Senior Project 2: CS4175

Implementing a VR-based Parent-child Interactive Training Program to Encourage Positive Parenting Skills

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Abstract

Behavioural issues often contribute to the decision to place children in mental health facilities worldwide. Disruptive behaviour disorders (DBD) in children are characterized by aggression, rebellion, and obstinacy, with the potential for long-term negative consequences if left unaddressed. Research has demonstrated the efficacy of interventions involving parents as primary agents of change in mitigating disruptive behaviour. This senior project proposal aims to implement a parent-child interactive program based on virtual reality (VR) technology and evaluate its effectiveness in promoting positive parenting skills. The proposed methodology involves the creation of a VR environment featuring an interactive avatar child powered by machine learning to simulate realistic parent-child interactions. In addition, a child development expert will provide parents with guidance and training through various mediums to equip them with the skills necessary for fostering positive interactions with their children.

This research project holds significant potential for societal impact and aligns with Vision 2030's goals of fostering a Vibrant Society with Strong Roots, improving health and well-being (SDG#3), enhancing quality education (SDG#4), and encouraging strong institutions (SDG#16). Furthermore, it can revolutionize parent training by introducing VR technology as an innovative tool. Expected results include improvements in children's social behaviour and a reduction in negative long-term consequences, such as school dropouts and criminal behaviour. By addressing disruptive behaviour disorders in children and providing a valuable preventive tool, this project aims to revolutionize parent training techniques for fostering positive parent-child interactions.

Keywords: Virtual reality, VR-based Training, Machine learning, Positive Parenting, Child Development

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Chapter 1

Introduction

1.1 Overview and Background

Behaviour problems are a frequent factor in sending children to mental health facilities around the world. In the US, 7-9% of children are diagnosed with a behavioural issue, and such difficulties and disorders are becoming more prevalent in Western culture [7]. Children with disruptive behaviour disorders (DBD) are often described as being (physically) aggressive, rebellious, and stubborn. If left untreated, disruptive behaviour can lead to long-term negative consequences, such as school dropouts, peer rejection, the emergence of antisocial personality disorders, increased public expenditures on health care and education, and non-violent and violent delinquency and criminality in adulthood [8].

In recent years, there has been an increasing interest in the potential of virtual reality (VR) technology to support training and education in a variety of domains [9]. Implementing a VR-based Parent-child interactive training program to encourage positive parenting skills has the potential to revolutionize how parents are trained to interact with their children. VR provides an immersive and realistic experience that can simulate real-world scenarios, making it an ideal tool for teaching parents the necessary skills to respond effectively to their children's behaviour [10].

Figure 1.1 shows that the global virtual reality market size was valued at USD 28.41 billion in 2022 and is expected to grow at a compound annual growth rate (CAGR) of 13.8% from 2023 to 2030.[1]

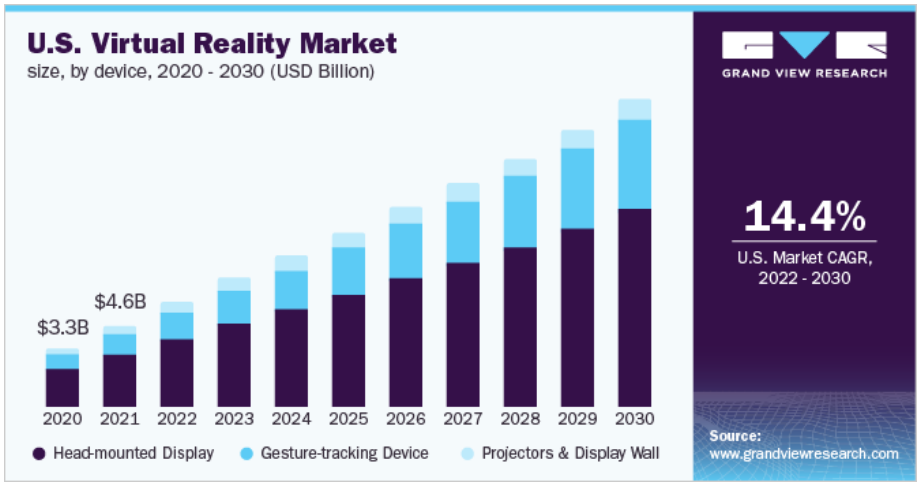


Figure 1.1: Virtual Reality Market Size, Share & Growth [2023 Report][1]

The family is the basic unit of society, and the quality of parent-child interactions has a significant impact on children's development and well-being [11]. Evidence-based parent-child interventions such as Parent-Child Interaction Therapy (PCIT) [11, 12], Parent Management Training (PMT) [13], Filial Therapy [14], Child-Parent Psychotherapy (CPP) [15], and Theraplay [16] are effective in improving parent-child interactions and child mental health outcomes. However, despite their effectiveness, challenges remain in terms of the accessibility and scalability of these interventions. The use of virtual reality (VR) technology has the potential to address some of these challenges by providing a safe and cost-effective means of delivering these therapies in a controlled and immersive environment.

Interventions with parents are successful in lowering children's disruptive conduct. However, few families participate in parenting programs, indicating a need for improved access to evidence-based parenting interventions [11]. Online parenting education could greatly expand the impact of such treatments, but there are concerns that families who benefit the most from online strategies may need help accessing web-based material. Virtual Reality (VR) based parent-child interactive training [11] may solve this problem.

In Figure 1.2, regarding early adulthood problem outcomes [2], those with very

supportive parent-child ties were much less likely than those with less supportive relationships to have recently experienced depression or anxiety (12% vs 30% vs 25%, respectively). Supportive parent-child relationships were not associated with long-term health issues, illicit drug use, binge drinking, or adolescent antisocial behaviour.

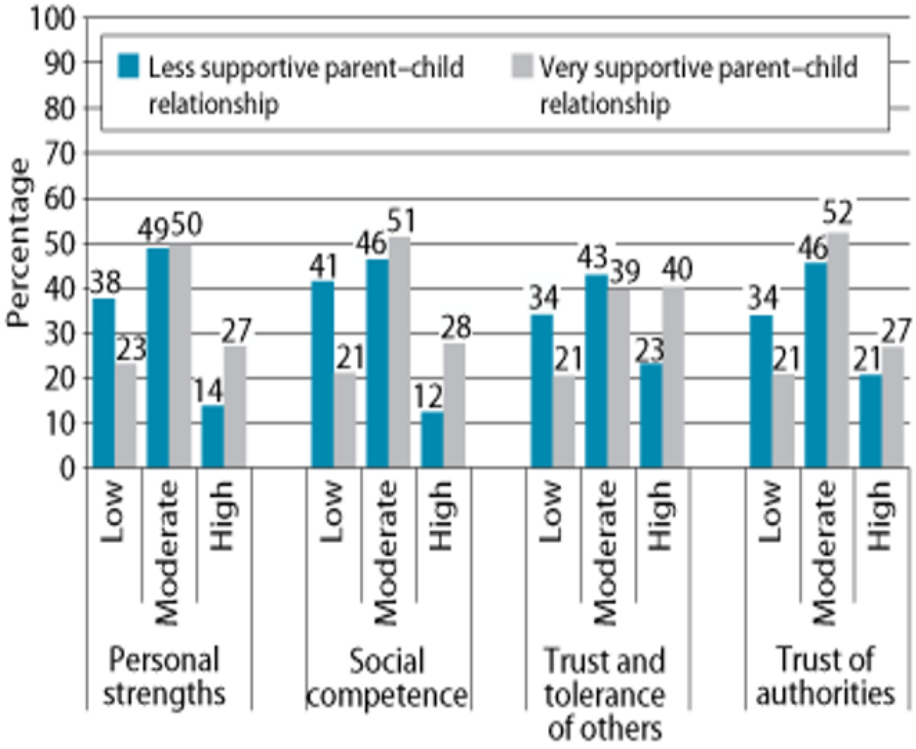


Figure 1.2: Groups of 23–24-year-olds parent–child relationships based on their level of growth.[2]

Research suggests that the most effective child disruptive behaviour interventions involve parents as the primary change agents [11]. Parent-Child Interaction Therapy (PCIT) [12, 2] is a therapy that focuses on improving parenting skills and has been shown to significantly improve parenting warmth, responsiveness, and efficacy over time. Parenting programs that allow parents to practice new skills with their children are more successful interventions than those that do not [2]. VR can provide a helpful aid in treatment by manipulating and controlling surroundings, showing stimuli in three dimensions, and providing immersion. It has already been used to treat eating disorders [17], substance abuse disorders [18], schizophrenia [19], PTSD [20], and anxiety disorders [21]. Therefore, incorporating VR in parenting interventions may

help bridge the gap between developing parenting skills in treatment and applying them in a home setting.

1.2 Problem Statement

Research suggests that the most effective child disruptive behaviour interventions involve parents as the primary change agents [11]. Parent-Child Interaction Therapy (PCIT) [12, 2] is a therapy that focuses on improving parenting skills and has been shown to significantly improve parenting warmth, responsiveness, and efficacy over time. Parenting programs that allow parents to practice new skills with their children are more successful interventions than those that do not [2]. VR can provide a helpful aid in treatment by manipulating and controlling surroundings, showing stimuli in three dimensions, and providing immersion. It has already been used to treat eating disorders [17], substance abuse disorders [18], schizophrenia [19], PTSD [20], and anxiety disorders [21]. Therefore, incorporating VR in parenting interventions may help bridge the gap between developing parenting skills in treatment and applying them in a home setting.

1.2.1 Research Question

Can implementing a VR-based parent-child interactive training program encourage positive parenting skills effectively and to what extent?

1.2.2 Research Aim

The aim of this research is to investigate the potential of utilizing virtual reality (VR) technology in parent-child interactive training programs for children with disruptive behaviour disorders. The primary focus is on implementing VR technology as an effective intervention to encourage positive parenting skills and address the challenges associated with disruptive behaviour disorders.

1.2.3 Research Objectives

The objective of the proposal can be summarized as follows:

- Gaps in the current literature on parent-child interventions and disruptive behaviour disorders.
- Investigate the limited accessibility and scalability of evidence-based interventions.
- Evaluate the effectiveness of VR-based training programs in improving parenting skills and addressing disruptive behaviour disorders in children.
- Implement a parent-child interactive VR-based training program
- Test the program on a selected group of parents
- Give outlined measurements of the program's effectiveness in encouraging positive parenting skills

1.3 Significance of the Study

This research project has the potential to revolutionize parent training and make a significant impact on society. Aligned with Vision 2030's objectives, it aims to foster a Vibrant Society with Strong Roots by incorporating virtual reality (VR) technology as a novel tool for parent training. It also contributes to sustainable development goals such as health and well-being (SDG#3), quality education (SDG#4), and the development of strong institutions (SDG#16) [3, 4]. By offering an immersive and realistic experience, VR provides a unique platform for parents to practice and refine their parenting skills, leading to improved interactions with their children. The application of VR technology in addressing disruptive behaviour disorders in children is particularly significant, as it allows for early intervention and prevention of long-term negative outcomes, such as school dropouts and antisocial behaviours. By equipping parents with the necessary skills and resources, this project aims to enhance children's social behaviour, promote prosocial behaviours, and create a positive impact on their overall well-being.

This project holds immense potential in terms of enhancing children's social behaviour and driving long-term benefits. By implementing effective interventions focused on positive parenting, the project aims to contribute to higher productivity and reduced healthcare and educational expenditures. This, in turn, leads to significant economic advantages. Addressing disruptive behaviour disorders in children is not only crucial for the affected individuals but also for preventing negative consequences that can impact society as a whole. Recognizing the pivotal role of parents as agents of change, this project strives to provide them with a valuable tool to prevent and mitigate these adverse outcomes. By doing so, it aims to create a brighter and more prosperous future for children, fostering healthier and more productive lives.

Figure 1.3: Sustainable Development goals and Vision2030(KSA)[3, 4]

1.4 Limitations and Constraints of the Study

The proposed project acknowledges several limitations and constraints that may impact its findings and implementation. One limitation is the potential lack of generalizability due to contextual factors and cultural variations that may influence the outcomes. The study also faces constraints related to the accessibility and scalability of virtual reality (VR) technology, including the cost, specialized equipment requirements, and potential challenges in user adoption. Ethical considerations, such as ensuring data privacy and managing potential risks, need to be carefully addressed. Additionally, constraints regarding the duration of the study and available resources may impact the sample size and the length of the intervention program. Despite these limitations, recognizing and addressing these constraints will enhance the transparency, validity, and future applicability of VR-based parent-child interactive training programs.

1.5 Outline

The remaining sections of this proposal are structured as follows. Chapter 2 includes a literature review that highlights previous studies related to the prediction of childhood obesity using machine learning. Chapter 3 outlines the research methodology, including details on the approach, data collection, and design. In Chapter 4, the expected results of the study are presented and compared with the findings of the literature review. The final chapter, Chapter 5, provides the main conclusions of this study, along with recommendations for future work in the area of study.

Chapter 2

Literature Review

2.1 Introduction

Virtual reality (VR) technology has experienced a surge in popularity due to its increased accessibility and affordability. Ongoing developments in VR technology have resulted in the creation of more user-friendly and cost-effective interactive VR applications [9, 10]. The research community has responded positively to these advancements, with the IEEE Virtual Reality Conference receiving a record number of submissions in 2020, indicating the increased interest in VR technology [10]. This trend has contributed to the success of VR training across various industries. Notably, a recent poll [9, 10] revealed that VR training is the most widely used VR application in businesses, with a usage rate of 62%. VR training has proven to be a cost-effective solution that expands training opportunities while reducing training costs in certain fields [10]. This is due, in part, to the fact that most 3D images used in VR training scenarios are computer-generated, allowing for the quick creation of various training scenarios using pre-existing 3D assets [9]. While VR training does not guarantee reduced costs, the benefits it offers to the training audience may justify the investment expenses. The impact of parents and primary caregivers on children's development has been the subject of several research studies. Parents and caregivers play a crucial role in shaping children's daily experiences, which has a significant influence on their cognitive, academic, and socioemotional development. In the 21st century, it is essential to understand the nature of modern parenting to comprehend children's lives. Although parenting has always been demanding and challenging, changes in

family life over time have introduced new difficulties for parents. This has led to the question of whether child-rearing practices should also evolve. Consequently, many parents are unsure of how to navigate the parenting landscape successfully [7].

2.2 Search Strategy

In this study, a systematic search was conducted using various scientific databases, including Scopus, Lens.org, Effat Library, PubMed, PsycINFO, and Google Scholar. The search terms used included "disruptive behavior disorders," "VR-based parent-child interactive training program," "traditional parenting programs," "virtual reality," "parent-child interaction," "positive parenting," "training program," "longitudinal analysis," and related terms. Only peer-reviewed articles written in English and published between 2010 and 2023 were included, Figure 2.1 shows the filtered publications used for the study based on Lens.org. Studies that focused on the effectiveness of virtual reality-based parent-child interactive training programs designed to promote positive parenting practices were included, while studies that did not focus on virtual reality, parent-child interaction, positive parenting, training programs, or longitudinal analysis, studies that were not peer-reviewed, and studies published before 2010 were excluded.

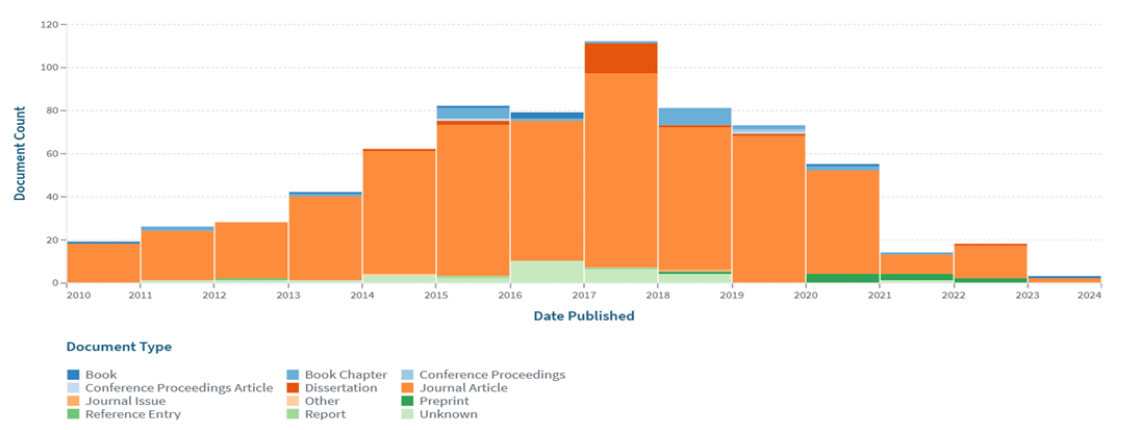


Figure 2.1: Numbers of publications from 2010 to 2023 on selected relevant topics [5].

2.3 Synthesis of Existing Literature and Evaluation of Solution

Disruptive behavior in young children is a common reason for mental health referrals worldwide. Research suggests that involving parents as the primary agents of change is the most effective approach to treating this behavior [22]. In the Netherlands, Parent-Child Interaction Therapy (PCIT) is a successful parent-management training program used in therapeutic settings [23]. Ongoing research is being conducted to increase the efficacy of PCIT, including using virtual reality (VR) as an additional homework component to provide parents with more opportunities to practice effective parenting techniques outside the therapeutic setting. PCIT has been shown to have a significant long-term positive impact on parental warmth, responsiveness, and the parent-child relationship [23, 24]. The use of VR allows parents to practice the techniques they have learned in the comfort of their homes [11]. However, the longitudinal analysis of the study [11] is expected to be available later in 2023, and it is anticipated that the implementation of the VR-based training program will lead to improvements in children's social behavior and a reduction in negative long-term consequences. This paper [8] claims that modest praise can inspire exploration. Thus, they carried out a unique virtual reality experiment. Children (N = 202, aged 8 to 12) completed a virtual reality 3D trajectory-matching activity while expressing their self-worth and received feedback on their performance after each trial. Parents either gave their kids genuine praise ("You did well!"), exaggerated praise ("You performed amazingly well!"), or no praise at all. Researchers gauged a child's motor exploration as their willingness to change course after failing [8]. When compared to receiving no praise, modest praise—as opposed to inflated praise—encouraged exploration in kids with lower self-esteem [8, 25]. In contrast, youngsters with greater levels of self-esteem were discouraged from exploring by mild praise [8, 25]. The effects were modest but substantial, and the study [8] reveals that little praise can encourage curiosity in children with poor self-esteem. Following PCIT therapies, research has shown statistically and clinically substantial reductions in children's disruptive behaviors and non-compliance [23]. Oppositional child behaviors, parent reports of activity level,

parental stress, internalizing difficulties, and children's self-esteem have all improved [12, 26]. Additionally, PCIT has been shown to enhance language development in toddlers who have developmental delays [12]. Additionally demonstrated to generalize to childcare, preschool, and elementary classroom settings are these beneficial results. The instructor reported assessments of disruptive and noncompliant behaviors in the classroom, such as talking back to the instructor, teasing, hitting, whining, yelling, and breaking rules, have demonstrated clinically significant changes [26]. Based on these findings [12, 23, 26], it is important to consider the potential costs and benefits of VR-based training programs. While implementing VR technologies into training may be costly, the benefits to the training audience may make the investment expenses justifiable, even though VR training does not guarantee a cheaper cost [10]. Moreover, VR-based training programs may be particularly effective in contexts where parents are the main change agents in the treatment of disruptive behavior in children, such as in PCIT [11]. By including VR as an additional homework component, parents can practice effective parenting techniques in the comfort of their own homes. Finally, the study by Brummelman et al. [2] highlights the importance of providing modest praise to children to encourage exploration and curiosity. Thus, combining the findings from Brummelman et al. [2] and Gunderson et al. [25] along with the potential benefits of VR-based training programs [9, 11], it is evident that virtual reality technology can be used to enhance the effectiveness of parenting techniques and encourage exploration in children, particularly those with poor self-esteem. Despite the effectiveness of all evidence-based interventions that aim to improve parent-child interactions and child mental health outcomes, challenges remain in terms of the accessibility and scalability of these interventions. The use of virtual reality (VR) has the potential to address some of these challenges by providing a safe and cost-effective means of delivering these therapies in a controlled and immersive environment [10, 11]. VR could allow for guided practice of positive parenting skills, virtual play sessions, and exposure to feared or traumatic situations in a controlled and gradual manner [10]. Research on the use of VR in these therapies is still in its early stages, but initial studies show promising results in terms of feasibility and acceptability. The integration of VR technology has the potential to enhance the effectiveness and accessibility of

evidence-based parent-child interventions, and further research is needed to fully understand its potential impact [10, 11].

Parent management training (PMT) is the gold standard for treating child behavior issues. Despite evidence that parents of children with behavior problems usually struggle personally, the secondary impacts of these therapies, particularly on parent well-being, are rarely researched. In 48 controlled treatment studies, this narrative review assessed the affective and parenting cognition effects of PMT for mothers and fathers of children aged 2 to 13 years. After PMT, there was strong evidence to support decreases in parenting stress and gains in perceived parenting competence. Evidence showed that areas farther removed from parenting, such as parent depressive symptoms and marital relationship dysfunction, showed less change [27].

In the field of mental healthcare, human-computer interactions are a novel form of therapy. An intriguing example of a digital tool that can be employed in the treatment of mental problems is virtual reality technology. It might help in developing personal skills or overcoming deficiencies. The article [28] lists several effective VR applications in psychology and psychiatry. VR has been proven to be useful in the treatment of schizophrenia, PTSD, eating disorders, and substance use disorders [28].

This study aimed to examine the effectiveness of a VR-based parent-child interactive training program for promoting positive parenting skills through a longitudinal analysis. While the study is still ongoing, we expect that the implementation of the program will lead to improvements in children's social behavior and a reduction in negative long-term consequences, such as school dropouts and criminal behavior. By providing parents with a realistic virtual environment, guided by child development experts, we anticipate that parents will be able to develop positive parenting skills that will foster more effective interactions with their children.

However, we acknowledge that this study has limitations. The results of the study [11] will not be available until later in 2023. Additionally, this study's focus is limited to virtual reality-based parent-child interactive training programs designed to promote positive parenting practices, and studies that do not meet this criterion have been excluded. Nonetheless, this study's results will contribute to the growing body of

research that examines the effectiveness of using VR technology as a tool for parent training programs and its potential impact on children's behavior and development.

2.4 Identification of Gaps in Existing Knowledge

By applying the keywords combination indicated in the previous section, 2.2 [6] shows that Psychology, Medicine, and Social Science were the most three common topics and make 87.9% of all subject areas. Figure 2.3 [6] VOSviewer was used to illustrate a network visualization of the authors' keywords occurrence. It's observable that keywords like "parent training", "parenting", "parent-child interaction", "disruptive behavior disorder", and "technology" had the most co-occurrence. These findings point to a lack of efficient digital visualizations and VR implementations in this field.

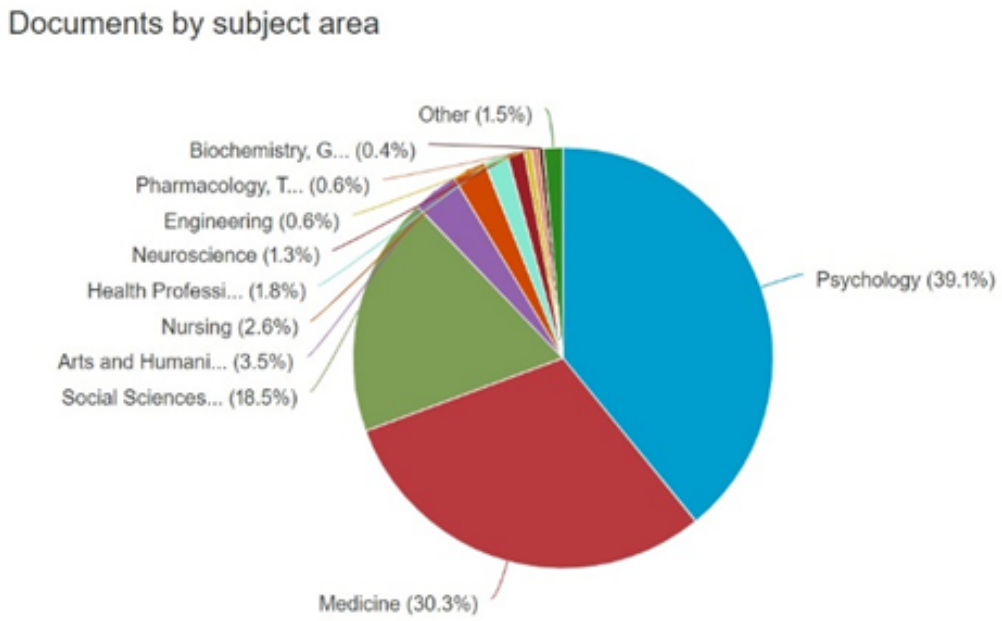


Figure 2.2: Chart of papers by subject area from Scopus [6].

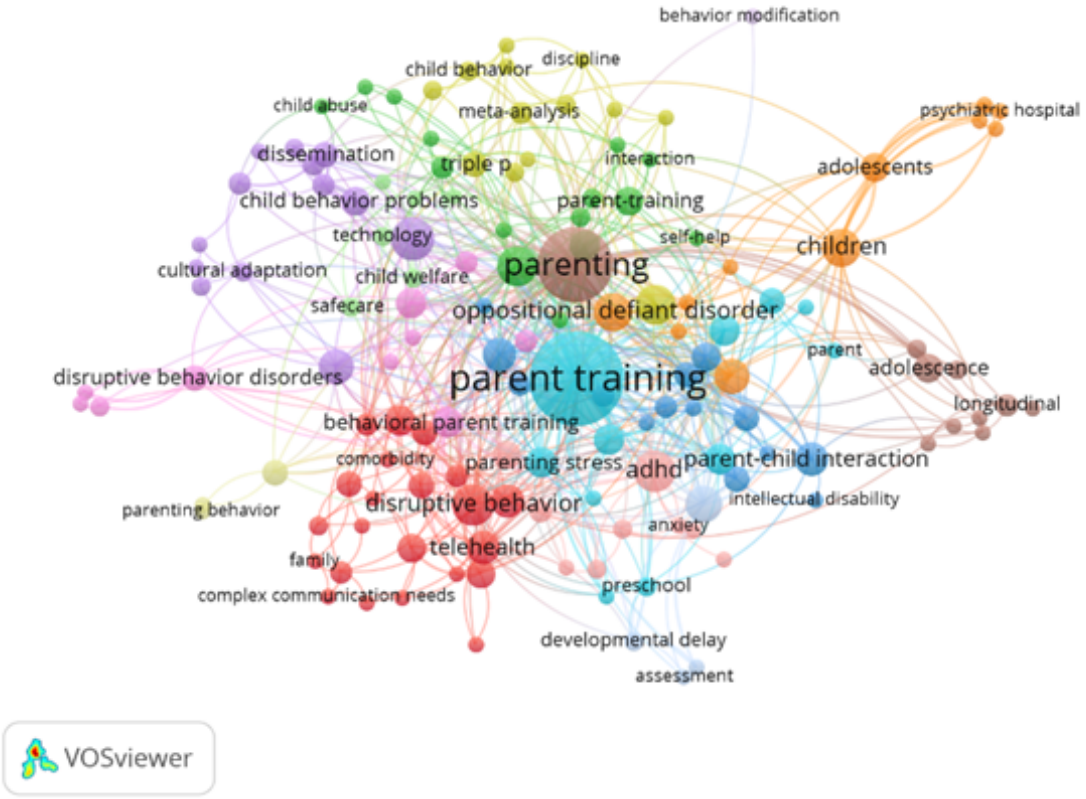


Figure 2.3: Chart of papers by subject area from Scopus [6].

Table 2.1 summarizes the main gaps in the literature on VR-based parent-child therapy programs. The gaps include limited research on the long-term impact of VR-based training programs, the impact of VR-based training programs on children's social behavior, the use of VR in combination with evidence-based interventions, and the potential negative effects of VR-based training programs. These gaps pose challenges in assessing the effectiveness of VR training and its value in different industries, particularly in the long run. Addressing these gaps through further research is necessary to develop strategies to mitigate the potential risks associated with VR-based training programs.

Table 2.1: Gaps in the Currently Reviewed Papers

Gap	Description
Lack of long-term follow-up [10]	The majority of studies had follow-up periods of 12 months or less, making it difficult to assess the long-term effectiveness of VR-based parenting programs
Limited research on the long-term impact of VR-based training programs	There is a lack of long-term research on the impact of VR-based training programs, making it difficult to assess the overall effectiveness of VR training and determine its value in the long run.
Limited research on the impact of VR-based training programs on children's social behavior	There is a lack of research on the impact of VR-based training programs on children's social behavior, and whether they can effectively address disruptive behavior in children and improve their social behavior.
Limited research on the use of VR in combination with evidence-based interventions	There is a lack of research on the use of VR in combination with other evidence-based interventions to determine whether VR can enhance their effectiveness.
Limited research on the potential negative effects of VR-based training programs	There is a lack of research on the potential negative effects of VR-based training programs, such as motion sickness or increased anxiety, and more research is needed to assess potential risks and develop strategies to mitigate them.
Cost and implementation	VR-based training programs might be expensive especially when used by individuals, and implementation of VR-based training methods by individuals is not guaranteed to have a considerable impact.

Table 2.2 summarizes five evidence-based parent-child interventions, including Parent-Child Interaction Therapy (PCIT), Parent Management Training (PMT), Filial Therapy, Child-Parent Psychotherapy (CPP), and Theraplay, and their potential applications in virtual reality (VR) settings. Each therapy focuses on different aspects of improving parent-child interactions and child mental health outcomes, but all face limitations in terms of accessibility and scalability. The use of VR has the potential to address some of these challenges by providing a safe and cost-effective means of delivering these therapies in a controlled and immersive environment. The table also identifies the limitations of each therapy and how VR technology can address them. This information is valuable for clinicians and researchers interested in the use of VR technology to enhance the effectiveness and accessibility of evidence-based

parent-child interventions.

Table 2.2: Evidence-based Parent-Child Therapies and Their Potential VR Applications and Limitations

Therapy	**Description**	**Potential VR Application**	**Limitations**	**How VR Can Address Limitations**
Parent-Child Interaction Therapy (PCIT) [10, 17]	Behavioral intervention to improve parent-child interactions	Realistic virtual environment for parent training	Limited access to trained therapists	Increases accessibility and reach of therapy
Parent Management Training (PMT) [13, 18, 3]	Teaches parents positive reinforcement and management techniques	Virtual environment for parent training and communication practice	May not address underlying issues	Can be combined with VR exposure therapy to address underlying issues
Filial Therapy [19]	Coaches parents to conduct child-centered play sessions	Virtual play environment for parent-child coaching	Limited generalization to home setting	Can provide in-home VR coaching for generalization
Child-Parent Psychotherapy (CPP) [20]	Improves relationship between young children and caregivers after trauma	Virtual exposure therapy to gradually expose children to feared situations	Exposure therapy may not be enough	Can be combined with other VR interventions, such as coping skill practice
Theraplay [21]	Builds healthy attachment through play and physical touch	Virtual physical play and structured games	Limited access to trained therapists	Increases accessibility and reach of therapy

Based on these findings, several recommendations can be made to maximize the potential of VR technology in parent training programs. Firstly, future research could investigate using VR technology to manage children's emotions and behavior and enhance communication skills between parents and children. Secondly, mental health services can consider integrating VR-based parent training programs into their existing service delivery to improve access to evidence-based interventions for parents who may not have access to traditional face-to-face parent training programs. Thirdly, collaborations between mental health professionals and VR developers can facilitate

the development and design of effective VR interventions. Finally, further research is necessary to evaluate the long-term impact of VR-based interventions on children's behavior and development.

In conclusion, the use of virtual reality (VR) technology has shown promise in enhancing the effectiveness of evidence-based interventions for improving parent-child interactions and child mental health outcomes. VR-based training programs have been found to be cost-effective and expand training opportunities while reducing training costs in certain fields. However, there are still gaps in the literature, including limited research on the long-term impact of VR-based training programs, the impact of VR-based training programs on children's social behavior, the use of VR in combination with evidence-based interventions, and the potential negative effects of VR-based training programs. Addressing these gaps through further research is necessary to fully understand the potential impact of VR technology and develop strategies to mitigate potential risks. Overall, the integration of VR technology has the potential to enhance the accessibility and effectiveness of evidence-based interventions for parent-child interactions and child mental health outcomes.

Chapter 3

Methodology

3.1 Introduction and Research Design

The objective of this chapter is to outline the methodology that will be employed in the implementation of the VR-based parent-child interactive training program, aimed at promoting positive parenting. This chapter provides a detailed description of the research design, data collection and analysis methods, as well as ethical considerations of the implementation. The research design for this project involves the implementation of a VR-based parent-child interactive training program. The program utilizes virtual reality technology to create a simulated environment where parents can engage in interactive experiences with virtual avatar children. This environment enables parents to practice and improve their parenting skills, fostering positive interactions with their children. Data collection for the implementation will involve leveraging Large Language Models (LLMs) to generate the child interactions and scenarios within the virtual reality environment. These models will play a crucialcrole in providing the necessary data inputs to authentically replicate realistic child behaviors and interactions exhibited by the interactive avatar. The language generation capabilities of LLMs will be used to create diverse and realistic parent-child interaction scenarios, capturing the intricacies of communication, discipline, and emotional support. Through the utilization of LLMs, the data collection process ensures a data-driven and sophisticated approach to crafting interactive scenarios. These scenarios aim to closely mimic real-life situations that parents commonly encounter, offering a dynamic and realistic training ground within the virtual environment. The

analysis of the implementation data will focus on evaluating the effectiveness of the VR-based parent-child interactive training program in promoting positive parenting skills. Various assessment methods will be used to measure the impact of the program after the training session. We will follow a structured software development process to ensure the successful completion of our project. This process consists of six main phases: requirement collection, design, software development, testing, and deployment and maintenance as shown in Figure 3.1 [29].

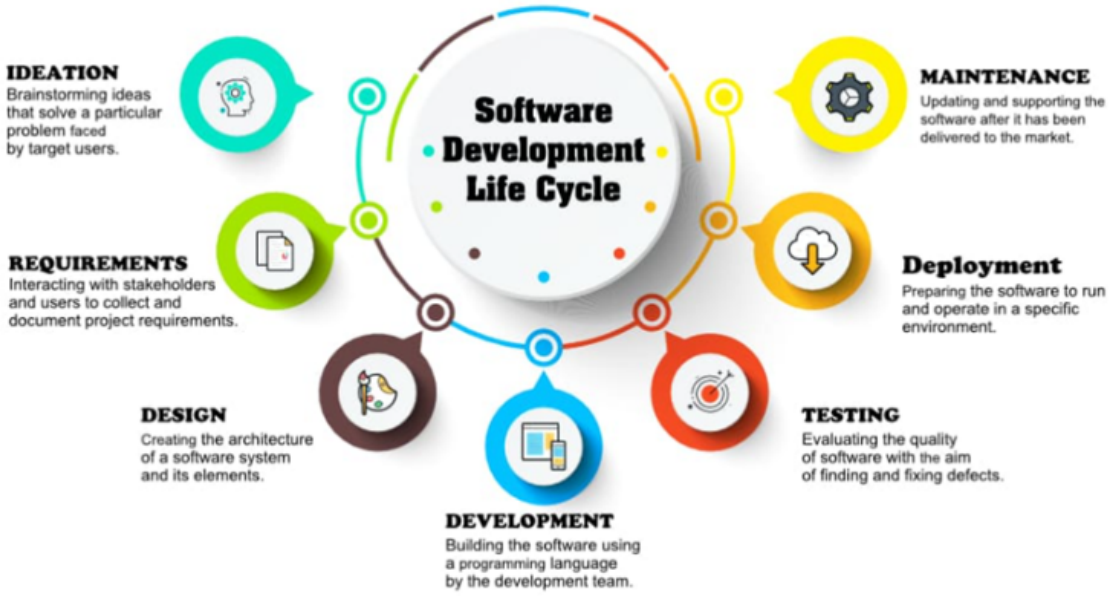


Figure 3.1: Software Development Life Cycle (SDLC)

The methodology for implementing the VR-based parent-child interactive training program to promote positive parenting involves several key steps. Firstly, a virtual reality (VR) environment will be designed to create an immersive and interactive experience. This environment will feature an avatar child powered by machine learning, enabling realistic simulations of parent-child interactions. The aim is to provide a platform that mimics real-life scenarios and allows parents to practice positive parenting techniques. To ensure the program's effectiveness, the involvement of a child development expert is crucial. This expert will contribute their knowledge and expertise in child development and positive parenting strategies. Their guidance will help inform the development of training materials and ensure that the program aligns with best practices in promoting positive skills for effective parent-child interactions.

Various mediums will be used to develop comprehensive training materials for parents. These materials may include instructional videos, interactive modules, and written guidelines. The content will focus on equipping parents with the necessary skills and knowledge to foster positive interactions with their children. The training materials will be designed to be easily accessible and user-friendly, allowing parents to navigate the program effectively. Parents will be actively engaged in the program by participating in the VR-based training. They will be provided with access to the VR environment and training materials, allowing them to practice positive parenting techniques in a controlled and supportive setting. The engagement and commitment of parents are crucial for the success of the program and the development of their parenting skills. The implementation of the VR-based training program will be followed by an evaluation phase. This evaluation will involve pre and post-training assessments, surveys, and observations of parent-child interactions. By collecting data on the program's effectiveness, the evaluation aims to assess the impact of the training program on promoting positive parenting skills. The data collected will be analyzed using appropriate statistical methods to derive meaningful insights and identify areas for improvement. Based on the findings from the evaluation, the program will be iteratively improved. Feedback from parents and the child development expert will be carefully considered and incorporated into refining the training materials, VR environment, and overall program design. This iterative improvement process ensures that the VR-based parentchild interactive training program remains responsive to the needs and preferences of parents and continues to enhance positive parenting skills effectively. Through this methodology, the implementation of the VR-based parent-child interactive training program aims to empower parents with the skills and knowledge needed to foster positive parent-child interactions. By leveraging Large Language Models (LLMs) to create authentic child interactions and scenarios within the virtual environment, coupled with expert guidance and comprehensive training materials, the program aims to revolutionize parent training techniques. This approach ensures a sophisticated and immersive virtual environment, allowing parents to engage in realistic scenarios and interactions with the child avatar. Through

the data-driven contributions of LLMs, the program seeks to enrich the learning experience and contribute significantly to the promotion of positive parenting practices

Figure 3.2 shows the main steps of building this project.

Figure 3.3 shows our Machine Learning Model methodology and the steps we will take to develop the ML Model in the project.

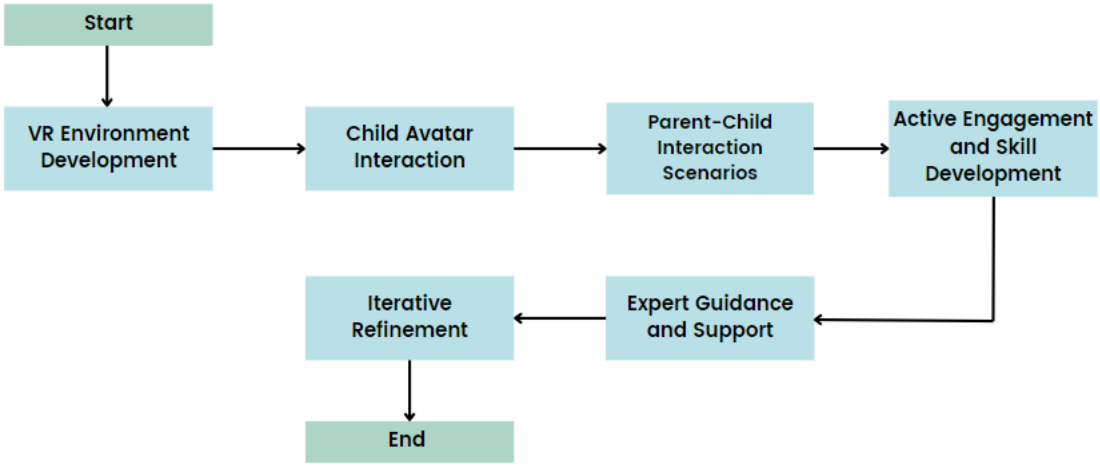


Figure 3.2: Steps of the project

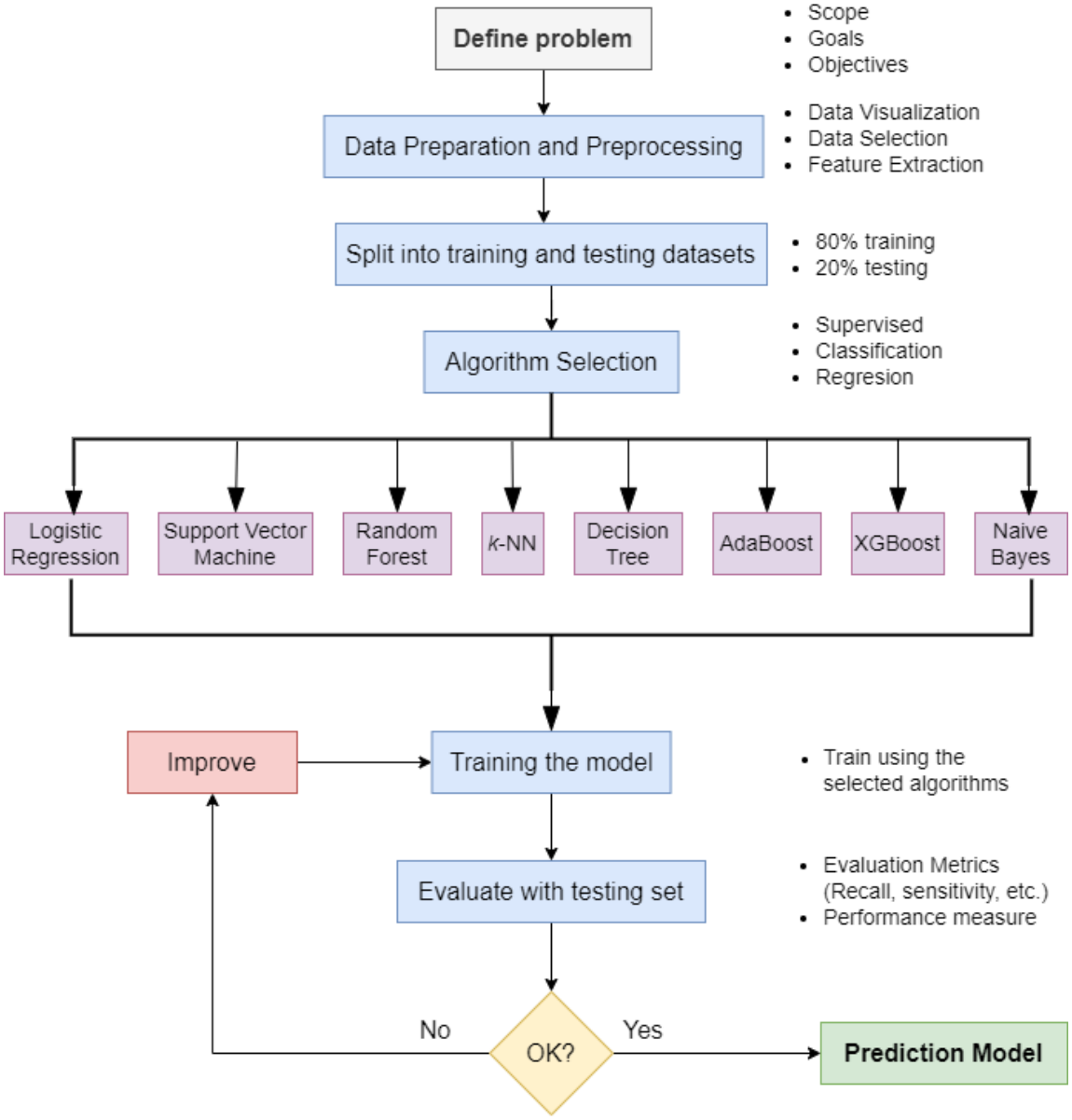


Figure 3.3: Steps of building the ML model of the project

Overall, the proposed methodology for the VR-based parent-child interactive training program strives to provide an effective and innovative approach to promoting positive parenting skills and aims to contribute to the advancement of parent training techniques and ultimately foster improved parent-child relationships.

3.2 Data Collection and Preparation

The data collection and preparation phase in the context of VR parenting implementation is vital for obtaining relevant information and ensuring its suitability for the program's effectiveness assessment. The data collection and preparation phase within the VR parenting implementation is critical to acquiring relevant information, especially with the integration of Large Language Models (LLMs) for crafting realistic child interactions and scenarios to enhance the program's effectiveness assessment. The target population consists solely of parents participating in the VR-based parentchild interactive training program, where the child is represented as an avatar within the virtual reality environment. Also, data will be collected through multiple sources, including the parent interactions in the virtual reality environment. As well as surveys, observations, and feedback from participants before and after the training session. Figure 3.4 illustrates the data collection method.

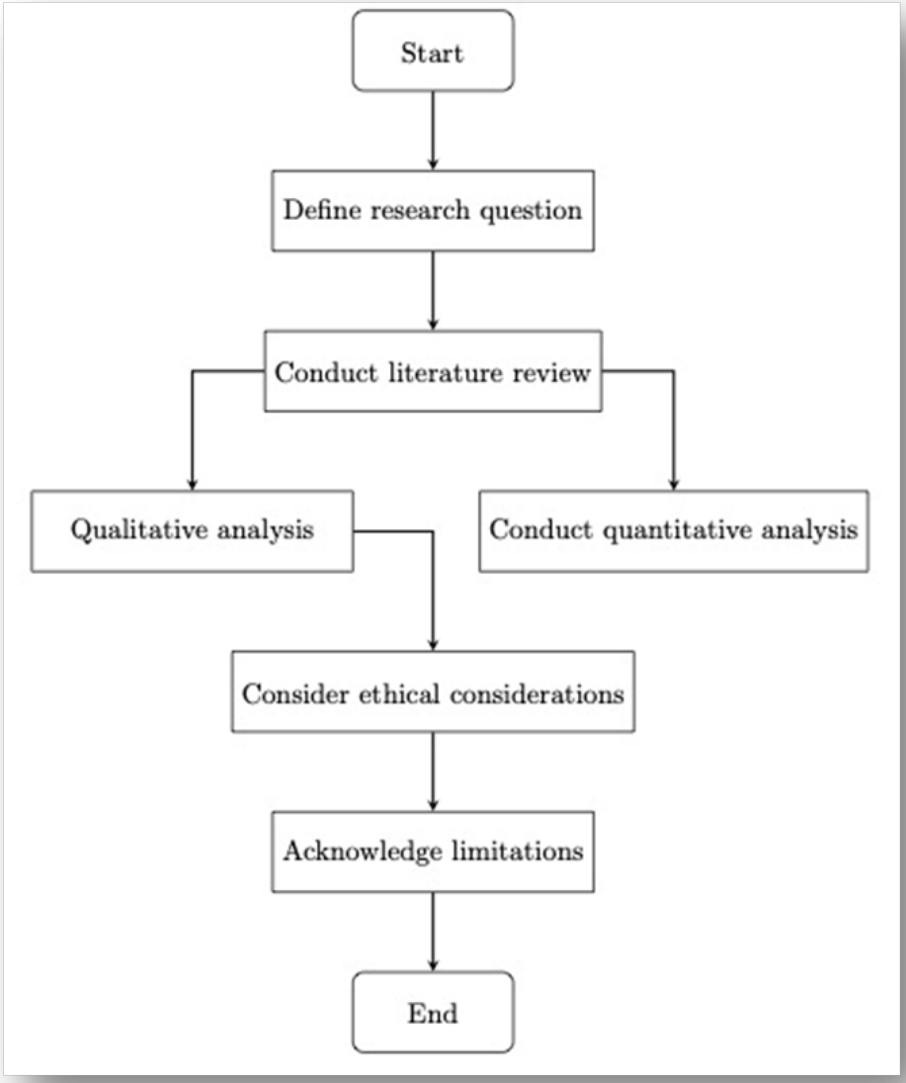


Figure 3.4: Diagram of the search and analysis strategy.

Ethical considerations are of paramount importance throughout the data collection process. Informed consent will be obtained from all participating parents, clearly explaining the purpose of the program, the data collection procedures, and how their privacy and confidentiality will be protected. Measures will be taken to de-identify and anonymize the collected data to ensure the privacy and confidentiality of participants.

To ensure a comprehensive understanding of the parent-child interactions, a combination of quantitative and qualitative data collection methods will be employed. Quantitative data will be collected through surveys and assessments, capturing vari-

ous aspects of parenting skills and the child's behaviour. Qualitative data will be gathered through observations and feedback, allowing for a deeper exploration of the experiences and perceptions of both parents and children during the VR training sessions.

Prior to analysis, the collected data will undergo a rigorous process of cleaning and preprocessing. This involves checking for missing or inconsistent data, resolving any discrepancies, and organizing the data in a structured format suitable for analysis. The data will then be subjected to various analytical techniques, including statistical analysis and thematic coding of qualitative data, to derive meaningful insights regarding the effectiveness of the VR-based parent-child interactive training program.

By following this data collection and preparation methodology, valuable insights can be obtained to evaluate the impact and efficacy of the VR parenting program. The rigorous approach to data collection, considering ethical considerations, will ensure the validity and reliability of the findings, leading to a better understanding of the program's effectiveness in promoting positive parenting skills and enhancing parent-child interactions.

3.3 AI-Powered Dialogue Generation for Enhanced Parent-Child Interactions in VR

3.3.1 Data Generation

- Utilize AI models like ChatGPT to generate conversational data specifically tailored for parent-child interactions in a virtual reality (VR) environment.
- Generate dialogues reflecting scenarios commonly encountered between parents and children within the VR setting, considering aspects such as guidance, encouragement, storytelling, and education.

3.3.2 Data Finetuning

- Finetune a base model, such as Mistral, using the generated conversational data tailored for parent-child interactions in the VR environment.
- Adjust the model's parameters to capture the nuances of parent-child conversations, including tone, vocabulary, and context sensitivity within the VR environment.

3.3.3 Chat Template Creation

- Develop a chat template outlining the structure and dynamics of parent-child interactions within the VR environment.
- Include prompts and responses encouraging positive engagement, fostering learning, and promoting emotional connection between parents and children in the virtual space.

3.3.4 Dataset Evaluation and Size Assessment

- Evaluate the collected dataset to ensure it encompasses a diverse range of parent-child interactions relevant to the VR environment.
- Assess the size of the dataset to ensure it provides an adequate training sample for effective finetuning of the model, considering the unique context of VR-based interactions.

3.3.5 Training and Validation

- Train the finetuned model using the VR-specific parent-child interaction dataset, focusing on optimizing its performance for generating meaningful and engaging dialogues.
- Validate the model's responses to ensure they align with the intended dynamics of parent-child interactions within the VR environment, maintaining appropriateness, coherence, and emotional resonance.

3.3.6 Iterative Refinement

- Iterate on the finetuning process based on feedback from users engaging in parent-child interactions within the VR environment.
- Continuously refine the model to enhance its ability to simulate realistic and immersive dialogues, addressing any areas of improvement identified through user testing and evaluation.

By following this adapted methodology, we aim to leverage AI-powered dialogue generation to enhance parent-child interactions within the virtual reality environment, fostering meaningful connections and facilitating immersive experiences for families in VR settings.

3.4 Algorithms, Classifier Evaluation, and Prediction Model

Various machine learning algorithms, such as logistic regression, decision trees, random forests, support vector machines (SVM), and neural networks, will be considered for this project [30, 31]. These algorithms will be evaluated based on their suitability for handling the unique characteristics and complexities of the parent-child interaction data collected in the virtual reality environment.

To assess the performance of these algorithms, several metrics will be used, including accuracy, precision, recall, F1 score, and area under the receiver operating characteristic curve (AUC-ROC) [32, 33]. These metrics will measure the algorithms' predictive capabilities and their ability to accurately capture and predict positive parenting behaviors and outcomes.

Cross-validation techniques, such as k-fold cross-validation, will be employed to ensure the reliability and generalizability of the prediction model. The dataset will be divided into training and testing sets, with the training set used for algorithm training and the testing set used for evaluating performance [34, 35]. This process will

be repeated multiple times using different data splits to obtain unbiased performance estimates.

Additionally, feature selection and dimensionality reduction techniques may be applied to identify the most relevant and informative features for the prediction model. This will improve the model's efficiency, interpretability, and reduce the risk of overfitting.

The final prediction model will be developed based on the selected algorithm with the best performance and generalization capability. It will be integrated into the VR-based parent-child interactive training program, enabling real-time feedback and guidance to parents based on their interactions with the virtual avatar child.

By utilizing appropriate algorithms, conducting thorough classifier evaluations, and developing an accurate prediction model, the VR-based parent-child interactive training program will be equipped with a robust tool for assessing and guiding positive parenting behaviours. This section plays a critical role in ensuring the program's effectiveness and the provision of personalized training experiences for parents within the virtual reality environment.

3.4.1 Client Feedback

Through collaboration with the Saudi Ministry of Health and the National Family Safety Program, valuable feedback and suggestions were incorporated into the project proposal, resulting in a refined and improved program. The consultations provided insights into existing programs, regulations, and ethical considerations, enabling alignment with the clients' objectives. The program now focuses on addressing specific challenges faced by parents, improving access to resources, and promoting child well-being. A follow-up meeting is scheduled to present the updated proposal and finalize the program, ensuring its practical implementation and effectiveness. The engagement with the clients has been instrumental in shaping a successful VR-based training program for positive parenting.

3.5 Deployment

The "Deployment" phase focuses on the implementation and rollout of the VR-based parent-child interactive training program following the development and evaluation phases. This section outlines the steps and considerations involved in deploying the program to reach the target audience effectively.

1. Prepare hardware and software infrastructure: Ensure compatibility and functionality of VR devices, set up the virtual reality environment, and install necessary software components.

2. Develop a comprehensive training plan: Provide instructional materials, tutorials, and guidance to familiarize parents with the program's features, functionalities, and objectives. Ensure parents are comfortable and confident in using the VR technology.

3. Address accessibility and limitations: Consider language support, accommodate varying levels of technological proficiency, and address any physical or cognitive challenges that may affect participants' engagement with the program.

4. Encourage participant engagement: Implement strategies such as gamification elements, rewards, or progress-tracking mechanisms to motivate parents to actively participate and sustain their engagement with the program.

5. Establish communication and support channels: Set up regular communication channels to address participants' questions, concerns, and technical issues they may encounter during the deployment phase.

6. Monitor and evaluate: Continuously monitor and evaluate the program's effectiveness and collect feedback from parents regarding their experiences within the virtual reality environment.

7. Incorporate feedback for improvement: Analyze feedback to identify areas for enhancement and iterate on the program, incorporating updates based on the insights gained from participants' experiences.

3.6 Software Testing and Maintenance

Software testing plays a critical role in the development of software systems [29, 36]. It verifies that the software meets the specified requirements and operates as intended, while also identifying and rectifying any errors or defects. Thorough testing is essential to ensure that the software is reliable, secure, and performs optimally under various conditions and workloads. Table 3.1 provides an overview of the main types of software testing.

Table 3.1: Types of Testing

Testing Type	Description
Unit testing	Testing individual units or components of the software to ensure they function as expected.
Integration testing	Testing how different components of the software interact with each other.
System testing	Testing the entire system as a whole to ensure it meets the requirements and functions.
Acceptance testing	Testing the software's performance under different conditions and loads to ensure it can handle user traffic.
Performance testing	Testing the software's performance under different conditions and loads to ensure it can handle user traffic.
Security testing	Testing the software's security measures to ensure it is protected against attacks.
Regression testing	Testing the software after changes to ensure that previous functionality is not affected.
Compatibility testing	Testing the software's compatibility with different operating systems, browsers, etc.
Usability testing	Testing the software's usability and user experience.
Recovery testing	Testing the software's ability to recover from crashes.

After the deployment of software, software maintenance becomes a critical phase in the software development life cycle [29]. It involves making changes to the software to fix defects, improve performance, add new features, or address security vulnerabilities. Maintenance can be classified into four categories: corrective, adaptive, perfective, and preventive maintenance. Corrective maintenance focuses on fixing defects or errors

identified during testing or production use. Adaptive maintenance involves modifying the software to adapt to changes in the environment, such as hardware or operating system updates. Perfective maintenance aims to enhance the software's performance or functionality without changing its core features. Preventive maintenance involves making changes to the software to prevent future issues, such as applying security patches or complying with new regulations. Effective maintenance is crucial to ensuring that the software continues to meet user requirements and performs well throughout its life cycle.

3.7 Ethical Considerations

The "Ethical Considerations" section of the VR-based parent-child interactive training program focuses on ensuring the well-being and rights of the participants throughout the research and deployment process. Informed consent is obtained from parents, providing them with comprehensive information about the program's purpose, procedures, potential risks and benefits, and their rights as participants. Privacy and confidentiality measures are implemented to protect the participants' personal information and data, ensuring secure storage and limited access. Adherence to data protection regulations and guidelines safeguards the participants' personal data. The voluntary nature of participation is emphasized, allowing parents to withdraw from the program without facing any negative consequences. Child protection measures are in place to prevent harm or distress to children during their interactions in the virtual reality environment, ensuring appropriate parental supervision and support. Research ethics approval is obtained from the relevant ethics committee, ensuring compliance with ethical standards. Continuous monitoring is conducted to address any ethical concerns or issues that may arise, providing mechanisms for participants to provide feedback and seek assistance. By addressing these ethical considerations, the VR-based parent-child interactive training program upholds integrity, promotes participant protection, and fosters trust in the research process.

3.8 Constraints and Limitations

In the pursuit of developing a virtual reality (VR)-based parenting solution, it is important to acknowledge the following constraints and limitations:

- **Availability of VR resources**: The implementation of a VR-based parenting solution may be constrained by the availability of necessary VR resources, such as headsets, controllers, and software. Access to these resources may impact the scale and scope of the solution.
- **User acceptance and familiarity with VR**: The success and adoption of a VR-based parenting solution rely on the acceptance and familiarity of users with VR technology. Some individuals may be hesitant or unfamiliar with using VR, which could affect their engagement and overall experience with the solution.
- **Technical limitations of VR technology**: Virtual reality technology is constantly evolving, and there may be technical limitations that affect the realism, immersion, or performance of the VR-based parenting solution. These limitations could impact the effectiveness and user experience of the solution.
- **Ethical considerations**: As with any technology-driven solution, ethical considerations must be prioritized throughout the development and deployment of the VR-based parenting solution. Ensuring user privacy, data security, and informed consent are paramount to protect the well-being of participants and adhere to ethical guidelines.

In conclusion, this section has highlighted the constraints and limitations that should be considered in the development of a VR-based parenting solution. While acknowledging these constraints, we remain optimistic about the potential of VR technology to enhance parenting practices. We will work diligently to overcome these limitations by leveraging available resources, ensuring user acceptance, addressing technical challenges, and prioritizing ethical considerations. Through ongoing research and development, we aim to create an immersive and effective VR-based parenting solu-

tion that can positively impact the parent-child relationship and contribute to the well-being of families.

The next chapter will focus on the expected outcomes of the project

Chapter 4

Requirements Specification and system analysis

4.1 Introduction

The primary objective of this chapter is to outline the detailed requirements for the development of a VR-based parent-child interactive training program aimed at enhancing parenting skills and addressing disruptive behavior disorders in children. This innovative solution employs virtual reality technology to create a lifelike environment where parents can interact with an avatar child, driven by machine learning. To ensure the effectiveness of the program, a child development expert will guide parents through various mediums, creating a comprehensive training experience.

4.1.1 Background

Behavioral issues in children, particularly disruptive behavior disorders (DBD), can lead to long-term negative consequences. This project proposes a VR-based parent-child interactive training program to address these issues by leveraging virtual reality (VR) technology and machine learning models, specifically ChatGPT.

4.1.2 Objectives

1. Develop an immersive VR environment using Unity.

2. Create an interactive avatar child powered by ChatGPT for realistic child interactions.
3. Provide expert guidance and training for parents to promote positive parenting skills.
4. Implement machine learning models for Speech Recognition, Natural Language Understanding (NLU), Gesture Recognition, and Emotion Recognition to enhance interactivity within the VR environment.
5. Evaluate the effectiveness of the program in improving parent-child interactions and reducing disruptive behavior in children.

4.2 Users/Stakeholders Requirements Specification

4.2.1 Users

- Parents: Need a user-friendly VR interface, access to training materials, and guidance and interaction with the avatar child in the VR environment.
- Child Development Expert: Requires a space/platform to provide guidance and training to parents.

4.2.2 Stakeholders

- Parents and families.
- Child development experts.
- Educational institutions.
- Society at large.

4.3 Functional and Non-Functional Requirements

4.3.1 Functional Requirements Analysis - Details

1. Avatar Interaction
    - Description: Parents should be able to interact with the avatar child.
    - Roles: Parents, Avatar Child
    - Preconditions: VR environment initialized.
    - Postconditions: Successful interaction logged.
2. Speech Recognition
    - Description: The system transcribes spoken words of the avatar child.
    - Roles: Avatar Child, ChatGPT
    - Preconditions: Speech input from avatar child.
    - Postconditions: Transcription provided to parents.
3. Natural Language Understanding
    - Description: NLU models interpret the context of the child's statements.
    - Roles: ChatGPT, NLU Models
    - Preconditions: Avatar child's statement.
    - Postconditions: Contextual interpretation provided to parents.
4. Gesture Recognition
    - Description: ML models enable gesture recognition for intuitive interaction.
    - Roles: Parents, Gesture Recognition Models
    - Preconditions: Gesture input detected.
    - Postconditions: Successful recognition triggers appropriate responses.
5. Interactive VR Environments

- Description: The VR parenting program will include immersive virtual environments that will accurately simulate real-life parenting scenarios.

6. Parenting Skills Training Modules

   - Description: The program will feature modules dedicated to essential parenting skills, providing step-by-step guidance on communication, discipline, empathy, and problem-solving.

7. Customizable Avatars

   - Description: Users will be able to choose an avatar from a set of options to represent themselves within the virtual parenting environment, including options for various family structures.

8. Scenario Customization

   - Description: In future development, an expert dashboard (UC-5) will allow experts to customize parenting scenarios in the VR program. This includes adjusting variables like child age, temperament, and behavioral challenges, and providing tailored training experiences to meet each parent's unique needs. This feature demonstrates a commitment to ongoing refinement and adaptability within the program, enhancing its effectiveness for parenting experts.

9. Adaptive Learning Paths

   - Description: The adaptive learning system of the VR-based parenting program employs user profiling by collecting and analyzing data on interactions, assesses performance metrics related to parenting skills, utilizes machine learning algorithms to identify learning behavior patterns, dynamically adjusts content based on analysis, including difficulty levels, and recommended modules, and provides real-time feedback. This comprehensive approach fosters a personalized and effective learning experience, guiding users through tailored scenarios aligned with their skill development needs.

10. Immersive Audio-Visual Experience

    - Description: The VR program will deliver an immersive audio-visual experience, incorporating realistic sounds to enhance the sense of presence within the virtual environments.

4.3.2 Non-Functional Requirements

1. Performance

    - Response Time
        - Description: The system should respond to user interactions within a maximum latency of 200 milliseconds.
        - Measurement: Monitor and analyze response times during user testing.
    - Scalability
        - Description: The VR environment should be scalable to accommodate a growing user base without compromising performance.
        - Measurement: Evaluate system performance under increasing user loads.

2. Reliability

    - Availability
        - Description: The system should be available 99.9% of the time, excluding scheduled maintenance.
        - Measurement: Track system uptime and downtime for assessment.
    - Fault Tolerance
        - Description: The system should gracefully handle errors or failures without compromising the overall experience.
        - Measurement: Test the system's behavior under simulated failure scenarios.

3. Usability

    - User Interface (UI)

        - Description: The VR interface should be intuitive and user-friendly to ensure a positive user experience.

        - Measurement: Conduct user satisfaction surveys and usability testing.

    - Accessibility

        - Description: The VR environment should adhere to accessibility standards to accommodate users with disabilities.

        - Measurement: Ensure compliance with WCAG guidelines for accessibility.

4. Compatibility

    - Hardware Compatibility

        - Description: The VR application should be compatible with a range of VR headsets, including HTC Vive and similar high-quality devices.

        - Measurement: Test the application on various VR hardware to ensure compatibility.

    - Software Compatibility

        - Description: Ensure compatibility with the Unity 3D development platform and the required machine learning models (ChatGPT, NLU models, Gesture Recognition models).

        - Measurement: Validate compatibility with specified software versions.

5. Maintainability

    - Code Maintainability

        - Description: Codebase should be well-documented and modular to facilitate easy maintenance and updates.

        - Measurement: Regular code reviews and documentation audits.

- Model Updates
  - Description: Machine learning models (ChatGPT, NLU, Gesture Recognition) should be updatable without disrupting the overall system.
  - Measurement: Develop a streamlined process for model updates and evaluate its effectiveness.

6. Compliance and Legal
   - Regulatory Compliance
     - Description: Ensure compliance with relevant data protection regulations, especially regarding the use of personal data in a virtual environment.
     - Measurement: Regular audits to verify adherence to legal requirements.
   - Ethical Considerations
     - Description: Implement ethical guidelines for the use of AI in the VR environment, ensuring responsible and unbiased interactions.
     - Measurement: Conduct periodic ethical reviews and assessments.

4.4 User Role

- Parents: Interact with the VR environment, receive guidance, and practice positive parenting skills.
- Child Development Experts: Provide guidance and support through various channels.
- Technical Teams: Develop, maintain, and support the VR environment and machine learning models.

4.5 Security Requirements Measurements

- User Authentication: Implement secure login protocols for both parents and experts.
- Data Encryption: Employ robust encryption methods to secure communication channels.
- Access Control: Utilize role-based access to safeguard user privacy and limit unauthorized access.

4.6 Updated Gantt chart as necessary

4.7 Summary

The proposed VR-based parent-child interactive training program aims to address disruptive behavior disorders in children through an innovative and immersive approach. By leveraging VR technology, ChatGPT, and machine learning models, we seek to revolutionize parent training techniques, promote positive parent-child interactions, and contribute to societal goals outlined in Vision 2030. The comprehensive plan includes functional and non-functional requirements, user roles, and security measures to ensure the success and effectiveness of the program. The project aligns with SDG#3, SDG#4, and SDG#16 by improving health and well-being, enhancing quality education, and encouraging strong institutions, respectively.

Chapter 5

System Design and Development

5.1 Introduction

The system design phase aims to solve the problem at hand by providing a detailed low-level design for a feasible solution. This includes various components such as the system architecture diagram, database conceptual design, database logical schema, entity relationship diagram, data dictionary, prototype system components, and a summary. The objective is to create a comprehensive blueprint for the implementation phase, ensuring that all aspects of the system are well-defined and aligned with the project requirements.

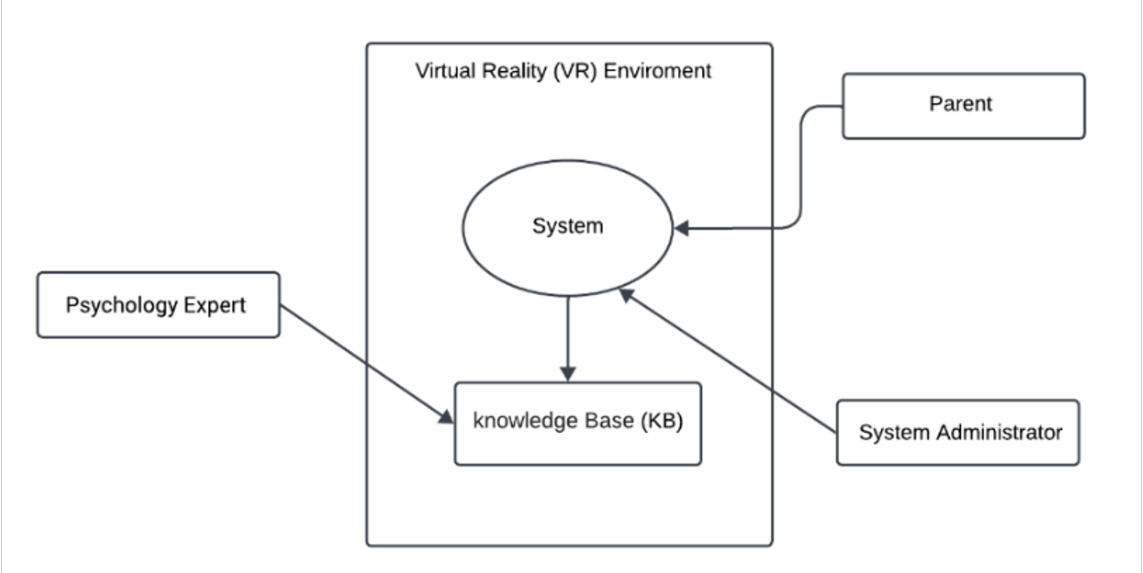
In this context, the project focuses on implementing a VR-based parent-child interactive training program to promote positive parenting. The methodology involves designing a virtual reality environment that simulates realistic parent-child interactions. The program incorporates an avatar child powered by machine learning models to provide an immersive and interactive experience. Expert guidance, comprehensive training materials, and evaluation mechanisms contribute to the program's effectiveness in fostering positive parenting skills.

System design plays a crucial role in ensuring that all components and functionalities of the VR-based parent-child interactive training program are thoughtfully planned and integrated. The following sections outline the key aspects of the system design, providing a solid foundation for the subsequent implementation phase.

5.2 System Requirements

- R1. A virtual reality (VR) environment where parents can engage in interactive training with a machine learning-powered child avatar to practice positive parenting skills.
- R2. A system for parents to register for the VR training program, including setting up their profiles and scheduling their training sessions.
- R3. A knowledge base that collects and stores data from the interactions between parents and the avatar child during VR training sessions.
- R4. A feature for parents to access their past VR training sessions and receive generated reports on their interactions with the child avatar.
- R5. A portal where the psychology expert can review recorded VR training sessions and provide feedback and recommendations for the parents.
- R6. An administrative interface for the system moderator to manage user accounts, sessions schedule, and oversee the overall system workflow.

5.3 Context Diagram



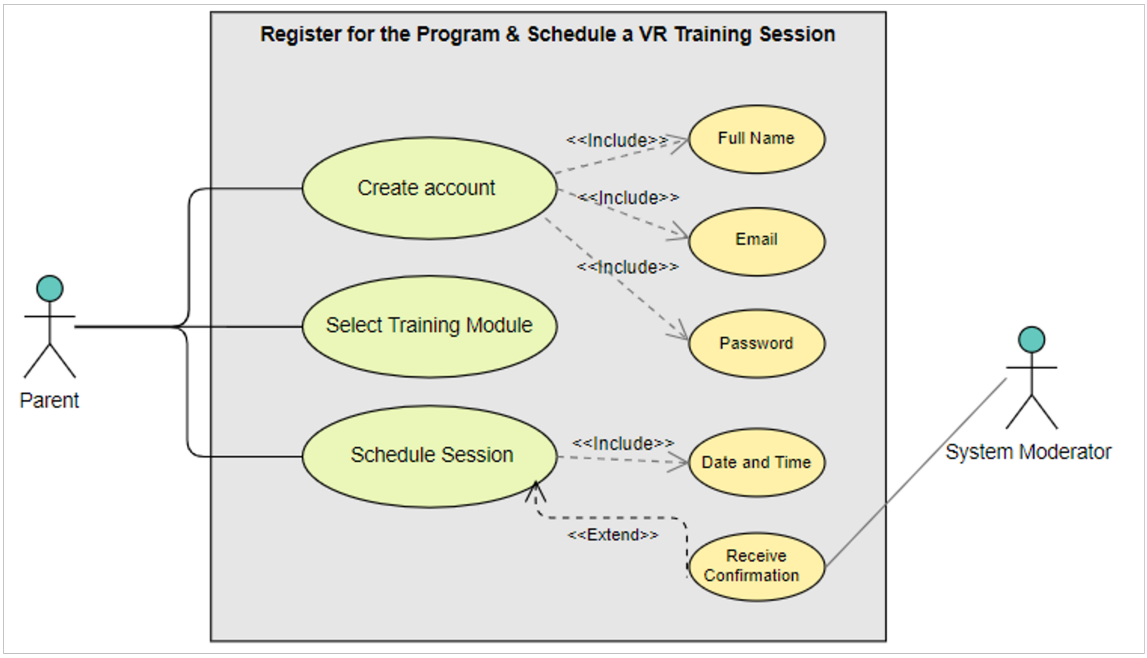
5.4 Traceability Matrix

Requirement ID	Requirement Description	UC1	UC2	UC3	UC4	UC5	UC6
R1	VR environment for interactive parent-child avatar training.		X				
R2	System for parents to register for the VR training program, including profile setup and session scheduling.	X					
R3	Knowledge base that collects and stores data from parent-avatar interactions during VR training sessions.			X			
R4	Feature for parents to access past VR training sessions and reports.					X	
R5	Portal for psychology experts to review recorded VR training sessions and provide feedback.				X		
R6	Administrative interface for system moderators to manage user accounts, session scheduling, and system workflow.						X

5.5 Use Case Diagrams

UC1

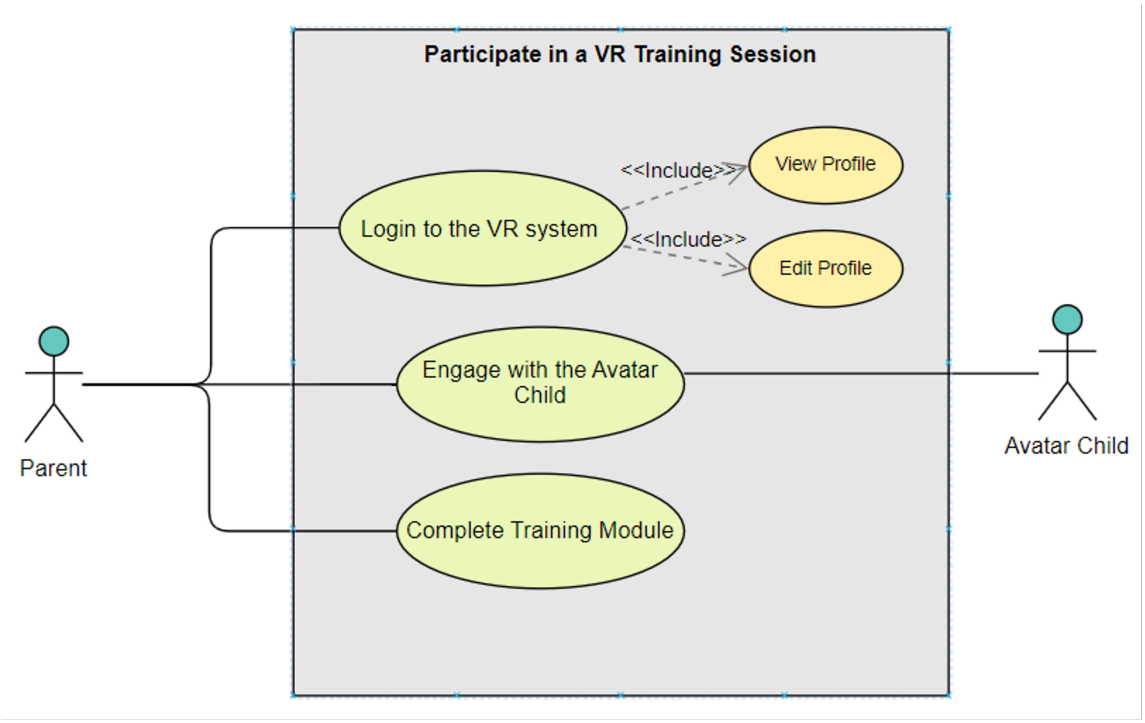
- The process is broken down into three primary use cases: creating an account, selecting a training module, and scheduling a session. Creating an account requires the input of the user's full name, email, and password. Once the account is created, the user can select a training module and proceed to schedule a session. Scheduling is finalized upon the system moderator's action, which triggers a confirmation receipt back to the user.



UC1

UC2

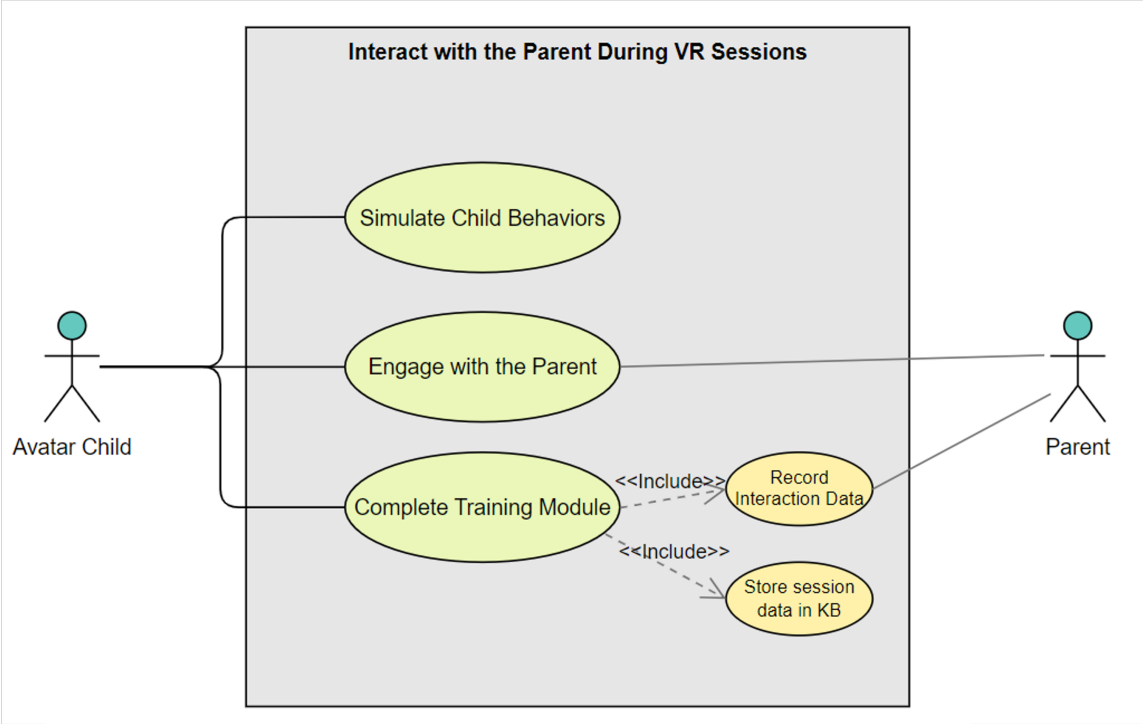
- Once logged in, the parent can 'Engage with the Avatar Child', leading to the main goal of the diagram, which is to 'Complete Training Module'. An 'Avatar Child' actor is shown on the right, suggesting that they are an integral part of the engagement process within the VR environment.



UC2

UC3

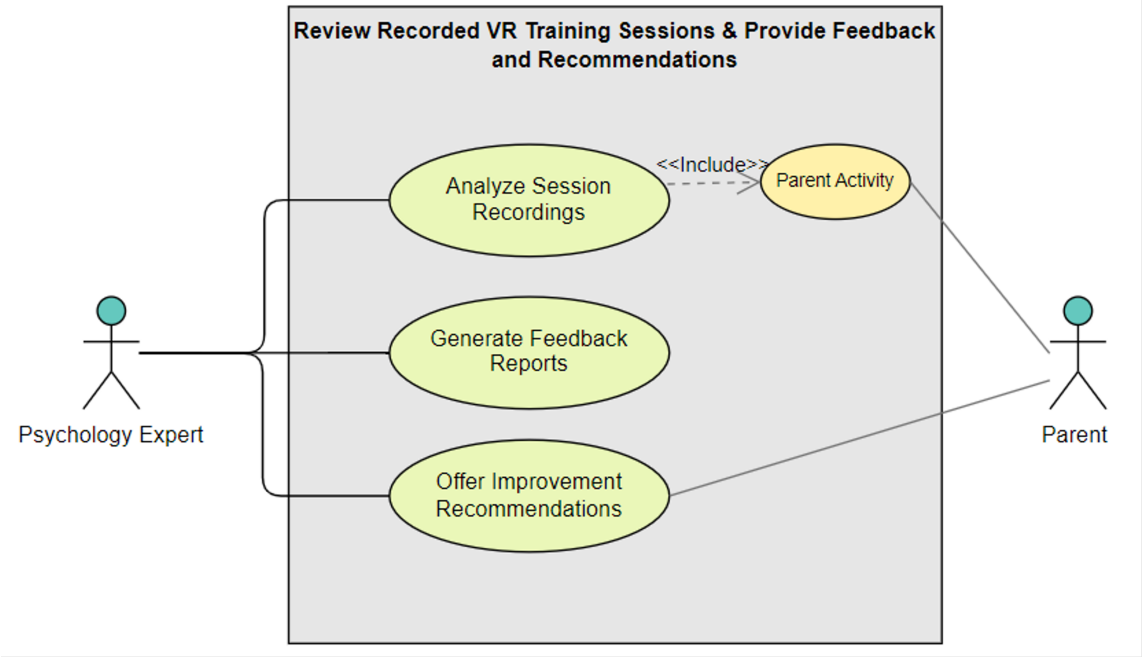
- This diagram outlines interactions within VR sessions involving an 'Avatar Child' and a 'Parent.' The 'Avatar Child' engages in 'Simulate Child Behaviors' and 'Engage with the Parent,' indicating two-way interaction between the avatar and the parent. The central use case, 'Complete Training Module,' suggests the culmination of the VR session's activities. Additionally, this central use case includes two critical functions: 'Record Interaction Data' and 'Store session data in KB (Knowledge Base)', which are essential for capturing the session's details and outcomes.



UC3

UC4

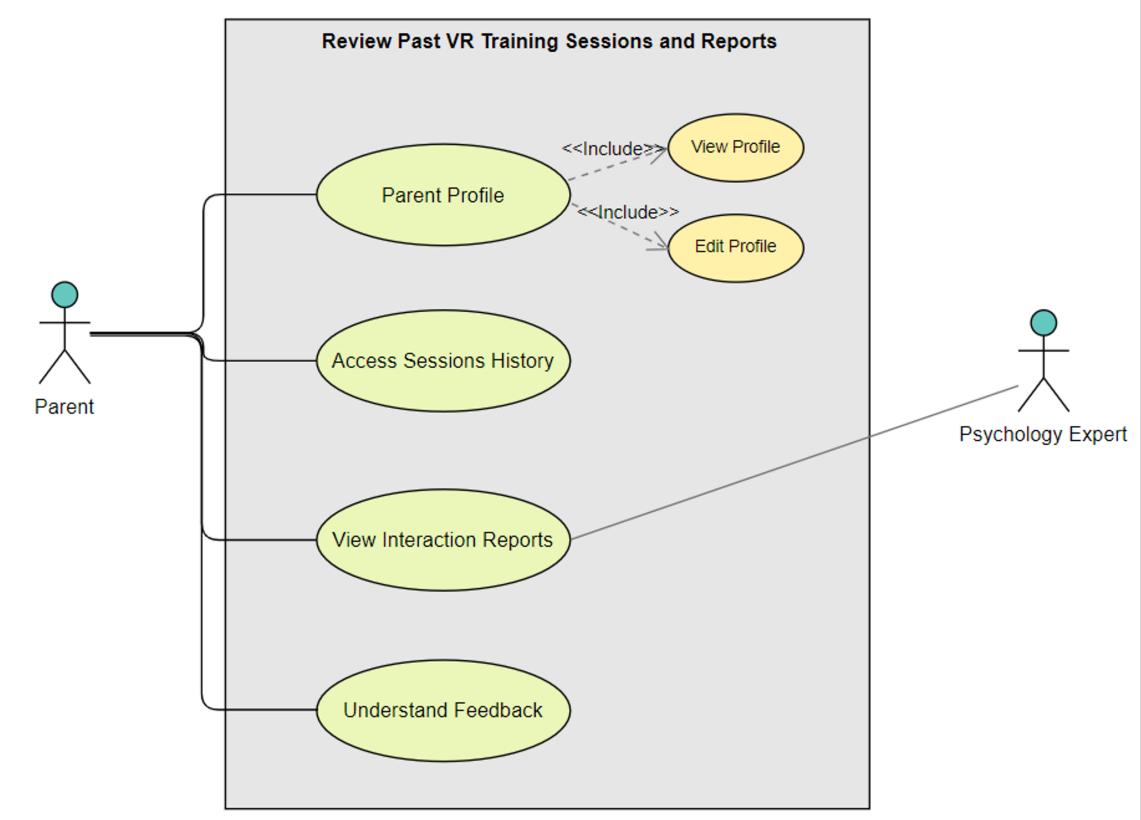
- Facilitated by two actors: a 'Psychology Expert' and a 'Parent.' The expert's primary actions are 'Analyze Session Recordings' and 'Generate Feedback Reports,' with the latter including the detailed activity of the parent (Parent Activity) as an integral part of the analysis. Finally, the expert is responsible for 'Offer Improvement Recommendations,' which likely draws on insights from the feedback reports. This interaction flow illustrates the expert's role in reviewing VR training sessions and providing constructive feedback to the parent.



UC4

UC5

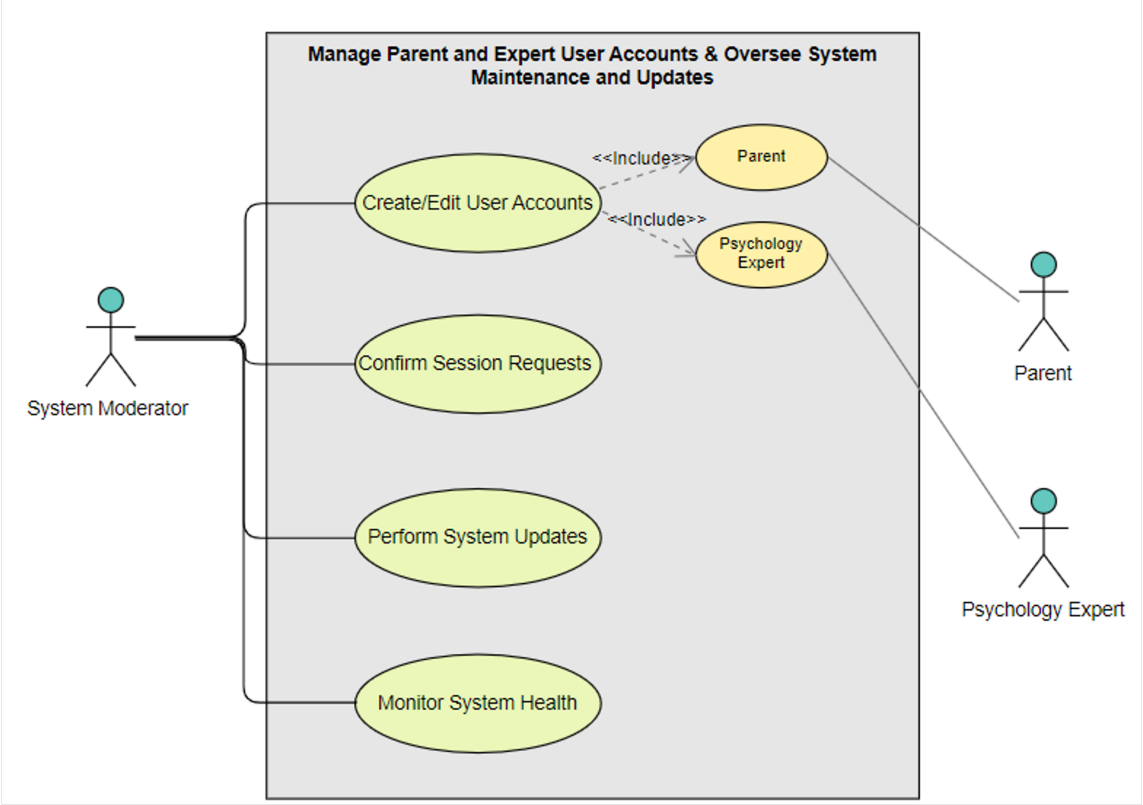
- The parent can 'View Profile' and 'Edit Profile,' which are included as part of managing their 'Parent Profile.' The next step is 'Access Sessions History,' which is a prerequisite to 'View Interaction Reports'. These reports detail the parent's interactions during VR sessions. Lastly, 'Understand Feedback' is shown as a use case, indicating the parent's need to comprehend the feedback provided by the 'Psychology Expert,' who is linked to this use case. The expert's role is to give feedback that the parent must understand, suggesting a loop of review and improvement.



UC5

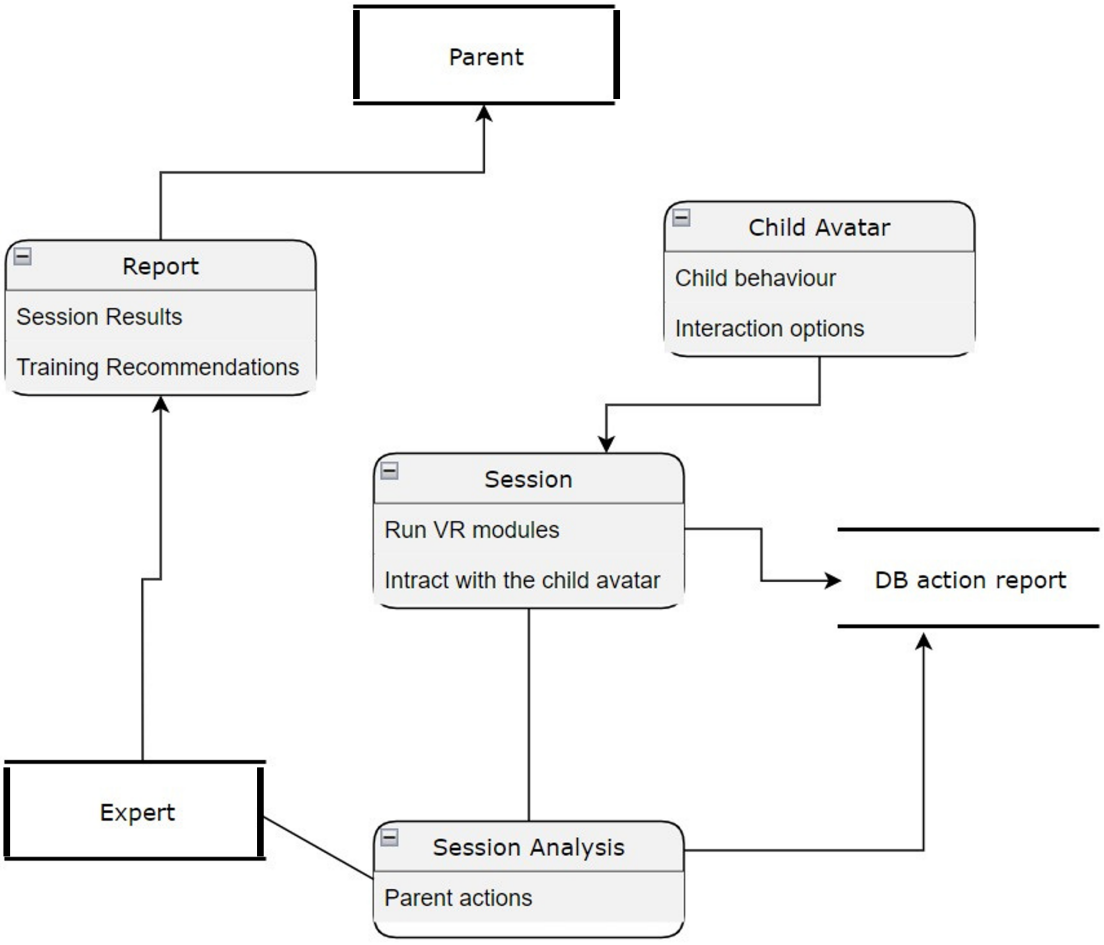
UC6

- This use case diagram illustrates the responsibilities of a 'System Moderator' in managing user accounts and overseeing the maintenance and updates of a system. The moderator is tasked with creating and editing user accounts for both 'Parent' and 'Psychology Expert' user roles. Additionally, the moderator confirms session requests, which is a separate use case connected directly to the Parent and Psychology Expert actors, suggesting that both can make such requests.

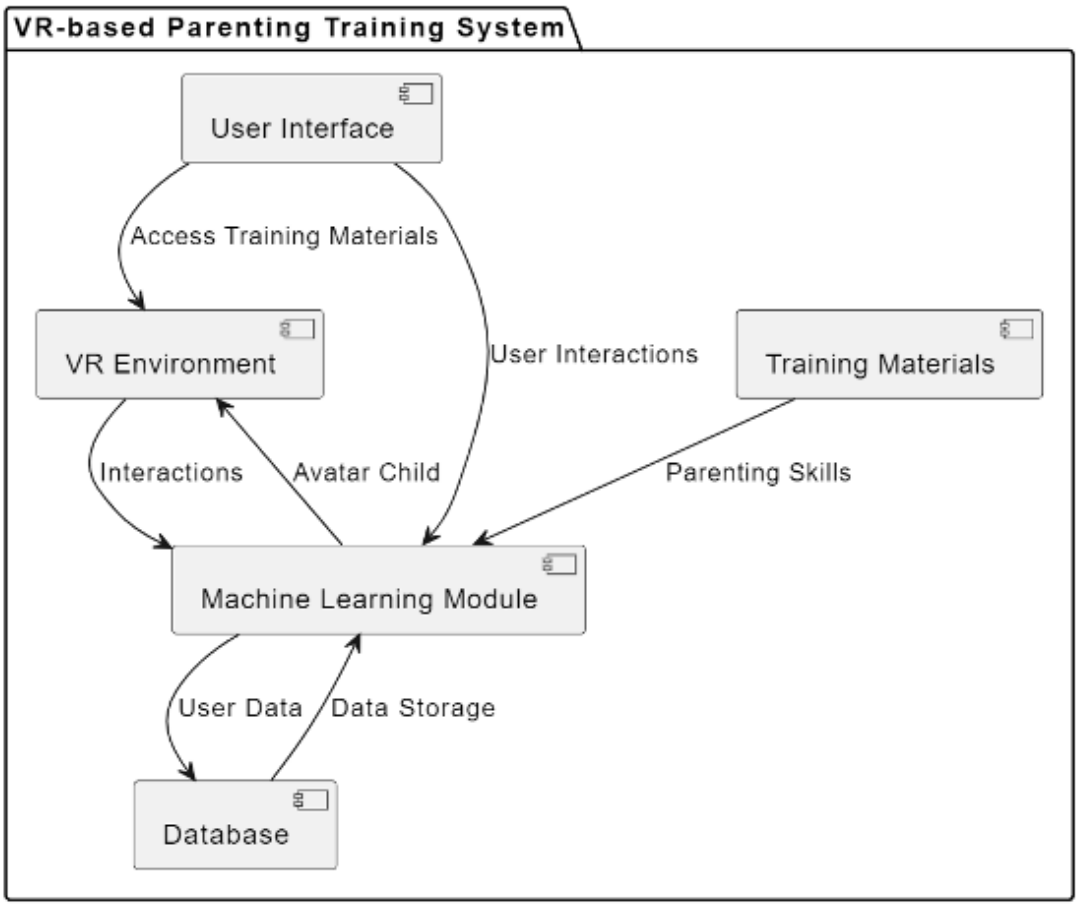

Manage Parent and Expert User Accounts & Oversee System Maintenance and Updates
Create/Edit User Accounts
<<Include>>
Parent
<<Include>>
Psychology Expert
Confirm Session Requests
Perform System Updates
Monitor System Health
System Moderator
Parent
Psychology Expert

UC6

5.6 Data Flow Diagram



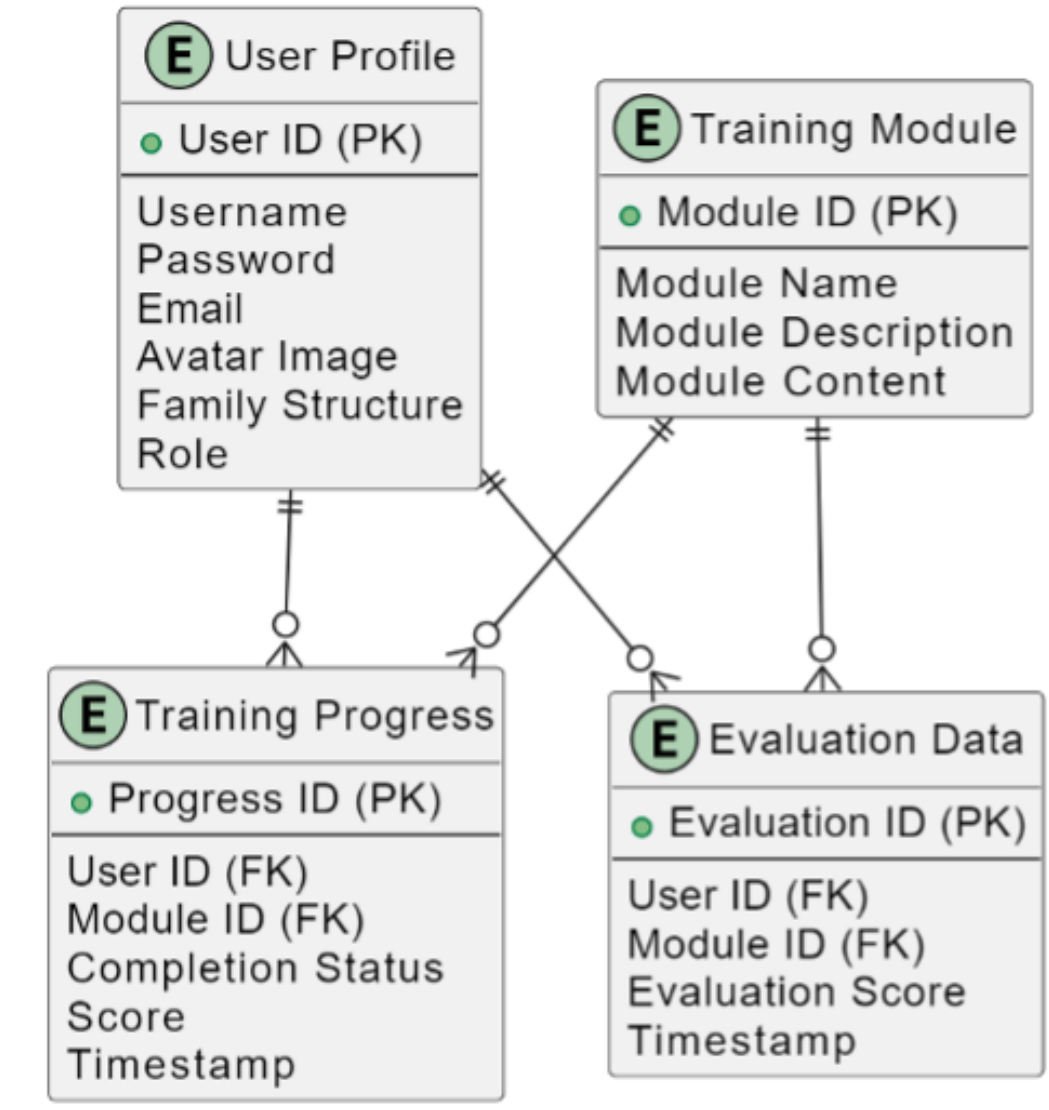
5.7 System Architecture Diagram



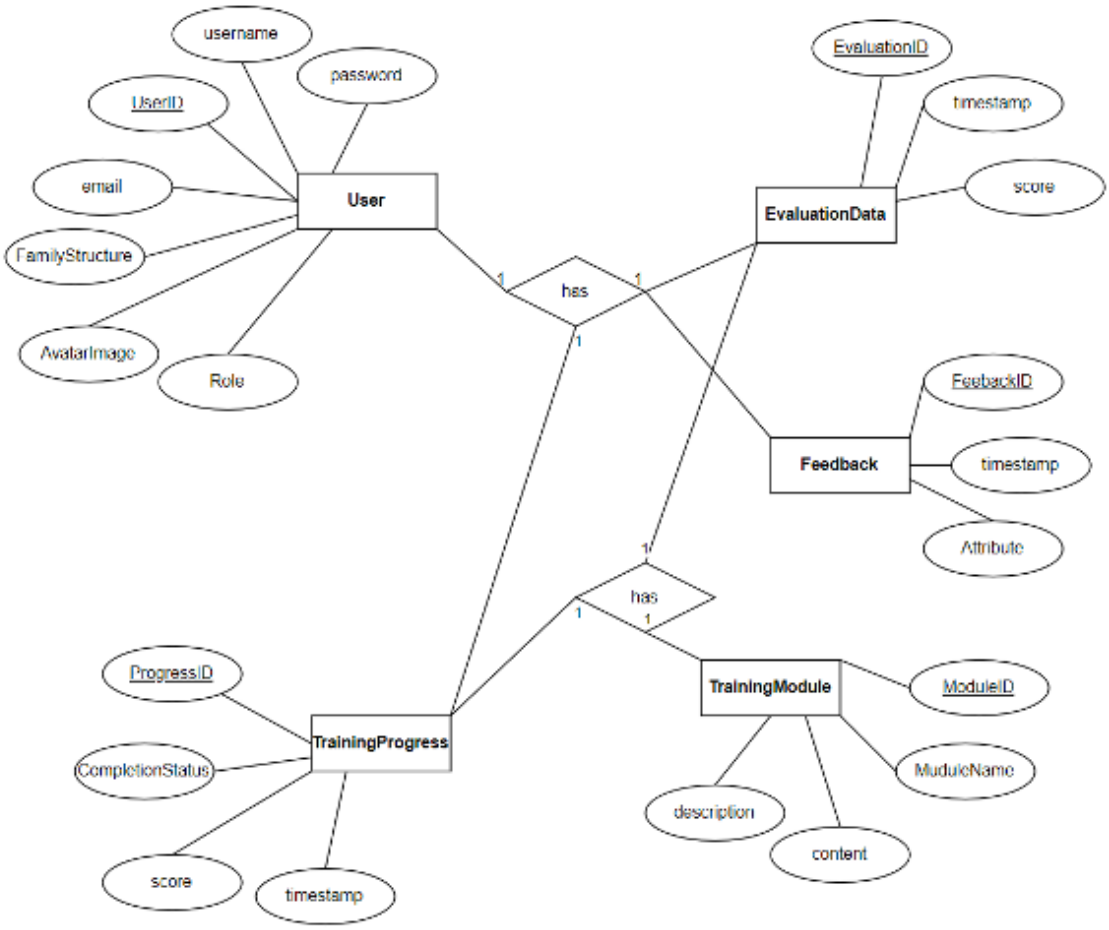
In this diagram, the VR Environment is the core component of the system, featuring immersive VR scenarios, interactive elements, customizable avatars, adaptive learning paths, and an immersive audio-visual experience. The Machine Learning Module incorporates ChatGPT for the avatar child's interactions, including speech recognition (ChatGPT + ASR) for transcribing spoken words, natural language understanding (NLU) for interpreting the context of the child's statements, gesture recognition for intuitive interaction, and emotion recognition for capturing the child's emotional responses. Training Materials encompass parenting skills training modules and expert guidance and interaction to provide parents with the necessary knowledge and skills for positive parenting.

The User Interface ensures a user-friendly VR interface, granting access to training materials and facilitating interaction with the avatar child within the VR environment. The Database stores user profiles, training progress, evaluation data, and feedback, enabling data-driven improvements and personalization of the training experience.

5.8 Database Conceptual Design



5.9 Entity Relationship Diagram



5.10 Data Dictionary

Data Dictionary	Column	Data Type	Description
User_Profile	User_ID (PK)	Integer	Unique identifier for a user.
User_Profile	Username	String	User's username.
User_Profile	Password	String	User's password.
User_Profile	Email	String	User's email address.
User_Profile	Avatar_Image	String	User's avatar image file path or reference.
User_Profile	Family_Structure	String	User's family structure.
User_Profile	Role	String	User's role.
Training_Progress	Progress_ID (PK)	Integer	Unique identifier for a training progress entry.
Training_Progress	User_ID (FK)	Integer	Foreign key referencing User_Profile.User_ID.
Training_Progress	Module_ID (FK)	Integer	Foreign key referencing Training_Module.Module_ID.
Training_Progress	Completion_Status	String	Status of the training module completion.
Training_Progress	Score	Float	User's score for the training module.
Training_Progress	Timestamp	DateTime	Date and time of the training progress entry.
Evaluation_Data	Evaluation_ID (PK)	Integer	Unique identifier for an evaluation entry.
Evaluation_Data	User_ID (FK)	Integer	Foreign key referencing User_Profile.User_ID.
Evaluation_Data	Module_ID (FK)	Integer	Foreign key referencing Training_Module.Module_ID.
Evaluation_Data	Evaluation_Score	Float	User's evaluation score for the training module.
Evaluation_Data	Timestamp	DateTime	Date and time of the evaluation entry.
Feedback	Feedback_ID (PK)	Integer	Unique identifier for a feedback entry.
Feedback	User_ID (FK)	Integer	Foreign key referencing User_Profile.User_ID.
Feedback	Feedback_Text	String	Feedback provided by the user.
Feedback	Timestamp	DateTime	Date and time of the feedback entry.
Training_Module	Module_ID (PK)	Integer	Unique identifier for a training module.
Training_Module	Module_Name	String	Name of the training module.
Training_Module	Module_Description	String	Description of the training module.
Training_Module	Module_Content	String	Content or materials of the training module.

5.11 Prototype System Components

1. User Interface (UI):

- Design and develop a virtual reality user interface for the VR parenting system.
- Create VR environments and scenes for user interaction.

- Implement UI elements such as buttons, sliders, and menus in the virtual environment.

2. Database:

- Design and create a database to store and manage user profiles, training progress, evaluation data, and feedback.
- Define tables for user profiles, training progress, evaluation data, and feedback with appropriate relationships.
- Implement mechanisms for storing and retrieving VR parenting system data.

3. Authentication and Authorization:

- Develop a login and registration system for parents to authenticate themselves in the VR parenting system.
- Implement user roles and permissions to control access to different features and functionalities.
- Ensure secure storage and handling of user credentials and personal information.

4. Training Modules:

- Design and develop interactive VR training modules for various parenting skills.
- Create VR scenarios and simulations to provide realistic parenting experiences.
- Implement interactive elements and feedback mechanisms within the training modules.

5. Progress Tracking and Evaluation:

- Develop a system to track and record parents' progress in completing the training modules.

- Implement mechanisms to evaluate parents' performance and provide feedback on their parenting skills.
- Store and analyze evaluation data to track parents' improvement over time.

6. Reporting and Analytics:

- Create reporting features to generate reports on parents' training progress and evaluation results.
- Implement data visualization tools and charts to present training performance and growth.
- Incorporate analytics capabilities to gain insights into the effectiveness of the VR parenting system.

7. Communication and Support:

- Integrate communication features, such as chat or messaging, to facilitate interaction between parents and experts.
- Provide access to parenting resources, articles, or videos within the VR parenting system.
- Implement a support system to handle user inquiries, feedback, and technical issues.

8. Security and Privacy:

- Implement security measures to protect user data and ensure privacy.
- Apply encryption techniques for secure storage and transmission of sensitive information.
- Implement user privacy settings and compliance with relevant data protection regulations.

9. Error Handling and Logging:

- Implement mechanisms to handle and log system errors, exceptions, and user-reported issues.
- Capture and store error information for debugging and system improvement purposes.
- Display meaningful error messages or notifications to guide users in case of errors.

10. Testing and Quality Assurance:

- Develop testing strategies and scenarios to ensure the functionality and performance of the VR parenting system.
- Conduct user testing and feedback collection to improve user experience and system usability.
- Implement quality assurance processes to ensure the system's reliability and stability.

5.12 Summary

In conclusion, the system design assignment covers the essential components of the VR-based parent-child interactive training program. The system architecture diagram illustrates the overall structure, while the database conceptual design and logical schema ensure efficient data management. The entity relationship diagram depicts the relationships between entities, and the data dictionary provides a comprehensive reference. Lastly, the prototype system components showcase the various elements of the program. Together, these components form a solid foundation for implementing the program, aiming to empower parents with positive parenting skills through an immersive virtual reality experience.

Chapter 6

Implementation Requirements

6.1 Introduction

The development of a Virtual Reality (VR) training platform designed to improve parenting skills through interactive engagement with a machine learning-augmented child avatar requires a specific assembly of hardware and software components. This chapter outlines the essential implementation requirements necessary to build and maintain an immersive, reactive, and educationally effective VR environment.

6.2 Software Requirements:

- VR Environment Development Platform: Unity Engine to create and simulate the VR training scenarios.
- Machine Learning Framework: TensorFlow or PyTorch for developing and integrating the machine learning models that power the avatar child's behavior.
- Integrated Development Environment (IDE): Software such as Visual Studio for writing and testing code.
- VR Software SDKs: Software Development Kits that are specific to the chosen VR headset.
- Database Management Software: A system like MySQL to handle data storage, retrieval, and management for the knowledge base.

- Operating System: A compatible operating system such as Windows 10 or a Unix-based system that supports all the above software requirements.

6.3 Hardware Requirements:

- Virtual Reality Headset: A commercially available and compatible VR headset, such as Oculus Quest or HTC Vive, to display the VR environment.
- Virtual Reality Headset: A commercially available and compatible VR headset, such as Oculus Quest or HTC Vive, to display the VR environment.
- VR Capable Computer: A computer with sufficient CPU, GPU, and RAM specifications to support VR software, such as a gaming PC with a VR-ready graphics card.
- Motion Tracking Hardware: Sensors and controllers for tracking user movements and facilitating interaction within the VR environment.
- Audio Output Device: Headphones or speakers capable of delivering clear audio from the VR environment.

Chapter 7

Evaluation and Testing

7.1 Introduction

This chapter discusses the expected outcomes and results of our senior project proposal. Although we have not yet conducted any experiments or tests, we have conducted an extensive literature review and explored various methods in the implementation of the VR-based parent-child interactive training program to formulate our approach. As a result, we have identified several potential outcomes and benefits that we expect to achieve through our project. We will discuss the potential outcomes and performance metrics we anticipate achieving through our proposed VR-based parent-child interactive training program. We will also consider its sensitivity, interpretability, deployment, scalability, and potential avenues for future research. Furthermore, we will discuss any relevant results from previous work in the field that can provide a basis for comparison and evaluation of our project's success. Overall, this chapter will outline our project's goals and objectives in terms of expected outcomes.

After conducting a thorough literature review in Chapter 2, it has become evident that traditional parent-child therapy interventions exhibit certain limitations. Nonetheless, the emerging VR technology presents a promising solution to address these limitations. Therefore, further analysis will be conducted to determine the optimal approach for addressing these drawbacks by integrating VR technology into parent-child therapy interventions.

The project's methodology includes collecting and preparing data, evaluating results through quantitative and qualitative analysis, discussing several potential models,

and deploying the program to reach the target audience effectively. The project will also conduct a critical analysis of the study's strengths and limitations and suggest future research directions.

The ultimate goal of this senior project is to implement a VR-based parent-child interactive training program to encourage positive parenting in Saudi Arabia. The expected results of the project include developing and implementing a parent-child interactive VR-based training program, and testing the program on a selected group of parents evaluating the effectiveness of VR-based training programs in improving parenting skills and addressing disruptive behavior disorders in children. These results could contribute to the development of more effective and accessible interventions for parents and children dealing with disruptive behavior disorders, potentially advancing the field of parent-child interventions.

7.2 Performance Metrics

We will evaluate the algorithm's performance using evaluation metrics [37].

- True Positive (TP): the model correctly predicts the positive class. (classifies actual obese people as obese)
- True Negative (TN): the model correctly predicts the negative class. (classifies actual non-obese people as non-obese)
- False positive (FP): the model incorrectly predicts the positive class. (classifies non-obese people as obese)
- False negative (FN): the model incorrectly predicts the negative class. (classifies actual obese people as non-obese)

$$\text{Sensitivity (Recall)} = \frac{TP}{TP + FN} \tag{7.1}$$

$$\text{Specificity} = \frac{TN}{TN + FP} \tag{7.2}$$

$$\text{Positive predictive value (PPV) - also known as Precision} = \frac{TP}{TP + FP} \tag{7.3}$$

$$\text{Negative predictive value (NPV)} = \frac{TN}{FN + TN} \tag{7.4}$$

$$\text{F-Score} = \frac{2 \times Precision \times Recall}{Precision + Recall} \tag{7.5}$$

$$\text{Overall accuracy} = \frac{TP + TN}{TP + FP + TN + FN} \tag{7.6}$$

The TP and TN rates show how often the model correctly identifies obese and non-obese individuals, respectively, while the FP and FN rates indicate how often the model makes mistakes. Sensitivity, specificity, PPV, and NPV provide more detailed information about the model's performance on different subsets of the data, which can help identify potential weaknesses or biases in the model.

7.3 Algorithm Comparison with a Baseline

In order to evaluate the effectiveness of our proposed VR-based parenting model, we will employ a range of performance metrics, including accuracy, precision, recall, F1-score, and area under the curve (AUC) [37]. These metrics will serve as indicators of how well our model is able to accurately identify the target variable and perform in a multi-class classification setting.

To ensure a thorough analysis, we will explore and compare nine different algorithms for our specific problem. By comparing our model's performance with established baselines and existing models in the literature, we aim to gain insights into its relative effectiveness. Our primary goal is to identify the algorithm that achieves a high accuracy rate of over 90

Furthermore, we will conduct a comprehensive analysis of each algorithm's performance, highlighting their respective strengths and weaknesses within the context of our problem. This detailed assessment will not only contribute to the advancement of research in this field but also provide practical guidance for practitioners working on similar problems. By sharing our findings and insights, we aim to facilitate informed decision-making and support the development of robust and effective VR-based parenting solutions.

7.4 Sensitivity Analysis

To evaluate the robustness of our proposed model, we will perform a sensitivity analysis [38]. This will involve varying the hyperparameters of the models, evaluating the performance on different datasets, or analyzing the impact of missing data. This will help us determine how sensitive our model is to changes in data or hyperparameters.

7.5 Deployment and Scalability

To ensure the practical applicability of our proposed VR-based parenting model, it is crucial to make it deployable in real-world settings and capable of handling large volumes of data. In order to achieve this, we will employ advanced techniques such as model compression, distributed training, and leveraging cloud computing services. These strategies will enable us to optimize the model's performance, enhance its scalability, and ensure its feasibility across diverse environments. By adopting these approaches, we aim to create a robust and versatile solution that can effectively handle real-time data and provide seamless experiences for parents and children in a variety of contexts.

7.6 Future Directions

Lastly, we will explore potential opportunities for future research in the field of VR-based parenting based on the outcomes of our proposed model. This may involve enhancing the model's performance, assessing its effectiveness in specific parenting scenarios, or extending its application to different types of virtual reality experiences. By identifying these avenues for future research, we aim to contribute to the continuous development and improvement of VR-based parenting practices.

In this chapter, we have presented a comprehensive analysis of the chosen algorithm, performance metrics, algorithm comparison, sensitivity analysis, deployment considerations, and scalability aspects in the development of our machine learning-based

prediction model for VR-based parenting. By addressing these key elements, our aim is to deliver valuable insights that can benefit policymakers, healthcare professionals, and parents seeking effective and immersive parenting solutions in the virtual reality domain. The timeline for the study is presented in Appendix A (see Figure A.1).

The next chapter will conclude our study by providing the conclusion and future research directions.

Chapter 8

Conclusions and Future Work

8.1 Conclusion

In conclusion, the proposed VR-based parent-child interactive training program presents a promising solution to address the limitations of traditional parent-child therapy interventions. This senior project aims to develop and implement an effective and accessible intervention for parents and children dealing with disruptive behavior disorders in Saudi Arabia. By testing the program on a selected group of parents and evaluating its effectiveness in improving parenting skills and addressing disruptive behavior disorders in children, this project could contribute to the development of more personalized and effective interventions in the field of parent-child interventions. While this project has identified several potential outcomes and benefits, further analysis is needed to determine the optimal approach for integrating VR technology into parent-child therapy interventions. Future research directions could explore the potential of combining VR-based training programs with other evidence-based interventions, using machine learning techniques to enhance their effectiveness, and applying VR technology to other areas of child development.

8.2 Future Work

Future work in the field of parent-child interventions and disruptive behavior disorders could involve conducting larger-scale evaluations of the effectiveness of VR-based training programs, exploring the potential of combining VR-based training programs

with other evidence-based interventions, investigating the use of machine learning and artificial intelligence techniques to enhance the effectiveness of VR-based training programs, conducting cost-effectiveness analyses, and exploring the potential of using VR-based training programs in other areas of child development. Mental health services can consider integrating VR-based parent training programs into their existing service delivery to improve access to evidence-based interventions for parents who may not have access to traditional face-to-face parent training programs. Collaborations between mental health professionals and VR developers can facilitate the development and design of effective VR interventions. Finally, further research is necessary to evaluate the long-term impact of VR-based interventions on children's behavior and development.

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Appendix A
Project Timeline

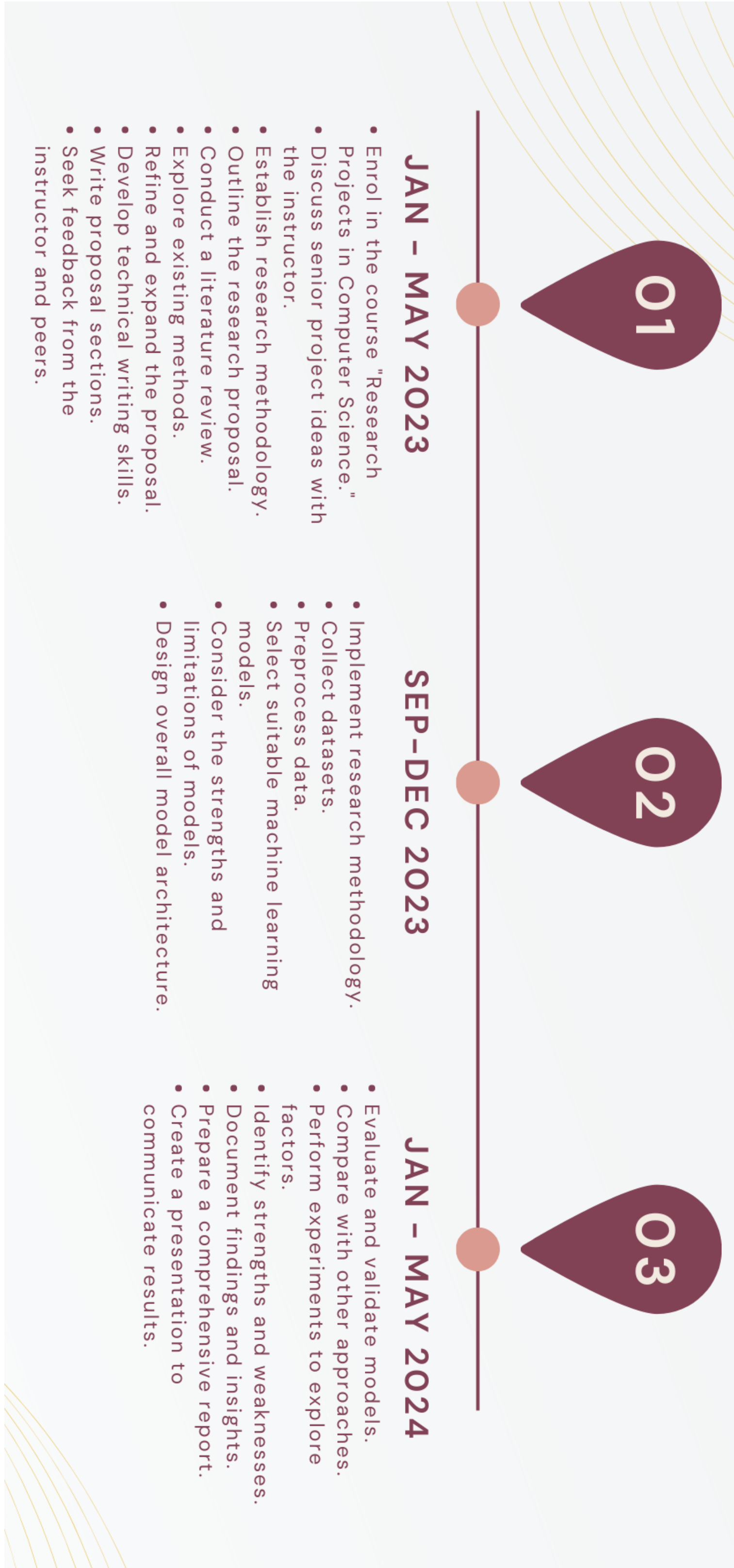

Figure A.1: Project Timeline

Appendix B

4th Undergraduate Research Forum, 2023

Longitudinal Analysis of the Effectiveness of a VR-Based Parent-Child Interactive Training Program in Promoting Positive Parenting

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Abstract*-- Disruptive behavior disorders (DBD) in children are a significant public health concern that can significantly impact a child's social, academic, and emotional development. Recent research has emphasized the importance of involving parents as the primary agents of change in treating DBD. This study compares the effectiveness of VR-based parent-child interactive training programs and traditional parenting programs in improving parent-child interactions and child behavior outcomes. The available evidence indicates that PCIT therapies, both traditional and VR-based, could potentially enhance parent-child relationships and reduce disruptive behaviors in children. Notably, VR-based therapy could offer several advantages, such as more enjoyable and engaging experiences for parents and children, as well as the opportunity to practice skills in a simulated environment before applying them in real-life situations. However, more research is necessary to increase the accuracy and validity of the findings of this study.

Keywords— PCIT, VR-based, Parenting Skills, Child Development

I. Introduction and Background

Behavior problems are a frequent factor in sending children to mental health facilities around the world. In the US, 7-9% of children are diagnosed with a behavioral issue, and such difficulties and disorders are becoming more prevalent in Western culture [1]. Children with disruptive behavior disorders (DBD) are often described as being (physically) aggressive, rebellious, and stubborn. If left untreated, disruptive behavior can lead to long-term negative consequences, such as school dropouts, peer rejection, the emergence of antisocial personality disorders, increased public expenditures on health care and education, and non-violent and violent delinquency and criminality in adulthood [2]. .

In recent years, there has been an increasing interest in the potential of virtual reality (VR) technology to support training and education in a variety of domains [3]. Implementing a VR-based Parent-child interactive training program to encourage positive parenting skills has the potential to revolutionize how parents are trained to interact with their children. VR provides an immersive and realistic experience that can simulate real-world scenarios, making it an ideal tool for teaching parents the necessary skills to respond effectively to their children's behavior [4].

The family is the basic unit of society, and the quality of parent-child interactions has a significant impact on children's development and well-being [5]. Evidence-based parent-child interventions such as Parent-Child Interaction Therapy (PCIT) [5], [6], Parent Management Training (PMT) [7], Filial Therapy [8], Child-Parent Psychotherapy (CPP) [9], and Theraplay [10] are effective in improving parent-child interactions and child mental health outcomes. However, despite their effectiveness, challenges remain in terms of the accessibility and scalability of these interventions. The use of virtual reality (VR) technology has the potential to address some of these challenges by providing a safe and cost-effective means of delivering these therapies in a controlled and immersive environment.

Interventions with parents are successful in lowering children's disruptive conduct. However, few families participate in parenting programs, indicating a need for improved access to evidence-based parenting interventions [5]. Online parenting education could greatly expand the impact of such treatments, but there are concerns that families who benefit the most from online strategies may need help accessing web-based material. Virtual Reality (VR) based parent-child interactive training [5] may solve this problem.

In Figure 1, regarding early adulthood problem outcomes [11], those with very supportive parent-child ties were much less likely than those with less supportive relationships to have recently experienced depression or anxiety (12% vs 30% vs 25%, respectively). Supportive parent-child relationships were not associated with long-term health issues, illicit drug use, binge drinking, or adolescent antisocial behavior.

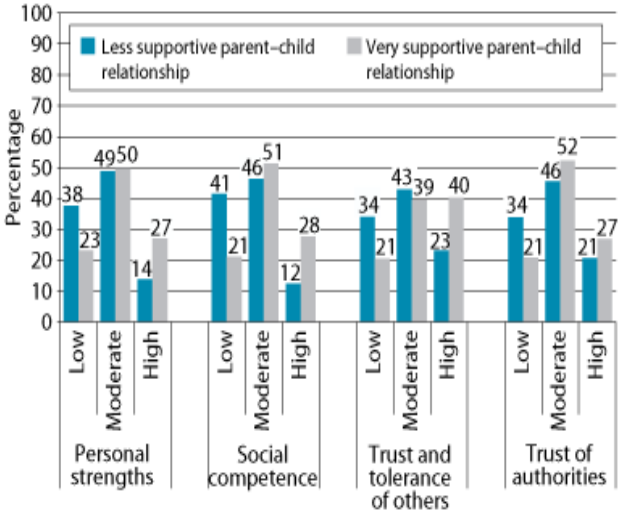

Fig. 1. Groups of 23–24-year-oldsparent–child relationships based on their level of growth [11].

Research suggests that the most effective child disruptive behavior interventions involve parents as the primary change agents [5]. Parent-Child Interaction Therapy (PCIT) [6], [11] is a therapy that focuses on improving parenting skills and has been shown to significantly improve parenting warmth, responsiveness, and efficacy over time. Parenting programs that allow parents to practice new skills with their children are more successful interventions than those that do not [11]. VR can provide a helpful aid in treatment by manipulating and controlling surroundings, showing stimuli in three dimensions, and providing immersion. It has already been used to treat eating disorders [12], substance abuse disorders [13], schizophrenia [14], PTSD [15], and anxiety disorders [16]. Therefore, incorporating VR in parenting interventions may help bridge the gap between developing parenting skills in treatment and applying them in a home setting.

This research aims to address gaps in the current literature on parent-child interventions and disruptive behavior disorders such as limited accessibility and scalability of evidence-based interventions, limited participation in parenting programs, and a need for more research on the effectiveness of VR-based training programs. The objective of this research paper is to explore the potential of using virtual reality (VR) technology in parent-child interactive training programs to encourage positive parenting skills as an effective intervention for children with disruptive behavior disorders. This study has significant potential for impact and value to society, and addresses the research question: What is the potential of using virtual reality (VR) technology in parent-child interactive training programs to encourage positive parenting skills as an effective intervention for children with disruptive behavior disorders? It aligns with Vision 2030's goal of fostering a Vibrant Society with Strong Roots and improving health and well-being (SDG#3), quality education (SDG#4), and encouraging strong institutions (SDG#16) [17], [18]. Furthermore, the use of VR technology as a new tool for parent training could revolutionize how parents learn and interact with their children. The potential to address disruptive behavior disorders in children and provide a valuable tool to prevent these adverse outcomes makes this study significant.

The rest of the paper is structured as follows: Section 2 provides a comprehensive review of the literature on disruptive behavior disorders in children and the importance of involving parents in treating these disorders. Section 3 presents the research methodology, Section 4 summarizes the main findings of the study Finally, the paper concludes with a summary of the findings and recommendations for future research in this area in Section 5.

II. Literature Review

Virtual reality (VR) technology has experienced a surge in popularity due to its increased accessibility and affordability. Ongoing developments in VR technology have resulted in the creation of more user-friendly and cost-effective interactive VR applications [3], [4]. The research community has responded positively to these advancements, with the IEEE Virtual Reality Conference receiving a record number of submissions in 2020, indicating the increased interest in VR technology [4]. This trend has contributed to the success of VR training across various industries. Notably, a recent poll [3], [4] revealed that VR training is the most widely used VR application in businesses, with a usage rate of 62%. VR training has proven to be a cost-effective solution that expands training opportunities while reducing training costs in certain fields [4]. This is due, in part, to the fact that most 3D images used in VR training scenarios are computer-generated, allowing for the quick creation of various training scenarios using pre-existing 3D assets [3]. While VR training does not guarantee reduced costs, the benefits it offers to the training audience may justify the investment expenses.

The impact of parents and primary caregivers on children's development has been the subject of several research studies. Parents and caregivers play a crucial role in shaping children's daily experiences, which has a significant influence on their cognitive, academic, and socioemotional development. In the 21st century, it is essential to understand the nature of modern parenting to comprehend children's lives. Although parenting has always been demanding and challenging, changes in family life over time have introduced new difficulties for parents. This has led to the question of whether child-rearing practices should also evolve. Consequently, many parents are unsure of how to navigate the parenting landscape successfully [1].

Disruptive behavior in young children is a common reason for mental health referrals worldwide. Research suggests that involving parents as the primary agents of change is the most effective approach to treating this behavior [19]. In the Netherlands, Parent-Child Interaction Therapy (PCIT) is a successful parent-management training program used in therapeutic settings [20]. Ongoing research is being conducted to increase the efficacy of PCIT, including using virtual reality (VR) as an additional homework component to provide parents with more opportunities to practice effective parenting techniques outside the therapeutic setting. PCIT has been shown to have a significant long-term positive impact on parental warmth, responsiveness, and the parent-child relationship [20], [21]. The use of VR allows parents to practice the techniques they have learned in the comfort of their homes [5]. However, the longitudinal analysis of the study [5] is expected to be available later in 2023, and it is anticipated that the implementation of the VR-based training program will lead to improvements in children's social behavior and a reduction in negative long-term consequences.

Brummelman et al. [2] claim that modest praise can inspire exploration. Thus, they carried out a unique virtual reality experiment. Children (N = 202, aged 8 to 12) completed a virtual reality 3D trajectory-matching activity while expressing their self-worth and received feedback on their performance after each trial. Parents either gave their kids genuine praise ("You did well!"), exaggerated praise ("You performed amazingly well!"), or no praise at all. Researchers gauged a child's motor exploration as their willingness to change course after failing [2]. When compared to receiving no praise, modest praise—as opposed to inflated praise—encouraged exploration in kids with lower self-esteem [2], [22]. In contrast, youngsters with greater levels of self-esteem were discouraged from exploring by mild praise [2], [22]. The effects were modest but substantial, and the study [2] reveals that little praise can encourage curiosity in children with poor self-esteem.

Following PCIT therapies, research has shown statistically and clinically substantial reductions in children's disruptive behaviors and non-compliance [20]. Oppositional child behaviors, parent reports of activity level, parental stress, internalizing difficulties, and children's self-esteem have all improved [6], [23]. Additionally, PCIT has been shown to enhance language development in toddlers who

have developmental delays [6]. Additionally demonstrated to generalize to childcare, preschool, and elementary classroom settings are these beneficial results. The instructor reported assessments of disruptive and noncompliant behaviors in the classroom, such as talking back to the instructor, teasing, hitting, whining, yelling, and breaking rules, have demonstrated clinically significant changes [23].

Based on these findings [6], [20], [23], it is important to consider the potential costs and benefits of VR-based training programs. While implementing VR technologies into training may be costly, the benefits to the training audience may make the investment expenses justifiable, even though VR training does not guarantee a cheaper cost [4].

Moreover, VR-based training programs may be particularly effective in contexts where parents are the main change agents in the treatment of disruptive behavior in children, such as in PCIT [5]. By including VR as an additional homework component, parents can practice effective parenting techniques in the comfort of their own homes. Finally, the study by Brummelman et al. [11] highlights the importance of providing modest praise to children to encourage exploration and curiosity. Thus, combining the findings from Brummelman et al. [11] and Gunderson et al. [22] along with the potential benefits of VR-based training programs [3], [5], it is evident that virtual reality technology can be used to enhance the effectiveness of parenting techniques and encourage exploration in children, particularly those with poor self-esteem.

Despite the effectiveness of all evidence-based interventions that aim to improve parent-child interactions and child mental health outcomes, challenges remain in terms of the accessibility and scalability of these interventions. The use of virtual reality (VR) has the potential to address some of these challenges by providing a safe and cost-effective means of delivering these therapies in a controlled and immersive environment [4], [5]. VR could allow for guided practice of positive parenting skills, virtual play sessions, and exposure to feared or traumatic situations in a controlled and gradual manner [4]. Research on the use of VR in these therapies is still in its early stages, but initial studies show promising results in terms of feasibility and acceptability. The integration of VR technology has the potential to enhance the effectiveness and accessibility of evidence-based parent-child interventions, and further research is needed to fully understand its potential impact [4], [5].

Table I summarizes the main gaps in the literature on VR-based parent-child therapy programs. The gaps include limited research on the long-term impact of VR-based training programs, the impact of VR-based training programs on children's social behavior, the use of VR in combination with evidence-based interventions, and the potential negative effects of VR-based training programs. These gaps pose challenges in assessing the effectiveness of VR training and its value in different industries, particularly in the long run. Addressing these gaps through further research is necessary to develop strategies to mitigate the potential risks associated with VR-based training programs.

TABLE I. GAPS IN THE CURRENTLY REVIEWED PAPERS

Gaps	***Description***
Lack of long-term follow-up [4]	The majority of studies had follow-up periods of 12 months or less, making it difficult to assess the long-term effectiveness of VR-based parenting programs
Limited research on the long-term impact of VR-based training programs	There is a lack of long-term research on the impact of VR-based training programs, making it difficult to assess the overall effectiveness of VR training and determine its value in the long run.
Limited research on the impact of VR-based training programs on children's social behavior	There is a lack of research on the impact of VR-based training programs on children's social behavior, and whether they can effectively address disruptive behavior in children and improve their social behavior.
Limited research on the use of VR in combination with evidence-based interventions	There is a lack of research on the use of VR in combination with other evidence-based interventions to determine whether VR can enhance their effectiveness.
Limited research on the potential negative effects of VR-based training programs	There is a lack of research on the potential negative effects of VR-based training programs, such as motion sickness or increased anxiety, and more research is needed to assess potential risks and develop strategies to mitigate them.
Cost and implementation	VR-based training programs might be expensive especially when used by individuals, and implementation of VR-based training methods by individuals is not guaranteed to have a considerable impact.

III. RESEARCH METHODOLOGY AND DATA

The methodology for this study involved a systematic search of relevant scientific databases, including Scopus, Lens.org, Effat Library, PubMed, PsycINFO, and Google Scholar. The search terms used included "disruptive behavior disorders," "VR-based parent-child interactive training program," "traditional parenting programs," "virtual reality," "parent-child interaction," "positive parenting," "training program," "longitudinal analysis," and related terms. Only peer-reviewed articles written in English and published between 2010 and 2023 were included. Studies that focused on the effectiveness of virtual reality-based parent-child interactive training programs designed to promote positive parenting practices were included, while studies that did not focus on virtual reality, parent-child interaction, positive parenting, training programs, or longitudinal analysis, studies that were not peer-reviewed, and studies published before 2010 were excluded.

A qualitative analysis and discussions of the most relevant papers were conducted. However, a quantitative analysis of a larger scope of work was conducted on Lens.org and Scopus using the combination of the following keywords ("disruptive behavior disorders" OR ("VR-based parent-child interactive training program" OR ("traditional parenting programs" OR ("parent-child interaction" OR "positive

parenting")))) AND ("virtual reality" OR ("training program" OR "longitudinal analysis")).

Based on Figure 2, obtained from Lens.org [24], it is evident that there is a growing interest in the use of virtual reality technology in parent-child interactive training programs. The figure shows an increase in publications on this subject over the past decade, indicating that researchers are recognizing the potential of VR technology as a tool for improving parent-child interactions and addressing disruptive behavior disorders in children.

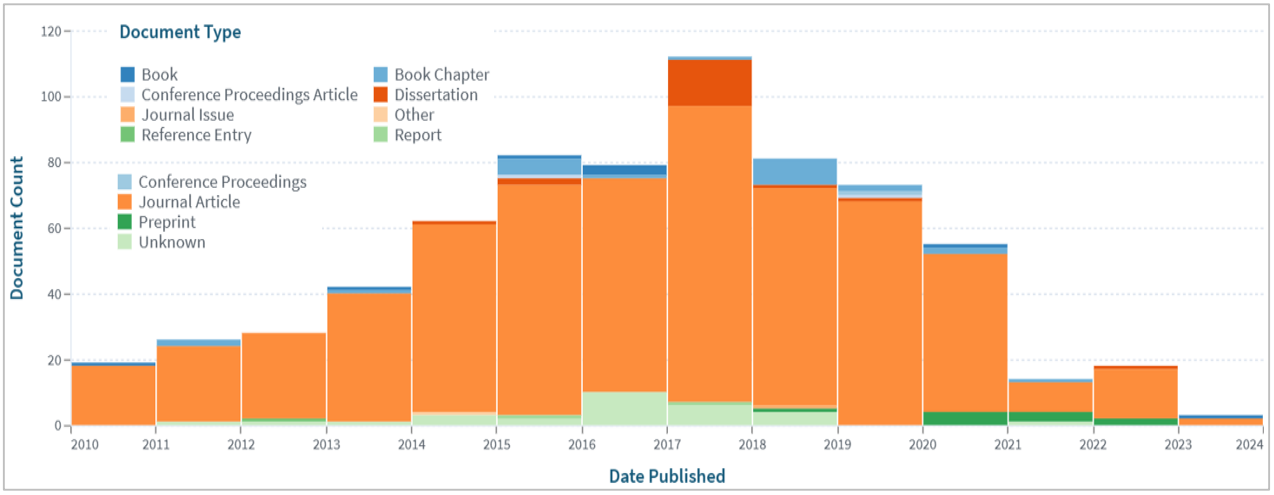

Fig. 2. Numbers of publications from 2010 to 2023 based on lens.org.

Ethical considerations were considered throughout the study. This research did not involve direct contact with human participants or the use of personal data and focused on analyzing existing research. However, we ensured that the selected studies followed ethical standards and guidelines, such as obtaining informed consent, protecting the confidentiality and anonymity of participants, and avoiding harm or exploitation. Potential limitations in the literature that could impact our analysis and interpretation of the findings were also acknowledged.

In this study, the research findings are presented utilizing various formats, including data, tables, and figures as described in the next section.

IV. Results and Discussion

By applying the keywords combination indicated in the previous section, Figure 3 [25] shows that Psychology, Medicine, and Social Science were the most three common topics and make up 87.9% of all subject areas.

Figure 4 [25] VOSviewer was used to illustrate a network visualization of the authors' keywords occurrence. It's observable that keywords like "parent training", "parenting", "parent-child interaction", "disruptive behavior disorder", and "technology" had the most co-occurrence. These findings point to a lack of efficient digital visualizations and VR implementations in this field.

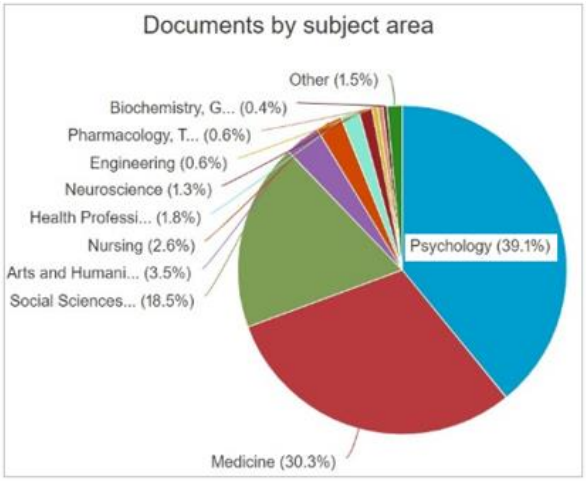

Fig. 3. Chart of papers by subject area based on Scopus.

Parent management training (PMT) is the gold standard for treating child behavior issues. Despite evidence that parents of children with behavior problems usually struggle personally, the secondary impacts of these therapies, particularly on parent well-being, are rarely researched. In 48 controlled treatment studies, this narrative review assessed the affective and parenting cognition effects of PMT for mothers and fathers of children aged 2 to 13 years. After PMT, there was strong evidence to support decreases in parenting stress and gains in perceived parenting competence. Evidence showed that areas farther removed from parenting, such as parent depressive symptoms and marital relationship dysfunction, showed less change [26].

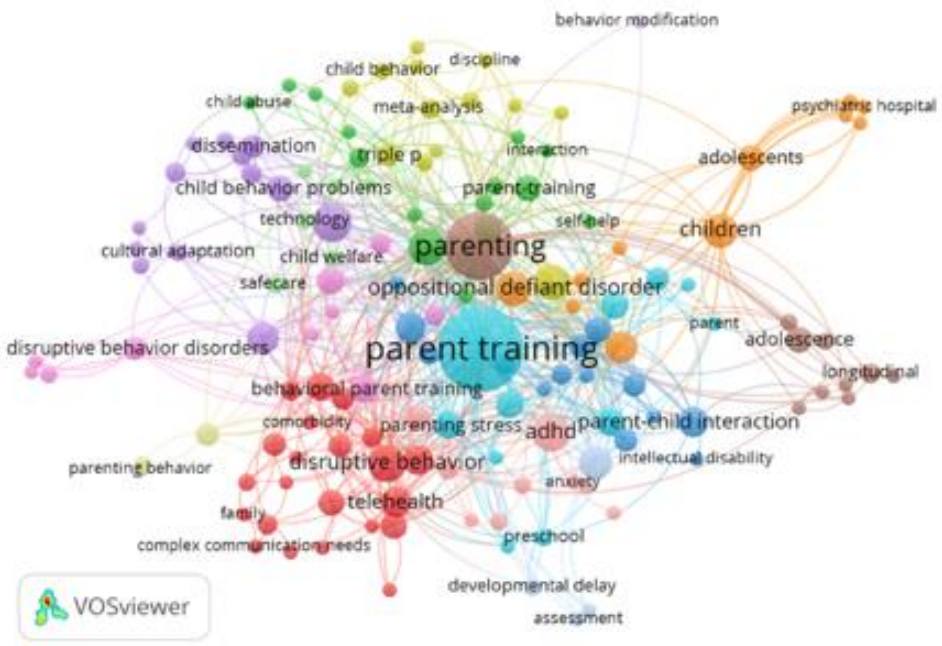

Fig. 4. Network Visualization of the authors' keywords based on Scopus.

Table II summarizes five evidence-based parent-child interventions, including Parent-Child Interaction Therapy (PCIT), Parent Management Training (PMT), Filial Therapy, Child-Parent Psychotherapy (CPP), and Theraplay, and their potential applications in virtual reality (VR) settings. Each therapy focuses on different aspects of improving parent-child interactions and child mental health outcomes, but all face limitations in terms of accessibility and scalability. The use of VR has the potential to address some of these challenges by providing a safe and cost-effective means of delivering these therapies in a controlled and immersive environment. The table also identifies the limitations of each therapy and how VR technology can address them. This information is valuable for clinicians and researchers interested in the use of VR technology to enhance the effectiveness and accessibility of evidence-based parent-child interventions.

TABLE II. EVIDENCE-BASED PARENT-CHILD THERAPIES AND THEIR POTENTIAL VR APPLICATIONS AND LIMITATIONS

Therapy	***Description***	***Potential VR Application***	***Limitations***	***How VR Can Address Limitations***
Parent-Child Interaction Therapy (PCIT) [4, 12]	Behavioral intervention to improve parent-child interactions	Realistic virtual environment for parent training	Limited access to trained therapists	Increases accessibility and reach of therapy
Parent Management Training (PMT) [7, 13, 17]	Teaches parents positive reinforcement and management techniques	Virtual environment for parent training and communication practice	May not address underlying issues	Can be combined with VR exposure therapy to address underlying issues
Filial Therapy [14]	Coaches parents to conduct child-centered play sessions	Virtual play environment for parent-child coaching	Limited generalization to the home setting	Can provide in-home VR coaching for generalization
Child-Parent Psychotherapy (CPP) [15]	Improves relationship between young children and caregivers after trauma	Virtual exposure therapy gradually expose children to feared situations	Exposure therapy may not be enough	Can be combined with other VR interventions, such as coping skill practice
Theraplay [16]	Builds healthy attachment through play and physical touch	Virtual physical play and structured games	Limited access to trained therapists	Increases accessibility and reach of therapy

In the field of mental healthcare, human-computer interactions are a novel form of therapy. An intriguing example of a digital tool that can be employed in the treatment of mental problems is virtual reality technology. It might help in developing personal skills or overcoming deficiencies. The article [27] lists several effective VR applications in psychology and psychiatry. VR has been proven to be useful in the treatment of schizophrenia, PTSD, eating disorders, and substance use disorders [27].

This study aimed to examine the effectiveness of a VR-based parent-child interactive training program for promoting positive parenting skills through a longitudinal analysis. While the study is still ongoing, we expect that the implementation of the program will lead to improvements in children's social behavior and a reduction in negative long-term consequences, such as school dropouts and criminal behavior. By providing parents with a realistic virtual environment, guided by child development experts, we anticipate that parents will be able to develop positive

parenting skills that will foster more effective interactions with their children.

However, we acknowledge that this study has limitations. The results of the study [5] will not be available until later in 2023. Additionally, this study's focus is limited to virtual reality-based parent-child interactive training programs designed to promote positive parenting practices, and studies that do not meet this criterion have been excluded. Nonetheless, this study's results will contribute to the growing body of research that examines the effectiveness of using VR technology as a tool for parent training programs and its potential impact on children's behavior and development.

Based on these findings, several recommendations can be made to maximize the potential of VR technology in parent training programs. Firstly, future research could investigate using VR technology to manage children's emotions and behavior and enhance communication skills between parents and children. Secondly, mental health services can consider integrating VR-based parent training programs into their existing service delivery to improve access to evidence-based interventions for parents who may not have access to traditional face-to-face parent training programs. Thirdly, collaborations between mental health professionals and VR developers can facilitate the development and design of effective VR interventions. Finally, further research is necessary to evaluate the long-term impact of VR-based interventions on children's behavior and development.

V. Conclusion and Recommendation

This study have shown that a VR-based parent-child interactive training program can be a promising tool for promoting positive parenting skills and improving parent-child interactions. The analysis emphasized the importance of early intervention in addressing disruptive behavior disorders in children and highlighted the potential benefits of evidence-based interventions, such as PCIT and PMT.

VR technology is recommended to be used to manage children's emotions and behavior, improve access to evidence-based interventions, facilitate collaborations between mental health professionals and VR developers, and evaluate the long-term impact of interventions.

The study's findings have significant implications for mental health care and parent training programs. The use of VR technology in parent training programs has the potential to revolutionize how parents learn and interact with their children and prevent adverse outcomes in children. Policymakers, mental health professionals, and researchers should consider the recommendations above to maximize the potential of VR technology in promoting positive parenting practices and improving child outcomes.

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