, 9], often leading to a lower likelihood of developing meaningful friendships [9]. These challenges emphasize avoidant behavior in regards to addressing psychosocial challenges and are suggested to negatively impact psychosocial well-being and result in low self-esteem [14].

Psychosocial development for preadolescents with disabilities is crucial to their well-being over time, as research has demonstrated significant associations between behavioral and peer problems in adolescence to lack of education or employment as a young adult [17]. Understanding how to adequately address psychosocial challenges also serves to benefit these individuals as they enter the workforce as adults, as many workers with disabilities face poor psychosocial working conditions, often impacting their mental health and ability to maintain employment [32]. In this section, the importance of psychosocial development through examining the impact of self-esteem on the well-being of preadolescents was described, with some discussion on the impact of social skill development on self-esteem in preadolescents with CLP. In the next section, existing methods of psychosocial support for preadolescents with CLP to address some of the challenges outlined in this section will be described, where the benefits as well as the limitations to this type of support will be discussed in further detail.

1.1.2 Existing Methods of Psychosocial Support for Individuals with CLP and Limitations

While there is no standardized method for providing psychosocial support for children with CLP, research has suggested that Cognitive Behavioral Therapy (CBT) is the most commonly used [30, 6]. As a therapeutic method, CBT focuses on the management of thoughts, perceptions and negative associations to social stimuli [41]. This method aims to help an individual manage their thoughts in order to increase awareness of their own personal biases and errors in judgment to encourage changes in behavior

[41]. CBT places great importance in identifying and addressing underlying causes for certain behaviors, providing guidance on how to manage cognitive distortions, negative memories and maladaptive schemas to encourage behavioral changes. In addition, this method also promotes the use of positive reinforcement as new behaviors occur in order to allow for positive associations to be made in the individual's memory [49].

The use of CBT as a method of psychosocial support for individuals with CLP primarily focuses on addressing social anxiety and anxiety surrounding CLP surgical procedures [6] and is suggested to promote the development of self-esteem [30]. A review on the psychosocial adjustment of people with CLP found that CBT was commonly used to support the development of social skills, especially targeting improvements in social interactions [6]. Researchers also found that CBT was effective in providing support for individuals with CLP during the transition phase between cleft surgeries, helping to reduce anxieties and improve self-esteem during the process [6]. Another review conducted by Jenkinson et al. [30] evaluated the use of CBT on improving self-esteem for individuals with CLP and similar appearance altering conditions. In this review, it was found that CBT used in a one-on-one or group format helped to improve self-esteem and psychological well-being for children with CLP and similar appearance altering conditions. However, researchers suggest that further exploration be conducted to understand this method's impact on children and adolescents with appearance altering conditions, as current evidence is supportive but weak.

Access to psychosocial support can be crucial to the psychological well-being and psychosocial development of children with CLP [16]. Individuals with CLP across

the globe face challenges in accessing psychosocial support from licensed and qualified psychologists [5, 42], especially in low and middle-income countries where these resources are sparse [42]. The studies described above provide evidence supporting the use of CBT in promoting psychosocial development for children with CLP, but without access to this type of support it can be difficult for them to develop self-esteem, social skills and maintain their psychological well-being. In the following section, the potential of virtual reality (VR) technologies in promoting access to this type of care for individuals with CLP will be described, outlining its current use in providing psychosocial support to individuals with disabilities and how it is being used to address the needs of individuals with CLP and those providing them with support.

1.2 VR Technologies

VR in research has been used to broadly refer to any type of virtual environment presented to the user through non-immersive (computer monitor, tablet screen) or immersive (head mounted displays, projections) methods. For the purposes of this dissertation, we will use VR to refer to immersive VR. Users may access VR environments (VREs) through the use of dedicated VR systems, such as the HTC Vive or Oculus Quest, which are systems involving the use of head mounted displays (HMDs), otherwise referred to as headsets, which users wear over their eyes to view the environment. VREs may also be accessed with the use of room-based VR systems, such as the Cave Automatic Virtual Environment (CAVE), which displays the VRE to the user through

projections onto the walls of the room while the user wears 3D glasses. Users are able to interact with their environment, including objects and characters, in a first-person perspective while using a VR system, but may also view the experience through a third-person lens depending on the intent of the application. Most VR headsets and systems, such as the HTC Vive and Oculus Quest, are available at mass retailers for less than \$1000 [43]. However, CAVE systems will often cost anywhere from \$10,000 to \$500,000 or more depending on the model and included features of the system [44, 45].

Research on VR and non-immersive VR, along with similar technologies, such as augmented reality (AR), for the use of providing psychosocial support to individuals with disabilities has shown to be beneficial in improving symptoms of social anxiety [19, 21, 20, 46], and developing social skills [47, 24, 48, 49]. Research described in this section will go over existing literature regarding the use of these technologies in providing psychosocial support to individuals with disabilities to understand its current impact on psychosocial development and the factors of these technologies that may contribute to this impact. In particular, this section will discuss the use of VR applications developed specifically to support individuals with psychosocial disabilities and those demonstrating psychosocial need, including populations with social anxiety disorder and autism spectrum disorder (ASD). At the end of this section, research involving the use of VR and similar technologies to help individuals with CLP and their clinicians or family members in providing care will also be discussed to understand existing support for this population and how VR applications for psychosocial support may help promote their psychosocial development.

1.2.1 VR and AR Technologies for Psychosocial Support

Reviews on existing literature describing the impact of VR and AR technologies for the psychosocial support of individuals with disabilities has suggested that they have promoted positive outcomes for people with neurodevelopmental disorders [47], psychosocial disabilities [50, 21] and even clinicians providing psychosocial support to patients in clinical settings [51]. In this section, an overview of the broader field of VR and AR technologies in providing psychosocial support to individuals with disabilities will be discussed, as well as the implications for promoting further psychosocial support for individuals with CLP.

In a review conducted by Tan et al. [47], the use of VR and AR technologies in providing support to individuals with neurodevelopmental disorders, such as ASD and attention-deficit hyperactivity disorders (ADHD), for psychosocial rehabilitation was evaluated through analyzing literature regarding its use in promoting the development of independent living and social skills, as well as quality of life. Researchers found that AR interventions were primarily developed to facilitate the development of independent living skills and vocational skills for individuals with neurodevelopmental disorders. In terms of VR literature, it was suggested that VR applications providing CBT-based social skills training helped to improve symptoms of social avoidance and quality of life for individuals with schizophrenia. This effect was attributed to the integration of CBT methods into VR, allowing patients to work with a clinician in overcoming symptoms of social anxiety or practicing interacting in difficult social scenarios. Additionally,

studies involving the use of VR in providing virtual characters for individuals with neurodevelopmental disorders to practice conversations and social interactions have shown progress in promoting the learning of appropriate social behaviors in workplace settings. While the review suggests that research in AR and VR has been beneficial in providing psychosocial rehabilitation to individuals with neurodevelopmental disorders, it also suggests that research is limited in terms of integration with existing psychosocial rehabilitation practices and in evaluating the generalization of skills learned from AR and VR applications to real-world instances. Studies involving the incorporation of CBT methods into VR applications were evaluated in controlled laboratory settings, where clinicians may have been present to assist with facilitation of the application's use, but research has yet to understand the impact of integrating these VR applications into existing resources and services for psychosocial support. Additionally, studies have also not focused on understanding or measuring the generalization of the skills learned in AR and VR applications to the appropriate real-life contexts.

A similar review conducted by Rowland, Casey, Ganapathy, Cassimatis and Clough [21] shares similar findings where VR interventions to help address emotional disorders have been shown to promote psychosocial development, especially in terms of addressing symptoms of social anxiety and PTSD. In particular, this review points out that the use of VR technologies for this purpose has primarily focused on non-immersive formats using computer-based systems or older computer-tethered VR systems. Researchers suggest that the use of more updated VR technologies, and more specifically systems with head mounted displays (HMDs), may improve user experience with VR

applications for psychosocial development. Similar to the review by Tan et al. [47], researchers in this review emphasize the importance of having clinicians utilize these VR applications within their practices to understand its impact in a clinical setting. Researchers also suggest the evaluation of a VR application as a standalone supplement to support from clinicians could be beneficial to patients who experience obstacles to accessing psychosocial support and stigma against receiving this type of support.

Perra et al.'s [50] review on VR interventions for adults with psychosocial disabilities also suggests that VR interventions included in the review did demonstrate improvements to symptoms of depression, quality of life and general clinical outcomes. Similar to what the previous reviews mentioned, this review suggests that the utilization of modern, fully immersive VR systems should be explored to understand its impact on the provision of psychosocial support to this population. Researchers also suggest that more detail regarding the development of the VR application, including its evaluation in existing clinical settings and understanding on its impact on the generalization of skills learned would be useful in gauging whether VR applications may truly benefit adults with psychosocial disabilities in developing these kinds of skills.

Based on these literature reviews, VR applications for the psychosocial support of individuals with disabilities has demonstrated some evidence for its efficacy in addressing the development of psychosocial skills and similar needs, such as reduction of depressive symptoms [50], and improvement of social anxiety and social skills [47, 51]. However, these reviews also suggest that existing research on these applications is limited in understanding its ability to be integrated into existing methods of psychosocial

support, such as within clinics or psychological practices. The integration of VR applications into existing practices is stated by these reviews to improve understanding of the efficacy of these applications in promoting psychosocial skills in settings where they may actually be used by patients. The incorporation of VR applications into existing practices and resources for psychosocial support may also help improve understanding of whether the inclusion of these applications in the practice has any effect on the generalization of skills. Rowland, Casey, Ganapathy, Cassimatis and Clough's [21] review also suggests that further evaluation of VR applications for psychosocial support as a standalone supplement to existing psychosocial support resources may also be beneficial in increasing access to such support.

To further explore the impact of VR applications in providing psychosocial support to individuals with disabilities, the next two sections will go over existing literature on the use of VR applications to provide psychosocial support to individuals with psychosocial disabilities, such as SAD, and individuals demonstrating psychosocial need, including individuals with ASD. Through these two sections, discussion on the benefits and limitations of existing support for these populations will provide insight as to how the development of a VR game specifically for the psychosocial support of individuals with CLP may be beneficial.

1.2.2 VR for the Psychosocial Support of People with Psychosocial Disabilities

VR technologies for the psychosocial support of people with psychosocial disabilities have shown promise in helping to improve self-esteem [52] and social anxiety [19, 21, 20, 46]. In this section, psychosocial disabilities will be used to include psychological conditions that heavily impact an individual's social skill development or ability to socialize, such as Social Anxiety Disorder (SAD).

In a study evaluating the use of a VR environment (VRE) to help children with SAD, researchers evaluated the use of a VRE designed around Social Effectiveness Therapy for Children (SET-C) [20]. SET-C focuses on the provision of social skills training alongside therapist facilitated peer interaction sessions and homework, and has been demonstrated to help children with SAD improve their social skills. While this method may promote positive outcomes for this population, it is difficult to implement in more traditional settings where peers and therapists may not always be available and completion of homework may be difficult to monitor. In evaluating the use of a VRE to hold SET-C sessions with a therapist using a randomized control trial, where patients in the control group attended SET-C sessions in-person, it was found that there were no significant differences in treatment outcomes for each group. Beidel et al's [20] findings suggest that the use of a VRE may be just as beneficial at traditional SET-C sessions, as both groups demonstrated improvements to social skills.

A review conducted by Rowland, Casey, Ganapathy, Cassmatis and Clough

[21] suggests that the findings in Beidel et al's [20] study is consistent with data from literature surrounding the use of VR interventions for emotional disorders. This review discusses the effectiveness of VR interventions in providing treatment for social anxiety, PTSD and various phobias, attributing its success to the adaptation of traditional treatment methods to VR. Researchers also suggest that the realism of the VR environment along with the ability to learn and practice skills in a relevant space allows for generalization to real-life contexts to occur more naturally. Similar findings were also described in a review examining the impact of VR interventions on mental health when considering transdiagnostic factors, which address the primary disorder and any comorbidities [46]. In this review, VR interventions were found to help reduce social avoidance for adults with SAD. The impact of VR interventions used alongside traditional methods of psychosocial support were also evaluated in the review, with studies demonstrating improvements in emotion regulation for populations with mental health disorders. In particular, it was noted by these researchers that VR interventions have shown similar outcomes to traditional methods of support, such as CBT.

VR environments (VREs) for facilitating social interactions for individuals with psychosocial disabilities have also been explored for their impact on psychosocial development. In a study conducted by Hu, Lee, Chang, Lin and Huang [53], researchers evaluated the relationship between prosocial behaviors and self-consciousness for adolescents in a VRE. They suggested that adolescents with low private self-consciousness are less likely to engage in self-reflective behaviors, potentially leading to negative self-perception. Researchers believed that promoting prosocial behaviors in adolescents

would increase positive self-understanding and self-knowledge due to increased feelings of positive emotions. Through the use of a VRE, adolescents participating in the study were asked to assist a virtual character with getting to the hospital, allowing them to practice exhibiting prosocial behaviors. Researchers found that practicing prosocial behaviors in VR is beneficial to adolescents with low private self-consciousness by increasing their ability to gain self-knowledge and encouraging positive self-understanding through their experiences in the VRE.

While VR interventions and social interactions facilitated in VREs may be beneficial to the development of psychosocial skills, it is noted that the efficacy of these VR technologies may be dependent on the design of the intervention and guidance provided while using them. A study conducted by Lee, Kim and Uhm [54] evaluated the impact of social VR games on psychological well-being, depression and self-esteem for adults. Their findings suggest that social VR games may positively affect the well-being of individuals who regularly play them, but this was found to be dependent on their levels of self-esteem and social connectedness. In participants with higher levels of self-esteem or higher levels of social connectedness, there was a greater likelihood that they would demonstrate higher levels of psychological well-being. Whereas, participants with lower levels of self-esteem and lower levels of social connectedness were less likely to exhibit high levels of psychological well-being.

Based on the research described above, it is suggested that VR may be beneficial and effective in helping individuals with psychosocial disabilities in improving symptoms of social anxiety, developing social skills, and promoting psychological well-

being. However, these studies also highlight that encouraging social interaction in VR may not be enough to promote the development of psychosocial skills. Instead, adapting traditional methods of psychosocial support in the design of VR interventions and promoting the use of these interventions in conjunction with support from a psychologist may be factors that play a role in its success. In the next section, the use of VR to provide psychosocial support to individuals with ASD will be discussed to help provide an understanding of how this technology has been explored in promoting positive outcomes in psychosocial development for a population without specific psychosocial disorders. Additionally, research regarding the use of VR application for the psychosocial support of children with ASD in particular has been thoroughly researched, and may provide insight as to how the technology may be improved and useful for other populations with similar needs. This will be followed by a discussion on current AR and non-immersive VR technologies for individuals with CLP and those providing them with medical support, leading into a discussion on the potential for VR to provide psychosocial support to individuals with CLP and considerations that should be taken into account.

1.2.3 VR for the Psychosocial Support of Individuals with ASD

Research regarding the use of VR technologies in providing psychosocial support for individuals with ASD has primarily focused on its use on social skills training with children. In particular, studies involving the use of VR as a behavioral intervention to help with teaching social skills and behaviors has been of particular interest,

with studies demonstrating positive outcomes in terms of promoting socialization and communication skills [48, 24, 55]. In particular, reviews on literature regarding the use of VR interventions in assisting children with ASD in improving social skills suggests that the ability of these technologies to provide immersive and realistic environments and characters for them to practice socializing with is a key factor in its impact on improving social skills [48, 24]. VR interventions are also suggested to be beneficial to practitioners providing psychosocial support to children with ASD, as they enable them to work with patients on developing social skills in a safe, controlled environment where they can learn without worrying about experiencing harmful social consequences [24]. The environments and social scenarios presented in VR interventions are also highly customizable, suggesting that they can be tailored to meet the needs of the practitioner and their patients [24, 48, 55].

While VR interventions have shown great promise in providing evidence for improving social skills and providing psychosocial support to this population, these reviews also suggest that further involvement of stakeholders in the design of these VR interventions would be beneficial in improving their impact and usability [24]. In particular, a review conducted by Parsons [24] suggests that current VR interventions developed to provide psychosocial support to children with ASD are currently being underutilized in spaces where they normally receive support, such as schools and clinics. As a result, VR interventions are often only utilized within laboratory settings and their impact not understood in a realistic, integrated setting where they may actually be used or implemented. Parsons's [24] review recommends that future research regarding the

development of VR interventions works to include stakeholders, such as practitioners and teachers, and individuals with ASD in the development of these technologies to help improve the relevancy and usefulness of the VR content, but to also allow for ease of integration into these spaces for practical use.

Additionally, reviews have called for an understanding of how the skills learned from the VR intervention are generalized to the appropriate real-life contexts [48, 55]. Research regarding the impact of VR interventions on social skills have primarily focused on measuring changes in social skills within the user testing context, without understanding whether these effects are generalized to the appropriate instances outside of the testing environment. Generalization of skills learned from VR is an important factor to measure in terms of understanding the impact of psychosocial support, given that children with ASD must be able to understand how to apply the skills learned from the intervention to the appropriate situations in real-life.

In this section, a discussion on the benefits of VR interventions for the psychosocial support of children with ASD is presented with key findings from the literature outlined. In the next section, the use of VR and similar technologies, such as AR and non-immersive VR, for supporting individuals with CLP will be discussed to provide insight as to how this technology is currently used and how it has been accepted by this population. This will be followed by a discussion on why the design and development of serious VR games for the psychosocial support of individuals with CLP may be beneficial based on the studies and literature reviews outlined in this section.

1.2.4 VR, AR and Non-immersive VR Technologies for Individuals with CLP

Research regarding the use of technologies in addressing the needs of individuals with CLP and those providing them with medical or psychological support is sparse. Existing studies focus on the use of VR and similar technologies, such as augmented reality (AR) or non-immersive VR simulations, in supporting training for surgeons performing cleft surgeries [25, 26] and education for parents and caregivers on the condition itself and management of associated symptoms [27]. This section will discuss current research and its impact on individuals with CLP and those providing them with support.

Vyas, Sayadi, Bendit and Hamdan [25] developed an educational AR tool to help train surgeons overseas by connecting them with surgeons in the US. Through this tool, surgeons at overseas locations would be able to provide visual data to surgeons in the US, who would in turn provide advice and guidance to the overseas surgeons during the operation. Researchers evaluated the tool over the course of 13 weeks, where for 10 weeks the surgeons used the AR tool and for the remaining 3 weeks they received training in-person from onsite visits with the US surgeons. The study found that the overseas surgeons reported improvements in their understanding of cleft operative design and efficiency after using the AR tool, but other factors such as improvements in cleft diagnosis and repair technique were improved only after in-person training visits. However, for participants who completed the entirety of the 13 week training, all of them demonstrated significant improvements across all parameters of cleft surgery.

Similarly, Schendel, Montgomery, Sorokin and Lionetti [26] developed a non-immersive VR surgical training tool for cleft surgery, which involved a 3D model produced through patient facial data. The model was used to educate plastic surgeons on surgical planning and to provide them with feedback on simulated operations. Researchers evaluated the use of the tool with participants who were either plastic surgeon residents or individuals with no prior medical training. Their study found that while the residents demonstrated greater improvements, the simulation promoted surgical improvements in both groups, which suggests that the tool may help to promote pre-operative planning and visualization, helping surgeons to practice and understand cleft surgical procedures.

AR technologies and 3D medical models have also been used to assist individuals with CLP and their parents with understanding the condition. Lo et al. [27] developed an AR pamphlet aimed at providing detailed information regarding CLP through detailed interactive medical models. The study found that in comparison to a paper pamphlet, the AR pamphlet was preferred by patients and parents, as it provided better understanding of complex medical information.

While studies on the use of VR to address the needs of individuals with CLP and those providing them with support are sparse, research on similar technologies, such as AR and non-immersive VR tools, have suggested that their use may be beneficial to this population. In particular, the studies described in this section suggest that such technologies are widely accepted by medical professionals, patients with CLP and their parents or caregivers. As these studies have explored the use of these technologies

as tools to promote their education and have provided evidence for improvements in educational outcomes in surgical performance and understanding of the condition, it is suggested that a VR game for the psychosocial support of individuals with CLP may be feasible in promoting psychosocial development.

In this chapter, the need for psychosocial support for individuals with CLP is outlined, with a discussion on existing methods for psychosocial support, including CBT. While CBT is promising in its ability to promote psychosocial development for children with CLP, the inaccessibility of licensed psychologists and psychosocial support resources is a challenge that globally impacts many individuals. VR technologies have shown promise in its ability to increase access to psychosocial support, demonstrating success in promoting psychosocial development for individuals with psychosocial disabilities and has been accepted by medical professionals, parents, and patients with CLP.

Based on the research presented in this chapter, my dissertation focuses on evaluating the impact of a serious VR game designed with psychologists working with preadolescents with CLP and developed to promote psychosocial skill development for this population. In the next chapter, the design procedures of the game will be outlined, including interviews with experts and users, journey mapping and the iterative design process.

1.2.5 Developing VR for the Psychosocial Support of Individuals with CLP

In the previous sections, research regarding the use of VR as a psychosocial support tool for individuals with psychosocial disabilities or those demonstrating psychosocial needs is outlined. The literature described provides evidence suggesting that the creation of VR for the psychosocial support of individuals with CLP may be beneficial in helping to improve the development of psychosocial skills. In particular, findings from the reviews conducted from Tan et al. [47] and Rowland, Casey, Ganapathy, Cassmatis and Clough [21] suggest that the use of VR for the psychosocial support of individuals with neurodevelopmental disorders and emotional disorders is beneficial due to the ability to easily integrate existing psychological methods for psychosocial support, such as CBT, into VR. Additionally, these reviews suggest that the technology may be even more beneficial if used and evaluated as a support tool within existing clinics and hospitals. This sentiment is also shared by Parsons [24], who believes that the design and development of VR interventions for the psychosocial support of children with ASD with stakeholders and patients would increase the efficacy of these technologies, as it would increase their use in spaces where support is currently being provided. Literature also suggests that the success of VR in providing psychosocial support to populations with psychosocial disabilities or who demonstrate psychosocial need is often due to the adaptability of VR content, where modules can easily be created and modified to accommodate for the specific psychosocial needs of patients [48, 24, 55]. These technologies

also provide an opportunity for individuals with psychosocial disabilities and those with psychosocial need to practice social skills in safe and controlled environments, where harmful social consequences can be avoided [24].

Psychosocial support for individuals with CLP is often inaccessible [5, 10, 4], but crucial for the development of psychosocial skills, including self-esteem and understanding how to address challenging social situations. The development of VR for the psychosocial support of individuals with CLP may be beneficial in promoting access to and the efficacy of necessary psychosocial support and resources, based on evidence provided in the literature described above regarding studies involving VR for the psychosocial support of populations with similar needs. Research on the use of VR for the psychosocial support of individuals with psychosocial disabilities and those demonstrating psychosocial need provides evidence for positive psychosocial outcomes as a result of using the technology as either a standalone psychosocial support tool or used as a supplemental tool with a psychologist [48, 24, 55]. In particular, VR applications have been helpful in promoting the development of social skills, especially in terms of improving social behaviors and addressing social anxiety, through providing opportunities to practice socializing with virtual characters [21, 20]. Individuals with CLP will often face difficulty with psychosocial adjustment in childhood and adolescence [5, 12, 13], suggesting that developing VR for the psychosocial support of this population may be beneficial, as VR for the psychosocial support of children with ASD facing similar challenges has shown positive outcomes in improving social skills [24, 55]. The highly adaptable and customizable nature of VR also allows for VR developed for the

psychosocial support of children and adolescents with CLP to be created specifically to address the unique challenges they face in terms of psychosocial development.

While VR for the psychosocial support of individuals with CLP has yet to be explored, the benefits of this technology may promote positive outcomes in social skills development including dealing with challenging social situations and the development of self-esteem. Exploration into the use of VR, AR and non-immersive VR technologies to support individuals with CLP in educating surgeons performing cleft surgeries and parents and individuals with CLP in understanding the condition provides support for the acceptance of this technology and its benefits for this population [27, 25, 26]. Through my dissertation work I explore the feasibility of a serious VR game for the psychosocial support of individuals with CLP to address gaps in the literature regarding the impact of this technology on this population. Through my work, I design and develop a serious VR game for psychosocial support with psychologists and patients to understand its impact on ease of integration of the technology into existing support structures and resources, and its impact on the relevancy of the game's content for the psychosocial support of individuals with CLP, addressing existing limitations in literature discussing the impact of VR for psychosocial support of children with ASD [24]. I also evaluate the impact of the game as a supplement to existing psychosocial support sessions with a psychologist, providing insight into the impact of the game in a setting or format it may be incorporated into if used regularly. Although the game is used as a supplemental resource for existing psychosocial support resources, the evaluation provided in this dissertation will provide insight as to how the feasibility of

the developed VR game contributes to an understanding of how it might be used as a standalone supplement or in-place of existing psychosocial support resources in regions where support is increasingly inaccessible.

In this chapter, the need for psychosocial support for individuals with CLP is outlined, with a discussion on existing methods for psychosocial support, including CBT. While CBT is promising in its ability to promote psychosocial development for children with CLP, the inaccessibility of licensed psychologists and psychosocial support resources is a challenge that globally impacts many individuals. VR technologies have shown promise in its ability to increase access to psychosocial support, demonstrating success in promoting psychosocial development for individuals with psychosocial disabilities and ASD, and has been accepted by medical professionals, parents, and patients with CLP. Based on the research presented in this chapter, my dissertation focuses on evaluating the impact of a serious VR game designed with psychologists working with preadolescents with CLP and developed to promote psychosocial skill development for this population. In the next chapter, the design procedures of the game will be outlined, including interviews with experts and users, journey mapping and user-centered design processes.

Chapter 2

Designing a Serious VR Game for Psychosocial Support

In this chapter, the process of designing a serious VR game for psychosocial support of preadolescents with CLP will be described. The game was designed with clinicians and psychologists who currently provide psychosocial support to preadolescents and adolescents with CLP, and with data collected from adolescents and preadolescents with CLP and their parents and/or caregivers using user-centered design (UCD) methods. UCD is an iterative design process developed by Donald Norman in the 1980s, which places importance in designing products based on the needs and desires of the user and including users in the design process [56, ?]. Methods within UCD will often consist of usability testing, interviews and prototyping, leading to an understanding of the needs and wants of users in relation to the product being developed and how the product may be used within a specific context for the user [?]. UCD methodol-

ogy developed by Gabbard, Hix and Swan [57] for the design and evaluation of virtual environments was used to facilitate an understanding of designing and evaluating interactions with the VRE for the purposes of psychosocial support, in addition to more general UCD methods, including user and expert interviews, and journey mapping.

In section 2.1, user and expert interviews conducted with clinicians, psychologists, and preadolescents and adolescents with CLP and their parents will be described. The data collected from these interviews and their contributions to the initial design of the game will be discussed. In section 2.2, further design of the game with clinicians and psychologists will be described, detailing journey mapping and collaborative storyboarding procedures, as well as the use of the UCD methodology for VREs by Gabbard, Hix and Swan [57]. The data collected from these procedures will be discussed and their integration into the design of the initial game prototype will be detailed at the end of this chapter.

2.1 Expert and User Interviews

Expert and user interviews were conducted to gain insight into the existing structures of support for individuals with CLP, along with the methods for providing psychosocial support. These interviews also helped with gaining an understanding of the specific psychosocial skills the game should address, along with the experiences that were impacting psychosocial well-being for patients. Expert interviews were conducted with psychologists from Smile Train's global network of psychologists from partnering

hospitals and clinics in Colombia, Brazil and the Philippines. In total, 4 psychologists were interviewed on their current practices for helping patients with CLP in developing psychosocial skills. The following sections will discuss the data collected from these interviews based on the location of each participating psychologist.

2.1.1 Psychologist Interview Data: Colombia

Two psychologists participated in an interview from a partnering Smile Train hospital in Colombia. Both psychologists identified as female, with one having over 20 years of experience as a clinical psychologist and the other with about 5 years of experience as a clinical psychologist. Both psychologists work with children and adolescents with CLP, but note that they primarily work with preadolescents and adolescents, around the ages of 11 to 16, on psychosocial skill development. Their clientele also consists of mothers with a prenatal diagnosis of CLP and parents of children with CLP.

In terms of the specific psychosocial skill needs that patients exhibit, the psychologists identified social skills such as initiating and asking to join peers in play activities, and self-esteem as the most common. In particular, low self-esteem among preadolescent and adolescent patients was emphasized, where patients would have difficulty understanding and accepting their condition and associated symptoms, along with answering questions about their condition to family members and peers. The psychologists attributed the low self-esteem as a variable in patients' social skills development, where patients would often avoid interacting with peers at school and trying new activities.

To address the needs of their patients, the psychologists described the use of CBT methods to aid them with reframing situations where they may feel low self-esteem or social anxiety. Psychologists discussed helping patients with viewing themselves more positively by considering aspects of themselves that they are proud of and becoming more comfortable living with their CLP as a part of their identity. They also described roleplaying during sessions where patients would practice challenging social scenarios with the psychologist in a one-on-one session or in group settings with peers who also have CLP.

2.1.2 Psychologist Interview Data: Brazil

One psychologist was interviewed from a partnering Smile Train hospital in Brazil, who identified as female with over 5 years of experience as a clinical psychologist working with children and adolescents with CLP. The psychologist describes seeing approximately 60 patients a week with an average of 15 per day. The psychologist's primary role is to perform initial evaluations with patients with CLP to understand their psychosocial needs and based on these needs the patient may be referred to a psychological specialist within the hospital. After this referral, the patient will often visit the psychologist again to evaluate whether there have been any psychological or psychosocial changes.

Patients typically came to see the psychologist for an initial visit based on issues with bullying or academic problems, which she stated can occur for patients as young as 5 years old. Her patients are usually facing issues with self-esteem regarding

their cleft or cleft scarring as a result of their surgeries, where their peers will often bully or tease them about it. The psychologist also mentioned that due to the pandemic and the rise of online schooling, many of her patients started facing issues with cyberbullying, where their peers would often leave mean comments on their posts or create their own posts making fun of her patients.

The psychologist interviewed does not follow a specific method when addressing the needs of her patients, but provided insight on the current protocol that her hospital follows. Patients are generally asked to focus on understanding their CLP and encouraged to not hide their cleft or cleft scars. Parents of patients are also asked to observe and report their behavior to the psychologist so that they can analyze why certain behaviors are happening. The psychologist also emphasized that it can be difficult for patients to receive psychosocial support at their hospital, as there are often not enough licensed psychologists for the number of patients they work with. She stated that some patients will often have worse symptoms than when they first completed their initial visit if they are unable to receive psychosocial support from a psychologist soon afterwards.

2.1.3 Psychologist Interview Data: Philippines

One psychologist was interviewed from a partnering Smile Train clinic in the Philippines, who had approximately 1 year of experience working as a clinical psychologist with children and adolescents with CLP and their parents. This psychologist identifies as female and typically works with patients ages 14-28, including mothers

with children who have CLP. She focuses on helping patients in dealing with trauma surrounding living with their condition, especially regarding the development of self-esteem.

Her patients typically express difficulty socializing with their peers, especially at school where their physical and speech differences can make them feel othered. While the psychologist describes her patients as being high achievers academically, they are having difficulty feeling a sense of belonging within their communities. Discrimination and bullying are prevalent among her patients, where she describes a strong stigma in their culture towards mental illness and disability, impacting her ability to provide adequate support to many patients. She says that culturally having a disability or any type of mental illness is considered having a "broken brain", implying that there is something wrong with the individual and how they think. She states that many patients will come to initial sessions, but afterwards are not motivated to continue working with her on developing psychosocial skills due to this cultural stigma.

The psychologist described her regular patients as socially avoidant, only interacting with family members and other cleft patients that they meet at the clinic, but typically they do not make efforts to develop friendships with peers at school. Additionally, patients will avoid speaking up in class and participating in group activities in fear of being judged or ridiculed by peers. To address the needs of her patients, the psychologist uses Dialectical Behavioral Therapy and CBT to help them with unlearning harmful behaviors and learning how to respond to challenging social situations. She primarily works with patients remotely through telehealth video calls or in-person

through one-on-one sessions, where they will discuss the challenges that the patient is currently facing at home or school and how to address these challenges in a meaningful and productive way.

Data collected from interviews with psychologists working with preadolescents with CLP was helpful in gaining insight on the needs of patients, but also the difficulties that psychologists face in providing support to them. The next section will describe interviews with preadolescents and adolescents with CLP, who were interviewed to further understand what their experiences were in developing psychosocial skills and to understand how they sought and received support on their journey.

2.1.4 Patient Interview Data

Preadolescents and adolescents with CLP were interviewed on their experiences with developing psychosocial skills to further understanding of their needs, and existing structures and resources for psychosocial support. There were 6 subjects (4 female, 2 male) participating in the interview between the ages of 11 and 17 from the US and Colombia who are clinically diagnosed with CLP. Subjects were interviewed over Zoom or in-person by a psychologist or member of the Smile Train research team regarding their experiences as preadolescents (age 13-15) in developing psychosocial skills with a focus on self-esteem and socialization. In addition to patient interviews, 2 parents of these subjects were also interviewed to provide clarification and additional information regarding the experiences of their child in developing psychosocial skills. The following section will describe the data collected from these interviews as well as a thematic

analysis identifying themes encompassing common challenges faced by preadolescents with CLP in developing psychosocial skills.

2.1.4.1 Patient Interview Data Analysis

A thematic analysis of the transcribed interview data collected from preadolescents and adolescents with CLP was conducted with 7 undergraduate students to identify themes surrounding the psychosocial challenges that they faced during preadolescence. From this analysis the following themes arose: discomfort in unfamiliar or new social environments, aversion to interactions with new and unfamiliar peers, and difficulty accepting one's differences.

The preadolescents and adolescents interviewed described experiences as preadolescents where they had difficulty socializing in new environments, especially when participating in new extracurricular activities outside of school, fearing that someone will ask them about their CLP or point out notable differences in appearance or speech due to their condition. Participants interviewed made statements such as, *"My cleft was . . . a source of insecurity when it comes to my appearance"* and *"I was very self-conscious of speaking differently"*. These fears led to anxiety and aversion to interacting with new and unfamiliar peers, with some participants stating that they would attempt to hide their physical or speech differences during interactions with new people. Several participants made comments about hiding their smile or being *"hyper aware"* of their cleft, with one participant stating that they *"don't like talk[ing] to people because [they] don't like people seeing [them] without a tooth"* and another stating that they *"would*

always ... not smile as big" when speaking to new people to avoid them noticing their cleft. These quotes also exemplify the theme of difficulty accepting one's differences, as participants' experiences with self-consciousness when socializing with others is clearly demonstrated. Additionally, one participant describes their experience of self-consciousness regarding their CLP as follows: *"I do think definitely like my cleft did play a role [where I was] not comfortable smiling in front of new people or take photos where I'm smiling, just because like it has always been something I am hyper aware of and like I know people do judge it differently and can see it right away"*.

Themes identified using the thematic analysis were then evaluated by the psychologists interviewed to understand whether they believed the themes to be accurate to what their patients were experiencing. Based on their review of the interview transcripts, identified themes and experiences working with preadolescent patients, all of the psychologists believed the themes to accurately reflect the psychosocial challenges that preadolescents with CLP face. From these themes, I worked with the psychologists on developing the VR game storyline and modules using UCD methodology developed by Gabbard, Hix and Swan [57], and journey mapping and collaborative storyboarding methods with psychologists. In the next section, the process of designing the game will be described.

2.2 Game Design

The game was designed with the psychologists interviewed from partnering Smile Train hospitals and clinics in Colombia and Brazil. The themes identified in the thematic analysis and the data collected from the psychologist interviews were used to design a VR game aimed at helping to promote the development of psychosocial skills for preadolescents with CLP. The target age range for the game was 11-15 years old, which was decided based on research regarding the age when psychosocial development is most crucial [37, 29] and the psychologist's experiences working with child, preadolescent and adolescent populations of patients with CLP. In this section, journey mapping and collaborative storyboarding exercises with psychologists will be described, along with details on the iterative design process using UCD methodology for designing VREs.

2.2.1 Journey Mapping Psychosocial Support Sessions

To gain further insight into how Smile Train's partnering psychologists conducted psychosocial support sessions with preadolescents patients with CLP, I conducted a journey mapping exercise highlighting a typical session. This exercise was conducted with both of the psychologists from Colombia who were interviewed regarding their experiences working with patients with CLP. The psychologists participating in this exercise often led group therapy sessions together, so together we produced two journey maps: one outlining one-on-one sessions and one for group sessions with patients. Psychologists were asked to describe their one-on-one and group sessions with preado-

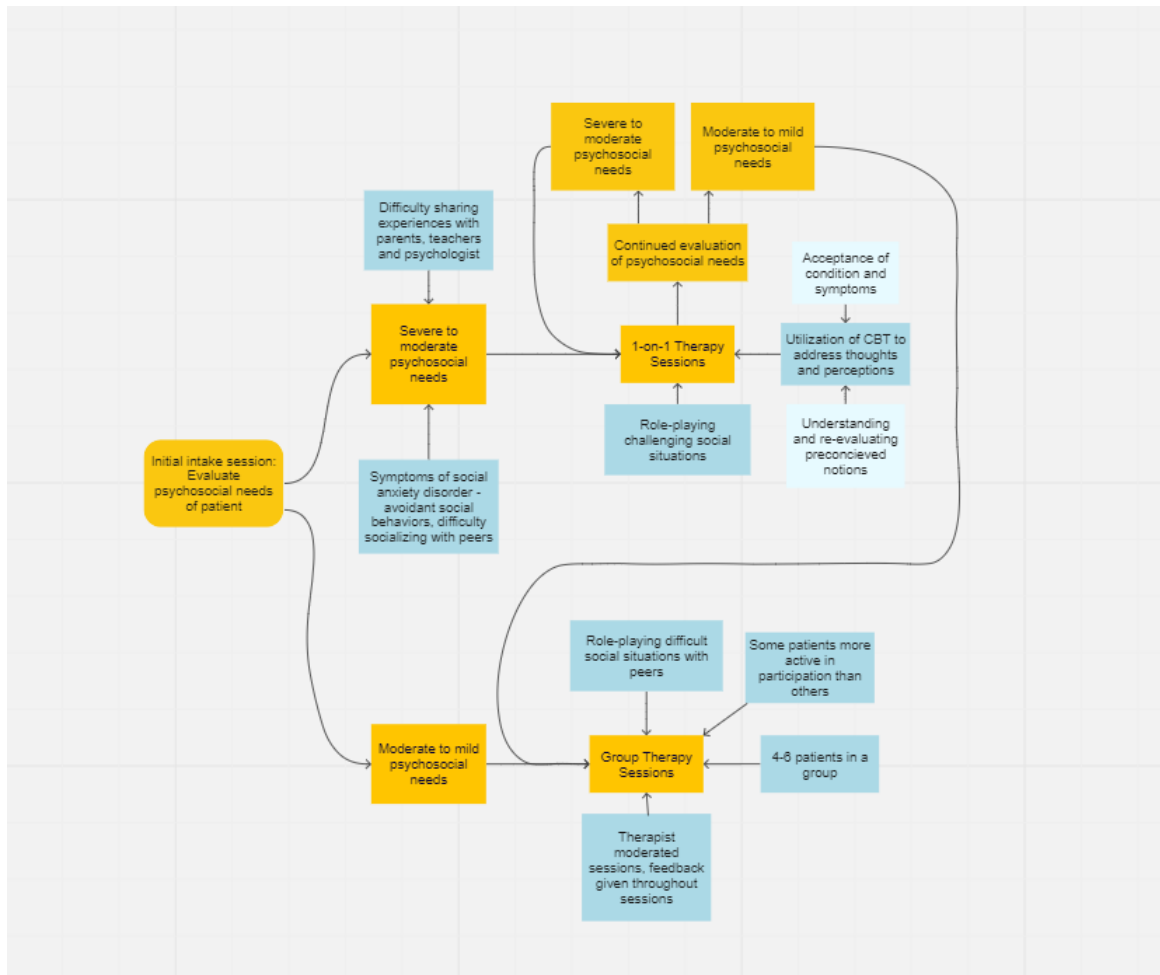


Figure 2.1: Journey map produced from journey mapping exercise conducted with Smile Train partnering psychologists from Colombia, outlining psychosocial support in 1-on-1 and group sessions based on severity of psychosocial needs.

lescent patients with CLP that they were supporting in developing psychosocial skills, such as self-esteem and socializing with others. They were also asked to provide detail on the methods used and how they were implemented during sessions with patients, highlighting instances along the journey where they learned more about the patient's existing needs or identified a new need, where the patient was asked to learn or practice a psychosocial skill, and where there were challenges or successes in their sessions. The following paragraphs provide further information collected from these exercises, separated by the type of session. The resulting journey map from these exercises are shown in Figure 2.1.

Psychologists described preadolescent patients with CLP needing one-on-one sessions as either newer patients who have yet to undergo an evaluation or patients who have more severe psychosocial support needs, such as symptoms of moderate to severe social anxiety or depression. These sessions typically take place once a week to every other week depending on the need of the patient and their availability. Initial sessions with the patient can be difficult, as psychologists describe lack of engagement from patients. After the initial session, patients may begin to open up and discuss some of the psychosocial challenges that they are currently experiencing, which may include instances of self-consciousness surrounding symptoms of their condition or feeling othered. The psychologists use CBT to help encourage patients to change the way that they perceive their CLP and to promote the development of self-esteem. They will often implement this through having the patient discuss how they feel about their condition and emphasizing that their condition is only one part of their identity. During one-on-

one sessions, psychologists will typically role-play through difficult social scenarios, such as dealing with bullying or teasing, with the patient to help them practice responding appropriately and productively. However, they acknowledge that this practice may not always be effective, as the patient is in a safe and controlled environment. After the patient becomes more comfortable working with the psychologist and has demonstrated improvements in psychosocial skills, often they will move onto participating in group therapy sessions.

Group therapy sessions consisted of a small group of about 4-6 patients, with both psychologists leading these sessions. The goal of these sessions was to encourage patients to discuss their psychosocial experiences with their peers who also have CLP and who may have similar experiences to share. They also practiced socializing and role-playing activities in these groups, where similar to one-on-one sessions, patients would practice playing through difficult or challenging social situations, with the psychologist providing feedback on their actions and behaviors. Psychologists stated that group sessions were very helpful, but not always the most practical, as patients who are new to the group or who are unfamiliar with the other patients in the group may not always actively participate. Also, similar to one-on-one sessions, role-playing may not always be as effective, as the patient is in a safe and controlled environment, where the interactions are more predictable and moderated. Group therapy sessions also do not happen very frequently, with the psychologists stating that they typically hold these sessions once a month due to the availability of patients.

Through the journey mapping exercise with the psychologists, I was able to

outline the two formats in which they worked with their preadolescent patients with CLP, as well as identify the segments of the sessions where patients had opportunities to practice and strengthen psychosocial skills and where there were some obstacles to psychosocial development. In the next section, the development of the game’s storyline and modules based on this exercise and the interview data will be described.

2.2.2 Storyboarding Game Modules and Storyline

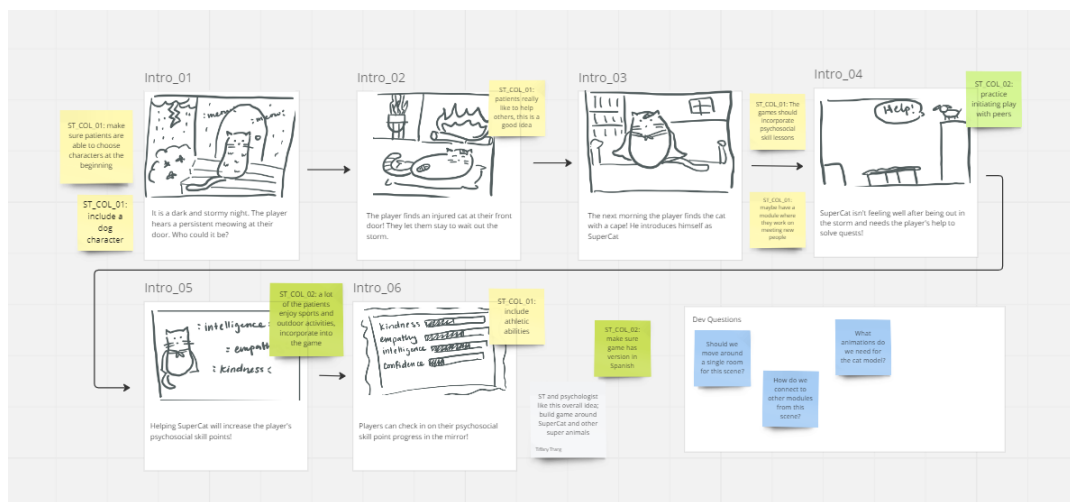


Figure 2.2: The initial storyboard for the Introduction module created with the psychologists from Colombia is shown here. Images drawn from collaborative discussions and comments from the psychologists and development team are included on the storyboard.

Psychologists from Colombia and Brazil who participated in the expert interviews also participated in a collaborative storyboarding workshop, where we designed the general VR game’s storyline and the storyline for each module within the game. The collaborative storyboarding workshop took place over Zoom, where initial designs were drawn on a digital drawing application and further iterations of the storyboard

were created using Miro, shown in Figure 2.2.

We first considered the data produced from the thematic analysis of our interviews with preadolescent and adolescent patients with CLP, and the collective data from the interviews with the psychologists when considering what to design the general storyline around. After reviewing the psychologist interview data, the psychologists participating in the storyboarding workshop believed that it was important to have the storyline help emphasize that the patient has *"traits they should be proud of beyond their cleft"* and wanted to reinforce this idea. We designed an overarching superhero narrative that the game would encompass, where the patient would be tasked with helping out a superhero pet, their Super Pet Pal, who would guide them on their journey to helping others using skills that they already have and can develop. I also included a mirror-feature in the game, where patients would be able to view these skills and their progress on developing these skills in a mirror accessed in their in-game bedroom, to help promote their recognition of these traits within themselves. The game would prompt the patient to go on quests to use their skills to help others in need who are facing challenging social situations that the patient may have some experience with themselves.

The modules that represent the quests that the patient must go on were designed around the themes identified from the thematic analysis of the patient interview data, with some suggestions implemented from the psychologists during the storyboarding exercise. From this, 3 modules were created to address the themes: discomfort in unfamiliar or new social environments, aversion to interactions with new and unfamil-

iar peers, difficulty accepting one's differences and cyberbullying. While cyberbullying was not a theme identified in the thematic analysis of patient interview data, the psychologists felt that due to the pandemic and the increase in online social interactions that patients are experiencing, a module providing advice on how to handle instances of cyberbullying would be useful for patients and would support their sessions with patients on safe online social interactions. More details on the specifics of each module are presented in Chapter 3.

In addition to designing the storylines for the game, we also collaborated on creating the structure of the modules to ensure that psychologists would be able to guide the psychosocial sessions according to their patients' goals. It was important to the psychologists that their role in the gameplay was more active, allowing them to help the patient understand the situation and to learn more about their perspectives regarding the scenarios presented to them in the game in comparison to the scenarios they experience in their own lives. It was also important to the psychologists from Colombia that there was homework included in each of the game modules, to help encourage patients to practice the skills that they have learned in the game in their real lives. The resulting format of the game introduces the patient to the social scenario of the module and then asks them to make a decision, at the decision point the psychologist is able to work with the patient on understanding their thought process behind their decision and can provide appropriate advice and guidance. After the patient makes a decision, the psychologist will progress the game accordingly, displaying the appropriate social consequence and the patient will then be brought to a relevant mini-game. After

the mini-game is completed, the patient will earn mirror skill points and may be asked to make additional social decisions, with further instruction from their psychologist and their Super Pet Pal. At the end of the module, homework is presented to the patient for them to attempt in the real world.

Here, the storyboarding workshop with Smile Train partnering psychologists from Colombia and Brazil was described, providing insight into the process of designing the game’s overall storyline and 3 modules, including the module structure. In the next section, I will go over the process of iterating over the design of the game, with details on changes made to the game’s user interface (UI), characters and storyline as feedback was received from psychologists on drafts and developed prototypes.

2.2.3 Iterative Design and UCD for VREs

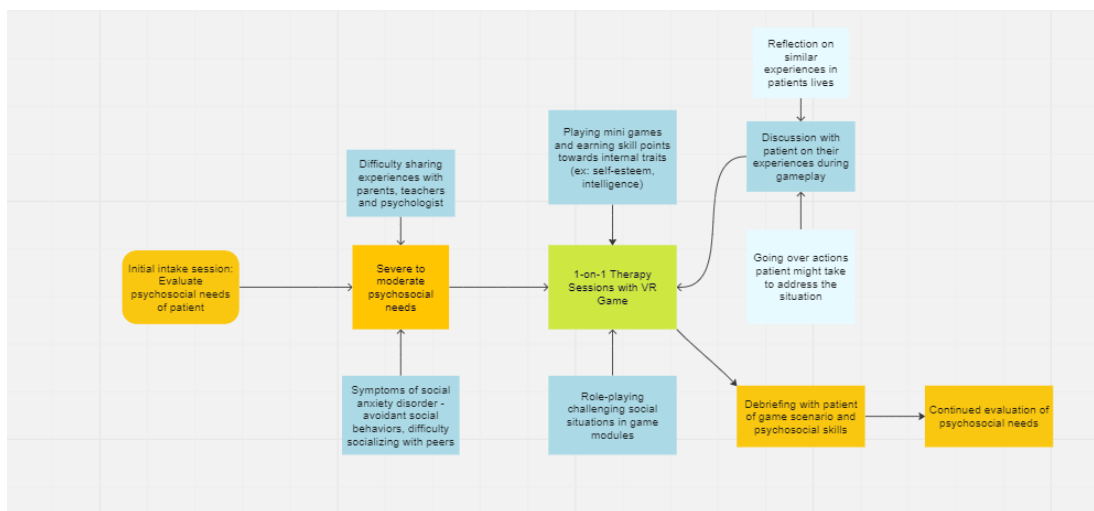


Figure 2.3: Diagram demonstrating how the VR game would be incorporated into 1-on-1 psychosocial support sessions with preadolescent patients with CLP

Upon working with the psychologists on designing the storyline for the broader

game and the 3 game modules, I began to work with them on designing and implementing the actual game, including game mechanics and user interfacing. To effectively integrate the psychologists in the design and development process, I utilized the UCD methods outlined in Gabbard, Hix and Swan's [57] VRE development protocol. The protocol calls for the following steps to be conducted when developing UIs and VREs for a VR experience: user task analysis, expert guidelines-based evaluation, formative user-centered evaluation and summative comparative evaluation. For this work, the first 3 steps of this protocol were used in the design and development of the VR game, and in place of summative comparative evaluation, feedback from the psychologists on each iteration of the VRE and the UI were taken into account and incorporated into the game until they felt comfortable using it in sessions with patients.

A task analysis was performed with the psychologists from Colombia who participated in the expert interviews, journey mapping and the storyboarding workshop. For this task analysis, psychologists were asked to consider the current structure or format of their sessions with patients and to imagine how the use of the VR game might be incorporated into these sessions. From this, we decided that it would be best to incorporate the use of the VR game in one-on-one sessions, due to limitations regarding the number of VR headsets available to the psychologists and the experimental nature of the game. The task analysis then focused on identifying and describing the tasks associated with incorporating and using the VR game in a one-on-one psychosocial support session with a preadolescent patient with CLP. A diagram demonstrating the tasks identified within this session is shown in Figure 2.3.

With the information from the storyboarding workshop and the task analysis, I began to develop prototypes of the game environment, mechanics and UI. An expert guidelines-based evaluation was performed with myself, 1 graduate and 1 undergraduate student researcher, who were not involved with the development of the game, with expertise in user experience research. Through this evaluation, we performed the following tasks, following the usability guidelines presented in [57]: signing-in as the psychologist or patient player, navigating to the Introductory module and the map (scene selection) scene, and playing through each of the 3 modules. During this evaluation, we examined several factors contributing to the usability of the game, including monitoring for in-game glitches, intuitiveness of the game's progression, controls and UI, and the amount of time it took to complete each module. From the expert guidelines-based evaluation, modifications to the placement of UI, length of game modules and controls were necessary to help improve the usability of the game.

Following this, the formative user-centered evaluations were completed with the Smile Train partnering psychologists in Colombia, Brazil and the Philippines. These evaluations were conducted remotely over Zoom with myself and an undergraduate research assistant present as evaluators, where the psychologists would evaluate the game through one headset as the "Psychologist" player. This was done, as the "Psychologist" player in the game is able to access the controls that the patient can, along with their unique UI, described in Chapter 3. During this evaluation the psychologists were asked to complete the following tasks to understand the usability of the system during one-on-one sessions with their preadolescent patients with CLP: login as the "Psychologist"

player, navigate to the map (scene selection), access Module B: Cafeteria Calculations and play through the module until the homework is assigned. Psychologists participating in this evaluation were not given further instruction beyond the tasks assigned to them to complete and were asked to discuss their thought process as they progressed through the game.

While all 4 psychologists participating in this evaluation were able to complete the tasks assigned to them within 30 minutes, it was noted that there were errors in the game that made it difficult for the psychologist to progress, including issues maintaining connectivity to the Photon servers and with using the controller to grab objects. In particular, when the game was unable to maintain a connection to the Photon servers, the game would freeze as it tried to reconnect, with no indication of what happened. There were also usability issues identified in the gesture used to pick up objects in this module, where the user would be required to grab objects by pushing 2 buttons on the Quest 2 controller simultaneously, mimicking a grabbing motion. While 3 of the 4 psychologists were able to eventually figure out how to grab objects in VR, 1 did struggle and it was necessary to explain the controls to her after a few minutes. Additionally, there were concerns from the psychologists about the positioning of the UI, where it felt too close to their field of view to be able to comfortably read the dialogue. Based on our observations, the undergraduate research assistant and I found that all 4 psychologists had a tendency to want to hold the headset throughout the entire process of playing the game. However, psychologists demonstrated great adaptability when it came to figuring out how to play the game without prior instruction from myself, the

undergraduate research assistant or an instructions document.

From these three steps from the UCD protocol for VREs, I gathered enough information to understand what to improve in the design of the game, including the following: providing further information to the player when an error occurs (ex: message indicating what happened), incorporating actions for the player to take to navigate back and forth between scenes to account for potential glitches (ex: home, main menu and scene selection buttons in every scene), and creating a user guide for psychologists to assist them with understanding how to comfortably use the headset, including how to adjust the headset straps, and how to identify and use the buttons on the controllers.

In the next chapter, more detail on the game's individual modules, as well as the UI and the process of developing the game using the Unity game engine and the Photon PUN2 multiplayer networking package will be given. Further information on the implementation of changes from the UCD protocol for VREs will also be included in the section regarding the "Psychologist UI" and the game's structure.

Chapter 3

Game Development

In this chapter, the development of the game based on the data collected from user and expert interviews, as well as the design procedures with the psychologists and clinicians, will be described. From the interviews and design procedures, an emphasis was placed on integrating CBT as a method for promoting the development of psychosocial skills for preadolescents with CLP. More specifically, psychologists and clinicians incorporated spaces in the game where they could speak with the patient about difficult social situations and discuss their experiences and feelings towards it. They also incorporated rewards and positive feedback to help encourage positive associations with the social situation in the design of each module. To help with understanding whether or not the skills and lessons learned in the module were generalized to the real-world, patients were given "personal quests" or homework at the end of each module to try on their own at school or at home. In the following sections, the overall game format will be discussed, along with the specific storyline and social skill goal that each module in

the game addresses.

This chapter also contains information about the implementation of multiplayer capabilities in the game using the Photon PUN 2 Unity networking package, as well as a description of how this tool is used throughout the game to allow for the psychologist or clinician to play the game with the patient. The game was developed for the Meta Quest 2 using Unity's XR Interaction Toolkit and the Meta Quest Developer Portal to allow for ease of VR game development and distribution for user testing. The game was also developed with assistance from undergraduate and graduate research assistants who assisted with writing scripts for the animation of dialogue, development of 3D game assets and troubleshooting the implementation of multiplayer capabilities. My specific contributions to the development of this game include the design and development of the game's storyline with Smile Train psychologists, the implementation of multiplayer capabilities and synchronization across scenes using Photon PUN 2 and writing the scripts for the mini games presented in each of the modules described below.

3.1 Game Format

Based on data collected from the design procedures with the psychologists and clinicians, along with data collected from user and expert interviews, the developed game follows a branching narrative format consisting of 4 modules: Introduction, Module A: Social Soccer, Module B: Cafeteria Calculations, and Module C: Cyberbully Bugs. In these modules the patient is given quests to go on with their Super

Pet Pal, SuperCat or SuperPup, who helps them with developing psychosocial skills. These modules are played by the psychologist and the patient, where the psychologist is given a psychologist-specific UI to help progress the game according to the goals and needs of the patient. Due to the branching narrative structure, the psychologist is able to progress the game according to the behavior or actions of the patient, providing a realistic social consequence. The game was developed in 4 languages: English, Spanish, Portuguese and Tagalog, to accommodate for the language(s) commonly spoken in the countries where user testing took place. Psychologists and members of the cleft care teams at Smile Train's partnering hospitals in Colombia, Brazil and the Philippines assisted with the translation of game dialogue to ensure its accuracy. This team also assisted with the development of a guide for clinicians and psychologists to help them understand how to play the game and how to use the breakpoints of the game to facilitate developing psychosocial skills. In the following sections, the storyline behind each module will be outlined, detailing the specific social skill being addressed and the actions the psychologist may take to encourage psychosocial skill development for the patient.

3.1.1 Introduction Module

The Introduction module is intended to give the patient practice using the game controls for the first time, along with introducing them to their Super Pet Pal who will be present throughout the game modules to help them with completing each quest. In the Introduction module, the patient is in their virtual living room while rain

is pouring outside and thunder is rumbling. They hear a cat meowing or dog whining, based on their preferred pet selected at the beginning of the game. After being prompted to investigate this noise coming from their front door, they find a cat or dog seeking shelter. The patient is then prompted to let the pet in to wait out the storm.

The next morning, the patient is met with their new Super Pet Pal, SuperCat or SuperPup. SuperCat or SuperPup introduces himself to the patient, thanking them for their kindness and asking if they would like to help out with some quests. Their Super Pet Pal then moves on to showing the patient a map with flashing dots where help is needed. Each time that a patient completes a quest, they are given psychosocial skill points (ex: self-esteem, kindness), which they can view in the mirror. The mirror was designed with the psychologists and clinician, as well as Smile Train stakeholders, to help imply that these valuable internal qualities already exist within the patient and can grow. They also intended to help encourage patients when they look in the mirror in real-life to think about these qualities whenever they have negative thoughts or feelings towards their physical appearance. Once the patient is introduced to the map and mirror feature, they are asked to choose a quest to embark on.

3.1.2 Module A: Social Soccer

The Social Soccer module focuses on targeting social skills focused on initiating or asking to join play activities with peers. This module was designed with psychologists and clinicians, who believed it would be beneficial for their patients to practice asking to join their peers in play activities. They also felt it was important to have their patients



Figure 3.1: A screenshot of Module A: Social Soccer, where the Psychologist UI is active. The psychologist or clinician must decide whether the patient’s response progresses the game or prompts the characters to ask them to repeat themselves.

practice repeating themselves whenever their speech is unclear to someone else, which was stated to often upset patients and cause them to avoid conversations with new or unfamiliar people.

This module begins with the patient’s Super Pet Pal asking the patient to win a soccer trophy that is embellished with a magical gemstone that they need to retrieve. The only way to win the trophy is to enter the soccer tournament and win the match, so the patient must find a team to join. The patient’s Super Pet Pal prompts them to ask the two characters standing next to the registration table if they can join their team. During this portion of the game, the psychologist or clinician will watch the patient verbally ask the two characters if they can join their team for the tournament. The psychologist or clinician will then choose to progress the game or trigger the characters

to ask the patient to repeat themselves because they could not understand what they said. Based on the needs of the patient, the psychologist or clinician may choose the "repeat" option, and may take a moment to discuss the situation with the patient, including how the patient is feeling towards being asked to repeat themselves and how they might combat negative feelings with respect to this situation in the future. The psychologist will then ask the patient to repeat themselves and will choose to progress the game when appropriate.

Once the game progresses, the characters welcome the patient into their soccer team and they progress into a game where the patient is a soccer goalie and must block the balls from entering the goal. This module was designed with this soccer game as a reward to patients, as interview data demonstrated that many of the users interviewed enjoyed playing sports and psychologists and clinicians felt that soccer was an appropriate team sport for their preadolescent patients. After the game is complete, they are rewarded with the trophy, skill points and are praised by the two characters they spoke to earlier in the game. Their Super Pet Pal congratulates the patient on their win and proceeds to ask them to go on a personal quest, where they will try to ask peers at school if they can join in their games or ask peers at school to play with them.

3.1.3 Module B: Cafeteria Calculations

Cafeteria Calculations is a module designed to help patients empathize with peers and understand how they might advise them to address difficult social situations



Figure 3.2: SuperPup is helping supervise the patient who must figure out the correct combination of food items to match the payment total of the student.

that the patient may have already encountered or will encounter in the future. Psychologists and clinicians discussed patients' difficulty with adapting to new social situations, such as joining a new school or participating in a new after school activity, especially when it came to making new friends or conversing with teachers or adults who may not know about their condition. In designing this module, psychologists and clinicians felt that it was important for the patient to identify and understand the emotions present in new situations and how these feelings cause them to behave or act.

This module brings the patient to a school cafeteria, where a new student is seeking help from the patient and their Super Pet Pal. The new student, Stephen, is very shy and was asked by his teacher to collect lunch orders from his classmates to help prepare for lunch time. As lunch approaches, Stephen is worried because he was too

afraid to ask his classmates for their order and does not have the information to give to the cafeteria staff. He wants the patient and their Super Pet Pal to determine the lunch order of each of his classmates based on their payment total at the cash register. The Super Pet Pal and patient agree to help and are brought to a mini game, where they must place food on a lunch tray in a specific combination in order to match the payment total, as shown in Figure 3.2. Once the game is over, the patient is rewarded with kindness and intelligence skill points and is thanked by Stephen.

However, the patient's Super Pet Pal notices a student waiting to speak with Stephen in the cafeteria. The student introduces herself as Sophia and welcomes Stephen to the school. She asks him how he managed to get her lunch order correct when she knew that he did not ask for her order earlier. Stephen becomes worried and asks the patient how they should respond: lie to Sophia to save himself from embarrassment or tell her the truth in hopes that she understands. The patient is prompted to respond to Stephen out loud, giving the psychologist or clinician an opportunity to discuss the situation with the patient. The intent is for the psychologist or clinician to have a conversation with the patient on what they would advise Stephen to do and why, leading to a discussion regarding the patient's experiences with similar situations. The patient will also discuss with the psychologist what the potential outcomes might be for Stephen choosing to lie to Sophia or choosing to tell the truth.

The psychologist will ask the patient to verbally respond to Stephen and then using their specific UI, will progress the game accordingly. Based on the actions of the patient, Stephen will lie to Sophia or tell her the truth, illustrating the respective

outcomes: Sophia will be upset that Stephen lies to her and tells him that she wanted them to be friends but not after lying to her or Sophia will be understanding of Stephen's situation and invite him to meet her friends. The patient's Super Pet Pal will prompt the patient to think about what happened with Sophia and Stephen, focusing on the emotions present in both characters and what the consequences of Stephen's actions were. He then provides the patient with their personal quest of thinking about the emotions present in social situations that make them uncomfortable and how it might cause them to behave or act, and what consequences that might have. The Super Pet Pal will then let the patient know that they have done a great job helping out Stephen today and will teleport back to the map to choose a new quest.

3.1.4 Module C: Cyberbully Bugs

Due to the recent increase in online schooling and interactions due to the COVID-19 pandemic, psychologists emphasized that their patients were dealing with more instances of cyberbullying. In particular, psychologists interviewed found that cyberbullying typically occurred in the form of mean comments and messages. For psychologists in Colombia, they noticed that patients were combating cyberbullying that they were experiencing with cyberbullying of their own, leaving mean comments and messages on their bully's social media accounts. Module C: Cyberbully Bugs was created to help patients reframe mean comments and understand the impact of cyberbullying to give patients the tools to effectively cope with and prevent cyberbullying.

This module begins by introducing the patient to a character, Angelina, who



Figure 3.3: In Module C: Cyberbully Bugs, the patient is inside of Angelina’s computer that is infested with bugs. The Psychologist UI is shown, where they can delete the bug that the patient has clicked once they have decided an appropriate way of reframing it

is having trouble with their computer overheating and not turning on. As the patient, their Super Pet Pal and Angelina are talking, a news report begins to play on the television. A news anchor briefly describes cyberattacks from The Mad Scientist, a social media influencer who creates scientific videos. The Mad Scientist is lashing out against people who have been cyberbullying her, leaving mean comments and negative reviews on her posts, by sending bugs to their computers and cellular devices, causing them to overheat and malfunction. Angelina recognizes The Mad Scientist as someone she dislikes, saying she has left mean comments on her videos before. The patient is then prompted to agree or disagree with Angelina, which triggers a positive or negative reaction from Angelina and their Super Pet Pal comes to The Mad Scientist’s defense. Although the patient’s Super Pet Pal disagrees with leaving mean comments on The

Mad Scientist's videos, he agrees to help remove the bugs from Angelina's computer.

In this portion of the game, the patient is teleported inside Angelina's computer with their Super Pet Pal. They can see that there are actual bugs in the computer, setting fire to it and causing it to overheat and malfunction. The patient is tasked with getting rid of the bugs by clicking on them, learning that each bug represents a mean comment left by one of The Mad Scientist's viewers. To get rid of the bug, the patient must attempt to reframe the mean comment to be more constructive, neutral or positive. Here, the psychologist may ask the patient to discuss with them experiences that they have had with cyberbullying or may ask about instances where cyberbullying may occur in their lives, and how they would choose to address it. The patient would then be asked to click on a bug and discuss the impact of the mean comment with the psychologist and work with them on reframing it to be constructive, neutral or positive. For example, a spider may hold a mean comment suggesting that The Mad Scientist's videos are boring. The psychologist and patient may discuss the impact it has on The Mad Scientist's feelings and what the comment might say instead to encourage her to create more interesting content.

Once the psychologist and patient agree on how the mean comment should be reframed or addressed, the psychologist will delete the bug using their psychologist-specific UI. When all of the bugs are destroyed, the user will be led to The Mad Scientist's lab, where she will speak with the patient about how the mean comments have made her feel terrible, even though she enjoys making scientific videos as a hobby. The patient's Super Pet Pal will then step in and give her some advice, encouraging her to continue the

activities she enjoys and to put more emphasis on listening to comments that encourage her to grow or that support her. The patient is then asked to share some advice they might have for The Mad Scientist, and then the patient and their Super Pet Pal are transported back to Angelina's home.

Angelina thanks the patient and their Super Pet Pal for helping to fix her computer, and begins to draft a mean comment to The Mad Scientist for bugging her computer in the first place. The patient's Super Pet Pal becomes worried and asks the patient to quickly stop Angelina by saying something to her. In this instance, the psychologist and patient may work together to discuss the ideas the patient may have about how to prevent cyberbullying and how to address how Angelina might be feeling about the whole situation. The psychologist may also take this opportunity to speak with the patient about times where they may have chosen to cyberbully someone in retaliation, and how they may consider alternatives the next time this situation arises. Once the patient and the psychologist feel they have a satisfactory response for Angelina, the game will continue with Angelina agreeing to no longer leave mean comments on The Mad Scientist's videos. The patient's Super Pet Pal then gives advice to the patient regarding how to address cyberbullying, including reporting users and asking parents or caregivers for help, and asks them to go on their own mission to consider how they might prevent or address cyberbullying in their own lives.

3.1.5 Game Conclusion

Upon completion of all 3 modules, players are rewarded with the option to play mini games with characters that they have met during their gameplay. Based on feedback from the psychologists, further detailed in chapter 4 and 5, a conclusion module was also added to the game to show patients what lessons they have learned from each module and what characters they have helped along the way. A total of the patient's skill points from each module is also shown to them in their mirror, with their Super Pet Pal congratulating them on growing their skills. The patient's Super Pet Pal will also thank the patient for their help throughout the game and will ask them to continue helping themselves and others through what they have learned on their missions. In the next section, the development of the game with a focus on implementing multiplayer capabilities using Photon PUN 2, a networking package for the Unity game engine, will be described.

3.2 Multiplayer Capabilities

In this section, the implementation of multiplayer capabilities in the VR game using Photon PUN 2, a Unity package that enables multiplayer networking capabilities, is discussed. Using Photon PUN 2, psychologists and patients are connected to a Photon Cloud server according to their server region and are joined together in specific rooms identified through their Photon app ID. In the developed VR game, this package is used to enable psychologists and patients with CLP to play together in real-time, each

on their own VR headsets. In this section, the use of Photon PUN 2 in enabling this multiplayer capability, along with synchronizing scenes and character dialogue across players will be described.

3.2.1 Implementation of Multiplayer Capabilities

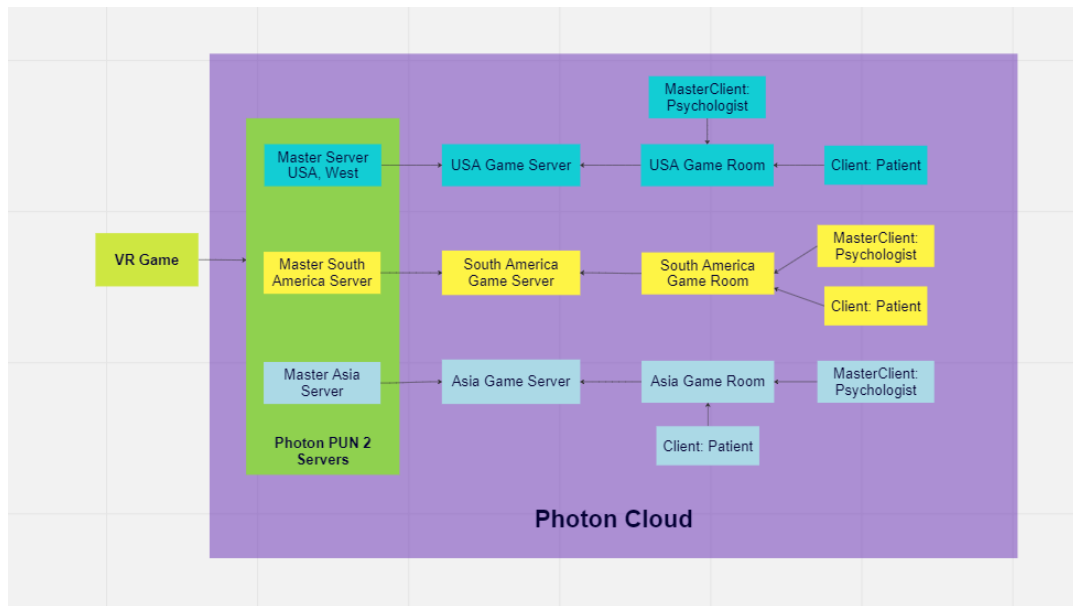


Figure 3.4: A system diagram depicting the use of Photon PUN 2’s regional servers to connect the MasterClient (Psychologist) and Client (Patient) in a game room is shown.

Initialization of Photon PUN 2 in Unity to implement multiplayer capabilities begins by creating an app ID linking your Unity project to a specific server in the Photon Cloud. While the server is responsible for connecting players across multiple devices running the game, only players in the same server region can connect with each other even though they are running the same game under the same app ID. To ensure a stable connection to the server, the game was created with multiple app IDs to allow for the

specific server region to be defined per build of the game for each country participating in user testing. This also ensured that there would be no issues for players across the globe attempting to use the game at the same time. A system diagram illustrating the use of Photon PUN 2 in the VR game is shown in Figure 3.4.

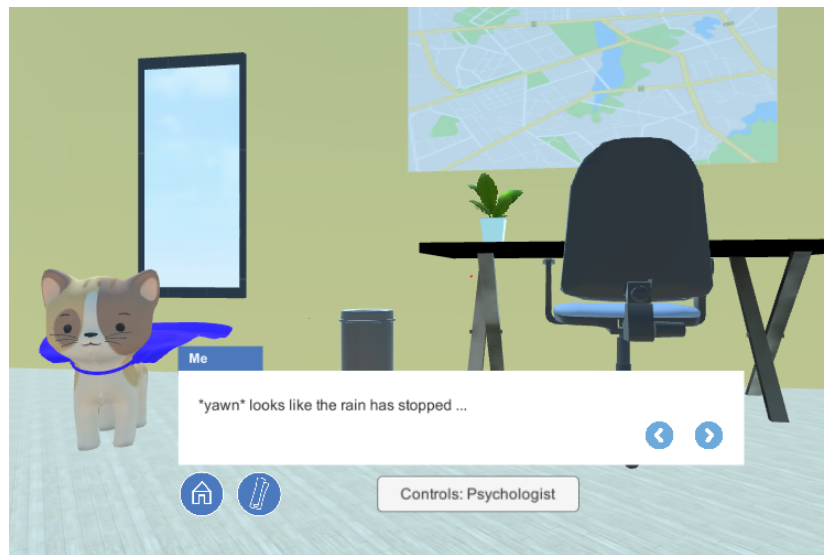


Figure 3.5: In this image the Psychologist UI is active. The button directly underneath the dialogue box allows the Psychologist player to switch the Master Client, allowing for proper synchronization of scenes and in-game actions.

After initialization, the players are sent to the Login Scene of the game, where they must sign-in as either the "Psychologist" player or "Patient" player. Similar to the concept of Host Migration commonly used in multiplayer games, Photon uses a Master Client, who initializes rooms and synchronizes scenes across all players. For the developed game, the Psychologist is defined as the Master Client to allow them control of the game as they guide their patient to the appropriate module for their session. Once the Psychologist player is signed in, a room with a 2 player maximum is automatically

created for the patient to then sign-in and automatically join. During gameplay, there are instances where the Patient player should be identified as the Master Client to ensure proper synchronization of scenes and in-game choices. The Psychologist UI contains a button that enables the psychologist to switch the Master Client role between the Psychologist and Patient players, as shown in Figure 3.5. The Psychologist is able to use this button to switch roles even when they are not currently the MasterClient.

3.2.2 Synchronization of Scenes, Dialogue and Objects

In this section, synchronization of the scenes, dialogue and objects in the developed game will be discussed. Information regarding the use of Photon PUN 2's included methods and classes will be outlined in the synchronization of scenes and objects, and the implementation of Remote Procedure Calls (RPCs) for synchronizing dialogue across players will also be described.

RPCs enable methods called by one player in a multiplayer game to be called for all of the other players in the same room. For example, if one player presses a button enabling the main menu to open and this button has a scripted behavior containing a RPC, then this action will cause the main menu to open for all of the other players currently active in the same room. RPCs were used to synchronize the dialogue in the game, as well as to update the status or behavior of certain objects within the modules of the game. In the following sections, the use of RPCs for the synchronization of dialogue and status or behaviors of certain objects will be described in relation to their implementation in the game. Towards the end of this section, the synchronization

of scenes using Photon PUN 2's built-in methods will also be described through its implementation in the game.

3.2.2.1 RPC Dialogue Synchronization

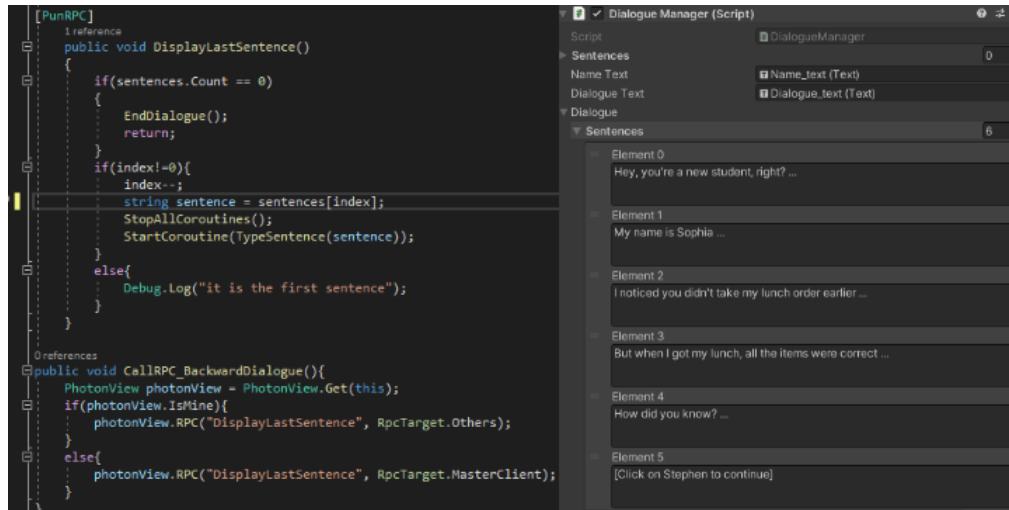


Figure 3.6: Screenshot of DialogueManager.cs script that enables the dialogue to synchronize across all players in the game (left) with the dialogue objects shown in Unity (right).

The dialogue of the game is implemented through a game object per scene, where each line of the character's dialogue and their name is stored. From the Dialogue Manager script, the DisplayLastSentence() function, shown in Figure 3.6, is used to produce the appropriate dialogue line for each time the dialogue progression button is pushed. Above this function, you will notice the code "[PunRPC]", which lets Photon know that the function will be referenced in a RPC. To use the RPC, a new function is created and in the example above is called "CallRPC_BackwardDialogue()", where the Photon View is accessed and used to allow us to know who is currently the player

calling this method. Within this function, the if-else statement helps to identify which player is calling the method and then determines which players should synchronize to the method called by this player. In the example, the if-statement checks if the current player is calling the method and directs the method to be called through an RPC to other players in the game. However, if the current player is not the one calling the method, the RPC is directed to the current player as a different player is calling the RPC function.

Throughout the game, both the Psychologist and Patient players have the ability to progress the game's dialogue backwards and forwards. For each push of the backward or forward dialogue button, the corresponding RPC for the appropriate dialogue function is called and directs the synchronization of the dialogue text.

3.2.2.2 RPC Object Behavior and Status Synchronization

Object behavior and status synchronization also occurs in the game through the use of RPCs, where behaviors, such as animations, or changes in status, such as active or inactive, are synchronized across all players in the game. Similar to the synchronization of the dialogue, the "[PunRPC]" code is placed before the function that will be used in the RPC and a new function is written referencing the RPC function. In Figure 3.7, the RPC to synchronize the destruction of spiders in Module C: Cyberbully Bugs is shown, where in the "callRPC_p.c()" function, the call is being made to all players in the room shown by the code "photonView.RPC("p.c", RpcTarget.All)". RPCs are also used to synchronize the behaviors of objects, where in Module B: Cafeteria


```

static int spider_num = 5;

[PunRPC]
0 references
public void p_c()
{
    var go = GameObject.Find(Spider_Destroy.go_name);
    Destroy(go);
    spider_num -= 1;

    if (spider_num == 0)
    {
        PhotonNetwork.LoadLevel("CatSp_MadSci_Game_Win");
    }
}

0 references
public void callRPC_p_c(){
    PhotonView photonView = PhotonView.Get(this);
    photonView.RPC("p_c", RpcTarget.All);
}

```

Figure 3.7: Code from Module C: Cyberbully Bugs, using a RPC to synchronize the deletion of spiders from the game scene.

Calculations, the total on the cash register will update and synchronize across players after the food objects are placed or removed from the lunch tray.

3.2.2.3 Scene Synchronization

Scene synchronization for the Psychologist and Patient players are not synchronized by RPCs, but are instead synchronized based on the actions of the MasterClient with built-in functions within Photon PUN 2. Photon will automatically synchronize the scene of the MasterClient with all of the other players in the room, meaning that if the MasterClient moves from Scene 1 to Scene 2, all of the other players will also move from Scene 1 to Scene 2. However, Photon will not synchronize scene changes that other players in the same room make, so if a non-MasterClient player changes scenes, no other players will synchronize to that scene. This was implemented in the multi-

player networking package to ensure that only one player would be able to control the changing and synchronization of scenes across all players. Due to this, it was necessary to implement the button allowing the Psychologist player to change the MasterClient in the Psychologist UI described in section 3.2.1.

In this chapter, the developed VR game's overall storyline and module storylines and formatting was discussed. The use of Photon PUN 2 in enabling multiplayer capabilities, along with the use of RPCs to synchronize game dialogue, object behaviors and states, and scene synchronization were also described. In the next chapter, the evaluation of the game through case studies with preadolescent patients with CLP will be discussed, where the study was conducted with a partnering Smile Train psychologist in Colombia.

Chapter 4

Case Study and Results

A case study evaluating the impact of the developed VR game was conducted at a partnering Smile Train clinic in Colombia with preadolescent patients with CLP. In this section, the study design will be outlined, including the measures used to collect information regarding changes in psychosocial skills and behaviors, and qualitative feedback on the overall game and individual modules.

4.1 Study Design

To evaluate the impact of the VR game on the psychosocial development of preadolescent patients with CLP, a case study involving a psychologist and 6 preadolescent patients with CLP was conducted. The study evaluated the use of the VR game in addition to existing psychosocial support sessions on a weekly basis across a 4-week period. In the evaluation of the game, a pre-test/post-test format was used to measure any changes in psychosocial skills or behaviors. The measures used include:

the Behavior Assessment System for Children, 3rd Edition (BASC-3) [58], Rosenberg Self-Esteem Scale (RSE) [59] and the Need to Belong Scale (NBS) [60]. In addition to these measures, a module qualitative feedback survey was administered to patients after completing each game module, concerning their experience using each individual game module as a part of their psychosocial support session.

Participants of the study were asked to use the game as part of their sessions over the course of 4 weeks, with pre and post-test measures conducted within a week prior and a week after user testing, respectively. Participants were also asked to fill out an overall game experience qualitative feedback questionnaire at the end of the user testing period, where they provided feedback on their overall experience using the game with their psychologist as a part of psychosocial support sessions. Additionally, the psychologist using the game with patients was given a qualitative feedback survey and participated in a follow-up interview regarding her experiences using the game with patients over the 4-week user testing period. These measures were chosen by the psychologist and myself to holistically evaluate changes in psychosocial skills with respect to social behaviors, self-esteem and the feeling of needing to belong or fit in with others.

The BASC-3 is a measure evaluating emotions, behaviors and personality in relation to psychosocial disorders for children and adolescents [58]. It consists of 3 components: a child/adolescent self-report scale, parent rating scale and a teacher rating scale, which are conducted by a clinician to identify potential psychosocial disorder or behavioral problems that the child may be facing. For the purposes of our study, we

utilized the child/adolescent self-report scale from the BASC-3 to measure any changes in psychosocial behaviors from using the VR game as a part of psychosocial support sessions. The child/adolescent self-report scale consists of 152 true-false questions, which are scored and converted into points for the following psychosocial factors: locus of control, social stress, anxiety, depression, feeling inadequate, interpersonal relationships, parent relationships, self-esteem, self-confidence, negative attitude towards school, negative attitude towards teachers and atypicality. The definitions of each of these factors is provided in Table 4.1 and 4.2. For this study, the psychologist conducting psychosocial support sessions with patients were responsible for collecting the BASC-3 child/adolescent self-report data before and after the 4-week user testing period and utilized an electronic scoring program to calculate the scores for each of these factors. Further information on the meaning of the scores for each factor will be described in chapter 5, where the BASC-3 results from user testing will be provided.

The RSE was used to measure changes in global self-esteem of preadolescent patients, and consisted of 10 statements regarding self-esteem that participants would need to rate on a scale of "Strongly Agree" to "Strongly Disagree". The ratings given to the statements are then scored where "Strongly Disagree" is given 1 point, "Disagree" is given 2 points, and the scale ascends to "Strongly Agree", which is given 4 points. However, 5 of the 10 statements are reverse scored. These scores are then summed, and a higher score is indicative of higher levels of self-esteem for an individual. In this study, the RSE was conducted by the psychologist, but scored by myself or a graduate or undergraduate member of the research team.

The NBS is a measure used to assess an individual's desire for acceptance and belonging and consists of 10 statements regarding the individual's experiences with belonging and acceptance. These statements are rated on a scale of "Strongly Disagree" to "Strongly Agree" and are scored similarly to the statements in the RSE, where "Strongly Disagree" is given 1 point and "Strongly Agree" is given 5 points. Three of the statements in the NBS are reverse scored. A greater summation of the scores of these statements suggests that the individual may experience higher levels of needing to belong and may worry more about belonging and being accepted. For this study, the NBS data was collected by the psychologist conducting the user testing, but was scored by myself or a graduate or undergraduate member of the research team.

Participants of the study were recruited from the psychologist's existing patients. They consisted of male and female patients between the ages of 9 and 15 who were diagnosed with CLP who have either undergone or not undergone cleft surgery. In the following section more detail regarding the study procedure will be described.

4.1.1 Case Study Procedure

The case study was conducted with one psychologist and 9 preadolescent patients with CLP from a partnering Smile Train clinic in Colombia. Due to issues with scheduling, only 6 patients completed the study. Of these 6 participants, 4 were female

Table 4.1: BASC Factor Definitions

BASC Factors	Definition
Atypicality	Evaluates if there are psychopathological problems (symptoms of psychosis, such as hallucinations, paranoid thoughts, etc.)
Anxiety	Evaluates the presence of feelings of fear, obsessive thoughts and worries, usually irrational.
Depression	Evaluates feelings such as sadness, loneliness and poor enjoyment of life, sometimes as consequence of anxiety and stress processes.
Feeling Inadequate	Evaluates the child's lack of confidence in his or her own ability to achieve his or her goals.
Interpersonal Relationships	Assesses success and satisfaction obtained by the subject in his relationships with others.
Locus of Control	Evaluates the attributions that the child makes about who controls what happens in his life, if he attributes responsibility to himself (internal locus of control) or to other instances (external locus of control).

Table 4.2: BASC Factor Definitions (Continued)

BASC Factors	Definition
Negative Attitudes Towards Schools	Evaluates the degree of satisfaction of the child in school. High scores indicate that the child is not well adapted to the school system which can cause additional problems.
Negative Attitudes Towards Teachers	Evaluates the degree of satisfaction of the child with his teachers (if they help them, show interest towards him, they are fair in the grades, etc.).
Parent Relationships	Assess the Child's Relationships with their parents and their role in the family.
Self-Confidence	Assesses the ability to make decisions for themselves and self-confidence in themselves.
Self-Esteem	Evaluates the degree of satisfaction with himself.
Social Stress	Evaluates the level of stress (tension, anxiety...) that children have in interpersonal relationships.

Table 4.3: Participant User Testing Schedule

Participant ID	First Session	Second Session	Third Session
1	Module C	Module A	Module B
2	Module A	Module B	Module C
3	Module A	Module B	Module C
4	Module A	Module B	Module C
5	Module B	Module A	Module C
6	Module C	Module B	Module A

and 2 were male, and their average age was 11.8 years old with a range of 11-13. These 6 patients had at least 3 years of experience working with the psychologist on developing psychosocial skills. They were asked to play the developed VR game once a week over a 4-week period with the psychologist as a part of their regular weekly psychosocial support sessions. These sessions took place in the office of the psychologist at the partnering Smile Train clinic.

A week prior to the start of the game evaluation, the psychologist conducted pre-test measures using the BASC-3, RSE and NBS to collect baseline data on psychosocial skills. During the evaluation of the game, a module qualitative feedback survey was given to participants after each session to gather feedback on their experience using each individual module. Post-test measures were collected within a week following the last psychosocial support session with the VR game and included the 3 measures from

the pre-test as well as qualitative feedback surveys regarding the patient's overall experience with the game. The psychologist was also given a qualitative feedback survey to complete after completing the last psychosocial support session using the VR game to collect information on her experiences using the game as a part of her sessions. Additionally, a parent of one of the participants participated in a post-test interview to identify if they have noticed any changes in their child's behavior after playing the game over the 4-week period.

To prevent any bias and to understand the impact of the game's modules played in an undefined order, patients were randomly assigned modules to play every week during their psychosocial support sessions, with the exception of the "Introduction" module, which every participant started with. The testing schedule with each module per participant is shown in Table 4.3. In the following section, the results and data analysis from the evaluation of the VR game in addition to psychosocial support sessions with a psychologist will be described, outlining data collected from the qualitative and quantitative measures.

4.2 Results and Data Analysis

In this chapter, the results from the case study conducted in Colombia to evaluate the impact of the VR game on the psychosocial development of preadolescents with CLP will be described. Qualitative and quantitative data collected will be described in its own section, where the quantitative data section will provide insights from

the BASC-3, NBS and RSE regarding changes in psychosocial skills and behaviors. The qualitative data section will focus on describing the data collected from qualitative feedback surveys completed by patient participants and psychologists, which were analyzed using thematic analysis.

4.2.1 Quantitative Data

Pre-test and post-test data collected from the BASC-3, RSE and NBS is presented with the data analyzed in this section. The average pre-test and post-test values for each factor measured by the BASC-3, as well as the t-value and p-value, are given in Table 4.4. Values for each factor of the BASC-3 child/adolescent self-report measure are used to indicate to what degree the individual exhibits that factor through their responses. For example, anxiety is one of the factors measured by the BASC-3 child/adolescent self-report, and a higher score for this factor indicates that the individual exhibits greater symptoms of anxiety, such as obsessive thoughts or irrational worrying. For factors such as parent relationships, a greater score indicates that the responses of the individual suggest that they have a more positive perspective towards their relationship with their parents.

Table 4.4: BASC Scale Results

BASC Factors	Average pre-test value	Average post-test value	t-value	p-value
Atypicality	63.3	49.50	t(5)= 0.80	p= 0.46
Anxiety	40.2	36.7	t(5)= 0.75	p= 0.49
Depression	34.2	46.7	t(5)= -1.06	p= 0.34
Feeling Inadequate	60.8	47.5	t(5)= 0.90	p= 0.41
Interpersonal Relationships	78.3	68.5	t(5)= 0.84	p= 0.44
Locus of Control	36.0	41.8	t(5)= -0.74	p= 0.50
Negative Attitudes Towards Schools	77.3	71.7	t(5)= 0.89	p= 0.41
Negative Attitudes Towards Teachers	44.0	47.8	t(5)= -0.29	p= 0.78
Parent Relationships	72.8	61.7	t(5)= 0.68	p= 0.53
Self-Confidence	49.7	45.5	t(5)= 0.25	p= 0.81
Self-Esteem	73.2	64.8	t(5)= 0.44	p= 0.68
Social Stress	46.7	43.3	t(5)= 0.31	p= 0.77

For this case study, there were no significant effects found for any of the factors measured by the BASC-3, RSE or NBS. A paired sample t-test with a statistical significance threshold of $p < 0.05$ was conducted for each of the factors measured by the child/adolescent self-report of the BASC and no significant effect was found for any of these factors. Although these findings were not significant, it is noted that for the BASC-3, average scores for atypicality, anxiety, feeling inadequate, and social stress decreased after the use of the VR game. Paired sample t-tests were also performed on the data collected from the RSE and NBS. For the RSE, the results were ($M = 1.2$); $t(5) = 0.82$ and $p = 0.45$, and for the NBS the results were ($M = -0.3$); $t(5) = -0.12$ and $p = 0.91$. There were no significant differences in scores from the pre and post-test RSE and NBS measures; however, it is noted that the negative mean difference for the NBS implies that on average participants demonstrated lower levels of needing to belong or worrying about belonging.

A module qualitative feedback survey was given to patients after playing each module of the game, which collected quantitative data through statements for them to rate on a Likert scale from 1 to 5, where 1 was "Strongly Disagree" and 5 was "Strongly Agree". These statements aimed to gather information regarding the reliability of the scenario presented in each module, along with statements regarding whether the module was enjoyable and user-friendly. The statements along with the median results from this portion of the module qualitative feedback survey is presented in Table 4.5. These results suggest that the game overall felt reliable to patients, was enjoyable and easy to play.

Table 4.5: Median Module Feedback Questionnaire Quantitative Responses

	Module			
	<i>Intro</i>	<i>Social Soccer</i>	<i>Cafeteria Calculations</i>	<i>Cyberbully Bugs</i>
I enjoyed playing the module.	5.0	5.0	5.0	5.0
The module was interesting to me.	5.0	5.0	5.0	5.0
The module presented a scenario with which I could relate.	3.0	5.0	5.0	4.5
I thought the module was difficult to play.	3.0	1.0	1.0	1.0
I felt that the controls in the module were easy to use.	3.5	5.0	5.0	5.0
I felt that the module was fun.	5.0	5.0	5.0	5.0
I felt that the module taught me something new.	4.5	3.5	4.5	5.0
I felt that the module helped improve my self-esteem or confidence in myself.	5.0	5.0	5.0	4.5
I felt that the module helped me prepare for similar scenarios that I could find in real life.	5.0	4.5	5.0	5.0
I would play this module again.	5.0	5.0	5.0	5.0

^aThe above statements are rated on a scale of 1 to 5, where 1 is strongly disagree and 5 is strongly agree.

4.2.2 Qualitative Data

Qualitative data was collected from preadolescent patients with CLP, the psychologist and a parent of one of the participants through qualitative feedback surveys and interviews. This section will provide further detail on the content of the qualitative feedback surveys and interviews, as well as the data collected from each of these instruments.

4.2.2.1 Patient Qualitative Feedback Surveys

A module qualitative feedback survey was given to preadolescent patient participants with CLP after each session with the psychologist to gauge whether the module was relatable and helpful. Questions on this survey asked patients about their general impression of the specific module they played that session and whether or not they felt they could relate to the scenario being presented. In addition to the module qualitative feedback survey, a qualitative feedback survey regarding participants' overall experience with the game was also used to gather feedback on their overall experience with using the game over the course of 4-weeks with the psychologist as part of their psychosocial support sessions. The survey questions focused on understanding the patient's perspective on the game's overall storyline, the relevancy of the game and each of its modules to the patient's psychosocial skill goals, and their experience using similar games or technology. Patient's responses were generally positive, with statements suggesting that the game was relatable and students were able to easily identify with the social scenarios presented to them in each of the game's modules.

Further analysis was done on the data collected from the overall game and module qualitative feedback surveys using thematic analysis conducted by 2 graduate and 4 undergraduate students. The following themes were identified relating to participants' experience using the game: skills learned, relatability, appeal and graphics. All participants believed that playing the game helped them learn new and useful psychosocial skills or promoted their understanding of known skills, particularly in the realm of communication. With respect to skills learned, participants believed that the game helped them with understanding how to respectfully and effectively communicate their emotions with others, with participants stating that they, *"learned to tell others [things] nicely"* and that they learned a lot about *"empathy, respect for others, [and] how to say things"* to their peers. Participants also described learning how to be more empathetic, with one suggesting that additional modules might teach themes including *"honesty or solidarity"*. Additionally, data collected from the psychologist qualitative feedback survey and interview suggests that she also noticed an increase in empathetic and reflective behavior from participants, which will be discussed later in this section.

Participants also related to the scenarios being presented in the game, stating that they can see themselves as the character experiencing the difficult social scenario or have experienced similar situations in their own lives. For one participant, they saw themselves identifying with The Mad Scientist in Module C, stating, *"I identified myself [in this module] a lot because I had been [in the same situation as] The Mad Scientist and I was also able to help her"*. Participants were also able to relate to scenarios they were presented with even if they have not experienced the situation themselves,

with one participant mentioning, "*some of the scenarios I have lived and others I can live*", suggesting that the game assists participants with understanding how they might approach this type of scenario if they were to encounter it in the future.

In terms of appeal, participants enjoyed the available interactions and different storylines presented in each module. They explicitly stated that they thought the modules were beneficial in helping them understand how to help others and how to share their opinions. However, participants also identified issues with the aesthetics of the game, making suggestions to create more realistic settings and characters and to improve upon glitches in the graphics during gameplay. This is consistent with statements made by other participants who also desired a more realistic aesthetic.

Overall, based on the feedback from the 6 preadolescent patients with CLP participating in the case study, it is suggested that they enjoyed the game and felt that it provided them with relevant practice in developing psychosocial skills. In the next section, the qualitative survey with the psychologist, and the interview with the psychologist and one of the participant's parents will be discussed to determine their perspective on the impact of the game on psychosocial development.

4.2.2.2 Psychologist and Parent Qualitative Data

The psychologist conducting psychosocial support sessions with preadolescent patients with CLP across the 4-week study period was asked to fill out a qualitative feedback survey after completing her last session with the VR game with the last patient. The questions on this survey focused on understanding the psychologist's experience

using the game as a part of her sessions in promoting psychosocial development for this population. In addition to this survey, a follow-up interview was conducted to allow for the psychologist to elaborate on her responses and clarify any of her statements.

Based on her experience using the game in addition to her typical psychosocial support sessions, the psychologist felt that the game was a *"really good tool to support therapy processes"*, where patients were able to receive practice with implementing psychosocial skills during sessions through role-playing them in the game. Patients were also able to ask questions and speak with the psychologists about their own experience with the situation being presented in the game, allowing for more detailed discussion about their psychosocial experiences. She suggested that the game encouraged *"a more open conversation"* between the patient and herself.

In particular, the psychologist stated that she really enjoyed Module C, as she believed that it impacted the empathy her patients demonstrated during sessions. She stated that her patients *"could really relate [to the module] and [that] their answers show ... a reflection of what they've been through"*. After each module, the psychologist said that the patients felt more ready to talk about whether or not they experienced similar social situations in their own lives or if someone they knew had gone through something similar, and were more willing to talk about how it made them feel. She also stated that they were more reflective after using the game each session, which allowed her to gain a better understanding of the experiences impacting each patient's psychosocial development in general.

Modifications that the psychologist suggested be made to the game to improve

impact on psychosocial development for preadolescent patients with CLP included the addition of a conclusion module to summarize all of the skills learned during the game, so that the patient would be able to better understand their progress after the 4-week period was over. Additionally, she felt that the use of avatars in the game would enable patients to be able to better *"identify with the person that is playing"*. However, the psychologist believed that each module effectively presented a psychosocial aspect to focus on per psychosocial support session and that the interactivity of the game kept her patients engaged the whole session. Her final remarks suggest that the game would be feasible in promoting psychosocial skill development for preadolescent patients with CLP, stating that the game is *"a great compliment to therapy . . . especially because kids are more into technology nowadays, sometimes it's easier for them to feel comfortable if that's the medium [they] use to do therapy . . . it's a great way to be closer to patients"*.

An interview was conducted with one of the parents of the preadolescent patients with CLP who participated in the evaluation of the VR game to better understand the impact of the game outside of sessions with the psychologist. This interview consisted of questions regarding how the parent perceived their child's social behavior after the 4-week study period, including whether they felt that their child had been impacted by the game in any way. From this interview, the parent shared that their child's experience with understanding their CLP has been difficult and complicated, stating that the support they have received from the psychologist has been beneficial in promoting their child's well-being.

In particular, the parent stated that their child had struggled with feeling

comfortable repeating themselves whenever they were speaking with someone, but felt that through these psychosocial support sessions with the VR game, their child was able to feel more comfortable repeating themselves whenever speaking to someone else. The parent also suggested that over the 4-week period of using the game, they noticed that their child has become more mature and can *"express herself very well"* and that she now *"knows how to defend herself"* and *"speaks with authority"*.

In this chapter, quantitative and qualitative data collected through the evaluation of the VR game over a 4-week period of being used as a supplement to psychosocial support sessions for preadolescents with CLP has been described. Data analysis suggests that while the quantitative data collected from the BASC, RSE and NBS did not reveal any significant effects, qualitative data from the preadolescent participants, psychologist and one of the participant's parents suggests that the game may be feasible in helping to promote psychosocial development for preadolescents with CLP. In the next chapter, discussion on what these findings may suggest in terms of the feasibility of VR games for psychosocial support, as well as directions for future research, will be outlined.

Chapter 5

Discussion

In the previous chapter, results from the case study involving the evaluation of the developed VR game for the psychosocial support of preadolescents with CLP were described. Quantitative and qualitative data collected from 6 preadolescent patients with CLP and their psychologist from a partnering Smile Train clinic in Colombia were analyzed and provided insight into the impact of the VR game on psychosocial development. In this chapter the implications of designing the game with psychologists, the case study and the results will be discussed, with an emphasis on addressing the following research questions presented at the beginning of this dissertation:

1. How does the inclusion of psychologists and individuals with CLP in the design of serious VR games for psychosocial support impact its efficacy and integration into existing practices?
2. Can a serious VR game be a feasible method of providing psychosocial support to preadolescents with CLP?

This chapter will also discuss future directions for VR games for the psychosocial support of preadolescents with CLP based on the findings presented in this dissertation, including the potential of this technology to promote access to necessary psychosocial support for this population.

5.1 Analyzing the Impact of Designing with Psychologists and Individuals with CLP

The game was designed in collaboration with psychologists from Smile Train's partnering clinics and hospitals in Colombia, Brazil and the Philippines. Design procedures included user and expert interviews, UCD methods for the design of VREs [57], journey mapping and storyboarding, as well as iterative prototyping. Through these procedures, 4 psychologists were able to contribute to the design of the game through providing insight on their experiences working with preadolescents with CLP on developing psychosocial skills.

User and expert interviews were conducted with psychologists from Smile Train partnering hospitals and clinics in Colombia, Brazil and the Philippines, to gather information regarding the existing structures of support for preadolescents with CLP in developing psychosocial skills. Through interviews with psychologists, it was understood that great importance was placed on encouraging patients to accept their condition, where they recognized that their patients often felt uncomfortable speaking about their condition with others and would sometimes have to deal with difficult social situ-

ations at school, including being bullied regarding their physical and speech differences. Additionally through these interviews, the psychological methods used to promote psychosocial development for preadolescents with CLP were also identified, including CBT and DBT.

Interviews with users involved interviewing 6 preadolescent and adolescent patients with CLP to further understand their experiences with psychosocial development and how they access support and resources for psychosocial development. In addition to these interviews, 2 parents of patients being interviewed were also interviewed to gain clarity on their child's responses and to gather further information on their experiences. Thematic analysis on the data collected from these interviews revealed that the psychosocial challenges patients were facing included discomfort in unfamiliar or new social environments, aversion to interactions with new and unfamiliar peers, and difficulty accepting one's differences.

After identifying these themes, they were then evaluated by psychologists who were then invited to participate in the game design process using journey mapping, collaborative storyboarding, and UCD methods outlined by Gabbard, Hix and Swan [57], which include a user task analysis, expert guidelines-based evaluation and formative user-centered evaluation. During these collaborative design processes, the psychologists and I were able to incorporate the themes identified in the thematic analysis from the interview data along with their experiences working with preadolescent patients with CLP into the design of the game's module and overarching theme. Additionally, psychologists were also able to contribute to designing the format of the game to better

fit the structure of their psychosocial support sessions with patients.

While the data analysis on the quantitative data collected from the case study found no significant effect on psychosocial behaviors and skills measured by the BASC-3, NBS and RSE, the qualitative data collected from this study suggests that the inclusion of psychologists and patient data in the design process of the VR game may be beneficial to its impact on psychosocial development. Based on thematic analysis of the qualitative feedback survey data from patients regarding the game's individual modules and the overall use of the game across 4 weeks, it is suggested that elements of the game designed with psychologists and based on patient interview data may positively impact their experience in using it.

In particular, it is noted that participants were able to relate to scenarios presented in each of the game modules, identifying with the characters and their experiences with difficult psychosocial situations, even if they personally had not experienced that situation themselves. Participants were able to understand that although the situations presented in the game may not be something that they have experienced or seen their friends or family go through, they understood that the situation could happen to them in the future. This effect may have been due to the integration of themes identified through thematic analysis of interviews conducted with preadolescents and adolescents with CLP regarding their experiences with psychosocial development, along with the involvement of psychologists in the design of the storyline for each of the modules and the overall game. Through the data collected from the interviews, it was understood that there were common themes among the experiences of preadolescents with CLP in

developing psychosocial skills, which were integrated into the game. Psychologists were also able to incorporate their experience working with preadolescent patients with CLP into the design of the game's storyline and modules, which may have also contributed to this effect. Cyberbullying was not a theme recognized in the interview data collected from preadolescents and adolescents with CLP, but psychologists did note that this was important to address in the game due to the recent increase of this situation during the pandemic. This module in particular was notable for patients and the psychologist conducting the evaluation of the VR game. Patients felt that they were able to identify with The Mad Scientist, where her experiences reflected similar experiences that the patients had gone through or had seen others go through. The psychologist also felt that this module in particular allowed patients to be more empathetic and open about similar experiences in their own lives, allowing for more information to be shared with her regarding her patient's psychosocial needs and the challenges they are currently facing.

The ability for preadolescent patients with CLP to relate to and empathize with the characters and scenarios presented in each module may positively impact their psychosocial development. In a study conducted by Paiva et al. [61], researchers evaluated the ability and impact of virtual characters to evoke empathy for children and adults. These researchers state that when individuals are able to relate to characters they often have more empathetic compassion towards them and thus will be able to better understand how they may feel in a similar situation as the character [61]. With this in mind, preadolescent patients with CLP may more easily be able to generalize

skills learned from the VR game to similar instances they may face in real life, as the qualitative data collected suggests that they are able to identify with, relate to and empathize with the characters and situations occurring in each of the game's modules. Empathizing with virtual characters and situations may also encourage the development of other psychosocial skills for this population, where a review conducted by Walker and Venker Weidenbenner [62] on the impact of virtual play on social and emotional learning found that virtual play technologies can promote the development of empathy and in turn the development of other psychosocial skills, including emotional regulation and prosocial behavior.

The design of the game in collaboration with psychologists and data collected from patients may have also contributed to the positive feedback received from the psychologist who conducted the evaluation with her patients. From the qualitative feedback survey and interview conducted with this psychologist, it was understood that she had an overall positive experience using the game in addition to her psychosocial support sessions with preadolescent patients with CLP over the 4-week period. The psychologist stated that the game encouraged patients to be more open to sharing their experiences with psychosocial challenges they were facing and allowed patients to be more reflective about their feelings during these experiences. This information was useful for the psychologist, who said that the additional details from patients allowed her to gain a better understanding of their experiences impacting psychosocial development and how they are currently approaching difficult social situations. She also stated that the game served as a method to help ease patients into psychosocial support sessions. She noticed

that her patients have become increasingly interested in technology and using the game allowed them to become more comfortable and open to receiving psychosocial support from her, encouraging patients to be more open and willing to share their experiences.

Research suggests that the inclusion of stakeholders, such as psychologists or patients, in the development of VR applications for psychological support may be beneficial to psychological development. In a literature review by Parsons [24] analyzing the impact of VR interventions for social and behavioral support of people with autism spectrum disorders (ASD), it was suggested that the inclusion of psychologists, behavioral specialists, teachers and individuals with ASD would promote the development of social skills and behaviors, as designing with stakeholders would improve the ease of integration and use of the VR intervention into existing structures of support. Additionally, this would increase the use of the VR intervention, as stakeholders would be more likely to use the system if they understood how to use it as a part of their existing practices. Similarly, a study conducted on the use of participatory design methods on exposure therapy for adolescents with performance-type anxiety disorder (PTAD) found that the inclusion of adolescents with PTAD in the design of the VR scenarios for exposure promoted the ability for adolescents to relate to them and better met their specific needs, reflecting their lived experiences [63].

Based on the findings of the case study conducted with preadolescent patients with CLP and their psychologists, the inclusion of psychologists and data from interviews with preadolescents and adolescents with CLP in the design of the VR game is suggested to be beneficial to the development of psychosocial skills for this population.

Similar to the findings presented in the work by Parsons [24] and Flobak et al. [63], the inclusion of these individuals in the design of the VR game has helped patients relate to the characters and scenarios being presented in the game, to the extent that they are able to empathize with characters even if they have not experienced the situation presented themselves. Data collected from the psychologist on her experience using the game suggests that co-designing the game with the 4 psychologists from Smile Train's network of partnering hospitals and clinics has enabled the game to be easily integrated into the existing practice of the psychologist and helps patients be more open with the psychologist during sessions, allowing the psychologist to gather more data from the patient and gain a better understanding of their psychosocial skill needs.

In this section, a discussion regarding the impact of designing the VR game with psychologists and data from preadolescents and adolescents with CLP was provided, analyzing the outcomes of the evaluation of the game in relation to the design work conducted with psychologists from Smile Train's network of partnering hospitals and clinics. In the next section, the impact of providing psychosocial support through VR games will be discussed, followed by a section exploring future work in relation to VR games for the psychosocial support of individuals with CLP and those with similar needs.

5.2 Analyzing the Impact of Providing Psychosocial Support Through VR Games

The game was evaluated through a case study as a supplement to psychosocial support sessions with a psychologist for preadolescents with CLP. Through this study, 6 preadolescent patients with CLP used the game as a part of their psychosocial support sessions with their psychologist over the course of 4 weeks. A pre-test/post-test design was implemented utilizing measures for psychosocial skills and behaviors, including the BASC-3, RSE and NBS, along with qualitative feedback surveys to collect data on the patients' and psychologist's experience using the game over this 4 week period.

From this evaluation of the game, quantitatively there were no significant effects presented by the results of the BASC-3, RSE and NBS from the pre-test to the post-test, but the data does demonstrate decreases in average scores for atypicality, anxiety, feeling inadequate and social stress from the pre-test to post-test BASC. It was also noted that the mean difference for the NBS was negative, implying that on average participants demonstrated lower levels of needing to belong or worrying about belonging after using the VR game as a part of their psychosocial support sessions over the course of 4 weeks. While the quantitative data analysis suggests that these results are not significant, decreases in average scores for the BASC-3 and the negative mean difference for the NBS results imply that it may be beneficial to further explore the impact of the game on psychosocial behaviors and skills through these measures to determine whether a greater and potentially significant effect may be observed. In particular, this

case study evaluated the use of the game over the course of 4 weeks with 6 participants and although insignificant, this data may suggest that with a larger sample size or over the course of a longer study period, more prominent effects may be examined.

Qualitative data from the patient feedback surveys and psychologist feedback survey and interview provided insight to the impact of the game's content and structure on the psychosocial development of preadolescents with CLP and their experience using the game during psychosocial support sessions. Additionally, one parent of one of the participants was interviewed to gain an understanding of if they noticed any changes to their child's behavior or psychosocial skills over the course of using the game in addition to sessions with the psychologist. The data collected suggests that while the game did not impact psychosocial skills in a way that significantly impacted the psychosocial behaviors and skills measured by the BASC-3, NBS and RSE, qualitative data collected through surveys and interviews with patients, psychologist and a parent suggests that the use of the game had some impact on patients' psychosocial behaviors and skills.

In particular, the patients found that the game helped them with learning empathy, respect for others and how to communicate appropriately with their peers, stating that they were able to identify with the experiences that characters in the game were going through and felt that because of this they were better able to help the character. The psychologist also felt that the patients were more empathetic and reflective during psychosocial support sessions after using the VR game, where they would have open discussions about their thoughts and feelings regarding similar experiences that they have had. The psychologist felt that this openness was beneficial to her psychosocial

support sessions, as it allowed her to gain a better understanding of the specific psychosocial challenges her patients were facing, giving her the ability to more accurately identify their needs. She also mentioned that the game kept patients engaged during the entire psychosocial support session and might allow them to become more comfortable sharing their experiences with her during sessions. The parent interviewed noticed that after the 4-week period of using the game in addition to psychosocial support sessions their child was more comfortable in situations where they needed to repeat themselves if someone could not understand them due to symptoms of their CLP. The parent also noted that their child seemed to become more mature and spoke with "authority" after using the game with the psychologist.

Based on this data, it is suggested that the VR game may have had a positive impact on psychosocial development for preadolescent patients with CLP and the ability of the psychologist to provide psychosocial support sessions to this population. The impact of the game on empathetic and reflective behavior on preadolescent patients with CLP is similar to that of the findings in Hu, Lee, Chang, Lin and Huang's [53] study involving the use of VR with adolescents to help improve prosocial behaviors. In their study, a VR environment was used to help adolescents practice psychosocial skills and helped increase positive self-understanding and self-knowledge. Additionally, research has also suggested that the use of VR applications in psychosocial development promotes the generalization of skills learned in the VR environment to the appropriate real-life contexts [20]. Data from the parent interview suggests that one of the patients may have been able to generalize skills learned from Module A: Social Soccer to real-

life, as this module focused on practicing responding to requests to repeat themselves to others and the parent stated that the patient felt more comfortable doing so after psychosocial support sessions with the game.

While the case study suggests that there may be some impact on psychosocial skill development for preadolescents with CLP in relation to the use of the VR game in addition to psychosocial support sessions with a psychologist, more research should be conducted to further explore the factors of VR games that may promote psychosocial development for this population and those with similar needs. In the next section, directions for future work regarding the design, development and evaluation of a VR game for the psychosocial support of preadolescents with CLP and populations with similar needs will be discussed.

5.3 Directions for Future Work

The results from this case study involving the design, development and evaluation of a VR game for the psychosocial support of preadolescents with CLP suggest that it may be beneficial for the psychosocial development of this population when used in conjunction with psychosocial support sessions with a psychologist. However, it is noted that there were several limitations of this study, including the sample size of preadolescent patients with CLP and the length of time that the evaluation with the VR game was conducted over. With a greater sample of preadolescent patients with CLP using the game over a longer period of time, significant results from measures such

as the BASC-3, RSE and NBS may have been found. Additionally, the use of other measures of psychosocial skills and behaviors may be useful to consider or include in future studies aiming to determine the impact of a VR game on psychosocial development, particularly those focused on the skills taught in the game's modules. While the pre-test/post-test study design is feasible in understanding and measuring broader psychosocial skills for patients, future studies may also want to consider different study designs, including multiple baseline and alternating treatments studies, to determine the impact of a VR game on a specific psychosocial skill, such as developing self-esteem or addressing social anxiety. Future research should also include measures of generalization of psychosocial skills learned from the VR game to the appropriate real-life contexts to further determine the impact of the game on psychosocial development.

Future work may also aim to determine factors of VR that may contribute to the efficacy of psychosocial support for preadolescents with CLP. From this case study, it was understood that the psychologist believed that preadolescent patients with CLP would be enticed by this new and innovative technology, as participants were actively engaged with the VR headset and game throughout each session using it. Researchers may want to evaluate the factors of VR that encourage and engage preadolescent patients with CLP so that those aiming to design and develop VR tools for psychosocial support may better understand and utilize such features. Additionally, future research should evaluate the impact of these technologies in different psychosocial support formats, including the use of a VR game as homework or in-place of psychosocial support with a psychologist, to better understand where this technology may best serve

preadolescents with CLP.

It is important to note that this study was conducted in collaboration with global cleft organization, Smile Train, who provided funding and support to partnering hospitals and clinics to allow for psychologists and patients to participate in the design, development and evaluation of the VR game. Future research should continue to work with these types of organizations providing psychosocial support to individuals with CLP or disabilities and special needs in general to best understand how this type of technology may be designed and distributed within existing support structures. Smile Train was also responsible for purchasing and distributing VR headsets to partnering hospitals and clinics, suggesting that further exploration into the accessibility of these technologies in various countries may be warranted to determine whether this would be feasible for individual clinics and hospitals providing psychosocial support to individuals with CLP. It is important for future researchers to take a holistic approach to examining the accessibility and usability of VR in clinical settings in regions where access to psychosocial support is needed. While VR may provide a method of accessing or improving existing psychosocial support from a psychologist, it is important to consider the factors that enable this type of technology to function properly, including stable and unlimited internet.

Studies aimed at evaluating the use of VR technologies in providing psychosocial support to individuals with CLP is limited, with very little research conducted on the design, development and evaluation of these types of technologies for this population. Research on similar VR technologies for individuals with psychosocial disabilities has

been extensively conducted, demonstrating promising results in improving psychosocial skills and addressing symptoms of social anxiety and avoidance [20, 21]. Based on existing research supporting the use of VR technologies for psychosocial support, further research should aim to determine what the impact of VR technologies for psychosocial support for individuals with CLP are, with a focus on preadolescent populations. Preadolescence is a crucial time for psychosocial development and it is acknowledged that preadolescents with CLP in particular are at heightened risk for difficulty with psychosocial adjustment, often facing bullying, peer rejection and teasing [5, 12, 13]. Future work should aim to continue designing, developing and evaluating VR games and technologies for the psychosocial support of preadolescents with CLP to promote access to and the efficacy of existing resources for support.

In this chapter, discussion on the findings of a case study conducted to evaluate the impact of a VR game designed and developed with psychologists for the psychosocial support of preadolescents with CLP was presented. Through these findings, it was understood that while there were no significant effects from the quantitative data collected through the study conducted with 6 preadolescent patients with CLP and their psychologist, the qualitative data collected suggests that the game may have promoted psychosocial development and helped to improve the psychologist's ability to provide psychosocial support to this population. In the next chapter, concluding remarks regarding the case study, the study's findings, and its impact and suggestions for future work will be described.

Chapter 6

Conclusion

In this dissertation, a case study involving the design, development and evaluation of a VR game for the psychosocial support of preadolescents with CLP is presented. The VR game was designed with 4 psychologists from Smile Train's global network of partnering hospitals and clinics using user-centered design methods, including interviews, collaborative storyboarding, journey mapping and task analysis. Data collected from interviews with preadolescents and adolescents with CLP on their experiences with developing psychosocial skills were also analyzed using thematic analysis and the resulting themes were evaluated by these psychologists and incorporated into the design of the game's storyline and content. The game was developed for the Meta Quest 2 using the Unity game engine and the Photon PUN 2 multiplayer networking package, which allowed for multiplayer capabilities to be incorporated into the game. The format of the game was developed with psychologists to ensure that the structure and content would align with the existing structure of their psychosocial support sessions with preadoles-

cent patients with CLP. Psychologist-specific UI was designed and implemented in the game to ensure that psychologists would be able to control the progression of psychosocial support sessions using the game, with the ability to pause the game and progress it according to the needs and responses of the patient.

The game was evaluated as a part of psychosocial support sessions over the course of 4-weeks with a psychologist from a Smile Train partnering clinic in Colombia with 6 preadolescent patients with CLP. Through a pre-test/post-test study, the BASC-3, RSE and NBS were used to measure changes in psychosocial skills and behaviors from before and after using the VR game as a part of psychosocial support sessions with a psychologist over the 4-week period. In addition to these measures, qualitative feedback surveys on the game modules and the game overall were given to patients to understand their experience with using the game and each of its modules with their psychologist. A qualitative feedback survey and follow-up interview was also conducted with the psychologist conducting the evaluation to gain an understanding of the impact of the game on her sessions with patients.

Data collected from the study suggests that the VR game may be beneficial to the psychosocial development of preadolescents with CLP and may also positively impact the efficacy of psychosocial support from a psychologist. Qualitative feedback from patients suggests that they were able to improve psychosocial skills, especially in terms of empathy and communication, especially with respect to sharing their emotions with others. Data collected from the qualitative feedback survey and follow-up interview with the psychologist conducting the evaluation of the VR game suggests that

the game helped encourage patients to be more open about sharing details regarding psychosocial difficulties that they have experienced in relation to the scenarios being presented in the game. The data also suggests that the incorporation of VR technologies in her psychosocial support sessions was helpful in keeping patients engaged in lessons and potentially could improve their level of comfort during sessions. These results also suggest that the game may be able to help with the generalization of psychosocial skills learned from the VR game to the appropriate real-life contexts, where an interview conducted with a parent of a participating preadolescent patient revealed that the patient felt more comfortable repeating themselves after playing the game.

Although quantitative data suggests that the game had no significant impact on psychosocial development for preadolescent patients with CLP using the game in addition to their psychosocial support sessions with a psychologist over the course of 4 weeks, it is suggested through the qualitative data that the game could have had some effect on their development of self-reflection, empathy and generalizing psychosocial skills learned from the game to real-life. To further explore the impact of a VR game designed with psychologists and data from preadolescents and adolescents with CLP, future research should aim to evaluate the impact of developing these games with psychologists and patients with CLP. Future work should also aim to conduct studies evaluating the impact of these games on the development of psychosocial skills for this population through the use of measures gauging the development of specific psychosocial skills according to patients' needs. Future research may also seek to evaluate the use of multiple baseline or alternating treatment studies with a VR game for the psy-

chosocial support of preadolescents with CLP to further examine its impact on specific psychosocial skills, such as self-esteem or prosocial behavior.

My specific contributions as a result of this dissertation work include the collaborative design of VR game for psychosocial support of preadolescents with CLP with psychologists, the development of a multiplayer VR game for psychosocial support, and the evaluation of the impact of this game on the psychosocial development of preadolescents with CLP in addition to psychosocial support sessions with a psychologist. My contributions also include two publications: a full paper on the design of the developed VR game with psychologists from Smile Train's partnering hospitals and clinics at the IEEE International Conference of Digital Health (ICDH '23) and a full paper on the case study involving the evaluation of the VR game with preadolescent patients with CLP in Colombia at the International ACM SIGACCESS Conference on Computers and Accessibility (ASSETS '23) (pending).

This dissertation has unveiled some support for the use of VR games to promote psychosocial development for preadolescents with CLP as a supplement to psychosocial support sessions with a psychologist. While there were some limitations to the case study, including a small sample size and short evaluation period, that may have impacted the quantitative results, the qualitative data collected from this study suggests that there are benefits to VR games for psychosocial support. In particular, designing and developing VR games for psychosocial support in collaboration with organizations, psychologists and patients has been suggested to help promote positive psychosocial outcomes in both existing literature examining the impact of co-designed

VR applications for psychosocial support and from the results of this study. I hope that my dissertation work encourages researchers to explore the design and development of VR games for psychosocial support for individuals with CLP and those with similar psychosocial needs, improving upon the accessibility and efficacy of such resources for those who need them.

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