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STUDENT’S PERCEPTIONS OF THE ROBOT’S POTENTIAL TO ALLEVIATE ANXIETY AND PANIC DISORDERS

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ABSTRACT

Eishika Hossain Omi: Student's Perceptions of The Robot's Potential to Alleviate Anxiety and Panic Disorders
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Today, technology has become an essential part of our daily lives, and mental health settings are no exception. We have been incorporating computers, mobile devices, and wireless devices into every aspect of our lives for years. Recently, The application of social robots has become prevalent in diverse areas, such as food delivery services, health services, and even the education service. However, utilizing human-centred robot design to enhance mental health and well-being is a relatively unexplored area. With the rapid advancement of technology, this new topic of social robots presents an exciting area worth exploring further.

In this research, we investigate the rising prevalence of anxiety and panic disorders among students and dive into the potential of robots as a supportive tool. While academic pressure can amplify anxiety and panic disorders among students, research shows that it can occur during childhood and adolescence. Social robots offer a unique approach for their consistent, unbiased, and reassuring nature, marking a promising novel avenue for intervention. Based on the literature review, most of the previous work on students' mental wellness supported by social robots has been conducted from the perspectives of coaches, psychologists, and educators. However, this analysis raises an essential question regarding mental health well-being involving social robots: how much are the perspectives and experiences of students accurately reflected?

The main goal of this research is to give priority to the perspectives of students, who are the primary users of social robots, with the goal of reducing anxiety and panic disorders. It is a comprehensive investigation into their perceptions, expectations, and requirements for these interventions. Furthermore, the research endeavours to evaluate the level of trust that people have in social robots and how well they can help in mitigating symptoms of anxiety and panic disorders. The latter part of the analysis is dedicated to pinpointing the qualities and features students consider appealing in social robots intended for these purposes. The study seeks to gather valuable insights from end-users.

The research methodology involves four strategic phases. The first phase is an extensive literature review to explore the intersection between mental health and social robots. This review involves analyzing many academic sources to chart the existing landscape, identify gaps, and assess the potential for social robots as therapeutic tools, particularly for students. This exploration forms a fundamental framework that emphasizes the creation of robotic designs that cater to the specific needs of students. As part of the research's second phase, sixteen high school students were engaged in focus groups and co-design sessions to gather feedback with the help of NAO robot- a social robot. This qualitative technique provided a deeper understanding of the students' needs and highlighted any potential obstacles that could hinder the robot's acceptance.

The knowledge obtained in this stage was crucial in directing the subsequent design phase. Following the pre-study session with sixteen high school students, a low-fidelity prototype of EMO-Dump was developed based on the results. EMO-Dump is a social robot that aims to assist individuals in coping with anxiety and panic disorders. A team of nine university students collaborated to refine the prototype of EMO-Dump further, incorporating feedback from the previous user study. This collaborative and iterative approach ensured that the final high-fidelity prototype was developed with the intention of being easy to use, showing understanding and care towards the users, and specifically meeting the requirements of students.

The results of this research are multi-faceted, contributing to developing guidelines for integrating social robots into mental health, identifying their limitations, and creating a high-fidelity prototype of a social robot in this instance. This study aims to pave the way for designing more intuitive, empathetic, tailored, and effective robot-assisted interventions, thereby advancing student mental health and well-being.

To summarize, this thesis proposes a unique combination of technological advancement and empathetic design. It utilizes student perspectives to create a social robot prototype that can effectively support mental health among students. The objective of this research is to establish the significance of social robots in therapeutic interventions by offering a fresh approach to support students, which can help enhance their mental well-being and academic success.

Keywords: Social Robot, Robot for Mental Wellbeing, Human-Robot Interaction, Robotic Coach

The originality of this thesis has been checked using the Turnitin Originality Check service.

PREFACE

“Fret not where the road will take you, instead concentrate on the first step. That’s the hardest part and that’s what you are responsible for. Once you take that step let everything do what it naturally does, and the rest will follow. Do not go with the flow. Be the flow.” - Elif Shafak

Writing my thesis was a rollercoaster ride with both good and bad times, but it proved to be one of the most enjoyable learning experiences for me. The journey started off rough with the loss of people I loved, which made me depressed. Additionally, I kept getting sick due to the cold weather in Finland which made me more worried and stressed, especially with all the deadlines. However, I am grateful for my supervisor, Aino, who supported me every step of the way with kind words. With Aino's help, this thesis was much simpler.
I chose Elif Shafak's quote because he is my favourite author. In terms of my thesis, I believe that everyone must start somewhere in life. My thesis topic, which focuses on how students perceive on robot’s potential to help with anxiety and panic disorders, is also a novel topic. After conducting the pre-study with high school students and reviewing other research, I was not sure if I would find enough information to support my thesis, but I did. With the first step taken and with the support of my supervisor, my friends at Robostudio, I finally completed my thesis. I want to extend a big thank you to everyone for their encouragement.
I also want to express my gratitude to all the students and friends who participated in my research and shared their thoughts. I am also very thankful to Tampere University for allowing me to pursue my master's degree in Human-Technology Interaction, HTI (tech) which was a dream come true.

I am immensely grateful to my family and friends in Finland and Bangladesh who have been my constant support throughout my academic journey. I am indebted to my Baba-Mum and Aditi for their unwavering encouragement and guidance. I am also profoundly thankful to Rajib, Anushka, Farah, Evana, Lawrence, Jitu, Shreya, Aditya, Shilpa, Nischal, Ornob, Husnain, Waqas, and Natalia for their invaluable support and presence in my life. I would also like to remember my grandparents, who are no longer with us but whose blessings and prayers continue to be the source of my strength and inspiration.

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LIST OF SYMBOLS AND ABBREVIATIONS

PD	Panic Disorder
GAD	Generalized Anxiety Disorder
ASD	Autism Spectrum Disorder
SARs	Socially Assistive Robots
HCD	Human-Centered Design
HRI	Human-Robot Interaction
AI	Artificial Intelligence.
GUI	Graphical User Interface

1. INTRODUCTION

Anxiety disorders are one of the most prevalent mental health conditions among students from all age, making this topic highly intriguing and deserving of attention. These disorders can profoundly disrupt academic and personal development, with social anxiety often first appearing during childhood or adolescence and potentially persisting into adulthood (Beesdo et al., 2009). Moreover, panic disorder frequently arises during the academically and emotionally demanding periods of school and college life. Notably, a significant portion of the student population experiences elevated anxiety without meeting full diagnostic criteria, yet these experiences still adversely affect their educational outcomes and well-being (Weems & Stickle, 2005). The burgeoning incidence of anxiety-related issues among students and their consequential impact on academic success and quality of life underscores the necessity for innovative and accessible interventions.

With the rapid evolution of technology, novel approaches to mental health support have emerged. Social robots, designed for interactive and engaging experiences, represent an innovative application with the potential to address student anxiety and panic disorders in educational environments (Riek, 2017). With sensors and artificial intelligence, these robots can understand and respond to students' feelings. This means that they can provide consistent support without the biases that come with human interactions. Introducing social robots in educational settings is more than just an auxiliary measure. However, it could be the primary way to help, especially when human therapeutic resources are limited or not used enough because of shame or difficulty getting to them (Breazeal et al., 2016).

This thesis explores the perspectives of students on the efficacy and acceptability of social robots to alleviate symptoms of anxiety and panic disorders. The research aims to help make mental health support in students more useful, engaging, and fair by discovering how students feel about and interact with these robotic interventions.

1.1 Background and Motivation

Anxiety and panic disorders are becoming increasingly prevalent among school students, affecting both their academic performance and overall well-being (Alves-Oliveira et al., 2019). Given the high incidence of mental health issues among students, it is crucial to explore and implement innovative interventions that can provide effective support. Recent technological advancements have introduced robots as potential tools for addressing mental health challenges in educational settings.

Robots are emerging as a unique and innovative means of support for students experiencing anxiety and panic disorders. Their inherent characteristics enable them to perform diverse tasks and facilitate interactions that potentially reduce anxiety symptoms. Robotic technologies can provide a safe and welcoming learning environment for students, especially those dealing with mental health issues. The technology's consistent and non-judgmental presence could be highly beneficial for such students. According to Alves-Oliveira et al. (2019), Scassellati et al. (2012) and Belpaeme et al. (2018) robotic technologies can cater to the specific needs of students dealing with mental health issues. According to Belpaeme et al. (2018), as robotic technologies are increasingly utilized in educational interventions for mental health support, they are emerging as a dependable and impartial approach to aiding students in need.

Despite the increasing interest in using robots in the classroom, research has focused on evaluating their effectiveness from the educators and professionals' perspective. However, there has been little attention given to understanding students' viewpoints on the potential of classroom robots as a support mechanism for anxiety and panic disorders. This research gap underscores the importance of exploring students' perceptions, expectations, and experiences to develop student-centered robot-assisted interventions.

The objective of this research is to investigate and gain insights into the perspectives of students regarding the use of robots as a means of supporting anxiety and panic disorders. According to Scassellati et al. (2012), the present study seeks to address the knowledge gap by engaging directly with students who have firsthand experience with these conditions and aims to contribute to developing more effective approaches. Understanding how students perceive the potential of classroom robots, their expectations regarding functionalities and interactions, and their experiences and feedback will be invaluable in informing educators, researchers, and practitioners. Understanding this topic would make it easier to produce interventions that are empathetic, tailored, and flexible enough to meet the needs of students in school who are dealing with anxiety and panic disorders.

The study seeks to contribute to the existing literature by investigating the perspectives of students on the use of robots. First, it will provide a comprehensive understanding of students' perceptions, shedding light on their attitudes and beliefs regarding the potential benefits and limitations of robot-assisted interventions. Second, it will uncover students' expectations regarding the functionalities and interactions of classroom robots, providing insights into the specific features and qualities that students value. Finally, by exploring students' experiences and feedback, this research will identify practical considerations and potential areas for improvement in implementing robot-assisted support mechanisms.

Overall, this study aims to pave the way for the development of more effective, student-centered interventions for anxiety and panic disorders in educational settings. This study seeks to contribute to the ongoing efforts to promote mental health and well-being among students by investigating the potential of classroom robots from a student perspective. This research gap aims to provide valuable insights into the role of robots in mental health well-being.

1.2 Research Objectives and Research Questions

To achieve the research goals, we will employ a qualitative research methodology, including in-depth interviews and focus groups with students who have personal experience with anxiety and panic disorders in educational settings. Thematic analysis will be used to analyze the collected data, identifying recurring themes, patterns, and valuable insights.

<u>Research Questions</u>

1. What are the perceptions of young people for using social robots for coaching anxiety and panic disorder?
    i. What are their perceptions of trust towards the robot in this context?
    ii. How do students perceive the effectiveness of social robots for anxiety and panic disorder in educational settings?

iii. What are the possible concerns and limitations of using social robots in coaching anxiety and panic disorder?

2. What are their preferred features and characteristics of the social robots for coaching anxiety and panic disorder?

As students are the primary users for this thesis. The anticipated responses to the research questions will be derived from the insights gained during the two user studies focusing on young individuals, specifically high school, and university students. The goal is collaborating with sixteen high school students during the pre-user study and co-design workshop. Together, we will design a unique robot tailored to their specific needs and expectations. For a comprehensive understanding an understanding and to further refine the initial robot prototype created based on insights from the pre-user study and co-design workshop, a subsequent phase of design evaluation and follow-up co-design will be undertaken with nine university students. The objective is to gain a thorough understanding of our primary user and build a robot that meets their expectations and needs.

1.3 Structure of Thesis

The rest of the thesis is organized as follows: Chapter 2 provides an overview of the related work that supports the thesis, and it includes four sub-sections: Anxiety and panic disorders, social robots, social robots in mental well-being, and a summary of the literature review.

Chapter 3 discusses the research Methodology, including research approaches, participants and research ethics, data collection methods, data analysis methods, and the research platform. In the Participants and Research Ethics section, there is a sub-section called Observation Studies and Note Taking. Furthermore, in Research Platforms, there are three subheadings: Nao robot, Temi Robot, and Choregraphe application.

Chapter 4 consists of User Studies, which are divided into three subheadings: Pre-study and Co-design Workshop, Design Evaluation and Follow-up Co-design Workshop, and Data Analysis Method. Each workshop chapter includes Procedure, Data

Collection, and Findings. All the findings from the workshops resulted in the Data Analysis Method.

Chapter 5, EMO-Dump, is the design part of the thesis. It includes a Storyboard, a Low-Fidelity Prototype, High-Fidelity Prototype, and design and justification from the findings.

Chapter 6, Evaluation includes the whole design procedure, participants and ethical considerations, data collection method, data analysis method, findings from the two user studies, and a summary of the whole evaluation. Chapter 7 lists guidelines for implementing social robots in mental well-being. Chapter 8 Discussion includes one subsection that has limitations and future work. Lastly, Chapter 9 provides for the conclusion of the research. Chapter 10 provides for the appendices of the consent form and questionnaires.

2. RELATED WORK

This chapter provides a literature review centered on the thesis's core themes. Section 2.1 delves into Anxiety and Panic Disorders, Section 2.2 explores Social Robots, and Section 2.3 examines the role of Social Robots in Mental Health Well-being.

Subsequent chapters will further elaborate on the interconnections between these concepts.

2.1 Anxiety and Panic disorders

Anxiety disorders hold a notable position in the domain of mental health, often manifesting through symptoms such as intensified fear, panic episodes, excessive sweating, and an accelerated heartbeat. Specifically, Panic Disorder (PD), a subset of anxiety conditions, is characterized by abrupt and inexplicable bursts of intense panic, encompassing both cognitive and physical symptoms. Such episodes can significantly disrupt an individual's sense of well-being. Historically, the recognition of 'panic' as a psychiatric symptom predates the establishment of formal diagnostic guidelines for PD in 1980 (Davidoff et al., 2012).

According to the Intolerance of Uncertainty Model proposed by Behar et al. (2009) and Dugas et al. (2007), the inability to accept uncertainty is a crucial factor in the development of Generalized Anxiety Disorder (GAD). This model holds a central position in the discourse on anxiety. Given that worry tends to manifest in situations laden with ambiguity, comprehending an individual's relationship with uncertainty is vital in deciphering and addressing extreme worry (Koerner et al., 2016). Recent research offers alarming insights into the psychological health of students. Based on a study conducted by Eisenberg et al. (2007), 15.6% of undergraduates and 13.0% of graduate students exhibited symptoms consistent with anxiety or depression disorders as assessed by the Patient Health Questionnaire.

This burgeoning prevalence of anxiety and panic disorder symptoms in the student demographic has spurred increased attention and research initiatives. Such prevalence is concerning, particularly given the transitional nature of the academic phase — a period marked by newfound independence, academic pressures, social dynamics, and career apprehensions. A study by Blanco et al. (2008) revealed that while school years can be immensely enriching, they are also accompanied by increased vulnerability to mental health challenges, often exacerbated by the lack of adequate coping mechanisms. Also, the stresses that students go through during transitions, like getting used to unfamiliar places, balancing school, and personal obligations, and dealing with money problems, can be potent triggers for anxiety disorders (Hysenbegasi et al., 2005). Furthermore, the onset of anxiety disorders during these formative years can have long-lasting implications, not only hindering academic performance but also affecting future career trajectories and interpersonal relationships. Efforts have been initiated across campuses globally to address this escalating concern. Mental health support systems, such as counseling services, peer support groups, and stress management workshops, are receiving increased investment from institutions. Nevertheless, early detection and intervention remain crucial. The integration of regular mental health check-ups, akin to academic evaluations, might be a step in the right direction, ensuring that students receive timely assistance, fostering a more holistic educational experience (Reavley et al., 2018). As the academic community becomes more attuned to these challenges, a concerted effort is essential to ensure the well-being of its members.

2.2 Social Robots

Social robots are meticulously designed to mimic human interactions, distinguishing them from traditional service robots. These robots are classified as 'social,' inspired by their unique communication styles and behavior in social contexts, as defined by Hegel et al. (2009). At their core, social robots integrate classical robotic functionalities with advanced social interaction capabilities, creating a harmonious blend of technology and sociability. Hegel et.al (2009) emphasizes critical design attributes, making robots seem more approachable and fostering spontaneous human-robot interactions.

The design complexities of social robots necessitate a multidisciplinary constructive interaction, incorporating insights from psychology, design, engineering, and anthropology. A profound comprehension of human behavioral tendencies and socio-cultural conventions significantly influences robot development, ensuring that the resultant robots are technically proficient and socially attuned (Fong et al., 2003). A notable challenge resides in aligning functionality with relatability. Robots must execute tasks efficiently, but their overarching success is contingent upon human acceptance and sociability.

According to Breazeal (2004), research has indicated a positive correlation between a robot's ability to interact like a human and its reception, leading to enhanced collaboration and trust. However, the phenomenon of the "uncanny valley" presents a paradox whereby hyper-realistic robots may unintentionally evoke feelings of discomfort or eeriness (Mori et al., 2012). Social robots have been utilized in diverse sectors such as education (Smakman et al., 2021; Hyun et al., 2010; Kozima et al., 2008; Tanaka et al., 2007), customer service (Nakanishi et al., 2020; Mubin et al., 2018), and healthcare (Wada & Shibata, 2006a, 2007; François et al., 2009). In the context of education, facilitators play a crucial role in enhancing learning experiences through interactive sessions and personalized assistance, leading to more effective learning (Alemi et al., 2017; Jones et al., 2014). Furthermore, social robots have been found to have the potential to benefit teachers by improving their job satisfaction (Shih et al., 2007).

In the dynamic domain of customer service, social robots have carved out distinctive roles, enhancing user interactions by guiding, responding to queries, and augmenting the overall customer journey. Particularly evident in the retail and hospitality sectors, the integration of these robots has resulted in notable shifts in service delivery (Ivanov et al., 2017). The growing interest in these robots has sparked numerous investigations into their efficacy and performance in varied service scenarios. For instance, their competence has been assessed at information desks, offering insights into how they manage queries and guide users in bustling environments (Nieto et al., 2014). Another dimension of research has delved into their ability to broadcast information, with studies examining both direct and indirect interactions in high-traffic areas like hotel lobbies (Pan et al., 2015). Additionally, their utility extends to collecting customer feedback, a critical aspect of the service industry, helping businesses fine-tune their offerings based on real-time inputs (Chung & Cakmak, 2018). To encapsulate, as customer service paradigms evolve, social robots are emerging as influential players, redefining how businesses interact with and serve their client.

In the rapidly evolving landscape of healthcare, social robots have emerged as a transformative solution, playing pivotal roles in patient care, companionship, and therapeutic interventions, underscoring their multifaceted utility (González-González et al., 2021). The development and deployment of robots in healthcare requires adherence to ethical principles. Panico et al. (2020) identified fundamental values that should be prioritized, including self-governance, doing good, avoiding harm, loyalty, fairness, usefulness, and self-sufficiency. dressing the global challenge of a scarcity in specialized medical professionals, social robots have shown potential in undertaking various tasks. Yet, their integration into hospital settings demands a meticulous and principled approach to ensure they complement rather than complicate healthcare provision (Beane, 2020). Clinical applications of these robots have spanned various domains: from assessing harm in autistic children, aiding elderly caregivers in professional capacities, assisting individuals with motor impairments, to even mediating patient-healthcare provider interactions (Moerman & Jansens, 2020c). Their versatility also extends to rehabilitation, where they can act as in-home therapists (Benedictis et al., 2020), perform administrative roles like hospital reception (Turja & Parviainen, 2020), and facilitate tasks such as medication reminders, entertainment provisions, and video conferencing support (Orejana et al., 2015). In summary, as the intersection of robotics and healthcare continues to mature, it presents a promising avenue for augmenting care, enhancing patient experiences, and bridging resource gaps. However, the key lies in navigating this path with a blend of technological proficiency and ethical sensitivity.

The domain of social robotics transcends mere technical mastery, embodying a comprehensive outlook that carefully intertwines form, behavior, and context. By leveraging a profound understanding of human psychology and societal nuances, designers can cultivate robots capable of seamlessly integrating into human societal realms. This nuanced approach heralds a future where robots and humans can coexist, interact, and collaborate with a higher degree of naturalness and efficacy.

2.3 Social Robots in Mental Health Well-being Setting

Social robots are a novel tool in the mental health field, providing therapeutic and engaging experiences to individuals facing mental well-being challenges in the ever-changing landscape of this domain. Specifically designed for human-like interactions, these robots demonstrate promise in mitigating symptoms and elevating life quality for individuals dealing with depression, anxiety, and cognitive disorders.

Previous research underscores the capability of social robots in mitigating feelings of isolation and loneliness, significant precursors to depression (Breazeal, 2004). Equipped with advanced sensors and AI (Artificial Intelligence) algorithms, they are primed to identify and resonate with human emotions, fostering empathetic exchanges vital in therapeutic settings. Particularly for those with cognitive dysfunctions or dementia, these robots offer medicinal reminders, memory-related aid, and emotional backing, fostering autonomy and confidence (Wagner et al., 2022). Interacting with robots can help individuals with Autism Spectrum Disorder (ASD) develop social skills in structured settings (Scassellati et al., 2012).

When adopting social robots in mental health settings, it is essential to consider their role as auxiliary tools that should never eclipse human connections or expert therapeutic interventions. There are valid concerns about potential overdependence, privacy challenges, and the ethics of utilizing AI in such intimate contexts. With the evolution of AI and technology, the prowess of social robots in mental health realms is poised for growth, promising more tailored and subtle care. The infusion of machine learning equips these robots with a deeper comprehension of individual needs, refining their reactions over time for enhanced assistance (Wada & Shibata, 2007). Through continuous interaction analysis, they might detect early signs of mental health decline, offering a proactive approach.

A burgeoning area of focus centers on the application of social robots in young and adolescent mental health. Preliminary research hints at the youth, more tech-savvy, finding robot interactions less daunting than human therapists, fostering a candid emotional expression (Belpaeme et al., 2018). This holds potential especially for early-stage interventions. Nevertheless, the intrinsic value of human interaction remains unparalleled. Social robots should complement, not supplant, conventional therapy. The profound trust and genuine compassion between a therapist and a patient are indispensable in mental health treatments.

As the integration of social robots into mental health care deepens, addressing ethical boundaries becomes paramount. Deliberations on data protection, informed consent, and potential emotional reliance on robots warrant meticulous scrutiny. Ensuring fair access to such technological interventions is equally critical to avert care disparities. Though research on Socially Assistive Robots (SARs) is nascent, initial findings indicate favorable outcomes in physical health interventions, like promoting exercise among the elderly (Fasola & Matarić, 2013), and aiding cardiac rehabilitation (Kyong et al., 2005). A 2013 meta-analysis emphasized the potential of robots in therapy, especially among children (Costescu et al., 2014). In summation, while the prospects of social robots in mental health are encouraging, an empathetic, patient-first approach remains essential to harness the true potential of technology in serving mental well-being.

Overall, the future of social robots in mental health looks promising, but a thoughtful, patient-centric approach is crucial to ensure that technology truly benefits those it aims to serve.

2.4 Summary (Literature Review)

The evolution of technology has ushered in the integration of social robots into various sectors, notably in mental health. Social robots, distinctively designed for human-like interactions, differentiate them from traditional service robots through their ability to facilitate organic human interactions (Hegel et al., 2009). Their design encompasses a combination of visual form, behavioral traits, and environmental context, all tailored to enhance their social capacity and usability.

There has been a growing interest in the potential of social robots to support mental health, particularly in alleviating anxiety disorders and promoting overall well-being. Specifically, their ability to help alleviate anxiety disorders and promote overall well-being has been identified as a promising avenue for research and development. Anxiety has been a major concern in mental health for many years, often characterized by increased nervousness and panic attacks (Davidoff et al., 2012). The Intolerance of Uncertainty Model highlights the significance of an individual's ability to tolerate uncertainty, particularly in cases of Generalized Anxiety Disorder (GAD). It also emphasizes the need for personalized therapeutic approaches (Behar et al., 2009; Dugas et al., 2007).

Here, the potential of social robots is clear and apparent. With advancements in AI and machine learning, social robots can provide tailored support, adapt responses over time, and even detect early signs of deteriorating mental health (Wada & Shibata, 2007). Especially among children and adolescents, these robots could serve as less intimidating therapeutic mediums, promoting open expression (Belpaeme et al., 2018). However, while their promise is undeniable, these robots are best viewed as complementary to traditional human therapy. The authentic human touch, characterized by genuine empathy and trust, remains unparalleled.

Ethical considerations, such as data security, user consent, and potential emotional dependency, also necessitate thorough examination as we continue integrating robots into mental health care. While the prospects are promising, a balanced, ethical, and human-centered approach will be pivotal to ensure the effective application of social robots in mental health.

3. METHODOLOGY

The methodology section contains a comprehensive breakdown of the research methods utilized in this study. The chapter emphasizes specifically Human-Centered Design (HCD) and Human-Robot Interaction (HRI). Additionally, it outlines the key technical tools and platforms that supported the research, the social robot NAO, Temi, and Choregraphe application.

3.1 Research Approach and Process

The central research approach of this thesis is Human-Centered Design (HCD), which serves as a guiding framework for the development of Human-Robot Interactions (HRI).

Human-centered design (HCD) is a design approach that highlights the importance of placing users at the core of the product or service development process. This ensures that the offerings align closely with the specific needs of the target audience. HCD emphasizes a continuous consideration of users' desires, challenges, and preferences throughout each developmental phase. This method facilitates a more user-friendly and efficient product or service development process. Consequently, products or services developed using this approach are not only more intuitive and user-friendly but also potentially more profitable, as they are shaped by and for the end-users, fostering a greater sense of investment and commitment from them. To design user-friendly products, we must understand the human mind; otherwise, our designs may be flawed and challenging to use. (Norman,1988)

Norman (1988) defined four main principles of Human-centered design as follows:
1. Clearly indicate available actions at any given time, utilizing constraints for guidance
2. Enhance visibility of system's conceptual model, potential actions, and their outcomes.
3. Simplify the process for users to understand the system's present status.
4. Ensure intuitive correlations between user intentions and actions, actions, and their consequences, and between displayed information and system state interpretation.

The second approach is Human-Robot Interaction (HRI), Norman's approach for HRI prioritizes a thorough understanding of users and their needs, advocating for systems that are not only intuitive but also emotionally resonant. Applying Norman's principles to HRI, it becomes evident that robots must be conceptualized with a profound grasp of human behavior, psychology, and emotional needs. The design should encourage effortless interaction and foster positive emotions. Analogous to Norman's discussion on how objects signal their purpose (affordances and signifiers), robots should offer clear cues to guide human interaction. Norman asserts that robot teachers will not replace human educators. Instead, they can augment traditional teaching methods. Robot teachers are especially beneficial in scenarios where human instructors are not available, such as in remote areas or during travel. They also cater to individualized study schedules, promoting anytime, anywhere learning based on the learner's interest and not a preset timetable. (Norman, 2013)

Both HCD and HRI approaches are related to each other.

1. **Foundation in User Needs:** The present thesis employs the Human-centered design (HCD) approach to develop products, systems, and services that cater to the needs, wants, and behaviors of users, with a particular emphasis on the context of human-robot interaction (HRI). The HCD methodology relies on gaining a comprehensive understanding of user experiences to inform design decisions, which is particularly relevant in the design of robotic interfaces. Therefore, this study aims to examine people's expectations of robotic interfaces in their surroundings with a view to informing the design of more effective and efficient HRI systems**.** The aim is to integrate robots naturally and seamlessly to promote mutually beneficial interactions between humans and robots, enhancing their usefulness and improving the quality of people's lives. To attain this objective, two separate user studies and co-design workshops were conducted with sixteen high school and nine university students to determine their needs and opinions on social robots assisting people with anxiety or panic disorders. The study's findings directly influenced the design of the robot, thus embodying the HCD methodology throughout the research process.

2. **Iterative Design and Testing:** HCD follows an iterative process of prototyping and user testing to ensure that the final product truly aligns with user needs. Similarly, in HRI, iterative testing with end-users helps identify potential improvements in the robot's design, functionality, or behavior, ensuring that robots are more effective and acceptable in their roles.

3. **Contextual Design:** HCD emphasizes understanding and designing for the context in which a product will be used. For HRI, the context in which a robot operates—be it a home, hospital, factory, or public space—significantly influences its design and functionality. Recognizing and adapting to these contexts is vital for the success of human-robot interactions.

4. **Emphasis on Ethics and Values:** Just as HCD promotes the design of products that respect and uphold user values and ethics, HRI considers the ethical implications of robot deployment in various sectors, particularly when it comes to issues like privacy, security, and autonomy.

While HCD provides a framework and principles for designing with the user at the center, HRI applies many of these principles specifically to the domain of robotics. When developing robots intended for human interaction, employing a human-centered approach ensures that the robots are not only functional but also intuitive, trustworthy, and adaptable to the diverse needs of human users.

In this study, a balanced integration of both approaches is employed. The research primarily focused on students' perspectives regarding the use of robots to mitigate anxiety and panic disorders. Thus, high school students were our primary target users, with university students being the secondary group. We initiated the co-design workshop with high school participants, the insights from which informed the preliminary robot design rooted in Human-Centered Design (HCD) principles.

Subsequently, a design workshop with university students served to validate and refine this initial design. Their feedback assessed the appropriateness of the initial design and underscored the importance of incorporating Human-Robot Interaction (HRI) principles into our approach.

3.2 Research Phases

Research phases for student's perspective to alleviate anxiety and panic disorder with the use of robots are given below:

1. Literature Review: The confluence of mental health and social robotics has emerged as a burgeoning field of study in recent times. To further investigate this evolving intersection, a thorough analysis of the literature was conducted, accentuating the manifold functions of social robots, particularly in the domain of mental health and wellbeing, from the student's perspective. By navigating through curated databases and scholarly publications, a focused attempt was made to understand the dynamic relationship between social robots, contemporary mental health frameworks, and interventions tailored for the student community.

The analysis of the available literature revealed prevailing research trajectories, diverse methodologies, pivotal findings, and identifiable research gaps. T In recent years, social robots have been used in mental health strategies in many new and interesting ways. This review gives an in-depth look at these methods, showing how vibrant academic research is in this area. By amalgamating these insights, a holistic overview of the present scenario was established.

Importantly, the analysis illuminated the vast potential of robotic interventions for enhancing the mental wellbeing of high school students. This underscores the transformative role they could play in sculpting therapeutic pathways for this age group. Moreover, the review identified untapped avenues and emergent areas of study, suggesting expansive opportunities for novel research and breakthroughs. This literature deep-diving not only fortified the foundational grasp of the topic but also provided a roadmap for innovative explorations at the intersection of social robotics and mental health.

2. Pre-Study of sixteen High-School Students: The pre-study was conducted with a workshop held in Robostudio. Before initiating the pre-study, Prior to the commencement of the study, informed consent was obtained from the educators and guardians of all participants, highlighting the significance of confidentiality and the right to withdraw from the study at any given stage. The intersection of sixteen high school students' mental wellbeing and technological interventions remains a critical area of investigation. To deeply understand this confluence, a pre-study was executed focusing on sixteen high school students' perspectives, needs, and potential challenges concerning social robot interventions targeting anxiety and panic disorder.

This aimed to capture a broad spectrum of viewpoints, laying the foundation for a more comprehensive and representative understanding of the topic. Central to the study's methodology was the deployment of qualitative research tools. Focus group discussions were orchestrated, fostering an environment conducive to open dialogue and exchange. Additionally, co-design sessions were integrated, promoting a collaborative spirit where students felt empowered to contribute to the design and conceptualization process. A significant highlight of this pre-study was the incorporation of the NAO robot, serving as a tangible touchpoint around which discussions and interactions revolved. However, for privacy concerns, the NAO robot's camera was tacked.

Post these sessions, a thorough data analysis was undertaken. This analysis aimed to unearth insights into students' openness to robotic interventions, identify potential roadblocks, and discern specific needs bridging mental health and robot-mediated interactions. Through this analytical prism, patterns emerged, painting a detailed picture of students' aspirations, apprehensions, and areas of intrigue.

The feedback obtained from real-life interactions during the pre-study has been extremely valuable in shaping subsequent phases of research. This has ensured that the research remains pertinent and effective. The research prioritizes ethical guidelines and the sensitive subject of mental health, with a focus on the well-being of the participants, making advancements in robot-assisted mental health interventions that are both ethical and effective.

3. Low-Fidelity Prototype Design of EMO-Dump robot: To tangibly visualize and evaluate this design, a low-fidelity prototype was designed. A low-fidelity prototype highlighted specific features and modules conceived in direct response to the needs previously identified by the high school students. Each element was thoughtfully incorporated to resonate with what students need and how they feel and used those feelings and requirements to shape the robot’s design, making sure it can effectively help and support them in the best way possible. With the anticipated user experience and address potential challenges.

4. Evaluation: To assure inclusivity and ensuring diverse perspectives, the low-fidelity prototype was then highlighted to an eclectic group of nine university students from varied academic and cultural backgrounds. Their position, being proximal yet distinct from the target demographic, offered a fresh lens through which the design could be evaluated. Multiple feedback avenues were employed to glean a comprehensive understanding of the design's strengths and potential areas of improvement. Structured feedback tools were deployed alongside more methodologies like direct observations and free-flowing discussions. This dual approach ensured that both quantitative and qualitative facets were captured.

5. Co-Design Workshop: In this stage, collaboration with nine university students was undertaken to refine the robot's design, leveraging the knowledge gained from preliminary workshops conducted with sixteen high school students. These collaborative sessions empowered participants to have a hands-on role in shaping the robot's design, its features, and its intended functions. In the session, participants designed models or prototypes based on the fresh ideas that emerged from these collaborative efforts, providing a concrete representation of the concepts discussed. Feedback was actively sought on these co-designed versions of the robot. This helped pinpoint strengths in the design and areas that could benefit from further tweaking.

This co-design workshop resulted in a robot design that was shaped by a diverse set of viewpoints. This collective approach ensured that our robot was not only innovative but also tailored to best serve its users. Adopting a structured, multi-phase approach to research ensures thorough exploration and user-centric design of social robots for mental health interventions among sixteen high school students. Each phase, building on the last, ensures that the final intervention is deeply rooted in both scholarly knowledge and real-world insights, optimizing its potential for positive impact.

6. High-Fidelity Prototype Design of EMO-Dump and Implementation: After gathering results from the design evaluation and follow-up co-design workshop with nine university students, we were able to improve the high-fidelity prototype of the EMO-Dump. The foundational knowledge gained was used to inform the creation of a meticulously crafted prototype using Adobe Illustrator, ensuring precision and clarity. This prototype is a tangible representation of EMO-Dump, a robot designed to support mental health and well-being. As we developed the prototype, we also established detailed guidelines. Throughout the research process, we emphasized gathering and interpreting vital information and insights from extensive research. These guidelines are not just for the current project but are designed to aid future endeavors in implementing robots within the realm of mental health. The goal is to ensure a legacy of informed and empathetic technological integration in therapeutic contexts.

Table 1: Research Phases

Phase	Tasks	Methods	Results	Time-Schedule
Phase 1 Literature review	• Conduct a literature search that pertains to anxiety and panic disorder, in the use of social robots, and in the context of social robots in mental health and wellbeing. • Identify relevant literature related to research approaches, data collection methods, and	• Browsing. • Searching. • Emphasizing key points. • Summarizing the main ideas.	• Background and motivation • Related works • Research approaches • Research methods	March 2023-April 2023

	analysis techniques. • The chosen literature should be used to provide support for the research being conducted.			
Phase 2 Pre-Study and Co-design workshop of sixteen High-School Students	• Discover the needs and expectations of high school students regarding social robot interventions targeting anxiety and panic disorder. • Capture a wide range of perspectives. • Discussions and co-design sessions are designed to encourage open dialogue, collaboration, and exchange of ideas	• Consent form. • PowerPoint presentation • NAO Robot •Choregraphe. • Workshop Canvas. -	• Qualitative research data -Students' needs and expectations -Design	April 2023

	among the students. • Thorough data analysis aimed to unearth insights into students' openness to robotic interventions, identify potential roadblocks, and discern specific needs bridging mental health and robot-mediated interactions.			
Phase 3 Low-fidelity design of EMO-Dump	• To tangibly visualize and evaluate the design, design a low-fidelity prototype • The low-fidelity prototype highlights specific features and modules conceived in direct response to the needs of previously identified	• Paper • Pen • Notes	• Design	May 2023-June 2023

	by the high school students.			
Phase 4 Design Evaluation with nine University Students	• A diverse group of nine university students with varied academic and cultural backgrounds to evaluate the prototype. • Multiple feedback avenues are employed to glean a comprehensive understanding of the design's strengths and potential areas of improvement. • Structured feedback tools are deployed alongside more methodologies like direct observations and free-flowing discussions	• PowerPoint Presentation • Storyboard • Low-Fidelity Prototype • Temi Robot • Pen • Paper • Workshop • Canvas • Notetaking	• Quantitative data • Qualitative data	September 2023-October 2023

Phase 5 Follow-up Co-design work-shop	• Collaborate with nine university students to refine the design of the robot. • The participants will have a hands-on role in shaping the robot's design, features, and intended functions. • They will co-design based on fresh ideas that emerge from collaborative efforts. • Actively seek feedback on co-designed versions of the robot to pinpoint strengths and areas for improvement. • This approach results in a diverse, innovative ro-	• Storyboard • Low-Fidelity Prototype • Pen • Paper • Workshop Canvas • Notetaking	• Qualitative data -Strengths, -Places for further improvements, • Data for High-Fidelity Prototype	October 2023

	bot design tailored to serve its users best. • Adopt a structured, multi-phase approach to research for thorough exploration and user-centric design.			
Phase 6 High-Fidelity Prototype Design of EMO-Dump and Implementation	• Collect and analyze all key learnings and insights gained throughout the research process. • Develop a high-fidelity prototype based on the findings. • Create comprehensive guidelines that can be utilized for future reference.	•Adobe Illustrator • Analyze • Summarize	•High-Fidelity Prototype of EMO-Dump •Robot guidelines for future implementation of robots in mental health well-being	October 2023-November 2023

3.3 Participants and Research Ethics

In alignment with the American Psychology Association's (APA) Ethics Code, which mandates that participants are ensured with specific information with the following details:

1. Objectives, anticipated duration, and methods of the research.
2. The right of participants to opt-out before starting or withdraw after initiation, along with any related implications.
3. Factors that might affect their decision to participate, including foreseeable risks, discomforts, or negative effects.
4. Expected benefits from the research.
5. Confidentiality boundaries, including data management, disposal, sharing, storage, and instances when confidentiality might be breached.
6. Any rewards or incentives for participating.
7. A contact person for any queries participants may have.

3.3.1 Observation studies and note taking

Research ethics in observation studies (Baker,2006) while data collection might appear benign, it can raise ethical concerns because it concerns one's privacy (Adler & Adler, 1994).

In the present study, participants received a consent form that also included introductory information about the workshop, given its observational nature. The form explicitly highlighted that there would be no recordings. Owing to potential privacy issues related to the NAO robot's camera, we took measures to obscure the camera and advised participants to avoid interacting verbally with NAO, given the unclear destination of the data.

During the co-design session with participants, we collaborated in groups to conceptualize the robot and its attributes. Throughout this process, I documented observations using pen and paper. These notes were subsequently analyzed to extract outcomes from the co-design workshop.

3.4 Research data collection methods

Data collection methods for research include:

Collaborative Approach: The co-design process was divided into two workshops. The first workshop was unique in its involvement with sixteen high school students, offering a fresh and youthful perspective on the robot's design and functionality. students collaborated in small groups, discussing and brainstorming features that they felt were essential or beneficial. This collaboration resulted in the initial prototype of the robot, an embodiment of collective ideas from young minds.

The second workshop was a synergized collaboration involving university students, who brought with them a more mature perspective and advanced understanding. Their role was pivotal in refining and enhancing the initial design created by the high school students, morphing it into a more sophisticated low-fidelity robot prototype. Their feedback was invaluable in realizing a design that was both innovative and user centric.

Comprehensive Questionnaire Strategy: To establish a comprehensive and resilient data collection method, the study employed a multi-faceted approach that involved the use of three distinct questions. For the pre-study and co-design workshop with sixteen high school students, the first question aimed to capture both quantitative and qualitative data, while the other two questions were designed to extract qualitative data. During the design evaluation and follow-up co-design workshop, the participants consisting of nine university students were requested to respond to a quantitative question and three qualitative questions. These questions were critical in refining the robot's design as they integrated quantitative metrics with qualitative feedback.

Workshop Canvas and Interactive Discussions: During both the pre-study and co-design workshop phases with the sixteen high schoolers and the design evaluation and co-design workshop phase with the nine university students of the research, one of the most pivotal tools in this research was the uniquely designed canvas (Ahtinen et al., 2023). Although data collection was not its primary function, the canvas proved to be a valuable educational resource. Designed to promote interaction among participants, the open structure of the canvas facilitated the free expression of ideas and feedback.

Through the use of this interactive platform, the workshop remained engaging and productive, aligning perfectly with the broader objectives of the study.

Observational Insights and Notetaking: Observation, often an underappreciated research tool, played a crucial role in these workshops. By observing participants during their interactions, invaluable insights were gleaned about their genuine responses, hesitations, enthusiasms, and reservations. These direct observations, made during both workshops, were complemented with meticulous notetaking. Notes were jotted down both in real-time, capturing the spontaneity of the moment, and post-session, reflecting on the broader themes and recurrent feedback patterns. This combination of real-time observation and reflective notetaking provided a holistic understanding of the participant experience, ensuring that the final robot design was both innovative and resonated well with the target demographic.

3.5 Data Analysis Method

To effectively analyze quantitative data obtained through questionnaires, it is crucial to first cleanse the data by addressing any missing or outlier responses. The next step involves the coding of categorical answers numerically, which is essential for conducting statistical analysis on the data. It is worth noting that this process is crucial in ensuring that the data is accurate and reliable for subsequent analysis and interpretation.

The study utilized content analysis to explore the underlying meaning of diverse texts that encapsulated varying message content (Krippendorff, 2004). The approach is renowned for its ability to accurately interpret texts while keeping the context in mind. Its use is supported by well-known theories and strict coding methods, which ensures that unstructured data provides clear and useful insights (White & Marsh, 2006). Specifically, the pre-study and co-design workshops, design evaluation and follow-up co-design workshop, sticky notes, and observational research data were analyzed using content analysis. The study's employment of this methodological approach enabled a nuanced comprehension of the data and facilitated the derivation of cogent conclusions.

3.6 Research Platforms

This section outlines the research platforms employed in the study, comprising three sub-sections, NAO and Temi robots, alongside the Choregraphe software.

3.6.1 NAO Robot

The Nao robot, depicted in Figure 1, is a bipedal robot developed by Aldebaran. Its physical dimensions, measuring 58cm (about 1.9 ft) in height, this bipedal robot boasts a friendly, rounded design, reflecting both innovation and aesthetic considerations. Introduced to the world in 2006 by the United Robotics Group, the Nao robot marked a significant advancement in humanoid robotics.

One notable characteristic that sets the NAO robot apart from its counterparts is its 25 degrees of freedom, which enable a wide variety of complex movements and gestures. This feature mimics human-like flexibility, allowing NAO to engage in activities freely. Augmenting its mobility, NAO is equipped with 7 touch sensors, thoughtfully located in its head, hands, and feet. These sensors provide NAO with tactile feedback, enhancing its interactions with objects and humans. Aiding to its navigational abilities, an inertial unit is embedded, enabling NAO to better perceive and adjust to its surroundings. In terms of communication, NAO is remarkably advanced. It incorporates four microphones and speakers, making two-way interactions possible in up to 20 languages. This multilingual capability makes NAO adaptable to diverse cultural and linguistic settings. Another commendable feature is its pair of 2D cameras, designed to recognize a variety of shapes, objects, and even distinguish individual faces. This recognition ability enhances its interaction potential, making it more responsive and interactive. Finally, a noticeable characteristic of NAO is its open-source nature. As a fully programmable platform, developers and researchers have the freedom to customize its functions, ensuring its adaptability to a myriad of tasks and environments. (Anter et al., 2009)

Figure 1 : NAO Robot (Source: https://www.aldebaran.com/en/nao)

3.6.2 Temi Robot

Designed with a height of 3 feet, Temi incorporates a sleek appearance that harmoniously fits into living spaces. The robot's 10-inch touchscreen serves multiple purposes, from enabling app interactions, facilitating video calls, to direct robot communications. Enhanced with features like LiDAR and depth cameras, Temi's design permits autonomous navigation, which Follman et al. (2021) highlight as critical for avoiding obstacles and achieving precise movement. Path-planning algorithms further augment this ability, letting Temi navigate frequently visited locations efficiently. Clear audio interactions are ensured through its far-field microphones and robust speaker system, even in ambient noise environments. The robot's telepresence feature amplifies virtual interactions, permitting users to remotely connect through video and achieve a semblance of physical presence. As an addition to contemporary smart homes, Temi effortlessly integrates with numerous devices, positioning itself as a pivotal home automation interface. Its design prioritizes safety, ensuring the robot avoids obstacles and remains within set boundaries. Notably, According to RoboTech Ltd. (2023) Temi's battery is designed for efficiency, supporting up to 8 hours of continuous operation and autonomously docking for charging when necessary.

Figure 2: Temi robot (Source: https://www.robotemi.com/product/temi/)

Emphasizing Temi's intrinsic suitability for human-robot interaction, it boasts features like autonomous navigation, ensuring smooth movement within human spaces. The added advantage of voice control ensures its accessibility, especially to those not well-versed with digital interfaces. Kim and Choudhury (2021) underline that voice-controlled devices can significantly enhance older users' digital engagement. Recognizing this, Temi has been adeptly employed to bridge communication lapses in senior care residences (Sapci & Sapci, 2019). Here, not only does it facilitate video communications, but it is also often perceived as a valuable community member by diverse user categories, from elderly inhabitants to caregiving professionals. Delving into its advanced capabilities, Temi incorporates emotion recognition functionalities. Leveraging its inbuilt camera and microphone, it can amass data and, through sophisticated algorithms, interpret emotional states from facial, vocal, and postural cues. This promotes adaptive navigation, empowering Temi to adjust its actions based on users' emotional manifestations. This could mean maintaining a gap from a user displaying stress indicators or approaching closer to a relaxed or content user. Temi's touchscreen and vocal mechanisms also let users offer direct feedback about its actions, iteratively enhancing its adaptive proxemic strategies. Temi's integration with principles from the research indicates a bright horizon for reshaping human-robot relations. Robots, upon recognizing and respecting emotional boundaries, could transition into being invaluable in varied spheres, from health and therapeutic spaces to daily human engagements.

One can envision a therapy setting where a robot, by interpreting a patient's emotional landscape, adjusts its behavior, potentially instilling a comfort sentiment.

In the broader societal context, Temi presents a strategic solution for the pervasive challenge of social isolation, a concern accentuated during global adversities like the pandemic. In transient spaces like hospitals, where establishing durable social connections is challenging, Temi can operate as a nexus, catalyzing interactions between inhabitants and their families (Duffy et al., 2003). Given that social isolation is a persistent concern, even beyond pandemics, innovative resolutions like Temi's application emerge as pivotal. The trajectory thus points towards the ongoing refinement of emotion-responsive robotic interfaces.

3.6.3 Choregraphe

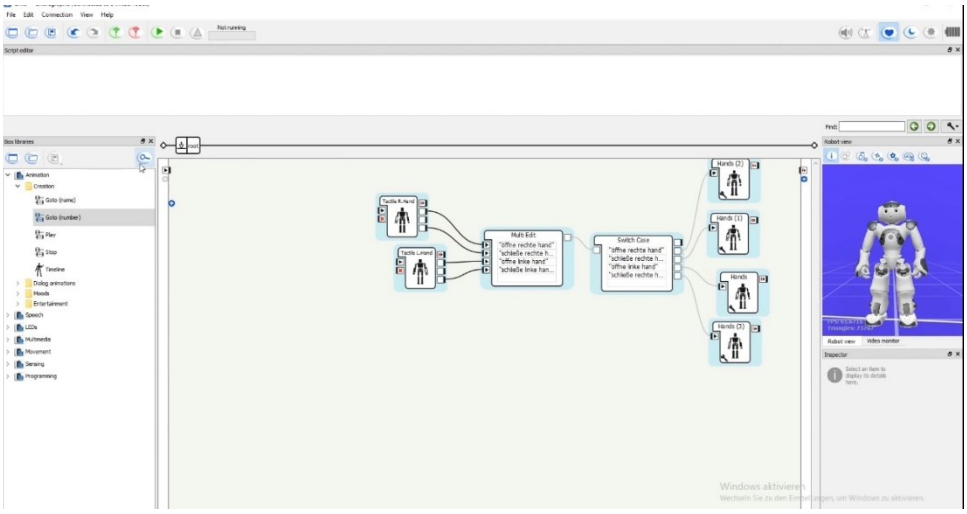

Figure 3: Choregraphe graphical user interface (GUI) (Jannes Weghake, 2018)

Choregraphe is a versatile desktop application compatible with various platforms, designed specifically to serve multiple functions in robot programming and control Choregraphe is a software that assists users in designing animations, behaviors, and dialogs tailored to specific requirements or tasks. Before deploying the behaviors on an actual robot, users can test and refine them on a simulated robot environment within the application to ensure efficiency and safety. Choregraphe also provides real-time monitoring tools, allowing users to oversee and control their robot's actions to ensure they align with intended behaviors.

For those with coding knowledge, Choregraphe offers an added advantage. While its interface is user-friendly and doesn't require coding for basic behaviors, users can use Python and C++ to augment and enhance robot behaviors, tailoring actions to more specific or complex tasks.

Creating comprehensive robot applications becomes seamless with Choregraphe. Whether it's designing interactions for human interaction, programming dance, or enabling functionalities like sending emails, Choregraphe facilitates it all without the necessity of coding. (Bravo et al., 2017).

Choregraphe serves as an all-encompassing solution that bridges the divide between complex robot programming and user-friendly design, enabling both beginners and professionals to unleash the full capabilities of their robotic systems.

4. USER STUDIES

There were two user study that has been conducted in this thesis. First one is the pre-study and co-design workshop with sixteen high school students, and the last one is design evaluation and follow-up co-design workshop with the university students.

4.1 Pre-study and Co-design workshop

This section presents a detailed account of the research procedure, data collection and analysis techniques, and principal outcomes obtained from the pre-study and co-design workshop "Student's Perception to Alleviate Anxiety and Panic Disorder," done with sixteen high school students.

4.1.1 Procedure

A co-design workshop was conducted at Robostudio, wherein sixteen high school students participated as the primary users. The research focused on gathering the students' perceptions. A PowerPoint presentation was utilized to facilitate the session, and the structure of the workshop was outlined.

Figure 4: Facilitating Pre-Study and Co-design workshop with the high school students

Introduction: Each participant began by introducing themselves by their first name. They were then acquainted with the day's topic and primary objectives. Throughout the session, utmost attention was paid to guaranteeing the well-being and agreement of all those involved. Every participant received a clear explanation of how their participation would remain anonymous and how they could leave the session at any time if they so desired. To further safeguard participant privacy, precautions were taken with the Nao robot used in the study. Specifically, its cameras were tacked to eliminate uncertainties about where the data might be transmitted or stored. Participants were reassured that any information shared during the session would remain confidential and be reported anonymously in subsequent documents or publications.

Social Robots: The session began by providing a clear definition of social robots, establishing a foundation for participants. This was then expanded upon with a comprehensive overview, highlighting the various capabilities, potential applications, and the evolving nature of social robots in contemporary settings.

Nao Robot: The Aldebaran-manufactured NAO robot has a friendly and modern design, standing at a height of 58cm (about 1.9 ft). It is a significant advancement in humanoid robotics that the United Robotics Group unveiled to the world in 2006. What sets NAO apart is its ability to mimic human body movements with its 25 degrees of freedom, making it capable of performing various activities. NAO has seven touch sensors across its head, hands, and feet for interactive feedback and an inertial unit to maintain balance and awareness. It also supports bidirectional communication in multiple languages with its four directional microphones and speakers. With dual 2D cameras for object and facial recognition, NAO has exceptional visual recognition capabilities. Its open-source framework enables customization, making it a flexible tool for developers and researchers globally. (Anter et al., 2009)

During the session, we introduced the social robot, NAO, elaborating on its distinct features. Participants were treated to a live demonstration, where NAO greeted them, displayed its unique ability to change eye color upon bumper presses, executed a dance sequence, and subsequently assumed a seated position. This hands-on interaction offered a tangible insight into the robot's capabilities.

Brainstorming: The session progressed into a qualitative research segment, characterized by an interactive brainstorming session. Participants were presented with a sizable paper canvas, and sticky notes were utilized as a means for them to articulate and visualize desired behaviors or activities they hoped a social robot would embody to aid in mitigating anxiety and panic disorders among students. The discussion extended beyond just features, delving into participants' expectations, their viewpoints on employing such a robot for mental well-being, and potential real-world scenarios. These dialogues encompassed both optimistic and skeptical perspectives on the proposed concept, ensuring a holistic understanding of their thoughts and concerns.

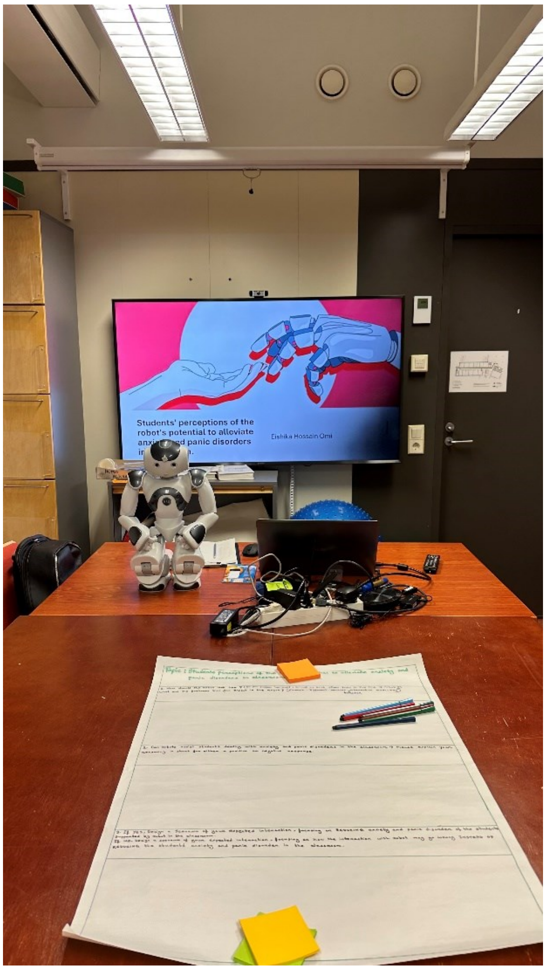

Figure 5: Canvas used in the Pre-study and Co-design workshop with sixteen high school students

Closing speech and Final feedback: Concluding Remarks and Final Reflections: As the session ended, the Robostudio team extended their gratitude, acknowledging and appreciating the invaluable contributions and insights provided by the participants.

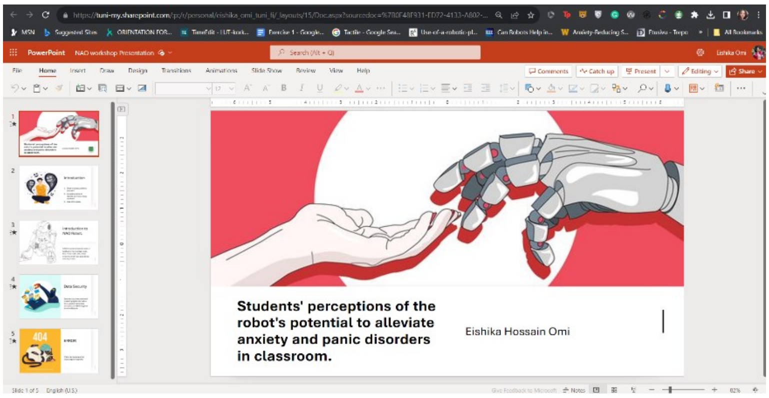

Figure 6: Presentation slides for the pre-study and co-design workshop

4.1.2 Data collection

The questions were answered during the co-design session in *Robostudio* after the high-school students interacted with NAO robot, which they used to see unique features of NAO robot.

The session began with an introduction to the robot's capabilities, which included pre-programmed dancing, greeting, and joking abilities through choregraphe software. The students were asked three questions during the session about what they wanted, needed, and expected from the social robot. They collaborated in a group and answered these questions in detail. The purpose of these questions was to gain a better understanding of the students' viewpoints.

Q1: How should the robot look like? (Do you prefer humanoid, animal or some other form in this kind of robot?) What are the features that you expect in the robot? (Example: Different sensors, interaction modalities)
Q2: Can robots assist students dealing with anxiety and panic disorders in the classroom? Please explain your reasoning in short for either a positive or negative response.
Q3: If yes, design a Scenario of your expected interaction, focusing on reducing anxiety and panic disorder of the students supported by robot in the classroom.
If No, design a scenario of your expected interaction, focusing on how the interaction with robot may go wrong instead of reducing the student’s anxiety and panic disorder in the classroom.

The data was gathered using the technique of note-taking and sticky notes on the canvas, while ensuring that no session was recorded to respect the privacy concerns.

4.1.3 Findings from the Pre-study

From the preliminary user study a co-design workshop conducted with sixteen high school students, several enlightening observations and insights were gleaned regarding the design and functionality of robots tailored for mental well-being.

Firstly, the appearance of the robot significantly influenced the students' perceptions. Robots that had humanoid or animal-like features were met with mixed reactions; they were simultaneously viewed as both eerie and remarkable. The act of listening to a humanoid robot articulate itself compounded the uncanny sentiment, evoking feelings of unease among participants.

Interestingly, while there was an overarching sentiment of mistrust towards robots, those with a more endearing or "cute" appearance were often exempted from such skepticism. This underscores the importance of aesthetics in building trust and rapport with users, especially in sensitive domains like mental health.

Furthermore, students emphasized the need for robots, especially those aimed at aiding individuals with anxiety or panic disorders, to have a gentle and non-intimidating appearance. They opined that materials such as hard plastics did not convey warmth or comfort, which are crucial in therapeutic contexts.

Based on the feedback, a design that emerged as favorable was a cylindrical robot reminiscent of a trash can. However, instead of a cold, metallic exterior, students favored a soft, cushioned body that would invite physical interaction, like resting one's head or hugging. The trash can resemblance was not just a nod to the form but also functioned symbolically, allowing users to metaphorically "dump" their negative thoughts and feelings.

As for features, the students highlighted the importance of the robot possessing a sense of humor, sound detection capabilities, and a camera for interactive functionalities.

Importantly, while they saw potential in the robot's role as a mental health aid, they believed that it should work under the guidance of trained psychologists. The sentiment was clear: while robots can assist, they should not be left to operate autonomously in therapeutic scenarios.

4.2 Design Evaluation and Follow up Co-design workshop

During the subsequent co-design workshop, we convened a diverse group of nine university students hailing from varied academic disciplines. Throughout this collaborative session, participants provided invaluable feedback on the low-fidelity prototype, actively contributing towards enhancing and refining its design.

4.2.1 Procedure

The design evaluation and follow-up co-design workshop took place face-to-face and lasted one hour. During this session, a PowerPoint presentation outlined the progress and findings of the thesis up to that point. The agenda encompassed the following topics:

Introduction: The session began with each participant sharing their first name, establishing an atmosphere of familiarity and comfort. Following the introductions, an overview of the day's agenda and the primary objectives were presented to the attendees. Maintaining an environment of trust and openness was paramount in ensuring that participants were well-informed about the anonymous nature of their involvement and their right to withdraw from the study at any time. Clarity was given to the promise that any shared information would be treated with confidentiality and reported anonymously in any subsequent materials or publications. The introduction also included a briefing on the overarching thesis topic and a status update on the progress made thus far.

Findings from the pre-study and co-design workshop conducted with high school students: During the presentation, an extensive analysis was carried out on the results of a the pre user study and co-design workshop with sixteen high schoolers was presented, and the aim was to explore their perspectives, issues, and potential applications of robotic interventions. This enabled the audience to gain an improved understanding of the pre-study and co-design workshop.

Introduction to EMO-DUMP Robot: The limelight then shifted to the EMO-DUMP robot. I showcased the preliminary design of this innovative robotic solution, delving into its unique features and the rationale behind each design choice. This segment served to orient participants with the robot's capabilities and intended functionalities.

Storyboarding: To bridge theory with practical understanding, a real-time story involving EMO-DUMP was narrated. This storytelling approach was leveraged to stimulate creative thinking among the participants and to guide them in visualizing the robot's potential applications, facilitating an easier transition into the design phase.

Brainstorming and Collaborative Design: The crux of the session was a qualitative research-driven brainstorming phase. A The participants were provided with a large paper canvas and sticky notes to conceptualize and map out the ideal behaviors, functionalities, and roles that they envisioned for EMO-DUMP in addressing student anxiety and panic disorders. The discussions were not confined to just the robot's features but expanded to encompass participants' aspirations, reservations, and visions for using such a robotic entity in mental health contexts. By covering a spectrum of opinions — both optimistic and apprehensive — the discourse aimed at garnering a rounded perspective on EMO-DUMP. These rich conversations were instrumental in refining and enhancing the robot's design, ensuring it resonated with real-world needs and expectations.

4.2.2 Data Collection

The questions were answered during the follow-up co-design workshop session on canvas after the university students got the clear idea of the thesis and its progress.

Q 1: Can robots assist students dealing with anxiety and panic disorders? Please explain your reasoning in short for either a positive or negative response.
Q2: Evaluate the Initial Robot Design

Provide an in-depth evaluation of the initial robot design, outlining your thoughts and opinions on its functionality, aesthetic appeal, and overall effectiveness. Highlight areas where the design excels and aspects that could be improved.

Q3: Design Feature Modifications

Identify and design features to be added or removed from the initial robot design. Justify your proposed modifications by explaining how each change would enhance the robot's performance, utility, or user-friendliness. Consider and address any potential challenges or limitations associated with your suggested modifications.

Q4: Develop a Scenario Featuring the Proposed Robot Design. Craft a detailed scenario in which your proposed robot design is utilized. Describe the setting, objectives, and tasks the robot is expected to perform, demonstrating how the design modifications you suggested in Task 2 and 3 contribute to the robot's effectiveness and efficiency in this scenario. Your scenario should illustrate the practical applications and benefits of your redesigned robot, providing insight into its potential real-world impact and value.

The data collection process involved the utilization of canvas and sticky notes, while notes were taken to document the collected data.

Figure 7: Canvas used in the Design Evaluation and Follow-up Co-design workshop with nine university students

4.2.3 Findings from the Design Evaluation and Follow-up Co-design workshop Study

Findings from the study are given below.

Perception of the Robot's Role: Most participants believed that the robot could serve as a helpful tool in managing anxiety and related issues. However, they emphasized that its role should be supplementary, operating alongside a psychologist and not replacing them. The robot was viewed more as a temporary aid rather than a long-term standalone solution.

This following report presents the outcomes of a design evaluation study and follow-up co-design workshop conducted with a cohort of nine university students.

Body Preferences: Adults may prefer a taller robot-like Temi robot, while miniature robots could be less intimidating for children. A warm, squishy body that simulates human touch and the comforting nature of a pet can be incredibly soothing.

Voice: Users want a calm, sincere, and natural-sounding voice from their robot. A non-mechanical voice that is genuine and soothing is essential, especially for interactions with children or those with visual impairments.

Expression and Emotional Responsiveness: The robot's facial expressions should be versatile and not limited to a cutesy look. The robot's expressions must be able to adjust to the context, ensuring that it doesn't appear overly cheerful when a user is in distress.

Design Aesthetics: Neutral color palettes, especially whites and browns, are preferred. A fluffy body texture is well-received, and the name "Emo-dump" is considered engaging and memorable.

Functional Features: The development of a robot that can exhibit a broader spectrum of emotions and offer comforting hugs that are centered on providing comfort is an area of interest. This involves the integration of key features such as emotion recognition, playing calming music, GPS functionality, user behavior analysis, and interactive games. The robot should also be able to tell when a user might benefit from professional support.

Emergency Response Functionality: For individuals facing social anxiety or experiencing panic attacks, the robot should be equipped with an assessment protocol to gauge the severity of the situation and possess the capability to contact healthcare providers as necessary on behalf of the user.

Potential Applications of Emo-Dump in Real-World Scenarios:

1. Public Speaking Preparation: One of the most common fears worldwide is the fear of public speaking. Emo-Dump can serve as a non-judgmental audience, allowing individuals to practice their speeches in a safe environment. Beyond merely listening, the robot can offer constructive feedback on speech content, clarity, and delivery. Additionally, it can provide strategies to manage the stress and anxiety typically associated with speaking in front of an audience.

2. Exam Stress Relief: Examinations can be a significant source of stress for students of all ages. Emo-Dump can intervene by introducing light-hearted elements such as playful dances, soothing music, or humor to provide a mental break. Its aim would be to distract and relax the student momentarily, allowing them to return to their studies refreshed.

3. Addressing Social Anxiety: For those struggling with social anxiety, reaching out for professional help can be a daunting task. Emo-Dump can play an intermediary role by recognizing symptoms and facilitating contact with a psychologist on the user's behalf. This can be particularly beneficial in cases where the individual might hesitate or procrastinate in seeking help.

4. Assisting Children: Childhood can be riddled with complex emotions and situations, making it essential to identify and address potential mental health challenges early on. Emo-Dump can analyze a child's behavior and emotional state over time. If it detects patterns indicative of depression or other emotional distress, it can advise caregivers or recommend professional intervention.

5. Behavioral Analysis and Intervention: Emo-Dump's capabilities can extend beyond momentary support. By continuously observing and analyzing user behavior, it can provide insights into their emotional well-being. If consistent patterns of distress are observed, Emo-Dump can recommend contacting a psychologist, ensuring timely intervention and support.

4.3 Data Analysis Methods

The qualitative data gathered from the pre-study and co-design workshop as well as the design evaluation and follow-up co-design workshop were both subjected to a thematic analysis using the affinity diagramming technique Beyer and Holtzblatt (1988) proposed. Furthermore, meticulous transcriptions of the observations and insights recorded on sticky notes during the co-design workshop were incorporated into the overarching thematic framework.

5. DESIGN OF EMO-DUMP

This section encompasses the conceptualization phase of the EMO-Dump Robot, where we delve into the intricacies of storyboarding, low-fidelity prototyping, and high-fidelity prototyping.

5.1 Storyboarding

In the context of user-centered design (UCD), storyboards have been recognized as essential instruments, mapping out scenarios that shed light on a system's prospective use. These illustrative narratives, through their varied styles, provide a visual and textual roadmap that captures the essence of user interactions, expectations, and potential challenges. Notably, the visual cues and linguistic elements embedded in storyboards make them easily decipherable, making them particularly effective across diverse teams.

The strength of storyboarding lies in its ability to visually convey complex ideas and workflows, allowing multidisciplinary teams to grasp the user journey and anticipated touchpoints. This ensures that designers, developers, and other stakeholders can align their strategies and decisions with the user's needs and preferences. Furthermore, the visual nature of storyboards facilitates discussions, brainstorming, and collaborative problem-solving, bridging the gap between technical jargon and user experiences. Storyboards serve not just as design tools but also as communication aids, fostering understanding and cooperation among varied team members in the UCD process.

Within the scope of this research, we employed two distinct storyboards as foundational tools in the design process of the low-fidelity prototype. These storyboards facilitated a clearer visualization of the user's journey and interactions with EMO-DUMP. By mapping out specific scenarios and touchpoints, the storyboards provided invaluable insights and a structured framework for the subsequent co-design phase. The visual narratives not only illuminated the potential challenges and opportunities inherent in the prototype but also acted as a catalyst for collaborative discussions and ideation. Consequently, the application of these storyboards was instrumental in refining and enhancing the design elements of EMO-DUMP, ensuring it was better aligned with user needs and expectations.

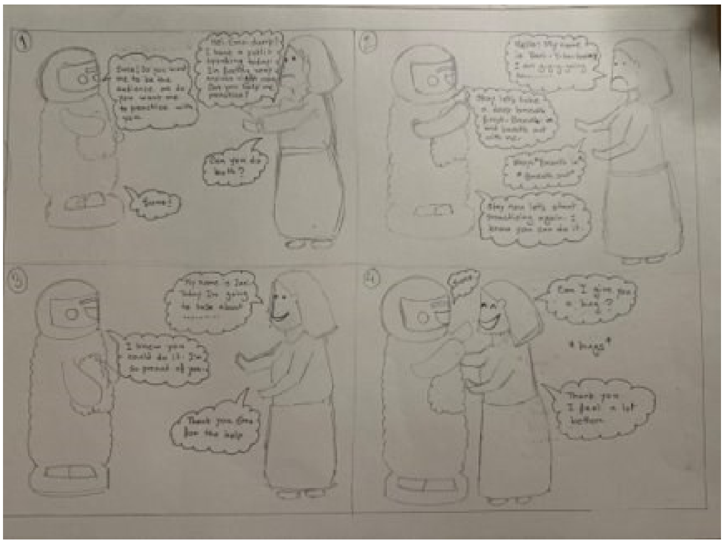

Figure 8: Storyboard

Scenario 1:
Jani has anxiety and panic disorder, as a result, it is hard for them to participate in public speaking. Hence, they asked the robot to give advice and act like the audience. Furthermore, in case they start stuttering the robot can help them to navigate through it.

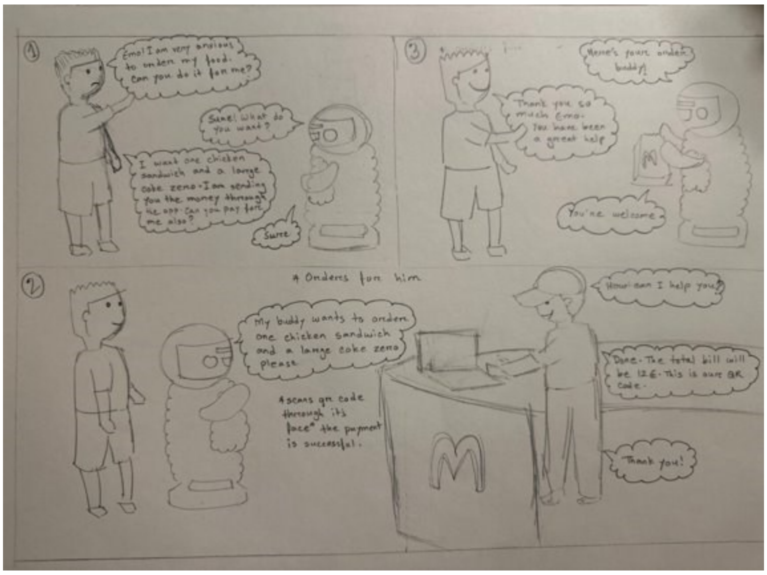

Figure 9: Storyboard 2

Scenario 2:
Leo has social-anxiety, and it is hard for him to speak to someone. He would rather not order something than speak to a salesperson. Hence, he asked Emo-dump for assistance in helping him order food and pay on behalf of him.

5.2 Low-Fidelity Prototype of EMO-Dump

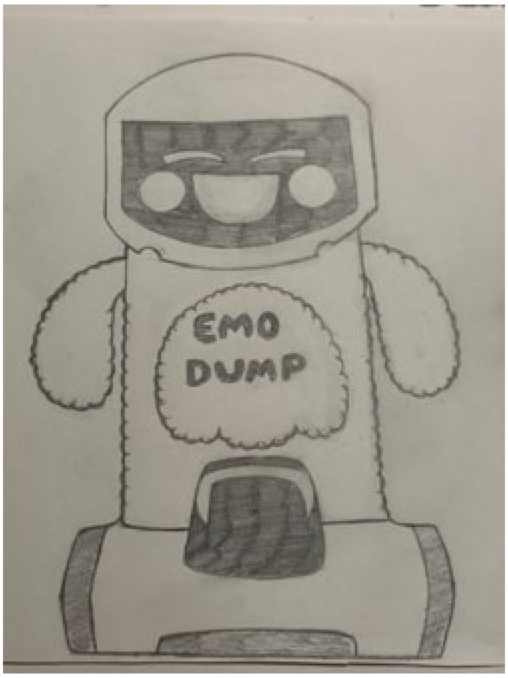

Figure 10: Sketch and Low-Fidelity prototype of EMO-Dump

EMO-DUMP's physical appearance is anchored by a fluffy body paired with a round head, invoking an innate sense of cuteness and approachability. Central to its design is a head with a screen that serves as a window to its emotional state, offering a dynamic visual representation of its feelings. Addressing the innate human need for comfort, Emo-Dump boasts elongated yet not human-like arms, designed to offer solace without intimidating younger users. Interestingly, the robot's body design draws inspiration from Finnish trash-can aesthetics, seamlessly blending functionality with a touch of playful charm. Borrowing design elements from the Temi robot, Emo-Dump's legs ensure stability and mobility. Beyond its physical attributes, Emo-Dump is also technologically equipped to engage with its users; it can speak and listen, fostering two-way interactions. Enhancing its perceptual capabilities, a camera is subtly integrated into its eyes, situated within the screen, enabling it to visually connect with its environment and users. Collectively, Emo-Dump's design and features epitomize a harmonious blend of aesthetics and functionality, positioning it as a valuable companion in various interactive settings.

5.3 High-Fidelity Prototype of EMO-Dump

The present study employed a multifaceted approach to develop EMO-Dump's high-fidelity prototype. A comprehensive literature review was conducted to acquire an intricate understanding of the existing research in the field. Then, a pre-study and a co-design workshop was conducted with sixteen high school students to obtain their inputs and perspectives was undertaken to identify the key issues and challenges faced by high school students in managing their emotions.

Following this, a low-fidelity prototype of EMO-Dump was developed, and a design evaluation and follow-up co-design workshop with nine university students was conducted to assess its effectiveness, usability in order to elicit feedback regarding the low-fidelity prototype and to make subsequent improvements. Based on the feedback received, a high-fidelity prototype was developed using Adobe Illustrator, considering all the requirements and expectations of the students.

Overall, this comprehensive approach ensured that the final product was tailored to the needs and preferences of the target audience, making it more effective and user-friendly.

Figure 11: High-Fidelity Prototype of EMO-Dump robot

Facial Expression Adaptation: Emo-dump can change its facial expression based on the situation. It has a camera in its eyes that can recognize facial expressions and detect behavior, allowing it to adapt to the user's behavior.

Warm and Squishy Design: Its body has a soft and warm texture that feels like a pet, with longer arms perfect for warm hugs. This design is intended to provide comfort and relaxation to the user.

Behavior Detection: Emo-dump has a camera in its eyes for facial expression recognition and behavior detection. This feature enables the device to identify and adjust to the user's actions and preferences.

Emotion Detection: Emo-dump can gauge user emotions through voice recognition technology. This feature enables the device to comprehend the user's emotional state and deliver appropriate assistance.

Distractions and Advice: It can identify user behavior and provide helpful advice, as well as offer distractions like games. This feature is designed to provide assistance and support to the user.

Relaxation Features: Emo-dump can play calming music for relaxation. This feature is intended to help the user relax and reduce stress.

GPS Tracking: The device is equipped with GPS capabilities, enabling it to track the user's location and provide appropriate assistance.

Voice: It has a calming, non-robotic voice that caters to different language preferences and maintains a calming tone, especially with children. This feature is designed to provide a calming and reassuring presence to the user.

Emergency Features It can contact the doctor for people with social anxiety or panic attacks if needed. This feature is intended to provide emergency assistance to users who may require it.

6. EVALUATION

The evaluation chapter outlines the study's objectives, the evaluation of EMO-Dump's design, and provides detailed information on the procedure, data collection, participants and ethical considerations, data analysis methods, findings, and overall summary.

6. 1 Procedure

This chapter presents an in-depth overview of the study, encompassing the evaluation of the low-fidelity prototype and the development of the high-fidelity prototype. Additionally, it offers a comprehensive account of the methods employed for data collection and analysis. The chapter culminates with the presentation of the principal findings of the study.

Implementation: Two separate sessions were conducted with different groups of students. The first was a pre-study and co-design workshop with thirteen high school students. Using a pre-programmed NAO social robot, students interacted with the robot and participated in co-designing it. The second session was the design evaluation and follow-up co-design workshop with nine university students. In this session, participants interacted with a Temi robot and two storyboard sketches, followed by completing a questionnaire. Each session lasted one hour.

6.2 Participants and Ethical Consideration

During the Pre-study and co-design workshop, 16 high school students participated, while nine university students from different backgrounds joined the design evaluation and follow-up co-design workshop.

Before the sessions, participants were required to sign a consent form. For high schoolers, the form was sent from Robostudio, and parents and teachers needed to sign it as students are underage. As for the university students, Microsoft Forms online consent form was sent to them, which they consented to before attending the session.

During both sessions, it was made clear that no audio or video recordings would be taken, and no personal questions would be asked. Only handnotes were taken, and the NAO robot camera was disabled for extra privacy. At the onset of the meeting, it was reiterated to the participants that they possess the importance of discontinuing their involvement without any obligation to state a reason.

6.3 Data collection methods

To collect data during the workshops, a diverse range of qualitative techniques were employed.

Questionnaire: As part of the design process of the EMO-Dump robot, students were asked to participate in a group discussion and answer questionnaires that assessed their perception, needs, and experience with social robots. Appendices 1 and 2 contains these questions and answers.

Paper Canvas: During the brainstorming session, students wrote their answers on sticky paper and posted them on the paper canvas. They also discussed possible designs and added them to the paper canvas.

Observation and notetaking: Observation and note-taking were also employed during the workshops. Appendix 3 contains handwritten note data from the sessions.

6.4 Data Analysis Method

The data was analysed using content analysis to understand the student's perception of the social robot to alleviate anxiety and panic disorder, and their needs and expectations, as well as the to help designing EMO-Dump robot's design and features.

6.5 Findings

This chapter presents the findings of the design evaluation, utilizing data that has been categorized into two distinct groups: findings from pre-study and co-design workshops, and findings from design evaluation and follow-up co-design workshops.

6.5.1 Findings from Pre-study and Co-Design workshop:

After the initial introduction of the thesis topic and NAO robot, all sixteen high schoolers expressed that they found NAO unsettling yet remarkable. The majority preferred a less human-like, more adorable robot. A G2 member mentioned, "If you are having panic attacks, you want something relaxing. Plastic will not help you with relaxation." A G1 participant added, "I do not trust a robot only if it is cute. So, it depends."

When pondering the desired appearance and functions of a robot, a G1 student whimsically suggested a "Maybe a cylinder-shaped trash can with legs." At the same time, a G2 member stated, "Features: Funny, Detect Sound and Have camera." G3 stated, "Pillow, You can rest if you need to calm down. Very soft material, Color: White, Blue."

Regarding the use of robots for anxiety and panic disorders, the students predominantly held skeptical views. G3: "Does not help. Not right now,"

The conversation then shifted to hypothetical uses of the robot to better understand student expectations. While G1 proposed an interactive robot that could offer public speaking practice and feedback, mimicking an audience and even participating in applause, a G2 respondent felt that such an idea would be patronizing, saying, "I will feel like a loser with the G1's clapping idea."

Findings from this session helped create story board (Fig 8, 9) which further helped to design EMO-Dump's low-fidelity prototype. (Fig 10)

6.5.2 Findings from Design Evaluation and Follow-up Co-design workshop

During a Design Evaluation and Follow-up Co-design workshop, nine university students were engaged in discussing robots that could aid students with anxiety and panic disorders. The consensus was that such assistance could be helpful, but it was seen as a temporary solution rather than a complete one. Overall, the group was cautiously optimistic about the potential for robot assistance in this area. P3 stated “I think robots may help with anxiety if its for temporary help only. One should not rely on such thing for a longer period since it would push you further away from “real life” encounters.” P4 also added, "With a psychologist/ therapist together, I think a robot could be a useful tool. On its own, I think it could only be a temporary distraction."

When asked to evaluate the initial low-fidelity robot prototype. Most of them stated Positively. P2: Height seems okay to me but for some users like children it might be too tall, Voice should be calming, Fluffy material could be a neutral color (light brown, white etc.) P5 stated that “Arms should be able to hug back. The name is really catchy, and the robot looks cute. I like the fact that it can move so in the case that is needed, it can reach the person. It is good that it is fluffy. It gives approachable look.”

When asked to modify the design, P3 stated that “The robot should be able to recognize emotions so it can also approach users (instead of users approaching it). For adults, the robot is perfect height, and it could be a bit taller. Some music features where the robot can play relaxing music if needed would be nice.” P4 stated that "I think the robot’s body should be a bit squishy and warm (not hot) Hugging something hard and cold even if it’s fluffy might feel strange. Not sure if that would be possible though. P6 stated that, "Voice detection to know how the user is feeling and then display emotions on that basis, maybe it can have some games in it which can help distract the user.” P5 added that, "Might add the GPS so the robot will not get lost, User behavior identify. More understand the user situation to have a talk, or advice suitably. P7 stated that, "Function identify the user behavior to adjust the suitable actions, Introvert and extrovert users, when to come to psychologist, aesthetic appeal good enough, overall effectiveness good enough.”

When asked to make a scenario there was different scenarios. One of them was, P3 stated that “User is tired after a long day of studying and working. Robot notice that and start the conversation about what day is going on. User have a talk and start crying. The robot reaches he has a very worst situation right now so suggest him go to the psychologist.“

6.6 Summary

Two workshops were conducted in person: one pre-user study and co-designing workshop, and another design evaluation and follow-up co-design workshop. Thirteen high school and nine university students participated in a hands-on workshop aimed at designing a social robot to assist in the management of anxiety and panic disorders. The workshop, which spanned two hours, was designed to elicit feedback from students on their expectations and requirements for a social robot. The data was collected through a combination of observation notes, questionnaires, and paper canvases. The collected data was subsequently analyzed, both quantitatively and qualitatively.
The following is a summary of the findings from the workshop, outlining the results of research on how students perceive the use of social robots in managing anxiety and panic disorders. The study reveals that students desire a multi-functional robot that can detect and responding to human emotions. This robot, EMO-Dump, would have a variety of interactive features to provide comfort and support to individuals who are experiencing high levels of stress or anxiety.

The desired robot should possess key attributes that allow it to adjust its facial expressions to reflect the user's emotional condition. This feature enhances empathy and connection. Additionally, the robot's physical design should be comforting, with a soft, warm exterior and elongated arms that are suitable for hugging. These characteristics provide a sense of security and comfort similar to that of a pet. The robot should also be equipped with advanced detection capabilities, utilizing cameras for facial expression and behavior recognition, as well as voice recognition systems, to assess emotional states accurately.

The EMO-Dump robot would engage users with advice and games to distract them from anxiety-provoking stimuli and offer options like playing calming music to promote relaxation. To ensure safety and reassurance, GPS tracking would be included for location monitoring. The robot's voice would be soothing and adaptable to various languages, making it user-friendly for all ages and maintaining a non-threatening presence, especially for children. In critical situations, the robot would have the ability to alert healthcare providers for individuals experiencing acute anxiety or panic episodes. These efforts have resulted in the development of EMO-Dump a social robot that is specifically designed to provide relief and support for individuals dealing with anxiety and panic disorders.

7. LIST OF GUIDELINES FOR IMPLEMENTING SOCIAL ROBOTS IN MENTAL HEALTH WELL-BEING

Through the utilization of a rigorous research process, encompassing user studies, design evaluations, and co-design workshops with high school and university students, a set of guidelines has been developed to address the creation of robots that have the potential to enhance mental health and overall well-being. These guidelines are intended to serve as a valuable resource for designers when developing robots that can positively impact the field of mental health.

1. Emphasize Empathy in Interaction:

Robots, such as EMO-DUMP, should be designed with a primary focus on showing empathy. Recognizing and responding to human emotions can make interactions feel more genuine and supportive, especially for those battling anxiety or panic disorders.

2. Prioritize User Comfort:

Given the sensitive nature of anxiety and panic disorders, the researcher should ensure that the user always feels comfortable. This includes the robot's appearance (not too tall for children, calming colors), voice modulation (soothing, natural), and adaptability (changing expressions based on the user's mood).

3. Intuitive Interaction Mechanisms:

Students are likelier to engage with a robot that offers straightforward interaction mechanisms. Features such as emotion recognition can help the robot approach a user instead of vice versa, making interactions feel more natural.

4. Privacy and Confidentiality:

Maintaining the confidentiality of student interactions is of paramount importance, particularly for those who seek to express their feelings or concerns. It is therefore, imperative that robots designed for this purpose adhere to rigorous data privacy protocols. In doing so, students can feel secure in sharing their thoughts and emotions, thus facilitating a safe and trusting environment for open communication.

5. Dynamic Adaptability:

The development of robots that can recognize and adapt to various human emotions is a crucial area of research in the field of artificial intelligence. Rather than being limited to displaying a fixed set of pre-programmed expressions that are merely "cute," robots must be capable of adjusting their behavior based on the user's current emotional state. This will ensure that the interactions between humans and robots are more meaningful, personalized, and effective. To this end, it is essential to equip these robots with advanced technology that enables them to accurately detect and interpret the emotions of their users. The use of such technology will enable the robots to respond appropriately and helpfully, thereby ensuring that they better meet the needs of their users.

6. Offer Distractive and Supportive Features:

As part of the design evaluation process, a co-design workshop was held with a group of nine university students. The outcome of this workshop revealed that implementing features like playing calming music, suggesting relaxation exercises, and providing engaging games or activities can effectively reduce anxiety or panic in users of the robot during heightened states of distress.

7. Prompt Professional Support:

While robots can offer immediate solace, they should also be programmed to recognize severe distress signs and suggest seeking professional help. For instance, in cases of extreme social anxiety, the robot could facilitate contacting a psychologist or counselor on the student's behalf.

8. Personalized User Experience:

Based on the feedback received on the EMO-DUMP prototype, more than a one-size-fits-all approach is required. The robot needs to be able to accommodate the unique needs of each student, such as distinguishing between introverted and extroverted users or adapting its approach based on the user's age. And, the size of the robot may vary for different age range users.

9. Educative Approach:

Besides offering comfort, robots should also have features that educate users about anxiety and panic disorders. This can help in demystifying these conditions and making students feel more informed and empowered.

10. Constant Feedback Loop:

To ensure that the robot remains effective over time, there should be a mechanism through which students can provide feedback on their interactions. This can help refine and improve the robot's features and responses.

11. Physical Comfort:

Based on the insights gained from the EMO-DUMP design, i It is apparent that the physical attributes of a robot play a pivotal role in determining the level of user comfort.. Notably, factors such as the warm and squishy body of a robot's body contribute significantly to enhancing its comfort level.

Human-robot interaction, when designed with empathy and understanding, can offer significant support to students grappling with anxiety and panic disorders. By integrating user feedback, staying updated with technological advancements, and prioritizing user comfort it can serve as an effective complementary tool in mental health support for students.

8. DISCUSSION

This chapter provides a comprehensive analysis of the results of a study on the effectiveness of social robots as an intervention strategy for anxiety and panic disorders among students. The study aimed to address two fundamental research questions and followed a mixed-methods approach involving a pre-user study and co-design workshops with sixteen high school students and a design evaluation and follow-up co-design workshop with nine university students.

The study's findings suggest that social robots can be a valuable tool in assisting individuals with anxiety and panic disorders, particularly in areas such as public speaking practice, relaxation, and providing non-judgmental support. However, the participants in both user-studies raised concerns about trust and the long-term use of these robots, emphasizing the need for supervision by professionals such as psychologists or counselors. Additionally, the study explored the preferences and characteristics of social robots for anxiety coaching. Sixteen High school students preferred cute, soft, and comforting designs, indicating a need for an approachable and emotionally reassuring presence. Conversely, nine university students emphasized the importance of clear boundaries and expectations for the robot's functionality, as well as the need for features such as sound detection, emotion recognition, and adaptability to different user profiles. The study's findings also highlight the critical role of trust in social robotics when addressing anxiety and panic disorders. While social robots can help assist individuals with anxiety and panic disorders, they should complement, rather than replace, human interaction in therapeutic relationships. Therefore, social robots should be considered part of a comprehensive treatment plan, ideally in collaboration with mental health professionals.

According to existing research, social robots hold promise in alleviating anxiety and panic disorders among students in educational setting. It is crucial to adopt a user-centric approach to design these robots, considering aesthetic appeal, emotional factors, and the ability to adapt to user profiles. Using social robots with a comprehensive mental health treatment plan is critical, and collaboration with trained professionals is essential. These findings provide a solid basis for the creation of social robots that can offer effective and comprehensive support to individuals dealing with anxiety and panic disorders, promoting their overall well-being.

Previous research in Social robotics has highlighted the importance of developing robots with advanced social interaction capabilities (Breazeal, 2004; Mori et al., 2012). Such robots must possess not only technical proficiency but also social attunement and approachability, striking a delicate balance between efficient task performance and engagement in spontaneous and relatable interactions with humans. Breazeal (2004) has emphasized the positive correlation between a robot's ability to mimic human interactions and the receptivity of humans, which fosters enhanced collaboration and trust. However, the "uncanny valley" phenomenon suggests hyper-realistic robots can evoke discomfort (Mori et al., 2012). Social robots occupy a unique space at the intersection of technology and sociability, designed to replicate human interactions and cultivate spontaneous engagement with humans (Panico et al., 2020). Achieving this balance requires a multidisciplinary approach integrating insights from psychology, design, engineering, and anthropology. These robots have made significant inroads into various sectors, including education, customer service, and healthcare, with the potential to enhance learning experiences, customer interactions, and patient care. However, ethical principles must guide their integration into healthcare settings, ensuring self-governance, doing good, avoiding harm, loyalty, fairness, usefulness, and self-sufficiency (Panico et al., 2020). Social robots have shown promise in the field of mental health, offering therapeutic support and alleviating feelings of isolation among individuals dealing with depression, anxiety, and cognitive disorders. While technology enables these robots to offer more tailored care and early interventions through continuous interaction analysis, they must be considered complementary tools that augment, rather than replace, human connections and expert therapeutic interventions. Ethical considerations must guide the seamless integration of these robots into mental health care, as human interaction remains irreplaceable in mental health treatments.

The present study underscores the significance of trust in social robotics for managing anxiety and panic disorders. It emphasizes that social robots should complement human interaction in therapeutic relationships instead of replacing them. A trust-based approach supports the conclusion that social robots should be integrated into a comprehensive treatment plan, ideally working with mental health professionals. The study raises ethical and practical concerns regarding the integration of social robots into mental health care, particularly concerning their long-term use and the need for supervision by trained professionals such as psychologists or counselors. In contrast, prior research has predominantly focused on the reception of social robots and their potential applications without delving into the specific role of trust or the need for collaboration with human professionals. These findings provide valuable insights into social robots, particularly in the context of mental health interventions, and underscore the significance of considering students' perspectives when designing and implementing social robots in educational and therapeutic settings.

The findings from the current study on the effectiveness of social robots as an intervention strategy to alleviate anxiety and panic disorders among students align with and are supported by previous research in social robotics. Trust, user-centered design, and collaboration with mental health professionals are crucial to the success of social robots in mental health care. These findings are backed by previous researches that highlights the role of social robots in various sectors, their impact on human-robot interactions, and ethical considerations (Breazeal, 2004; Mori et al., 2012; Panico et al., 2020). By considering these findings, researchers can further advance the field of social robotics and its integration into various sectors, including mental health care.

The current study contributes to the growing body of literature on social robots by providing new insights into the use of social robots for addressing anxiety and panic disorders among students. A significant finding of this study, which is consistent with prior research, is the critical role of trust in human-robot interactions. The study emphasizes the importance of trust, suggesting that social robots should complement as assistive tool, not replace human interaction in therapeutic relationships. Moreover, the study recommends supervision by trained professionals to ensure the safety and effectiveness of the intervention. This perspective agrees with Breazeal's (2004) research, which also recognizes the significance of trust in human-robot interactions. Breazeal's work highlights the positive correlation between a robot's ability to interact like a human and its reception, emphasizing the enhancement of collaboration and trust. Therefore, the current study's emphasis on trust in the context of anxiety and panic disorders aligns with the broader understanding of trust's pivotal role in social robotics. The present study provides valuable insights into a user-centered approach to designing social robots for anxiety coaching. Unlike previous studies that have mainly focused on technical and sociability aspects, this study delved into the specific user preferences and characteristics of high school and university students. The findings of this study revealed that high school students prefer cute, soft, and comforting robot designs that provide emotional reassurance, akin to hugging a pillow or a human. On the other hand, university students prioritize clear boundaries, sound detection, emotion recognition, and adaptability to different user profiles. These insights offer a more detailed and user-centered perspective on social robot design, highlighting the crucial role of aesthetics and emotional aspects in mental health support through robotics. This user-centered design approach aligns with the multidisciplinary approach proposed by previous studies, emphasizing insights from psychology, design, engineering, and anthropology to ensure that social robots are technically proficient and socially attuned. Therefore, this research contributes to a more comprehensive understanding of user preferences and the significance of a user-centered design approach in developing social robots for mental health.

The study also sheds light on the student's perspective regarding social robots as an intervention strategy to alleviate anxiety and panic disorders. Unlike existing research that has primarily focused on the perspective of educators, professionals, psychologists, and counselors, this study gathered insights and preferences from high school and university students through workshops. These insights contribute to a clearer understanding of the design and functionality of social robots for mental health support. This area has yet to be comprehensively covered in existing research on social robotics. Overall, this study contributes significantly to the literature on social robotics for mental health support. Considering the user's perspective, this study provides a more holistic approach to designing social robots that effectively deliver anxiety coaching. The findings of this study can inform the development of social robots that meet users' needs, ultimately contributing to improved mental health outcomes.

Despite the potential benefits that social robots hold in the area of mental health, certain limitations in the current research need to be addressed. For instance, user studies have highlighted issues related to the height levels of the robots for different age groups of users. In contrast, the robot's reliance on pre-set algorithms for evaluating users’ mental states has been found to limit their effectiveness. Additionally, the dynamic nature of mental states, which can change rapidly, presents a significant challenge that needs to be tackled in order to explore the potential of social robots in this domain fully. To improve their capabilities as anxiety coaching tools and improve their designs and functionalities, further research is necessary. It is also important to note that previous research has only involved a limited number of high school and university students, making it crucial to consider a diverse range of students from different levels of education, backgrounds, and nationalities. The implications of this research are significant, as social robots have the potential to be valuable resources in healthcare and therapy for those suffering from anxiety and panic disorders. However, ensuring their safe and effective use requires continuous investigation and improvement.

8.1 Limitation and Future Work

This study sheds light on the functional abilities and potential therapeutic benefits of the EMO-DUMP robot for students with anxiety and panic disorders. However, it is essential to acknowledge that the research has limitations.

During the pre-study with sixteen high school students, the NAO robot's speech recognition system exhibited limitations in understanding users with different accents, speech speeds, and complex sentence structures. The robot's positioning and the user's proximity to its microphones also affected speech recognition. As a result, there is a need for enhanced speech recognition systems to foster better empathic interactions, especially for interpreting children's speech.

The design evaluation and subsequent co-design workshop with nine university students brought to light one of the most significant challenges in designing social robots: the challenge of creating social robots that meet the needs of users of varying ages. It was noted that smaller robots may be less intimidating for children, while larger ones may be preferred by adults. Furthermore, it was suggested that the robot should adopt a softer tone while interacting with children to prevent any fear. Therefore, it is crucial to incorporate age-appropriate designs and functionalities to ensure that the robots are well-received and effective across a wide range of age groups.

Although algorithms can help assess users' mental states, they may struggle with the complexity and variability of human emotions and mental health conditions. This highlights the necessity for more advanced and flexible algorithms to tackle this challenge. It is essential to remember that social robots should not replace the knowledge and expertise of mental health professionals but rather work as an assistive tool for them. Emotions and mental health conditions constantly evolve, making it challenging for social robots to keep up with them. This underscores the significance of professional supervision and potential future advancements.

The study was limited to high school and university students, potentially excluding insights from other age demographics who experience anxiety and panic disorders. The impact of cultural, geographical, and socioeconomic factors on participants' feedback remains to be seen, which may limit the study's generalizability to other situations. Moreover, personalizing the robot to meet every individual's needs is challenging and may not be feasible, posing additional challenges not accounted for in this study.

The multifaceted nature of anxiety and panic disorders requires a broader range of research methodologies to understand the psychological and emotional dynamics at play. The study predominantly captured student perspectives, with limited input from mental health professionals. Therefore, in-depth insights from psychologists and therapists could enhance the robot's design and functionality for therapeutic use.

Ethical and safety concerns surrounding privacy, data security, and the risk of overreliance on technology must be rigorously addressed when deploying social robots in mental health settings. The long-term effectiveness and sustainability of these robots remain insufficiently explored, necessitating more extensive and extended research to assess their lasting impact in supporting individuals with anxiety and panic disorders. The prohibitive costs associated with developing, maintaining, and deploying social robots can limit their accessibility, calling for research aimed at cost reduction and enhanced affordability to benefit a broader population. Overcoming the stigma associated with mental health issues and resistance to accepting robotic assistance is another challenge that research should address to promote user acceptance. Finally, understanding the intricacies of human-robot interaction and its impact on the therapeutic relationship is an ongoing challenge, requiring research to determine the optimal balance between human and robot involvement in mental health interventions.

In conclusion, this study provides early insights into how EMO-DUMP could assist students with anxiety and panic disorders. It is of utmost importance to consider the limitations encountered when analyzing the outcomes of robotic assistance in therapeutic settings. Therefore, it is suggested that future research try to fill in these gaps to make robotic therapy more useful and effective.

9. CONCLUSION

Upon conducting extensive research for this thesis, it has become evident that the integration of social robots into mental health can serve as a valuable support system for students struggling with anxiety and panic disorders. The study has yielded insightful outcomes that have significantly contributed to the advancement of human-centered design (HCD) and robot interaction (HRI), thereby leading to an improved state of mental well-being for students. This conclusion serves as a comprehensive summary of the diligent efforts made, significant findings uncovered, and valuable contributions made to the field.

The objective of the research was to delve into the rising incidence of anxiety and panic disorders among students. Considering the pivotal role technology plays in our daily lives, this study endeavors to explore the potential of harnessing social robots as a novel form of aid. To pave the way for future research stages, a thorough review of existing literature was conducted.

The research study prioritized students' perspectives, who are the primary recipients of technological advancements. Through engaging students in focus groups and co-design sessions, the study was able to capture the authentic voice and emotions of this demographic accurately. Notably, the first phase of the research involved sixteen high school students who participated in Pre-study and co-design sessions; valuable input was instrumental in shaping the creation and progress of the EMO-Dump social robot low-fidelity prototype.

The EMO-Dump low-fidelity prototype began as a basic model and was further developed through a design evaluation and follow-up co-design workshop process with nine university students. These co-creative sessions were instrumental in refining the prototype to meet the unique needs and preferences of students. Valuable feedback was gathered through hands-on workshops and various feedback mechanisms, revealing the importance of a multifunctional and empathetic social robot to enhance the student experience.

The comprehensive research results shed light on students' expectations of social robots when managing their mental well-being. The findings highlighted several vital features, including emotional detection and response, a comforting physical design, advanced detection capabilities, and interactive support elements. These vital elements were incorporated into the final design of the EMO-Dump. This empathetic and supportive robot offers immediate comfort and crisis escalation functions when necessary, ensuring that professional help is always within reach.

This study goes beyond technology design by offering valuable insights into the critical elements of trust, empathy, and interaction essential for successfully integrating robots in mental health settings. The guidelines developed in this research provide a comprehensive framework for future design and research efforts, emphasizing the significance of empathy, user comfort, privacy, adaptability, supportive features, professional support, personalization, education, feedback, and physical comfort. These contributions have far-reaching implications for the field and will undoubtedly shape the future of mental health care.

This study highlights the importance of placing user experience at the forefront of design processes, particularly in areas as sensitive as mental health support. By utilizing an iterative design approach and consistently seeking feedback, the EMO-Dump prototype not only meets the immediate needs of students but also has the potential to evolve and adapt to changing requirements and technological advancements.

To summarize, this thesis presents compelling evidence for the significance of social robots in mental health interventions, particularly for students experiencing anxiety and panic disorders. The EMO-Dump robot was crafted with student involvement in the design process, addressing their needs and providing inventive support. This robot showcases the potential of empathetic technology and human-centered design in improving mental health, paving the way for further exploration into interactive social robots that can enhance academic achievement and overall well-being for students worldwide. By combining technology and mental health research, these interventions have the power to transform the way we approach mental health and well-being.

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10. APPENDICES

Appendix 1

Informed consent form for design evaluation and follow up co-design workshop

Prior to the design evaluation and follow-up co-design workshop, all participants were presented with an informed consent form. This form contained a link for participants to indicate their agreement to take part in the session. Participants were also informed of their right to withdraw from participation at any time, including during the session. Furthermore, participants were given a clear understanding of the ethical and privacy concerns regarding the session, including the fact that no audio or video recordings would be taken and that their personal information would remain completely anonymous.

Appendix 2

Questionnaire for the Pre-user study and Co-design workshop with sixteen highschool students.

Q0: Introduction to NAO

Q1: How should the robot look like? (Do you prefer humanoid, animal or some other form in this kind of robot?) What are the features that you expect in the robot? (Example: Different sensors, interaction modalities)

Q2: Can robots assist students dealing with anxiety and panic disorders in the classroom? Please explain your reasoning in short for either a positive or negative response.

Q3: If yes, design a Scenario of your expected interaction, focusing on REDUCING anxiety and panic disorder of the students supported by robot in the classroom.

If No, design a scenario of your expected interaction, focusing on how the interaction with robot may go wrong INSTEAD OF REDUCING the student's anxiety and panic disorder in the classroom.

Appendix 3

Questionnaire for the Design Evaluation and Follow-up co-design workshop with nine University students

Design Evaluation questions

Q1: Can robots assist students dealing with anxiety and panic disorders? Please explain your reasoning in short for either a positive or negative response.

Evaluate the Initial Robot Design.

Q2: Provide an in-depth evaluation of the initial robot design, outlining your thoughts and opinions on its functionality, aesthetic appeal, and overall effectiveness. Highlight areas where the design excels and aspects that could be improved.

Co-Design Workshop questions

Q3: Identify and design features to be added or removed from the initial robot design. Justify your proposed modifications by explaining how each change would enhance the robot's performance, utility, or user-friendliness. Consider and address any potential challenges or limitations associated with your suggested modifications.

Q4: Develop a Scenario Featuring the Proposed Robot Design Craft a detailed scenario in which your proposed robot design is utilized. Describe the setting, objectives, and tasks the robot is expected to perform, demonstrating how the design modifications you suggested in Task 2 contribute to the robot's effectiveness and efficiency in this scenario. Your scenario should illustrate the practical applications and benefits of your redesigned robot, providing insight into its potential real-world impact and value.