Tampere University

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EXPLORING THE EXPERIENCE OF DIFFERENT ROBOT PERSONALITIES IN ENHANCING UNIVERSITY STUDENTS' LEARNING

Comparative study on Furhat robot as a teaching assistant

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ABSTRACT

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This research explores the user experience of different robot personalities in enhancing university students' learning. To achieve this, the study utilizes the Furhat robot as the teaching assistant. By this, we aim to assess participants' engagement, attention level, perception, emotions, and experience towards robot personalities in the context of learning. While researchers have extensively explored the use of robots in the role of teaching assistants in education, there is a noticeable gap in exploring the impact of different robot personalities in enhancing university students' learning experiences. We conducted two study phases at Tampere University premises in order to examine the experience and impact of Furhat personalities on student engagement and learning outcomes.

In the pre-study, twelve participants who were students at Tampere University interacted with three different existing Furhat personalities as teaching assistants. The goal of this study phase was to assess the student engagement, attention levels, and to identify perceptions and emotions towards the robot. As data collection methods, questionnaires and canvas tasks were administered to the students and Affinity diagrams were utilized to analyze the findings. The results revealed that issues such as accuracy of the information, speech, communication style, behavior, and appearance led most students to perceive Furhat personalities as companions rather than effective teaching assistants.

For the main study, we introduced a newly designed personality named Astro Luna as an astrology teaching assistant to engage and enhance effective learning experiences for students. This new personality was designed by utilizing the Big Five personality traits. Astro Luna is a teaching assistant which provides educational content about astrology. It mainly facilitates learning and engagement in an academic context. Additionally, the appearance, speech patterns and interactions fulfil its perceived function by emphasizing clarity, professionalism and expertise in astrology. Therefore, participants perceived Astro Luna as a positive, engaging personality indicating its potential as a teaching assistant in educational settings.

Four participants studying at Tampere University joined this study. The goal was to assess students' experiences of the new personality in the context of learning. Surveys and interviews were conducted as data collection methods and content analysis was employed to analyze data provided by the participants.

Overall findings of this research contribute to the previous literature about the experience of the teaching assistant role. It identified limitations, which were related to accent detection, speech speed, and physical features of robots. Moreover, as a contribution, six design implications were derived from the findings of this research and were suggested for future research and development.

Keywords: Human-robot interaction,Social robots, Educational robots, Robot personalities, User Experience, Human-centered Design
The originality of this thesis has been checked using the Turnitin Originality Check service

PREFACE

“The way to develop self-confidence is to do the thing you fear and get a record of successful experiences behind you." --William Jennings Bryan.

Starting my first research was a completely new experience for me. I felt intimidated and wasn't sure where to start. Like many students in similar situations, I wanted to approach it with determination. Despite my anxiety, my family and friends stood by me, believing in me more than I believed in myself. Their unwavering support gave me hope and courage and kept me going.

Their encouragement inspired me to step out of my comfort zone and take on challenges. With each small victory, I began to feel more confident and resilient. Remembering the wisdom of William Jennings Bryan, I realized that true confidence comes from facing and overcoming our fears. To anyone reading this, I urge you not to let fear hold you back.

So I started this research journey based on the trust my loved ones placed in me. First of all, I would like to express my heartfelt thanks to my exceptional lecturer Dr. Aino, who serves as a role model for me as well as many students. Thank you for always believing in me and encouraging me. I am thankful to my supervisor Aparajitha for her guidance and support throughout this journey.

I would like to thank my family members for always standing up for me and believing in my abilities. Also, thanks to my friends at home and in Finland, especially Isivari and Vimukthika, for pushing me and motivating me to do my best.

I was determined to overcome any obstacle that came my way. As I overcame each challenge, I always thought I was getting closer to achieving my goals. Inspired by the words of William Jennings Bryan, I enter this journey with courage and determination, transforming fear into victory.

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Dakshika Erangi Kulathunga

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1. INTRODUCTION

This chapter outlines the essential concepts related to this research, including human-robot interaction, robot personality, social robots, and human-centered design. Additionally, it defines the research objectives and research questions that will guide this study.

1.1 Background and Motivation

Nowadays, the field of robotics is a field that shows great progress. One area that deserves special attention is the development and integration of social robots. Now who are these social robots? According to Fong et al., (2003), social robots, also known as social interactive robots, are designed to interact with humans in a way that mimics social interactions. They also incorporate human behaviors such as listening, speaking, and expressing emotions (Fong et al., 2003). Those robots also include human behaviors such as listening, speaking, and expressing emotions. These social robots have been used in various domains such as education, healthcare, customer service, etc., because they have the potential to enhance human experiences and interactions. Many researchers are interested in using robots to aid learning, and some are studying how these robots can be useful in classrooms.

The researcher Belpaeme et al., (2018) highlight the potential benefits of using robots in education, such as improving empathy, facilitating peer-to-peer learning, and reducing teacher workload. These benefits are considered valuable in educational contexts. They also discuss the role of humanoid robots in education. They argue that educational robots can help students to develop a variety of skills, including computational skills, language learning, problem-solving skills etc. This shows how interactive robots can help people learn in a way where they are actively involved and participating in their own learning. Understanding how robots influence human interactions in educational contexts are essential. This area of research can offer valuable insights into utilizing social robots' roles as teaching assistants and their potential impact on student learning experiences. This area of research can offer valuable insights into utilizing social robots' roles as teaching assistants and their potential impact on student learning experiences.

The study by Salem et al., (2013) examines the impact of robot gestures on perceived anthropomorphism and likeability. Although their research mainly focused on social robots' gestures, their findings provide important insights into how specific robot behaviors, such as facial expressions and non-verbal cues, could potentially influence human interactions. This insight aligns with my thesis research curiosity on how different robot personalities might similarly affect students' learning experiences as teaching assistants. It's understood that a human's personality is shaped by a mixture of genetic factors and environmental influences. According to Kernberg, (2016) personality is a dynamic fusion of an individual's complete subjective experiences and behavior patterns. This includes both conscious and unconscious aspects, along with personal views and intentional states. Simply a personality can be demonstrated as a combination of all the different parts of an individual's mind and emotions.

When exploring robot personalities, researchers have experimented with the concept of robot personalities and their potential applications across various sectors. The article by Paetzel-Prüsmann et al., (2021) shows that *robot personality is developed through a combination of affective content, facial expressions, behavioral patterns, and interaction strategies*. Affective content is expressed through conversational tone and emotional responses, with some personalities being optimistic and encouraging while others are impatient and provocative. Facial expressions are utilized to align with specific personalities, such as excitement or frustration. These attributes were utilized to create unique personalities for the robots, impacting how they interacted with humans. Based on this article, we state that using the term 'personality' to describe the different personas or characters of the robot is appropriate, as it highlights the importance of personality in shaping human-robot interactions. Specially, we have to keep in mind that robot personalities are not identical to human personalities. While human personality is complex as it also contains various genetic influences and molecular processes (Zwir et al., 2020), robot personality is typically designed by humans and is a much simpler concept than human personality.

To create these robot personalities, some researchers have used the Big Five-factor structure (Miwa et al., n.d.) by assigning different levels of factors to the robot's empathic and expressive personality. For example, the researcher was able to change the robot's level of agreeableness, one of the Big Five-factors, from highly cooperative to more antagonistic. Apart from that, other factors of the Big Five, such as extraversion and neuroticism, have also been used to enable robots to express a range of different personal-

ities. These efforts are part of a broader exploration into how robots can adapt their behavior and emotional expressions to interact more effectively with humans and serve specific roles in various fields (Miwa et al., n.d.).Not only that, but some of the research studies have also shown that various personality traits of robots can affect how trustworthy, intelligent, capable, and persuasive they are perceived to be. Especially when it comes to trustworthiness, communication style, including social characteristics, emotional behaviors, and natural communication cues, plays an important role in how robots are perceived by users (Robert Jr. et al., 2020).

The robot's communication style, behavior and appearance are important factors in human-robot interaction. Considering these factors in particular, various studies show that using the robot as a teacher assistant can significantly affect the way students interact. The study by Walters et al., (2008) highlights the importance of the interaction between voice style and appearance in relation to students' perception of and interaction with robots. It also shows the importance of combining both appearance and voice for the overall personality of the robot.

While most of the existing research has touched the aspects like robot appearances, gestures, and voice styles, *there is a noticeable lack of research specifically investigating the impact of different robot personalities on student learning experiences*. Therefore, this thesis aims to explore the use of the Furhat robot, a novel robot, equipped with OpenAI skills in the context of acting as a teaching assistant. The author of this thesis hypothesizes that combination of Furhat robot’s capabilities and OpenAI's technology can lead the way for a more effective and humanized approach to education. Therefore, this study aims to explore the application of the existing OpenAI skills within Furhat for the role of teaching assistants, utilizing the personalities integrated into these skills.

This research is an individual master thesis project conducted at Tampere University's RoboStudio. We were given access to RoboStudio to test out the different personalities of the Furhat robot. Furthermore, the target group of this study consists of university students as participants. These students will play a central role in the study by providing valuable insight into their experiences, perceptions and feelings about the different personalities of the Furhat robot.

By involving Tampere University students as the target group, the research aims to directly explore the impact of various robot personalities on individuals who are actively

engaged in the learning process. This approach ensures that the findings and conclusions drawn from the study are directly relevant to the target audience and can inform future implementations of robots in educational settings.

1.2 Research Objectives and Research Questions

The overall goal of this thesis is *to investigate how different robot personalities of the Furhat robot can enhance the learning experience of university students*. Additionally, this research aims to provide contribution to the field of social robotics and education, offering design guidelines for optimizing robot personalities as teaching assistants in order to enhance student learning experiences.

Research Questions

Question 01 (RQ1): How does the use of different robot personalities impact student engagement and attention levels during learning activities?

Question 02 (RQ2): What are the perceptions and emotions of students when interacting with a teaching assistant robot with various personalities?

Question 03 (RQ3): What are the students' experiences about the newly designed Astro Luna personality in the context of learning?

A series of educational tasks were conducted to address the first and second research questions regarding the impact of different robot personalities on student engagement, attention levels, perceptions and emotions during learning activities. For data gathering qualitative and quantitative data were gathered.

To address the third question regarding the students' experiences with the newly designed personality in the context of learning, a new personality was introduced named Astro Luna using Furhat robot. Astro Luna is a teaching assistant that helps students with astrology. Several educational tasks were conducted to assess the impact of the newly designed teaching assistant on student learning. Both quantitative and qualitative data were collected.

1.3 Structure of Thesis

The rest of the thesis is structured as follows:

The second chapter of this thesis includes the related work, which encompasses previous literature. It is divided into three sections: social robots, the role of robots as teaching assistants, and different robot personalities.

The next chapter, Chapter Three is Methodology. This chapter contains the research approach and methodology, research process and phases, research platform, and ethical considerations. The research approach and methodology are divided into two subsections: data gathering methods and data analysis methods conducted throughout the research.

Following that, we proceed to Chapter Four, which is the pre-study of Furhat robot personality exploration. This chapter contains the objective of the study, study procedure, data gathering, data analysis, participants, and findings. Under findings, eight themes were discovered. At the end of Chapter Four, a summary of the findings is presented.

Chapter Five describes the main study phase of this research, including objectives, new personality design and goals, procedure, introduction and exploration of the new personality, data gathering, data analysis, and findings. The findings section includes nine subsections which represent the themes found after conducting content analysis of gathered data.

Continuing to Chapter Six, it presents the design implications of Furhat robot personalities in the teaching assistant roles. This includes six implications identifies through the research, which will also serve as contributions to this thesis.

The next chapter, Chapter Seven, is the Discussion section. It consists of three subsections: summary of findings, discussion about ethical aspects and limitations, and future work. At the end of the thesis, Chapter eight includes the conclusion of this research.

2. RELATED WORK

In this chapter, the related work is presented. The chapter is structured into three sections, each contributing insights to the study. The first section explores social robots, describing their unique characteristics and capabilities in engaging with humans. The second section focuses on the role of robots as teaching assistants, exploring the understanding of robots as teaching assistants, the success of educational robots, and their advantages over human educators. Lastly, the third section focuses on the importance of different robot personalities, highlighting how the personality attributes of robots can significantly influence human interactions.

2.1 Social Robots

Social robots in educational settings have raised a lot of attention from researchers in recent years. Numerous studies have explored the potential benefits of using social robots as tutoring agents, emphasizing the importance of social interactions between robots and students in delivering personalized learning experiences. Characteristics of social robots.

2.1.1 Unique characteristics and capabilities of social robots

Duffy's article (Duffy et al., 1999) "What is a Social Robot?" explores the unique characteristics of social robots, highlighting their physical embodiment and social intelligence, which enable them to interact and engage with the real world. The capabilities of social robots in engaging with humans have quite a lot of attention in the field of human-robot interaction. Social robots are designed to enhance the user experience by interacting with humans (Corrales-Paredes et al., 2023). This section explores the characteristics and capabilities that make social robots uniquely suited for such interactions.

Social robot architecture: The article by Duffy et al., (1999) explains about the Social Robot Architecture, with its four layers: physical, reactive, deliberative, and social. The social robot architecture consists of four layers. Each layer has a specific role in effective interaction and coordination between robots. The first layer is the physical layer. It deals with the tangible presence of robots in the environment. Above this, the second layer named the reactive layer executes basic reflexive behaviors and processes sensory information, communicates agent events, and receives commands from higher layers. The next layer, Deliberative Layer uses a belief-desire-intention (BDI) architecture to manage cognitive processes, update beliefs, and coordinate actions based on commitments. The

last named as social layer facilitates interaction and coordination between agents using an agent communication language (ACL) ensuring effective communication and cooperation between heterogeneous agents. These unique features enable social robots to engage in meaningful interactions with humans, understand their intentions, and communicate effectively.

Social Intelligence: Conventional robots are also known as industrial robots. These robots' function within predetermined parameters and they lack autonomy. Social robots are different from conventional robots because they possess social intelligence, which sets them apart. This feature allows them to understand and respond to human interactions based on context (Williams, 2012). Williams argues that, as robots become more and more a part of human society. Their true potential impact can only be realized if they have the cognitive abilities to fluently interact with humans. Researchers have looked at these features and their impact on fields such as education, healthcare, and human-robot interaction. In theory, we can say these robots are built for social intelligence, but whether these social skills actually exist remains to be seen.

For example, Ahmad investigated the role of social robots in autism therapy. They found that socially intelligent robots can effectively connect and interact with children with autism. They were also found to facilitate improved social skills and communication abilities. This research shows that social robots have some ability to form personal relationships and exhibit advanced social behaviors with other beings

Similarly, the study by Graterol et al., (2021), shows that these social robots can understand emotions using technology such as NLP (Natal Language Processing) Transformers and Emotion Ontology. They used advanced technology to detect emotions by studying facial expressions and listening to voices. This shows that social robots have the ability to understand human emotions and communicate and interact with humans more sensitively and effectively. However, while these robots may be good at several tasks, it remains to be seen whether they still have high social skills.

Adaptability: Another aspect of the unique characteristics of social robots is their adaptability and behavioral heterogeneity. Research by Bartneck & Forlizzi, (2004) focuses on the design-centered approach to social robots. Their work shows that it is important to create robots with flexible and adaptive behavior, allowing them to respond appropriately to different social contexts and individual preferences. The paper also shows some important characteristics of social robots, one of the main aspects being their form and design. Robots take on a variety of appearances, including human- or animal-inspired forms.

Autonomy: Autonomy is a characteristic that differentiates between social robots, with some robots completely dependent on human control while other robots make decisions independently (Bartneck & Forlizzi, 2004). The article (Bartneck & Forlizzi, 2004) argues that existing definitions of robots focus primarily on their industrial applications and autonomous capabilities. The researchers say that social robots fail to sufficiently capture the interaction between robots and humans, and thus, research suggests defining social robots as autonomous or semi-autonomous robots. Furthermore, they discuss the importance of communication and interaction with humans in defining social robots. It states that robots that only interact with other robots do not qualify as social robots because the essence of sociality lies in human-robot interactions.

Aesthetic form : One defining characteristic of social robots, discussed by Hegel et al., (2009) is their aesthetic form. Social robots place a strong emphasis on their appearance, often resembling humans with features like a head, face, and body. This human-like form plays a special role in human-robot interactions by expressing social cues and signals. Unlike industrial robots, which prioritize functionality, social robots aim to be visually appealing and approachable, enhancing their acceptance and integration into human environments.

Human-robot interaction through affective computing: The article by Gunes & Churamani, (2023) shows that social robots are equipped with advanced emotional expressive abilities and these abilities help to communicate effectively and understand emotions. They use speech recognition and natural language processing to understand and generate human language. Another important aspect is affective computing, which enables social robots to understand and respond to human emotions. By integrating affective computing into robot design, they say that social robots can form deeper connections with humans and provide personalized experiences (Gunes & Churamani, 2023). By integrating affective computing into robot design, they say that social robots can form deeper connections with humans and provide personalized experiences.
As the article states, emotional expression includes facial expressions, body language, and verbal cues, while understanding emotion involves interpreting these expressions and identifying underlying affective states. Accurately capturing and analyzing emotional signals such as facial expressions and physiological reactions is important for sensing the impact of human-robot interactions. Furthermore, the article highlights the limitations of standard affect recognition tools and emphasizes the need for personalized models in affective behavior modelling. It also emphasizes continuous learning and adaptation in impact robotics. Finally, affective computing seeks to develop systems that can detect,

interpret, and respond to human emotions, thereby improving human-computer interactions.

Enhance student support with social robots : Another study by O'Connell et al., (2024) demonstrated that social robots are beneficial for college students with ADHD. The study showed various capabilities of social robots in assisting these students. Specifically, social robots proved effective and capable of providing companionship and accountability, aiding in time management, mitigating procrastination tendencies, and boosting user engagement.

The study conducted by Pop et al., (2013) highlighted the impact of the delivery method of Social Stories on the effectiveness of children with autism spectrum disorder (ASD). It compared the use of social robots to computer screens in delivering these stories. The results revealed that children interacting with social robots displayed a higher degree of independence in expressing their social abilities when compared to those using computer screens. This highlights the potential of social robots in enhancing the development of social skills, particularly for individuals with unique needs like those with ASD. The social robot's interactive nature and capacity to adapt to the child's emotional state plays an important role in achieving these positive outcomes (Pop et al., 2013).

In addition to their role in assisting individuals with ASD, social robots have a wide range of capabilities for engaging with humans in various contexts. Learning and adaptation are fundamental to their design, as they can evolve and refine their social skills through interactions with humans. Social robots are capable of effectively initiating conversations, maintaining eye contact, and responding to social cues, which are essential for establishing connections with humans. Some social robots are even equipped to build and maintain long-term relationships by recalling past activities, displaying contextualized affective reactions, and adapting to individual preferences(Baraka et al., 2019). Their interconnectivity allows them to access information on the internet and interact with other devices, making them versatile tools for various applications (Baraka et al., 2019).

Social robot role in supporting individuals with special needs and their broader potential for building long-term relationships, providing assistance, and facilitating companionship demonstrate the impact of social robots in various contexts.

Likewise, the unique characteristics and capabilities of social robots, including their aesthetic form, emotional expression, language processing, affective computing, presence of physical embodiment proves that it makes them important in enhancing human-robot interactions.

In conclusion, the unique characteristics of social robots, including their social intelligence, ability to connect with emotions, adaptability, and autonomy, make them unique from conventional robots. These features enable them to engage in meaningful interactions, understand human intentions, and communicate effectively. Social robots play a crucial role in various fields, such as healthcare and education, where their form, design, and interaction capabilities are utilized to meet specific needs.

2.2 Role of robots as teaching assistants

2.2.1 Defining Educational Robots

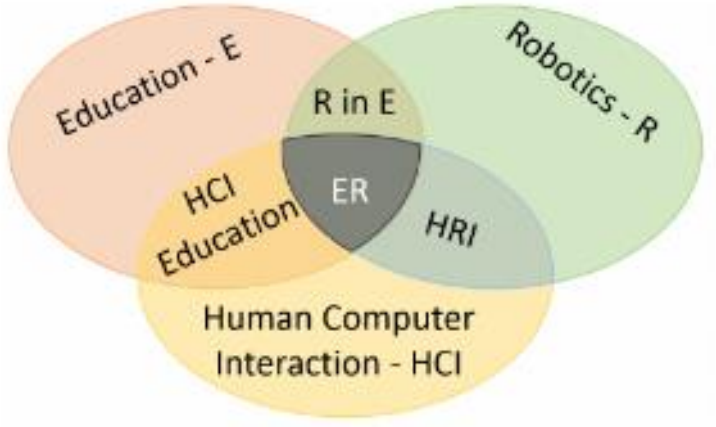

Figure 1 Basic components of educational robotics (Angel-Fernandez & Vincze, 2018)

First of all, to understand educational robots, it is important to know what are the fields of studies that involved (Figure 1). According to Angel-Fernandez & Vincze, (2018), three main fields have been introduced in the area of educational robots: Education, Robotics, and Human-Computer Interaction. Education covers all the subfields aimed at enhancing learning experiences and outcomes. So, educational robotics can be defined as the intersection of these fields, where robots are utilized as active tools or agents in the educational process. This involves utilizing robotic technology to facilitate and enhance learning across various subjects and levels of education. Educational robots are designed to engage with learners, deliver educational content, and provide interactive experiences that promote understanding and skill development. They can range from simple programmable robots used to teach basic coding concepts to advanced AI systems utilized for advanced learning scenarios. This explains that educational robots act as adaptable tools in educational settings by enhancing teaching methodologies and enhancing student learning. Robotics provides physical platforms for interactive learning and human-robot interaction ensures user-friendly and engaging interactions with these

robots. Together, they allow educational robots to provide effective educational experiences.

2.2.2 Understanding robots in education

As we know robots have increasingly become a part of educational settings. They offer unique opportunities to enhance the learning experience. The evaluation of robots in education is important as it explores the effectiveness of robotic teaching assistants. This section will explore the role of educational robots, defined by their embodiment, intelligence, and interactive capabilities.

Overview of ERA principle: The article by Catlin & Blamires, (2010)discusses the role of educational robots in providing positive learning environments and experiences. The article introduces the ERA (Educational Robotic Applications) Principles, which offer a framework for understanding the value of robots in education. They also provide guidelines for designing educational robots and activities. This article shows the importance of engagement, interaction, embodiment, and sustainable learning in enhancing students' educational experiences with robots.

Enhance learning outcomes through robot engagement: In education, robots are playing an important role in improving the learning experience. These robots come in different forms and roles, like social robots, teleconference robots, a tutor, peer or as a tool. The article by Mubin et al., (2013) demonstrated that integrating robots into education can lead to improved learning outcomes. As an outcome, researchers found out that students' education enhanced performance on post-learning examinations and increased interest in comparison to traditional methods. This suggests that robots have the potential to positively impact students' academic achievements. Moreover, robots make learning more engaging and enjoyable for students, capturing their interest through hands-on activities and interactive experiences.

The role of robot as teaching assistant also has unique qualities, like being patient and providing one-on-one instruction, which makes them good for helping students learn (Baxter et al., 2017). Therefore, building a good relationship with students is important in teaching, and the way robots behave and communicate is very important for success just like human teachers.

The article by Rosenberg-Kima et al., (2020) evaluated the effectiveness of robots as instructors or educators in guiding group activities. The robot's role involved managing group interactions, providing instructions, and facilitating discussions, which are fundamental aspects of education. The results showed that robots were perceived as non-

judgmental and could utilize in group activities to enhance the overall learning experience.

The article by Tolksdorf et al., (2021)highlights the positive impact of social robots on children's motivation and engagement in educational activities. The novelty of interacting with social robots can generate excitement and curiosity among children, leading to increased motivation to participate in learning activities. Unlike interactions with humans, according to the study children showed higher levels of motivation and engagement when interacting with social robots. This shows the potential of technology, specifically social robots, in creating a positive learning environment that enhances student learning. By utilizing social robots in educational settings, educators can enhance students' learning experiences and promote active participation in educational activities.

Socially programmed robot tutors: Saerbeck et al., (2010) highlights about the intentional programming of robots with social behavior. These behaviors, such as empathy and encouragement, foster a nurturing and supportive learning environment. Their research discusses the design of tailored social support behaviors for a robot tutor intended for language learning applications. By incorporating features such as modelling, nonverbal feedback, attention, empathy, and communication, this study emphasizes how these behaviors can have a powerful impact on student learning performance. The findings of this study show us that even when the content and duration of learning are held constant, the significant effect of social support on learning outcomes is emphasized. This suggests that beyond mere content delivery, having empathetic and encouraging robot teachers can greatly enhance the learning experience and foster motivation and engagement among students (Saerbeck et al., 2010).

Physical embodiment of robot: Some studies show that for learning languages, having a physical robot around is helpful because it can connect physical experiences and gestures to learning a new language. The study by Berland & Wilensky, (2015), conducted to compare the learning outcomes of students using virtual and physical robots, revealed several advantages associated with physical interaction. Students interacting with physical robots demonstrated an improved understanding of complex systems and computational thinking. These findings showed the importance of having physical robots in educational settings to enhance students' learning experiences and outcomes. The article by Catlin & Blamires, (2010) also emphasizes the importance of the physical embodiment of robots in the same space as students for their learning. The article discusses how this physical presence of a robot offers unique and tangible learning experiences. So, researchers have shown that engagement with educational robots provides positive

emotional states, creates positive learning attitudes, and improves the quality and depth of students' learning experiences.

The physical presence of these robots allows for direct interaction, simulating the dynamics of face-to-face communication, while providing consistent feedback and encouragement to recognize student achievements and build a sense of companionship (Baxter et al., 2017)

Robots with Artificial Intelligence: Another important aspect of the role of robots in education is intelligence. The article by OECD, (2021) shows how robots have been utilized in educational contexts with artificial intelligence (AI) and are being explored as teaching assistants. These robots with AI capabilities are designed to interact and engage more effectively with humans. Especially in educational settings, the ability of robots to communicate through speech, facial expressions, and interaction is very important in enhancing the learning experience of students. To be effective as a role in educational settings, robots need to adapt to each student's needs by considering their learning abilities and differences (Konijn & Hoorn, 2020).

When considering social robots, social robots are popular for their ability to form strong social and emotional connections with students in educational settings, which greatly enhances student engagement and the overall learning experience. These robots can be personalized or customized to meet the unique preferences and needs of each student. Which results in the development of a special bond between the student and the robot (Belpaeme et al., 2018).

All the above factors show that social robots have the potential to revolutionize educational environments as educators. As they offer personalized, empathetic, and emotionally expressive interactions that significantly enhance student engagement and the overall learning experience.

2.3 Robot Personality

The following graph illustrates the key aspects involved in robot personality as discussed in the literature findings.

Appearance	Behavior	Communication
Human likeness	Reliability and consistency	
Customization	Adaptability	Verbal
Emotions	Responsiveness	Non-verbal
Expressiveness	Ethical considerations	

Table 1 - Discussed aspects of robot personality

2.3.1 Appearance

If we look into the importance of the appearance of robots in the context of personality, it turns out that a robot's appearance plays a crucial role in shaping humans' interactions with it and influencing their perceptions. The study conducted by Walters et al., (2008) shows that when robots' appearance resembles more like humans, individuals tend to interact more with them. But what's interesting is that some individuals, especially those who are introverts or less emotionally stable, prefer non-human-like robots. This observation indicates that human personalities affect what kind of robot designs they prefer.

Fong et al., (2003)provide five common personality classifications utilized in social robots. Some are like tools, some as pets or creatures, some as cartoons, some as characters from science fiction, and some as humans. Each type of personality influences how individuals perceive and feel about robots. These personality classifications come from various factors such as including the robot’s emotions, physical appearance, movements or gestures, and communication style.

Figure 2 Furhat Appearances (Wood & Dillenbeck, 2023)

As an example, the novel robot Furhat brings unique and versatile features that make it an ideal platform for exploring the impact of robot appearances on student learning experiences. According to the Furhat team Wood & Dillenbeck, (2023), the Furhat Robot offers various range of appearance customization options as in figure (Figure 2). allowing for the representation of various personalities with different genders, ages, and degrees of human likeness. Its expressiveness, including expressions that mimic human behavior, enhances the potential for emotional connection and impacts students' perceptions and emotions during educational interactions.

The impact of a robot's appearance is not only effect on relationship and communication between humans and robots but also it helps in mutual understanding.

The article by Pakrasi et al., (2018) indicates various archetypes of robot personalities and their interplay with individuals' preferences. This observation highlights that designing robots with particular appearances and behaviors could provide feelings of comfort and friendliness among individuals. This shows that appearance is a crucial attribute of robot personality, as it directly influences how individuals perceive and interact with them. By understanding the impact of appearance on human-robot interaction, designers can customize robot appearances to specific emotional responses and facilitate more positive interactions. Additionally, the study highlights the importance of considering individual differences in preferences when designing robot appearances, as different individuals may respond differently to various archetypes.

The study by Walters et al., (2008) emphasizes the significance of different robot appearances and explores how the visual attributes of robots can exert a considerable influence on human interactions and perceptions. The findings underscore the critical role

that a robot's external appearance plays in shaping not only how it is received by individuals but also how they attribute personality traits and preferences to it.

The article by Abubshait & Wiese, (2017) discussed the crucial role of a robot's appearance in human interaction. It suggests that if a robot appears more human-like, it tends to be rated higher in terms of being perceived as having a mind. Another way around if a robot appears to be more like a machine, these ratings might decrease over time.

In conclusion, the above facts show that designing robots with visually appealing and emotionally responsive appearances can enhance user acceptance and engagement, leading to more successful human-robot interactions in various contexts.

2.3.2 Behavior

Additionally, while appearance mainly affects how people perceive the robot, its behavior influences how well people interact with it, such as its gazing behavior (Abubshait & Wiese, 2017). Understanding this interplay between appearance and behavior can greatly enhance human-robot interactions and user satisfaction with robotic technologies.

If we dig more into how crucial this behavior of robots is when it comes to human interaction, The research by Borghi et al., (2023) highlights the importance of robot behavior according to the user's expectations and preferences. It shows that when robot behavior is reliable and consistent, it helps to create positive interactions and boosts user satisfaction and trust in robotic technology. Additionally, understanding how different behaviors affect human-robot interaction allows designers to customize robot behaviors for various user groups, considering individual preferences and cultural differences.

Figure 3 Paro (IEEE Robotics and Automation Society., 2005)

The article by Institute of Electrical and Electronics Engineers, (2005) explored the psychological impacts of robot behavior on human interaction, specifically focusing on elderly individuals. Through a long-term experiment involving seal robots named Paro (Figure 3), researchers identified key design attributes such as emotional expression, adaptability, responsiveness, memory, and safety. The results demonstrated a reduction in depression among the elderly participants following interactions with the robot. These findings highlight the importance of considering robot behavior during the design process, as it can promote positive interactions and reduce psychological issues such as depression among users.

Then there is another area that we have to explore when considering the behavior of robot's personality. That is an ethical consideration. The article by Eiben et al., (2021)discusses the ethical considerations surrounding the behavior of evolving robots. It highlights concerns such as the unpredictability of the evolutionary process and the potential risks associated with robots developing harmful behaviors. The discussion revolves around the need for meaningful human control over the evolution of robots to reduce potential risks. It also discusses the concept of responsibility in ensuring the safe development and deployment of evolving robots. The article suggests that we need to set clear guidelines and control mechanisms to guide how robots evolve. When creating robots, it's crucial to think about ethics as much as technological progress. It highlights that safety, human-robot interaction, and the protection of personal information rank among the highest priorities. Ensuring that robots operate safely and respectfully in human environments is essential. Being open about how robots make decisions, fixing any biases, and following laws and rules also ensures fairness and responsibility. By considering these factors in the design and development of robots, we can ensure that robots exhibit positive behavior and contribute ethically to society.

2.3.3 Communication Style

When discussing communication style, there are two main types of communication. The first type is verbal communication in which we use words either spoken or written to express our ideas and emotions. The article by Marin Vargas et al., (2021) shows that human verbal communication is a powerful medium for expressing emotions. It also highlights that verbal communication enables robots to interact with humans more authentically and effectively. However, researchers found that robots still have trouble in accurately capturing sound from speakers, identifying talking individuals, speech interrup-

tions, etc. This can be a challenge when it comes to human-robotic interaction. By addressing these challenges, we can enhance the usability and acceptance of robots in various domains such as education.

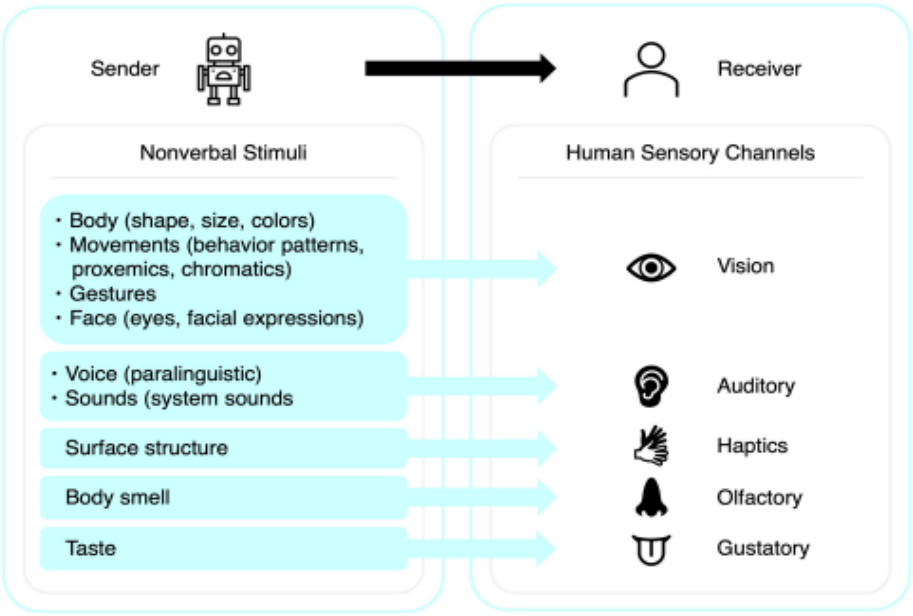

Figure 4 Five sensory Channels (Urakami & Seaborn, 2023)

According to the article by Urakami & Seaborn, (2023), nonverbal cues such as body language, gestures, facial expressions, etc are important factors in human-robotic interaction. Just as in human-to-human communication, the way information is conveyed nonverbally greatly impacts on the effectiveness and user experience of robotic systems in human-robot interaction. The above diagram (Figure 4) from the article shows the factors that need to be considered when it comes to nonverbal communication. The researchers have represented a model where a robot act as the sender and a Human act as receiver. Furthermore, researchers (Urakami & Seaborn, 2023) also show the importance of nonverbal cues in human-robot Interaction by considering five sensory channels which are vision, auditory, haptics, olfactory, and gustatory. Even though the traditional human sensory channels include vision, auditory, haptics (touch), olfactory (smell), and gustatory (taste), the article primarily focuses on the visual nonverbal cues in Human-robotic interaction. According to the article understanding and utilizing visual nonverbal cues are important for robots to effectively communicate and engage with humans in various social contexts.

2.4 Summary of the Related Work

In summary, utilizing social robots in education can be beneficial for several reasons. Social robots have unique characteristics and capabilities in educational settings, which enhance the experience of students and educators. These robots also help to facilitate personalized learning experiences. As teaching assistants, they enhance engagement, interaction, and understanding among students by providing positive learning environments and improving academic outcomes. Furthermore, the importance of robot personalities including appearance, behavior, and communication style highlights the importance of considering individual preferences and ethical considerations in robot design. Effective communication both verbally and nonverbally, is crucial for providing engagement in human-robot interactions. Understanding the potential of social robots in education is essential for realizing their transformative impact on learning experiences and outcomes.

3. METHODOLOGY

The methodology section is structured into four parts, namely, research approach and methodology, research process and phases, research platform and ethical considerations. The first section, research approach and methodology, is further divided into three sections: research approach and methodology, data gathering methods, and data analysis methods.

3.1 Research approach and methodology

Human-centered design is the key approach to this entire dissertation research process. This approach has been popular with researchers for years, especially when creating social robots. Human-centered design prioritizes the needs and experiences of users throughout the product design process (Willis, 2018). This thesis follows the principles described by (Willis, 2018) who provide guidelines for designing social robots. Following are the principles described by Willis,

First, there is the principle of “people first” (Willis, 2018). This shows the importance of creative efforts around human needs, behavior and understanding. After that, the principle of "collaboration" discusses the involvement of a diverse group of people in the design process, and this includes collaboration between people from different backgrounds. Then as the last, the principle of "iteration" describes how we should refine the design through testing and feedback.

This thesis focuses on using the Furhat robot, a social robot, to evaluate its suitability as a teaching assistant for students. To achieve this, the author utilizes the human-centred design approach, as outlined in Willis’s (2018). For the pre-study, three robot personalities are used for participant interaction. These existing personalities of Furhat robot, which has OpenAI skills were created through prompts. Based on the findings from the pre-study, a new personality was created for the Furhat robot which is Astro Luna, and this personality was optimized to address the issues raised in the pre-study.

3.1.1 Data Gathering Methods

In this thesis, various methods were used for data-gathering purposes. During both pre-study and main study phases, a mix of qualitative and quantitative data collection techniques was employed. The article by Lacey & Luff, (2009) discusses the importance of

asking "why," "when," or "how" questions to gain meaningful insights. Aligning with this approach, qualitative techniques were used effectively to address these questions.

A total of three main questionnaires were utilized as part of the research methodology (*a. Appendix 1* – Links). Each questionnaire addressed specific aspects of the study, which included participants' opinions, experiences, and knowledge about robots and astrology. The first questionnaire, known as the personality questionnaire, seen in *Appendix 4 – Pre-study Personality* Questions was conducted after the pre-study phase to gather feedback on user interactions with robot personalities. Then the survey questionnaire seen in *Appendix 5 – Main study Survey* Questions was given before conducting the main study because the aim was to collect information about participants' knowledge of social robots, astrology and their preferences. At last, the post-interview questionnaire (*Appendix 7 – Main study Interview* Questions) which contains both open-ended and closed-ended questions, was utilized to assess whether participants gained knowledge from the newly introduced personality and whether this personality could serve as an effective teaching assistant. It's important to note that all three questionnaires incorporated both qualitative and quantitative questions to ensure the understanding of the participant's perspectives and insights.

Additionally, Mural Canvas tasks seen in *Appendix 3 - Pre-study Mural* Task were used to assess user experiences regarding the appearance of the robot. This method, which involves utilizing sticky notes for data gathering on the Mural Canvas platform, provides easy analysis. The use of sticky notes allows for a more interactive and visually engaging approach to data collection, and it also helps to organize and categorize user feedback efficiently.

Apart from that an exercise sheet (*Appendix 6 – Main study Exercise sheet* Questions) was given for participants to answer the questions by getting help from newly designed robot personality. This was done especially to confirm students actively engage and learn something from the new personality.

At last audio recordings were utilized to gather data. This method ensures that no valuable information was missed during the interview session.

All of the above-mentioned data collection approaches were utilized to gain a better understanding of user interaction with the Furhat robot personality as a teaching assistant.

3.1.2 Data Analysis Methods

Affinity Wall: The first data analysis method was the Affinity wall diagram in *Appendix 2 – Pre-study Affinity Diagram* analysis. According to Hartson & Pyla, (2012) an affinity

wall is a technique which assists in visually organizing and grouping participants' issues and insights on a wall. By identifying similarities and common themes, researchers can understand patterns and strategies shared by users, providing them with useful insights. This technique was utilized during the pre-study phase to identify common themes through analysis. The author of this thesis used an online tool called Mural Canvas, which made it easy to create the affinity wall using digital sticky notes. Each participant's feedback was color-coded for easy identification, making it simple to analyze and understand the shared themes.

Content Analysis: The second data analysis method was Content analysis. Based on the principles outlined in the (*Content Analysis Method and Examples: Columbia Public Health*, 2023) content analysis, this technique was utilized in the main study to analyze the data gathered during the research. Before starting a content analysis, researchers must define the research questions of the study. Then, they divide these texts into different categories and check how the categories relate to each other. Ensuring the accuracy and reliability of the analysis is crucial because coding errors could affect the accuracy of the data. Essentially, content analysis helps identify communication patterns, attitudes, and behaviors, making it a valuable tool for researchers in various fields.

For this thesis, the author collected various forms of qualitative data, including transcripts of interviews, open-ended survey responses, and observations.

In the main study, the content analysis focused on exploring participants' perceptions and experiences with Astro Luna as a teaching assistant in the context of learning. The text was categorized into themes corresponding to the research questions, including participants' initial reactions, experiences during the lesson, perceptions of Astro Luna's teaching effectiveness, suggestions for improvement, and overall ratings of the robot's effectiveness. Each participant's response was obtained through audio-recorded post-interviews, which were then transcribed and coded according to these themes. This analysis was conducted to uncover patterns, recurring themes, and insights within the data. Through this process, common themes expressed by participants, as well as areas where Astro Luna was perceived positively or negatively, and suggestions for improvement were identified.

3.2 Research Process and Phases

The research process of this thesis consists of five phases (Figure 5).

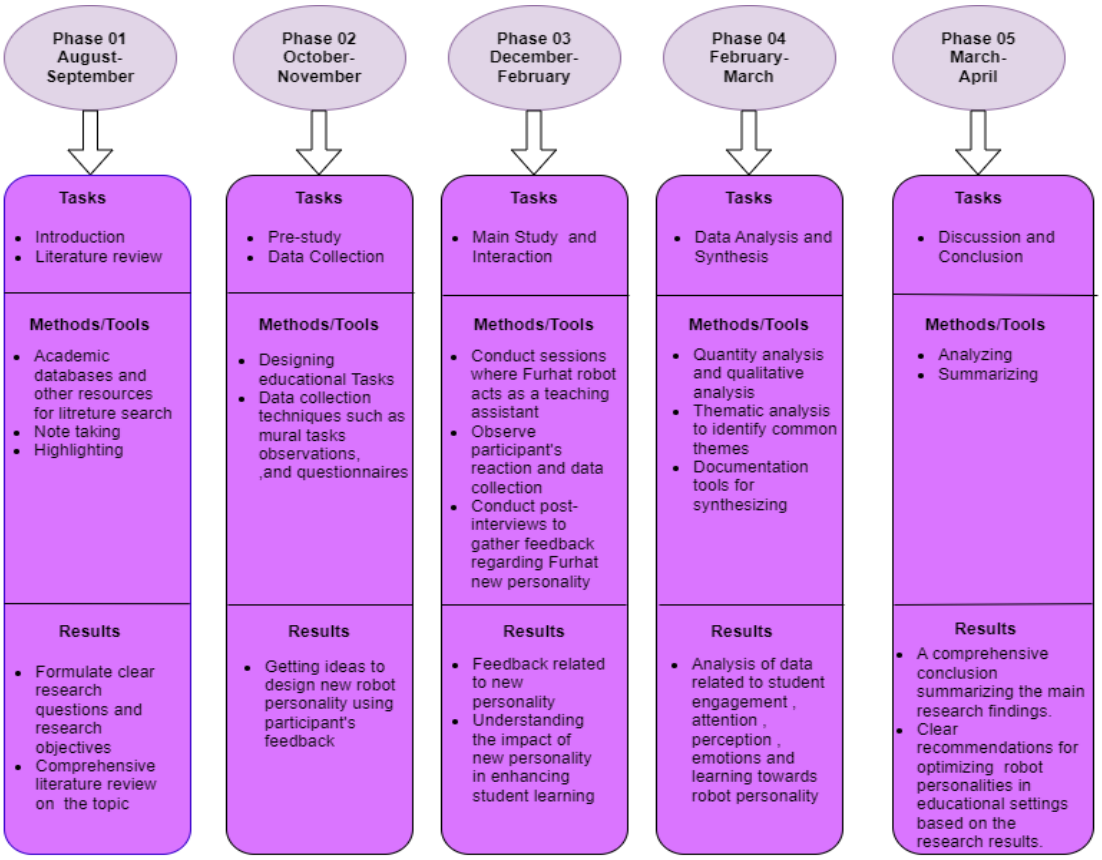

Figure 5 Research Phases

The first phase began in August 2023 and involved the introduction to the thesis and literature review. The introduction explains the chosen topic and discusses the research gap. Literature was sourced from numerous articles to provide support for the research topic. The literature review was an ongoing process throughout the thesis due to topic changes midway and the necessity of including recent articles with more relevant literature.

The second phase started from October to November 2023, and it focused on the pre-study. Various tasks and questionnaires were prepared and distributed to participants to gather valuable feedback. Data that was necessary for creating a new personality for the main study was collected during this phase.

The third phase was quite extensive as it involved the main study and interactions. Pre-study analysis and main study tasks were designed, and based on the findings of the pre-study, a new robot personality was developed. Paper exercise tasks and questionnaires were also created during this phase. The robot interaction took place in February for the main study, and all valuable data were collected at this phase.

The fourth phase, conducted from February to March 2024, included analysis and synthesis. Both qualitative and quantitative analyses were performed using the data obtained from the main study. Thematic analysis was conducted to understand whether participants actually learned from the new robot personality acting as a teaching assistant.

The final phase, which occurred until the first week of April 2024 involved the discussion and conclusion. During this phase, the design implications learned, as well as all the results and lessons learned throughout the thesis were thoroughly discussed.

3.3 Research Platform

This section represents how we used Furhat robot's platform throughout the research.

Furhat Robot

Furhat robot is made by a Sweden company named Furhat Robotics. its advanced motion platform consists of a system with three degrees of freedom, allowing it to move its head in ways that closely mimic natural human movements (*Furhat Platform*, 2022).
The Furhat Platform has a skill Library consisting of pre-built skills. And also, the library contains various faces and voice styles that allow the creation of unique characters of different genders, ages, skin tones, and communication styles. These skills range from simple demos to complex.
In addition to that, it has physical features like an onboard camera sensor and a microphone array (Figure 6 Furhat physical features (Furhat Platform,2022)). The onboard camera sensor enables it to perceive and interact with users visually, and the microphone array can capture and process audio from all directions, ensuring smooth communication (*Furhat Platform*, 2022).

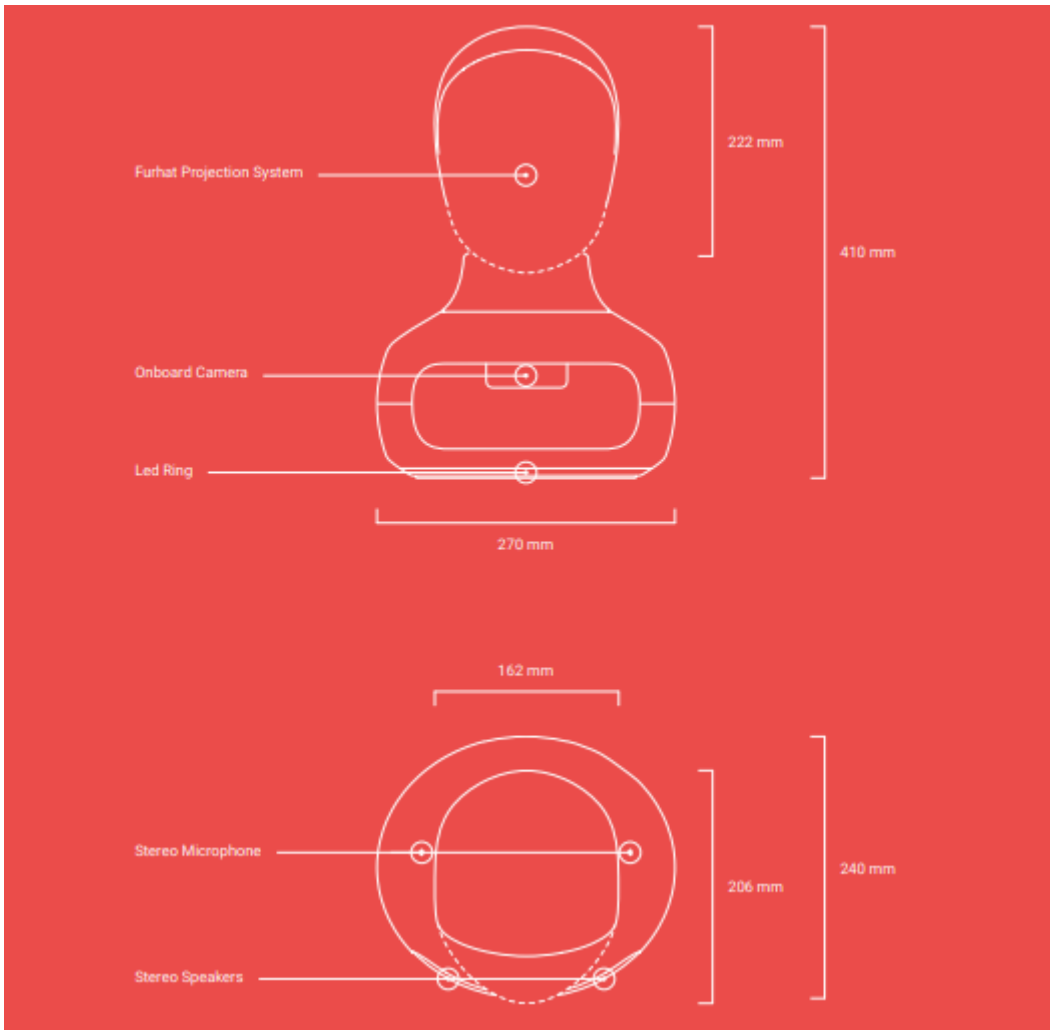

Figure 6 Furhat physical features (Furhat Platform,2022)

3.4 Ethical Considerations

Before participating in the pre-study and the main study, participants were asked to sign a consent form. Two consent forms were prepared for the user study on Robot Personalities.

The introduction of the consent form provided an overview of the aim of this thesis. Participants were informed that their feedback on their interactions with different Furhat robot personalities is important for understanding how robotics can enhance student learning.

Each consent form outlined the tasks participants would undertake during the study, including the time duration of the whole session.

Furthermore, students were informed that participation is voluntary, and they can withdraw at any time if they want. They were also informed that the provided data would only

be used for research purposes and the stored data, and that data would be destroyed after the end of the study.

When considering furhat's data privacy, it is important to know that Furhat Robotics team strictly adhere to ensuring user privacy. They follow strict guidelines such as GDPR to protect personal data. They specially ensure data security by restricting access to only authorized individuals and providing users with tools to delete their data when necessary (*Furhat Robotics Platform Data Security & Privacy Overview*, 2019).

4. PRE-STUDY OF FURHAT ROBOT PERSONALITY EXPLORATION: UNDERSTANDING USER NEEDS

This chapter describes the objectives of the pre-study, procedure, data collection methods, data analysis, findings and ethical concerns.

4.1 Objective of the Study

The pre-study was conducted in a classroom context at the university. The purpose was to gather feedback on how Furhat robot personalities function as teaching assistants for various subjects within a classroom, including students. The research questions:

RQ1:"What are the perceptions and emotions of students when interacting with a teaching assistant robot with various personalities?" and

RQ2: "How does the use of different robot personalities impact student engagement and attention levels during learning activities?" were the main questions for this pre-study. This study aimed to explore the possibility of using Furhat robot as teaching assistants and gather feedback from students regarding their engagement, attention levels, perception, and emotions.

4.2 Study Procedure

The pre-user study was carried out in Tampere University's RoboStudio. Three sessions were conducted over two days, with four groups of students. Each group consisted of three students. Two questionnaires implemented in Microsoft Forms were provided. The first form was given to obtain participants' consent and the other for a personality questionnaire about Furhat robot personalities that participants interacted with. A Mural canvas task was created for students, providing instructions for the pre-study task and questions they needed to answer regarding the emotional experiences they had with each personality.

4.2.1 Furhat robot personality exploration

In the beginning, the intention was to explore different Furhat robot appearances. The mural canvas task was designed with a focus on the robot's appearance and emotions. However, as the research progressed, the topic changed to explore different robot personalities. This decision was made because of recognizing that personality involves not

only emotions or appearance but also attributes like communication style and behavior. Therefore, even though the mural task primarily revolved around the robot's appearance, the students were informed that they would receive a personality questionnaire to complete after their interactions with the Furhat robot. This questionnaire aimed to gain a better understanding of the robot's personalities of Furhat robot.

In addition, the author informed the participants about the three personalities they would interact with, naming them as follows: Einstein- the science teaching assistant, Emma- the health teaching assistant and Marvin- the depression expert. These personalities were created using prompts by Furhat team. So, each personality that students interacted with had different personality traits.

So initially, an introduction was provided about the thesis topic and the changes made to the topic and Furhat robot's OpenAI skills. Participants were encouraged to consider each Furhat robot personalities as teaching assistants.

Before participating, students were asked to give their consent, and participants were reminded that the entire mural task would take around 30 minutes. They were also informed that they are free to withdraw at any time during the pre-study session.

4.2.2 Task: Exploring Robot using the Theme of Emotions and Creativity

The goal of this pre-study was to investigate how different robot personalities of furhat would influence participants' interactions and learning experiences. For this, students were asked to interact with three Furhat robot personalities named Einstein, Emma and Marvin.

Only three students from each group had the opportunity to interact with each personality (Figure 7), while others were asked to observe. It took 12 minutes for each group to interact with all three personalities.

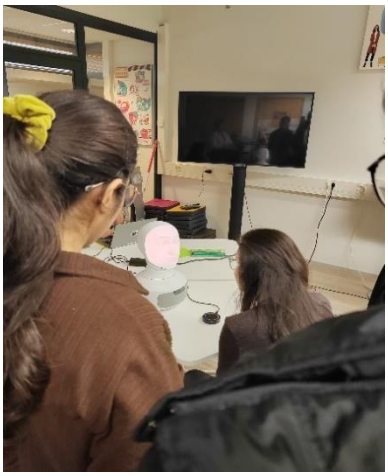

Figure 7 Participants Interaction with Furhat

After interacting with the robots, students were asked to reflect on their emotional experiences and the knowledge they had gained from each personality interaction. Then, they were tasked with providing answers to the questions presented on the Mural canvas for each appearance. For this task, 8 minutes were allocated.

4.3 Data Gathering

The data gathering was done mainly using questionnaires and observations. Firstly, a consent form was provided to obtain the consent of each participant. Next, the participants completed the Mural task canvas questions after the interaction. Following the session, each student was asked to complete the personality questionnaire for the robot.

In the Mural task, emotions and the robot's appearance were assessed. In the Personality questionnaire, five Likert questions were included, ranging from "strongly agree" to "strongly disagree". These questions were given to assess the participants' emotions and perceptions towards the robot. The verbal and non-verbal behaviors of the participants were also observed. The participants were also asked to rank the robot's personalities from favorite to least favorite in the questionnaire.

Furthermore, Attention level was measured by tracking instances like whether participants looked around or lost focus on the robot. Whenever such disengagement occurred, the robot personality skill was adjusted back to the initial stage where the participants were asked to select the personality once again.

4.4 Data Analysis

For the data analysis, the Affinity diagram analysis method was used. This Affinity diagramming is a powerful technique used in this pre-study data analysis. It involves externalizing, making sense of, and organizing extensive amounts of unstructured and diverse

qualitative data (Lucero, 2015). Utilizing the affinity diagram method, ideas collected in the pre-study were systematically organized. The affinity diagram was created utilizing an online design Canvas tool named Mural.

Each participant was assigned a specific color based on their ID and their data was represented by corresponding colored sticky notes on the affinity wall. This method made it easier to group similar ideas and make connections between them. The color-coded setup provided clarity, making it easy to identify patterns and themes within the data. This systematic organization enabled us to identify the important relationships by guiding design decisions for the study.

4.5 Participants

All the participants in the pre-study were university students. There were five groups, each made up of four students, altogether twenty students. Three of the group members from each group interacted with three different robot personalities while others acted as observers. The participants had no prior experience with the Furhat robot. It is even better because it ensures a uniform and unbiased introduction to technology. The participants came from different nationalities, bringing diverse perspectives to the evaluation of the Furhat robot as a teaching assistant experience.

4.6 Findings

By utilizing the Affinity diagram method and analyzing data from participant interactions, this thesis presents a comprehensive understanding of Furhat robot personalities as teaching assistants. The data gathered were systematically organized on an Affinity diagram by using an online tool. There were eight unique themes identified by utilizing various aspects of participants' perceptions, experiences, and recommendations.

The found themes such as Comfort and engagement, Perception of robot personalities, Impact and emotional state, Issues with interactions, Design suggestions, Attention/Focus, Relevance and appropriateness, and Key findings will be described next.

4.6.1 Comfort and Engagement

Participants expressed a range of emotional responses to Furhat robot personalities. As seen in the **Error! Reference source not found.** positive outcomes were gathered on t he left side under the theme while negative were gathered on the right side of the theme.

Some individuals reported feelings of discomfort and boredom (ID 01, ID 04, ID 05, ID 06, ID 07, ID 11, ID 12) while others expressed increased involvement, finding novelty

or humor in the interactions. Some felt uncomfortable and stressed because of the necessity of maintaining eye contact with robot personalities. The reasons for discomfort included stress and a perceived lack of engagement. On the positive side, increased engagement was seen because of the constant attention provided by the robot or the novelty of the interaction.

Some thought specific personalities were a bit scary or distant, while others thought they were friendly and engaging. This shows that the chosen personalities had a role in shaping how participants experienced robots as teaching assistants. This range of emotional responses highlights the nature of human-robot interactions and also suggests the importance of customizing robot personalities to individual preferences and expectations. This can be taken as an indication of the need for customization as many participants have mixed views on the interaction.

Figure 8 Comfort and Engagement

4.6.2 Perceptions of Robot Personalities

The second theme (Figure 9 Perception), 'Perceptions of Robot Personalities,' provides insights into students' perceptions and reactions to various robot personalities utilized as

teaching assistants. Participants expressed different preferences, favoring certain personalities for their humor or approachability while finding others annoying or passive-aggressive.

For example, some students preferred Einstein's personality because of his popularity, well-known status, and perceived authenticity. Participant ID 11 mentioned, *"It is a great and interesting idea to have Einstein in the interaction experience; students can be really excited to talk to him."* And another participant noted (ID02), "Einstein was the easiest to approach."

On the other hand, some participants found Emma to be the nicest, stating that "Emma seemed to be the funniest and nicest one out of the three of them," while others found her fast speech and voice to be passive-aggressive (ID 01) or annoying (ID 02). Marvin was found to be amusing, with a participant (ID 06) mentioning "*Marvin is amusing/humorous, not depressed."*

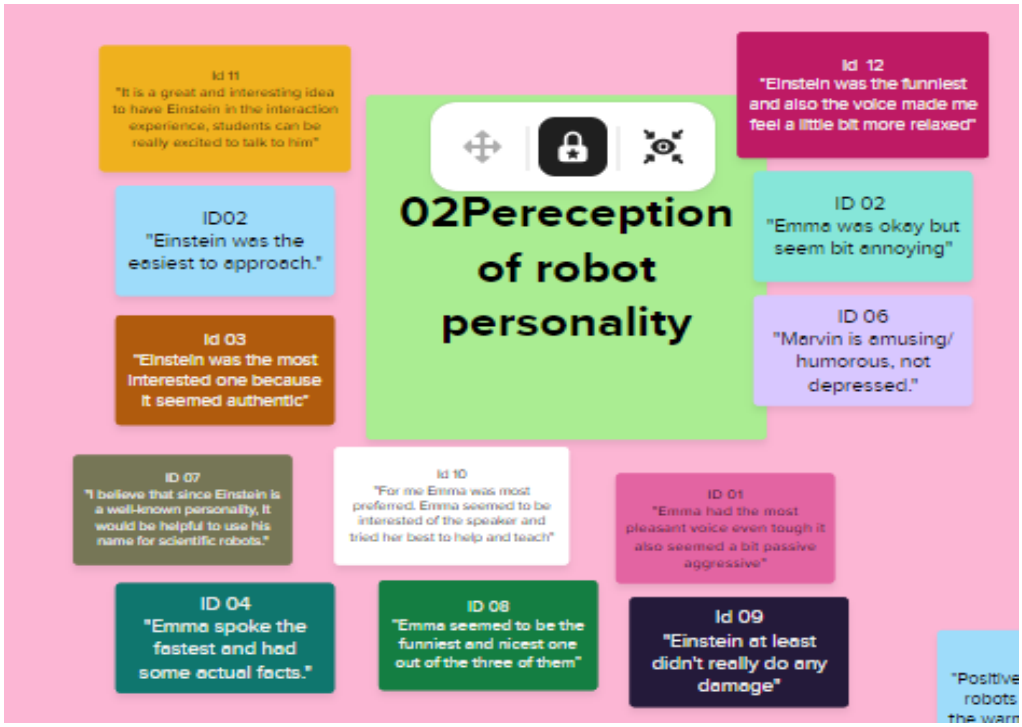

Figure 9 Perception

These preferences highlight the various expectations and reactions of participants towards different robot personalities. Specially participants generally found Einstein's personality as most positive because of his popularity, approachability, and perceived authenticity.

This feedback shows the importance of designing robot personalities to individual preferences and expectations to enhance engagement and user experience in human-robot interactions. These responses suggest that the use of different robot personalities can indeed influence student engagement and attention levels during learning activities.

4.6.3 Impact and Emotional State

The third theme that was discovered from the affinity diagram analysis was "Impact and Emotional State" (Figure 10). The feedback highlighted the participants' impact and emotional state regarding the effect of robot interactions on their overall experience.

Figure 10 Impact on emotional state

Many participants reported positive feelings towards robot personalities because of the friendly facial expressions and warmth expressed by the robots. This highlights the importance of facial cues in shaping emotional connections in human-robot interaction. However, some participants, such as participant ID 08, expressed feelings of shock after interacting with the Marvin personality, indicating that certain individuals experienced strong emotions during the interaction.

Additionally, participants noted that the tone and speed of the robots' speech significantly influenced their experience. Participant ID 04 mentioned that slower speech contributed to feelings of frustration or disengagement. Moreover, multiple participants highlighted the lack of emotional expression on the robots' faces, finding them very non-humanlike, which made the interactions seem less relatable and authentic.

These findings highlight the importance of considering emotional cues and responsiveness in robot design to enhance user engagement and facilitate more meaningful human-robot interactions.

4.6.4 Issues with Interaction

Within this theme, participants pinpointed specific problems and difficulties experienced in their interactions with the Furhat robot personalities. The identified issues with interaction highlight areas that require attention and improvement in the design and functionality of Furhat robot personalities (Figure 11).

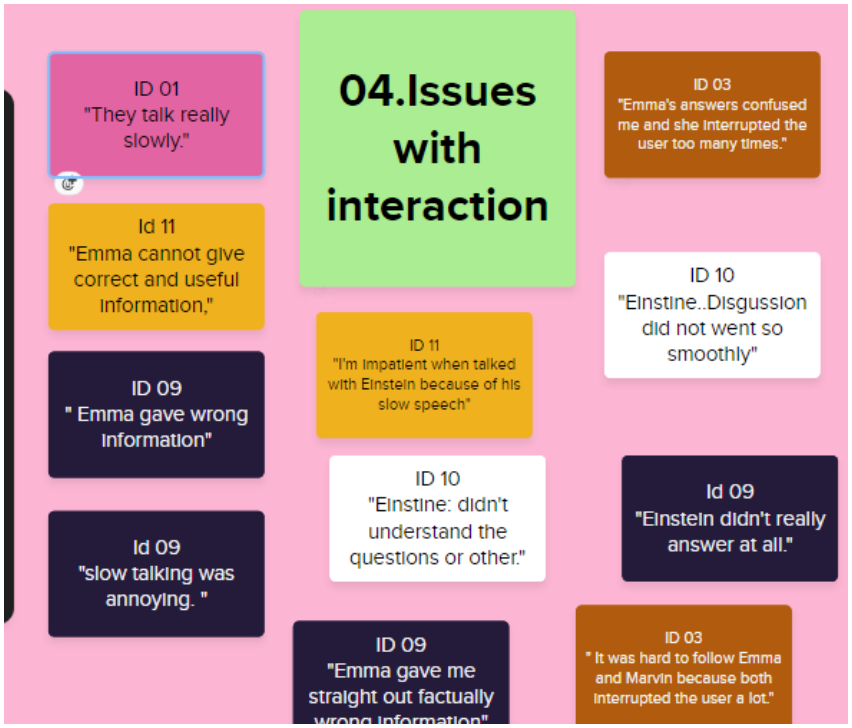

Figure 11 Issues with Interaction

The key issues found with Furhat robot interactions were requiring attention and enhancement in design and functionality. Specifically, concerns about speech, inaccurate information, difficulties in understanding questions, and frequent interruptions occurred during the sessions.

For example, participants like ID 01 and ID 09 expressed frustration with the slow pace of speech, finding it annoying and leading to difficulty in following the conversation. In terms of accuracy, instances were reported where Emma's personality provided incorrect information, raising concerns about the reliability of responses. Another finding was Einstein's difficulty in understanding questions.

Furthermore, participant ID 03 mentioned that interruptions from the robots during conversation caused confusion and made it challenging to engage in conversation effectively.

These findings highlight the importance of addressing these interaction issues to enhance the overall user experience. It is important to create satisfying interactions between users and robots by ensuring their successful integration into real-world applications.

4.6.5 Design Suggestions

The fifth theme identified utilizing affinity diagram analysis was "Design Suggestions". This theme offers valuable insights and recommendations from participants on how Furhat robot personalities can be enhanced.

The design suggestions given by two participants highlighted the desire for more positive and appealing emotional expressions in Furhat robot personalities. Additionally, participant ID 05 (Figure 12) suggested having physical features and body parts indicates a potential avenue for making the robots more relatable and engaging.

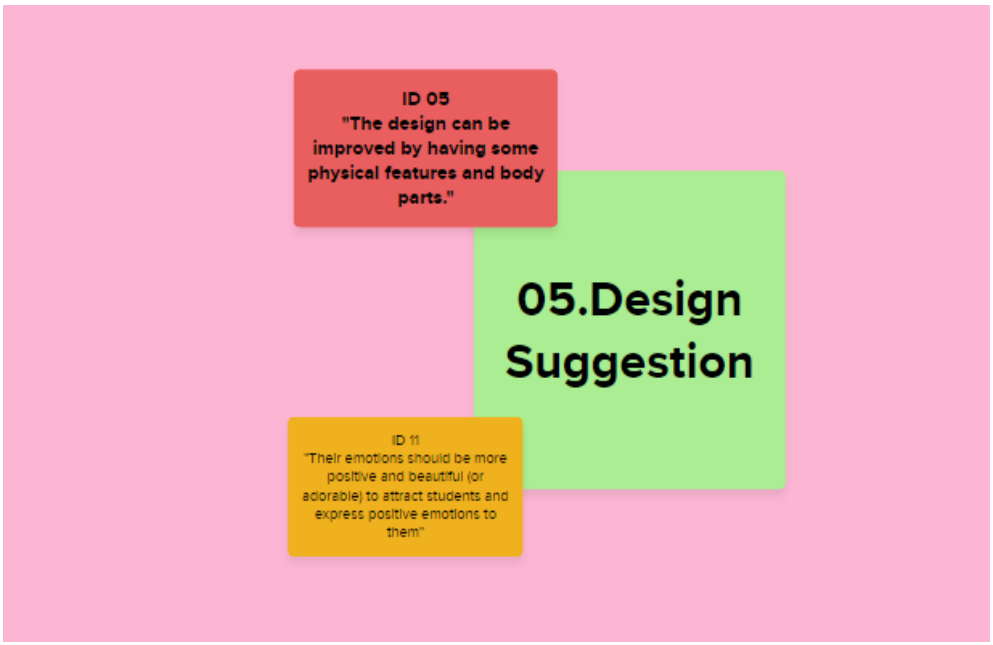

Figure 12 Design Suggestions

These suggestions highlight the importance of aesthetics and physicality in the design of social robots. It also highlights the potential impact on user attraction and interaction. Therefore, integrating these suggestions could create a more user-friendly environment that aligns with user expectations and preferences in education.

4.6.6 Attention / Focus

The sixth theme identified through the analysis of the affinity diagram was "Attention/Focus". Participants had varying experiences regarding their level of attention during interactions with the robots. According to the feedback provided, factors such as speech clarity, engagement level, and the novelty of the robot affected the attention/focus of the participants.

As shown in the presented figure (Figure 13), participants expressed varying feedback under the Attention/Focus theme. Some participants noted a negative impact on attention when the robot's speech was slow, finding it hard to follow. And also because of that it leads to a loss of attention (ID 03). On the other hand, engaging in discussions increased attention for some participants (ID 10). Especially when participants felt actively involved in the conversation. Some reported that distractions from certain robot personalities like Emma and Marvin provided a negative impact which affected participants' focus (ID 07). Others reported that they paid full attention because of the novelty of the robot (ID 02).

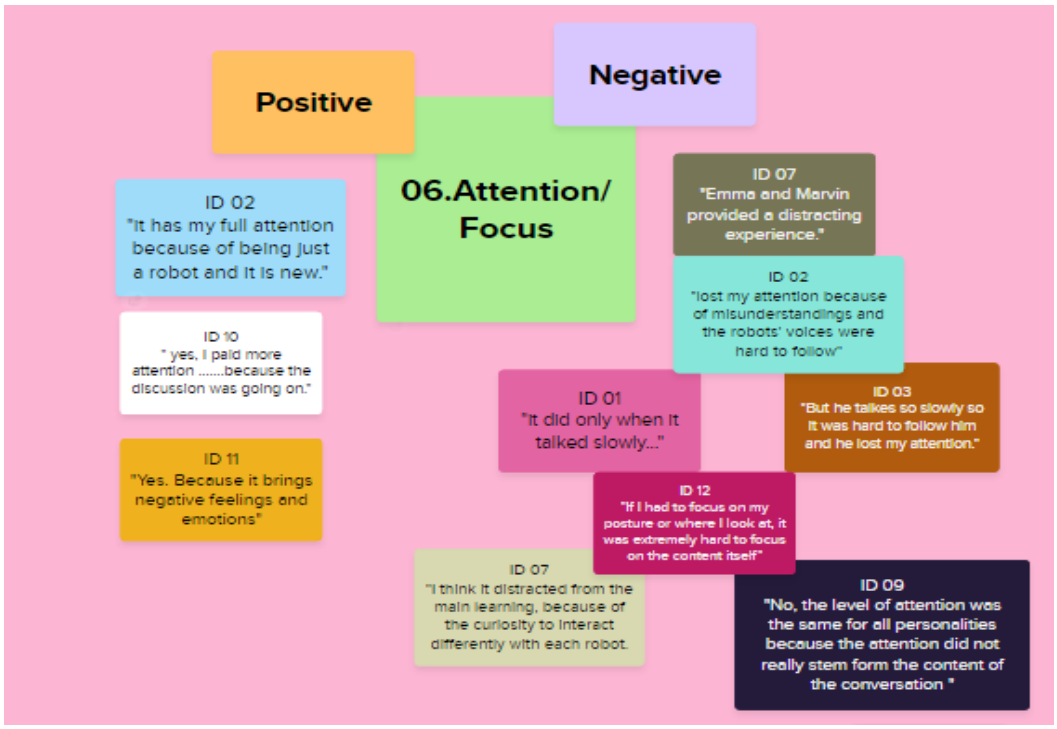

Figure 13 Attention/Focus

Therefore, these findings show the importance of optimizing robot behavior and communication style to enhance user engagement and minimize distractions during educational interactions.

4.6.7 Relevance and Appropriateness

The seventh theme taken from the affinity diagram analysis was "Relevance and Appropriateness". This theme provides participants perspectives on the usefulness and appropriateness of Furhat robot personalities as teaching assistants.

Participants expressed doubts and usefulness regarding the effectiveness of Furhat robot personalities in fulfilling the role of teaching assistants (Figure 14).

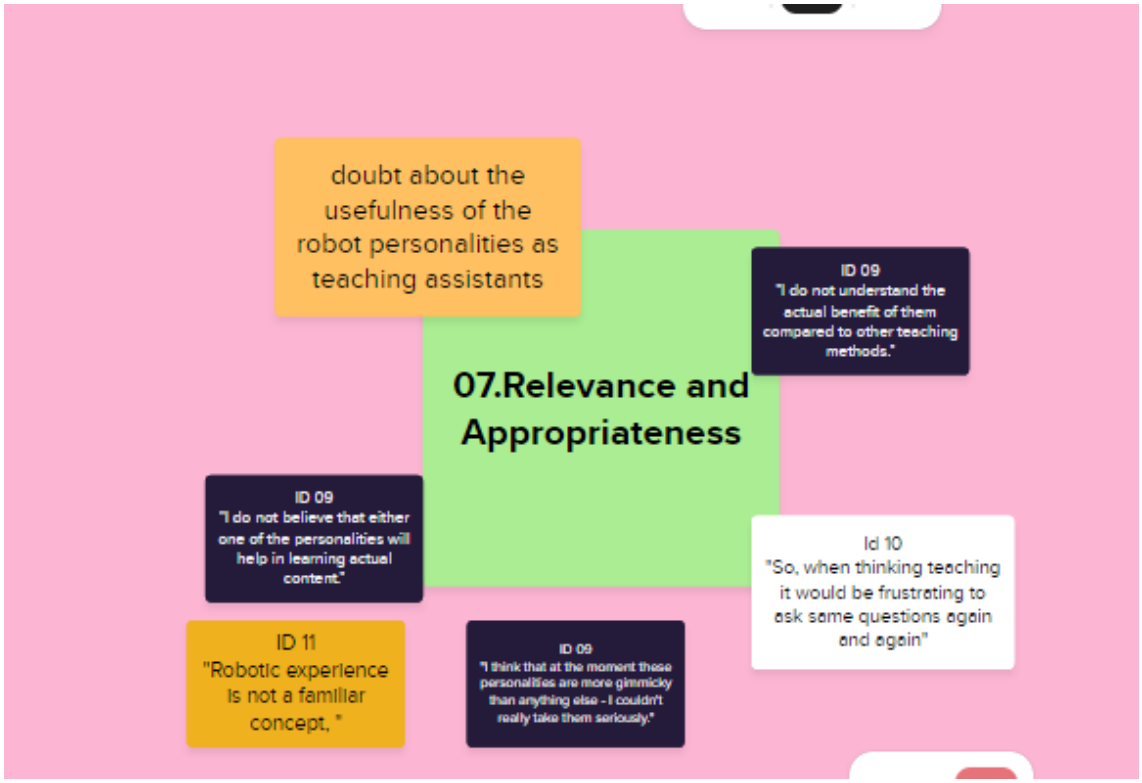

Figure 14 Relevance and Appropriateness

Participants expressed uncertainty regarding the potential for enhancing learning through the presented robot personalities. Some participants doubted the effectiveness of these personalities in helping the understanding of actual content (ID 09). Others found the repetitive questioning frustrating (ID 10). Additionally, one of the participants highlighted the unfamiliarity of robotic experience (ID 11). Furthermore, there was a perception among participants that, at the time, these personalities were seen as more gimmicky than practical. This led the participants to have difficulty taking them seriously in an educational context. These findings highlight the importance of making robot personalities better suited for their role as teaching assistants. To utilize these personalities effectively in educational settings, it is crucial to address the issues raised above and refine them accordingly.

4.6.8 Key Findings

The last theme discovered was "Key Findings" (Figure 15). This theme consists of various insights gathered from participant feedback regarding their overall impressions and expectations of the robots.

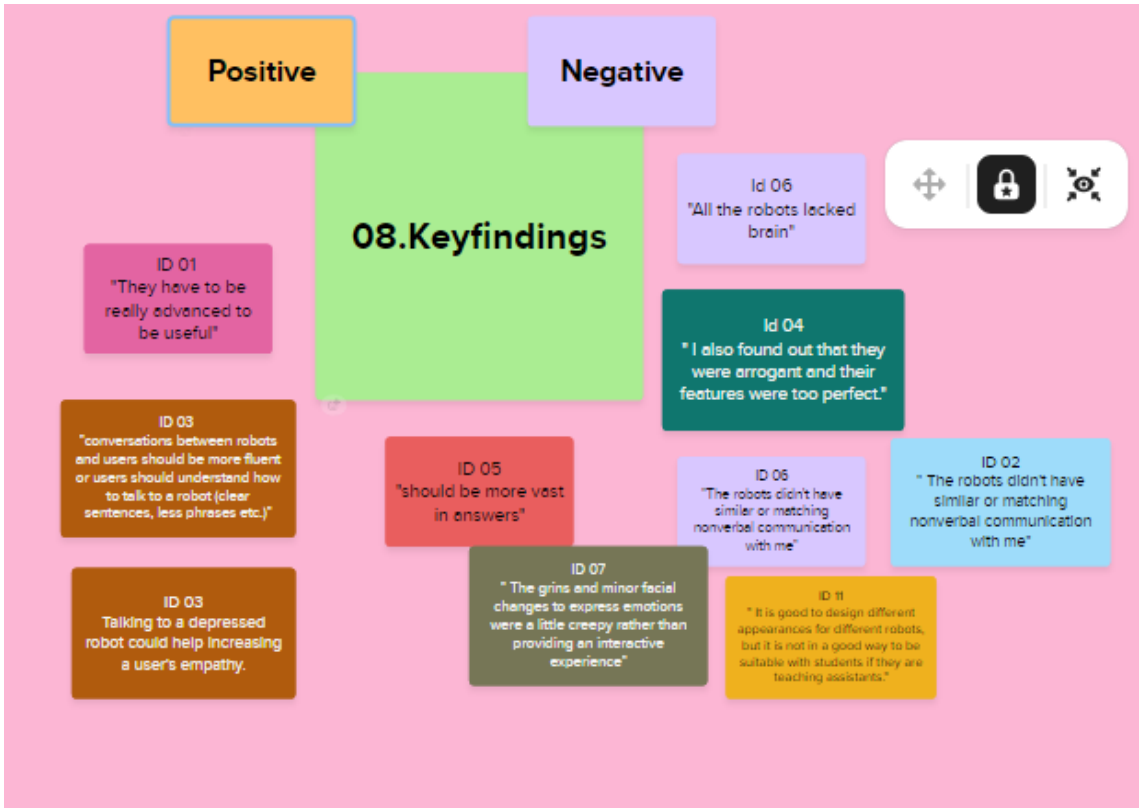

Figure 15 Key findings

Participants expressed a desire for advanced capabilities in the robots to make them more useful (ID 01). They also emphasized the importance of fluent conversations and clear communication to enhance user experience (ID 03). One of the participants mentioned that interacting with a depressed robot was noted to potentially increase users' empathy (ID 03). Participants suggested that the robots should provide more extensive answers to inquiries (ID 05). However, some participants found the facial expressions of the robots to be unsettling rather than enhancing the interactive experience (ID 07). Additionally, participants noted a lack of intelligence in the robots (ID 06). Some participants perceived the robots as arrogant and their features as too perfect (ID 04). There were also observations regarding the mismatch in nonverbal communication among the robots (ID 02).

All the above findings highlighted the need for improvements in robot design, communication style, and behavior to better align with user expectations. For more engaging and effective interactions, it is better to refine these aspects especially in educational settings.

4.7 Ethical Concerns

During the pre-study, several unexpected situations arose that needed careful ethical consideration and response. One such situation involved a participant who experienced stress due to the robot's personality. This participant, who had a history of depression, found the robot's personality to be emotionally triggering.

In response to this unexpected situation, the participant was immediately provided with support and offered a debriefing session to discuss their experiences and any concerns they had.

This unexpected situation raised important ethical considerations regarding the potential impact of the study on participants' mental health and well-being. It shows the importance of informed consent and voluntary participation, as well as the need for researchers to be prepared to respond to unexpected situations that may arise during the study.

This experience has highlighted the need for more robust ethical guidelines and procedures to address potential risks to participants' mental health and well-being in future research. It has also shown the importance of ongoing monitoring and support for participants throughout the study, particularly when unexpected situations arise.

4.8 Summary of Pre-study Findings

The findings revealed that students' engagement varied depending on the personality traits demonstrated by the robots. Einstein's personality was the most preferred personality by participants because of its intelligence and because it is a well-known character. The personalities perceived as friendly and engaging evoked positive emotional responses and increased student engagement. However, slow speech or unsettling facial expressions of some personalities decreased attention levels and evoked negative emotions among participants.

All of the participants felt somewhat mixed emotions towards robot personalities. These ranged from comfort and amusement to frustration and discomfort. Participants favored particular personalities based on traits like approachability, humor, and perceived genuineness. However, some had doubts about whether certain personalities were suitable and effective in the teaching assistant role. Some participants saw these personalities as more of a gimmick than a practical solution.

In summary, these findings highlight the importance of considering the design and characteristics of robot personalities in educational settings to optimize student engagement and enhance the learning experience. Further research and refinement of robot design

in behavior, facial expression and communication styles are recommended to match with user expectations and preferences.

5. THE MAIN USER STUDY

This chapter describes the objective of the main user study, new personality Design procedure, data collection methods, data analysis, findings and ethical concerns.

5.1 Objective of the Study

For the main study, we created a new personality named Astro Luna as a teacher assistant to address the issues identified in the pre-study. This personality is designed to increase user engagement, emotional connection, and overall effectiveness as a teaching assistant. For that, we analyzed prior studies and found that participants wanted a personality that included more positive emotional expressions and enhanced speech characteristics.

Additionally, the purpose of introducing this new personality is to address the identified issues the students had in the pre-study with interaction, including speech, accuracy, understanding questions, and interruptions. The third research question (RQ3), *"What are the students' experiences about the newly designed Astro Luna personality in the context of learning?"* was central to this main study. The purpose of this study was to evaluate the effectiveness of this new personality in addressing the challenges identified in the pre-study. And, to gather further insights into the user experience with Furhat robot personalities as teaching assistants in enhancing student learning.

5.2 New Personality Design and Goals

The new personality Astro Luna is a teaching assistant robot, specifically designed to educate individuals about astrology and to enhance their learning experience. This personality is designed with the latest OpenAI technology utilized by Furhat Robotics. The inspiration behind Astro Luna's creation comes from the latest interest in astrology among people on social media platforms for example; TikTok, Instagram (Apps, Social Media, and the Accessibility Revolution, 2024). Recognizing this trend, Astro Luna was developed to provide accessible and engaging astrology lessons to university students. This personality is capable of teaching the fundamentals of astrology, including zodiac signs, planetary influences, and the significance of astrological houses etc. Astro Luna – the newly designed robot personality is a flexible and interactive educational tool. The advanced AI capabilities of this personality enable users to gain a deeper understanding of the subject of astrology, providing them with an invaluable educational experience.

Figure 16 Astro Luna

According to the pre-study analysis, participants expressed a need for a warm and engaging teaching assistant. In response, the new personality was created in a friendly and approachable manner, characterized by a clear and understandable voice. The Big Five factors were taken into account when designing Astro Luna (Miwa et al., n.d.).

To design Astro Luna, following Big Five factors were considered:

Openness: Astro Luna is designed to encourage students to explore new ideas and concepts with an open mind.

Consciousness: We have taken care to design this robot to be reliable, organized and agile to effectively deliver educational content to students.

Extraversion: This Astro Luna shows warmth, friendliness and sociability for students making them comfortable and reassuring in interactions.

Agreeableness: An agreeable nature of this personality promotes cooperation, empathy and positive relationships with students and facilitates a supportive learning environment.

Neuroticism: Astro Luna is designed to maintain emotional stability and resilience. We believe that by integrating students' preferred faces and voices to Astro luna, it reduces anxiety and stress. Thereby we think it improves students' overall well-being during learning sessions.

Participants were also surveyed before selecting the appearance and personality of the new character. Based on the survey results, Astro Luna's appearance was chosen to have a warm smile and expressive eyes (Figure 16). And in response to the pre-study

suggestion of incorporating physical features and body parts into the Furhat robot teaching assistant, the author used a wig for the Furhat head to enhance its appearance and make it more engaging for students.

The design goal for Astro Luna is to create a positive and engaging learning environment. Its appearance expresses a friendly and approachable manner, with warm and expressive features that make students feel comfortable and encouraged. The overall goal of this design is to enhance the learning experience for students, making it more enjoyable and effective.

5.3 Procedure

The main study was carried out at the Tampere University Robostudio. Before the study, participants were selected through a survey that included questions about their interest in studying astrology and their interest in robots. The participants were students of the University of Tampere.

Two questionnaires were given using Microsoft Forms. The first form was a survey to recruit participants and the second form was for the consent of those who agreed to participate. Four participants took part in the study, which involved a paper task involving astrology-related questions (*Appendix 6 – Main study Exercise sheet* Questions). We asked students to fill out the exercises with the help of Astro Luna. Following this, a post-study interview was conducted to gather feedback on the participant's experience with the newly created robotic personality (Astro Luna) in the learning context.

5.4 Introduction and Explanation

Following the initial survey, 4 participants were selected to take part in the main study. Before their participation in interacting with Astro Luna, they were asked to provide consent for the study. The participants were briefed about the study's objectives and the paper task that would be given to them.

Moreover, the participants were introduced to Astro Luna, the new personality they would interact with during the study. They were encouraged to consider this personality as their astrology teaching assistant. Additionally, participants were given an exercise sheet(*Appendix 6 – Main study Exercise sheet* Questions) containing basic astrology questions that could be asked from Astro Luna. They were also encouraged to ask any questions they had about astrology, with the goal of gaining knowledge and new experiences from this robot teaching assistant.

Before the study, participants were reminded that the entire study, including the post-interview after the robot interaction, would take approximately 1 hour. They were also informed that they were free to leave at any time during the main study session.

5.5 Data Gathering

The main study involved gathering data through a *survey questionnaire, an exercise sheet, observations, and post-interviews*. Additionally, participants were given a consent form, which included questions about audio recording for the post-interview and their participation in the Astro Luna personality interaction.

The data collection process for the astrology study was conducted through a comprehensive *survey* aimed at understanding participants' attitudes, preferences, and experiences related to astrology and the use of a robot as a teaching assistant. The survey included questions about participants' interest in astrology, their familiarity with its basics, their comfort level with technology, and their openness to using a social robot for learning purposes. Participants were also asked to provide feedback on the characteristics they would prefer in a robot teaching assistant, such as being informative, friendly, and interactive. Additionally, participants were allowed to select a face for their astrology teaching assistant from three options and to indicate whether they believed having a robot teaching assistant would enhance their engagement with astrology studies. The survey also asked participants if there were any specific astrology topics or areas, they were particularly interested in. The data collected from this survey was used to design the Astro Luna robot personality for the main study, ensuring that it meets the needs and preferences of participants.

Before participating in the study, participants were given a *consent form* and filled it out using the author’s laptop. After that, an *exercise sheet* was provided, consisting of five questions. These questions covered basic astrology, the order of zodiac signs, and houses in astrology. Participants were asked to ask these questions from Astro Luna and fill in the answers with the help of it (Figure 17). During this time, students were informed to ask any questions they were not familiar with from Astro Luna and get answers for them. The students wrote the answers to the given exercises. For the accuracy of the answers provided by Astro Luna, the author referred to articles and checked the answers.

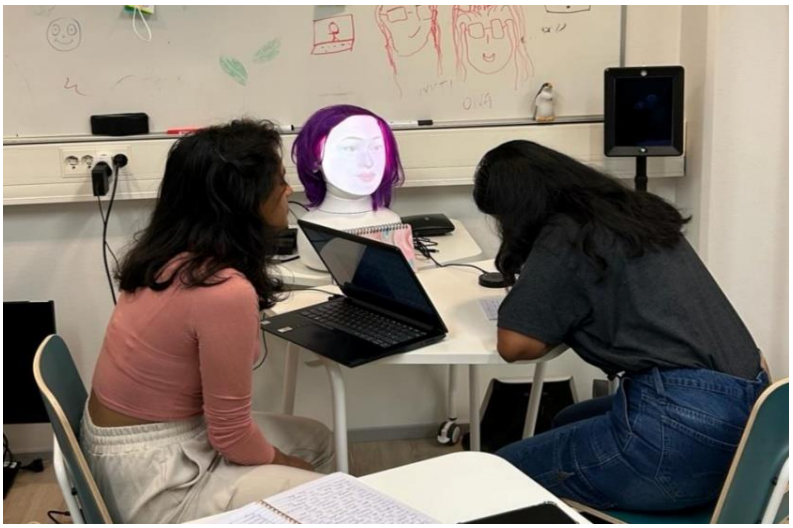

Figure 17 The participants filling in the exercise sheet

After the interaction, participants were *interviewed* by the author. The interview covered participants feelings towards Astro Luna's personality, attention, specific information that the new personality taught, comparison of traditional study vs learning from a robot, changes in their perspective after engaging with the robot, improvements that could be made for the new character, and lastly, to rate from a scale of 1-10 the effectiveness of the new personality as a teaching assistant.

5.6 Data Analysis

For the main study data analysis, content analysis method was conducted utilizing the post-interviews questionnaire. This method helped to identify common themes and patterns in their responses. Additionally, a chart was created based on the quantitative data gathered from participants' ratings of the newly designed Astro Luna personality. Each participant was color-coded in the chart. Additionally, observation notes were analyzed to get additional insights into the participants' experiences and interactions with the robot.

5.7 Findings

The findings of the main study were gathered from post-interviews and observations using content analysis. Through this method, there were nine identified themes. Each theme offers valuable insights into participants' experiences with the newly designed robot personality in the context of learning.

Next, we describe the themes that emerged from the data analysis.

5.7.1 Initial Interaction

Participants commented on their initial reactions to the robot's appearance and how it influenced their interaction. Some participants expressed excitement and engagement after seeing the robot, finding it interesting. However, others reported feeling slightly intimidated or finding the experience surreal. One participant mentioned feeling uncomfortable when the Furhat robot's appearance changed to Astro Luna. It's important to note that this participant was not aware of the possibility of the appearance change. Initially, the introduction was provided with the default Furhat appearance, and participants were then asked to select their preferred personality for interaction. Based on selection, the robot's face changed to match the chosen personality, which caught the participant off guard and caused a bit of anxiety. However, once the interaction began, this participant found the experience enjoyable, indicating a shift from initial discomfort to engagement.

Additionally, some participants expressed curiosity about the robot's capabilities, highlighting a broader interest in understanding the functionalities and potential of such technology. These findings highlight the perceptions towards robot interactions, emphasizing the importance of considering individual preferences and expectations in designing human-robot interactions.

5.7.2 Attention

According to most participants, the Astro Luna personality effectively captured their attention. Some also agreed that the robot was able to maintain their attention. However, a few reported that the speech was somewhat fast, although they still managed to understand it. One of the participants (ID 04) commented that Astro Luna provided detailed explanations, which were useful for deeper understanding. However, they found these explanations to be too lengthy, leading to a loss of attention span. However, when the participant asked for simpler explanations, Astro Luna responded effectively. These findings show the importance of balancing detailed information with students' attention for effective communication.

5.7.3 Learning Outcomes

Participants were asked to recall any specific information or concept that Astro Luna personality taught during the interaction. Some of the participants said they gained knowledge about zodiac signs and their representations of different characteristics. Additionally, some found the discussion of houses in astrology to be interesting. Others

learned about birth charts and how they are determined by the date and place of birth, gaining insight into the meaning of astrology. Only one participant reported uncertainty about the astrology topic but indicated a general understanding of it. These findings show that participants varied in their level of familiarity and interest in astrology topics, but somehow the above findings suggest that Astro Luna enhanced the participants' learning experience by introducing them to new astrology concepts.

5.7.4 Enhance learning

Participants were asked how the newly introduced personality, enhanced their learning experience. Some mentioned that apart from the slightly fast speech, they appreciated the robot's teaching efforts. Others found the interaction accurate and interactive. The author observed that participants interacting with Astro Luna asked questions about their birth charts and noticed surprised expressions on their faces when the information provided was accurate. Another valuable finding was that one participant highlighted the benefits of repetition in learning with the robot, stating that it allows for memorization and knowledge retention. These findings indicate that the interaction with Astro Luna positively impacted the participants' learning experience by providing accurate information, interactive engagement, and facilitating memorization and knowledge retention through repetition.

5.7.5 Comparison to Traditional Learning

According to most participants, having a teaching assistant in the form of a robot is a beneficial approach because it interactively stimulates students. Some noted that this method is particularly helpful for students diagnosed with ADHD who struggle to focus on traditional learning methods like reading books. Interacting with a robot that resembles a real human being was found to be especially helpful for such students. Participant 03 mentioned that it's easier to remember things when taught by a robot compared to studying from books, suggesting that having a robot teaching assistant enhances memory retention and learning efficiency. Another feedback from participants highlighted the importance of a personalized robot teaching assistant, which can adapt to different learning methods. Whether a student needs more time for learning or prefers shorter answers, the robot can adjust accordingly. Additionally, one observation noted that interacting with a physical robot was more useful, with a student comparing it to having a ChatGPT in real life. These findings suggest that traditional teaching methods may not be as effective as having an interactive teaching assistant, especially for students with

specific learning needs like ADHD, and that personalized robotic teaching assistants have the potential to enhance education by providing engaging learning experiences.

5.7.6 Complex Concepts Clarification

During the post-interview, participants were asked whether the Robot teaching assistant, Astro Luna, helped them clarify complex concepts for the particular subject. All participants agreed that Astro Luna indeed aided in clarifying various difficult concepts. They noted that the robot effectively provided simplified explanations, while also offering broader explanations when needed. One participant specifically mentioned that a concept in astrology was initially confusing, but Astro Luna helped clarify it. These responses indicate that Astro Luna was successful in assisting participants with understanding complex concepts, demonstrating its effectiveness as a teaching assistant.

5.7.7 Perspective Changes

One of the survey questionnaires given to the participants was, "Do you think having a robot teaching assistant would enhance your engagement with Astrology studies?". This question was provided to measure any changes in participants' perspectives after engaging with the robot teaching assistant. In the survey, two participants indicated uncertainty, while others had a positive aspect of having a teaching assistant (Figure 18).

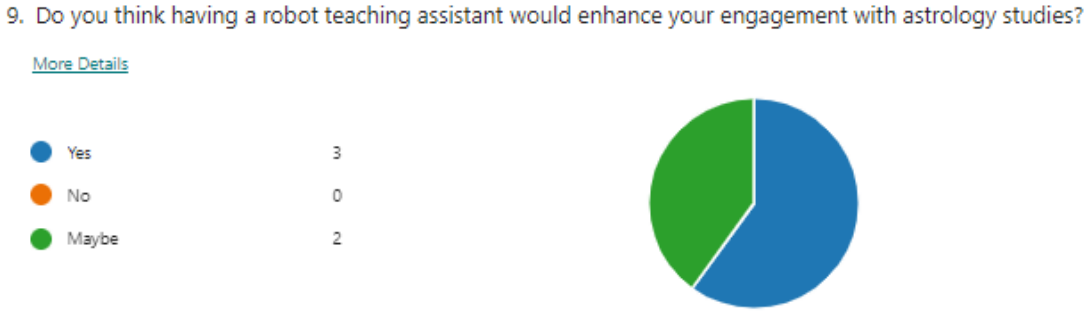

Figure 18 Perspective on having robots as a teaching assistant (N=5)

After interacting with Astro Luna, participants were asked if their perceptions had changed. Most reported that they initially didn't expect Astro Luna to be interactive or fun, assuming it would only provide direct answers to questions. However, they said they were surprised to find that Astro Luna could respond differently based on how questions were asked, showing a deeper understanding of the subject matter. These findings suggest that Astro Luna's interactive capabilities have exceeded participants' expectations, which also shows that it is able to enhance the learning experience.

5.7.8 Improvements

Participants were asked about any improvements that could be made to this new robot's personality, and most of them suggested that it would be beneficial if the robot could speak more slowly. Additionally, one participant recommended that it would be good if the robot could explain some concepts in a storytelling style, as it would make the explanations more engaging. Some participants expressed dissatisfaction with the appearance of the robot, noting that it did not meet their expectations. In response to this feedback, the author presented other existing appearances to the participants, and they found some appearances interesting for the Astro Luna personality. There was also a suggestion to have an appearance that is slightly more groomed.

One participant mentioned that sometimes when Astro Luna explains, slight changes in its tone give the impression that it is upset or agitated. Additionally, when providing broader explanations, Astro Luna stops sentences midway.

They suggested that if all these issues were addressed and improved, the overall experience would be more interesting.

Additionally, one participant gave a design suggestion that if Astro Luna could incorporate visuals, such as videos of constellations or houses into the robot's appearance to enhance the learning experience.

5.7.9 Ratings as a teaching assistant

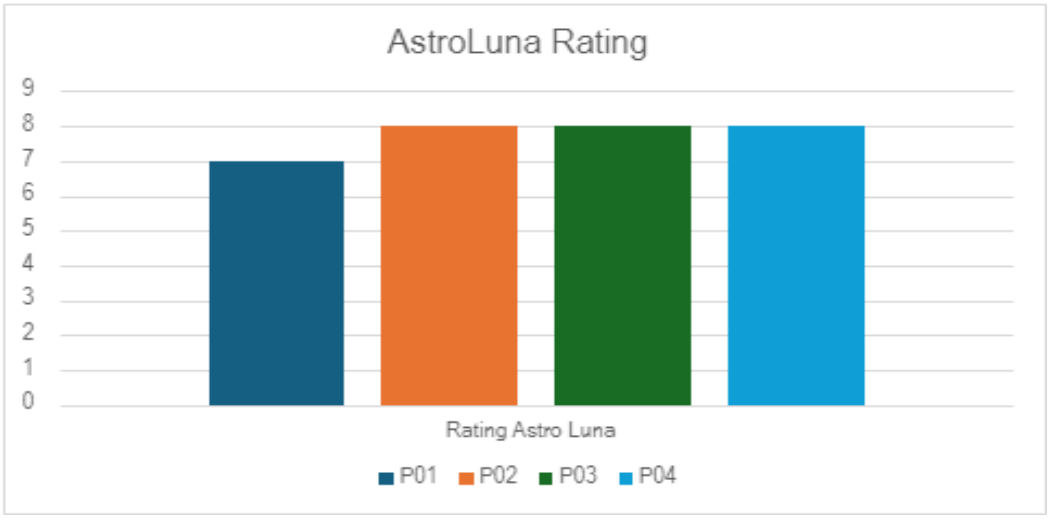

Figure 19 Ratings for Astro Luna (N = 4)

Participants were asked to rate the effectiveness of the new personality (Figure 19) on a scale of 1 to 10. Three participants gave a rating of 8, one mentioning that they occasionally had to repeat themselves clearly due to the robot's difficulty in detecting accents. And they believe this problem wouldn't occur with human teaching assistants. Other than that, they found the personality memorable and interesting.

Another participant mentioned repetition issues and stopping in the mid-sentence as reasons for their rating. The participant who rated 7 suggested that the speed could be slowed down and interaction could be enhanced.

These ratings provide valuable feedback for improving the effectiveness of the new personality.

6. DESIGN IMPLICATIONS OF FURHAT ROBOT PERSONALITIES IN TEACHING ASSISTANT ROLE

This chapter covers 6 design implications from the pre-study and the main study of the research. The results of these provide key insights into utilizing Furhat robot personalities as teaching assistants. From participant feedback, we derive design implications to enhance student learning by using a robot as a teaching assistant with a personality. For better teaching assistant roles, these implications could be considered for future improvement of Furhat robot functionalities. The design implications could be also taken as a foundational framework for innovation in the educational robotics field and enhance student learning outcomes. A list of implications is gathered to improve Furhat robots' functionality in education. The goal is to enhance student learning and facilitate better learning outcomes.

The design implications list is as follows,

Balance the speech pace of the robot for effective communication

Balancing the speech pace of a robot is crucial for effective communication. Especially if the robot acts as a teaching assistant. When designers design a teaching assistant robot personality for a specific subject, they better focus on the complexity of the subject matter for optimal communication. When it comes to speed of the speech, too fast speech can lead in frustration and confusion and too slow speech can lead to boredom and disengagement with the robot. So, it is very important to find the right balance in speech pace to keep students engaged with the subject matter.

Implement the robot’s accent recognition capabilities

Designers should be able to focus on developing accent recognition algorithms for robots when using them in educational settings. Accurately recognizing user accents enables the robot to better understand and respond to student questions by making the interaction more natural and accessible for students. Because if the accent is not recognized and students have to repeat themselves frequently, it can lead to frustration and hinder student's interest in learning. So having good accent recognition capabilities for a robot could lead to more smooth interaction and learning experiences for students.

Make accuracy of information as a priority when designing an educational robot

Making the accuracy of information should be a priority when designing a robot for educational purposes. Also ensuring that users receive reliable and trustworthy content is

essential to provide positive user experiences. In the study, it is proved that inaccurate information led to frustration, and it also affects users' trust in utilizing robots in education. To promote user satisfaction and trust, designers should prioritize the accuracy of information to enhance student learning outcomes.

Make improvements to the robot's emotional expression

Providing positive emotions while teaching or answering questions is found to be very crucial. The way information is delivered, the tone of the robot's speech, and its overall behavior can impact the user experience. For designers, it is important to focus on creating robots with expressive facial features such as happiness, empathy, and concern. The facial features can enhance the user experience and positivity of the environment. And also, enhancing the robot's ability to recognize students' emotions and reactions according to the robot can contribute to more meaningful interactions.

Consider ethical consideration and participant well-being in educational robotics

Ethical considerations such as privacy, consent, and participant well-being, should be carefully considered when utilizing robots in education. It is very important for designers to implement filters to safeguard sensitive information delivered by robots, especially when utilizing open AI skills for robot personalities.

Customize robot personalities for teaching purposes

Customizable features such as communication patterns, facial expressions, and appearance have the potential to enhance student learning experiences. When designing teaching assistant personalities, it is important to have a clear idea about student’s background and learning style before doing the research. Some students prefer a storytelling style of communication, while others prefer a more direct and informative style. Different students have different preferences regarding robot appearance. Some find human-like appearances unsettling, while others find them interesting. Therefore, having customizable robot personalities in education could enhance student engagement, satisfaction and learning.

7. DISCUSSION AND CONCLUSIONS

This chapter provides the summary of the study findings, limitations and future work, and conclusion.

7.1 Summary of Study Findings

Altogether, this thesis involved 16 participants. The initial phase of the study included 12 participants who engaged in the pre-study phase, where they interacted with Furhat robot personalities. These personalities were generated using prompts equipped with OpenAI skills. The pre-study of this thesis was aimed to respond to the RQ1 and RQ2.

Research question 1 (RQ1) was formulated as: *How does the use of different robot personalities impact student engagement and attention levels during learning activities?* The findings from the pre-study on the use of different robot personalities as teaching assistants provided valuable insights into how these personalities impact student engagement and attention levels during learning activities.

From the perspective of 12 students who participated in pre-study, each robot personality had different impacts on engagement and attention levels. The Furhat robot's unique characteristics provided a distinct impact on student engagement, especially as students interacted with three different personalities, each having different emotional responses. These emotional responses affected students' engagement in both positive and negative ways. Some felt they had friendly interaction because of the warmth of the face while some felt shocked because of the behavior of the robot. This also aligns with previous research indicating that social robots can form strong emotional connections with users learning experiences (Belpaeme et al., 2018).

Some findings from the pre-study highlighted the importance of appearance, behavior, and communication style when engaging with robots. Some students favored certain personalities for their humor or approachability, while others felt stressed because they had to maintain eye contact with the robot personalities to avoid interruptions. This highlighted the importance of the robot's gaze behavior in directing participants' attention and influencing their interaction (Abubshait & Wiese, 2017). Gaze behavior, such as maintaining eye contact, can affect the engagement and attention of participants during robot interactions both positively and negatively. On the positive side, we can confirm whether the student is genuinely paying attention because if not, the robot's personality reverts to its initial stage. However, on the other hand, since it makes the student uncomfortable,

it is not ideal to have such a situation because it can cause students more stress by decreasing engagement and effectiveness of the interaction.

The findings from the pre-study also highlighted that the novelty of the robot can enhance student engagement and attention levels in education. Researchers such as Tolksdorf et al., (2021) have previously reported the role of novelty in enhancing engagement with children by sparking curiosity and facilitating learning. Similarly, in this study, students reported increased engagement due to the robot's constant attention and the novelty of the interaction. This proves that the novelty of robot can boost student attention and engagement in education. Although the novelty of Astro Luna, particularly its robotics and AI capabilities, may influence student engagement, novelty alone cannot sustain long-term engagement. Because over time a student may lose interest and engagement. We suggest designers to always innovate and improve to maintain interest in solving this difficulty. The findings from the pre-study also revealed instances where students experienced difficulty following the robot's speech and reported instances where the robot misunderstood the students. These communication challenges should be addressed to enhance user engagement and minimize distractions (Marin Vargas et al., 2021).

The second research question 2 (RQ2) was: *"What are the perceptions and emotions of students when interacting with a teaching assistant robot with various personalities?"*. Participants were introduced to three different personalities: Einstein as the science teaching assistant, Emma as the health teaching assistant, and Marvin as the depression expert. The aim was to understand how these prompted personalities could be utilized as teaching assistants to enhance student learning, with a specific focus on the perceptions and emotions of students towards each personality. Pre-study observations revealed that participants had preferences for personalities based on factors such as humor, approachability, and authenticity. However, some participants found personalities like Marvin or Emma to be annoying or passive-aggressive due to factors such as appearance, behavior, and communication style. As seen in previous studies, it is important to design social robots with visually appealing and emotionally responsive appearances to obtain user acceptance and engagement (Pakrasi et al., 2018).

Some students perceived Einstein more favorably due to its intelligence and fame as a well-known character, providing positive feelings and possibly leading to emotions such as admiration or respect towards this personality. This finding highlighted that incorporating a well-known personality into a robot could influence students' perceptions, emotions, and attitudes towards the robot.

Some reported a desire for advanced capabilities in the robots to make them more useful, which also highlighted the need for the capability of understanding human interaction for better engagement with robots (Duffy et al., 1999),The need for fluent conversations and clear communication was also reported by the students because existing personalities had issues, and students had negative emotions towards some of the personalities, which also highlighted the need for advanced emotional expression and affective computing (Gunes & Churamani, 2023; Hegel et al., 2009).

Interestingly, one participant mentioned that interactions with a depressed robot personality potentially increased empathy, which also clarified the potential of social robots to form strong emotional connections with users (Ahmad et al., 2017). However, concerns were raised about unsettling facial expressions and perceived lack of intelligence in the robots, suggesting the importance of considering robot appearance and behavior, as well as their ability to meet human expectations (Bartneck & Forlizzi, 2004; Walters et al., 2008).

The last research question aimed to investigate the newly designed robot personality. The main study was conducted to address research question 3 (RQ3): *" What are the students' experiences about the newly designed Astro Luna personality in the context of learning?".* After conducting the pre-study, most participants considered existing Furhat personalities more as companions than as teaching assistants. They pointed the issues such as inaccurate information, speech interruptions, appearance, and behavior not meeting their expectations. Based on feedback, a new robot teaching assistant personality named Astro Luna was designed to enhance student learning using Big Five personality traits. We focused on accuracy of information, emotional expression, ethical considerations and adaptability to diverse learning styles.

For the main study, 4 students participated. Interestingly all of them found Astro Luna to be engaging and positive after the interaction. Although this new personality had issues with fast speech all participants found it to be effective and engaging. When they were asked about the learning outcomes or knowledge gained from this new personality, they all recalled information taught by Astro Luna which also highlighted its effectiveness in engagement and enhancement of the learning experience.

The findings from the main study aligned strongly with existing literature on the benefits of social robots in educational settings, particularly for students with specific needs such as ADHD (O'Connell et al., 2024). The researchers highlighted that social robot supported college students with ADHD symptoms and one participant in our study who was found to be having symptoms of ADHD found Astro Luna to be exceptionally beneficial.

Also, the same participant reported having such a teaching assistant to be effective in comparison to traditional learning methods like reading books.

Some participants found Astro Luna to be a successful teaching assistant due to its ability to clarify complex concepts and adapt explanations according to student preferences. For example, it could simplify, or elaborate explanations based on student needs. This capability aligns with the findings of the research study by Williams, (2012), which demonstrated that having a socially intelligent robot could be beneficial for different fields including education, as it could understand and respond to human interactions based on the context.

Having a physical embodiment of a robot was also found to be beneficial. During the main study observation, one participant mentioned feeling like they had ChatGPT in the real world, which was very beneficial. Researchers like Berlan have also proven that having the physical embodiment of a robot (Berland & Wilensky, 2015) is important, as it improves the understanding of computational thinking among participants by enhancing their learning experience. Furthermore, having the physical presence of a robot seemed to provide a positive emotional state with a better attitude Catlin & Blamires, (2010), which was also found to be true in the main study session.

At last, the novelty of this thesis is the use of Furhat robot personalities as teaching assistants for university students. This research emphasizes not only the identification of design implications for improving the robot's performance, but also the importance of emotional expression, information accuracy, customization and ethical considerations. This study provides valuable insights for researchers and designers attempting to integrate robots in educational settings.

7.2 Discussion about Ethical Aspects

After the pre-study session, a student raised an important question regarding the necessity of robot teaching assistants in the educational field. This question could also be shared by many people due to concerns about future issues related to job replacement and the impact on student learning outcomes and experiences.

Moreover, there was a situation where some personalities used for the pre-study provided inaccurate information. This could raise the concerns about reliability and trust of using such robots in education. Therefore, it is important to ensure and keep an eye on robots when utilizing them in educational settings. And also, it is the ethical responsibility of researchers to test and validate the accuracy of information provided by robots before releasing them for use in educational technology.

The unexpected situation that occurred with Marvin personality and student during the pre-study session also needs to be considered very carefully. Especially when involving individuals with special needs, researchers should be very cautious. These highly intelligent robots could sometimes have errors in programming or malfunctioning filters. Therefore, the emotional well-being and safety of students should be given primary consideration when using robots in educational environments. To avoid such unexpected situations, researchers should always conduct thorough investigations and background checks before using them with participants. Apart from that developers should also consider about data privacy and safety of the participants before releasing robots for research purposes.

7.3 Limitations and Future Work

Throughout this research, several limitations were identified along with suggestions for future work. The first limitation was the incapability of Furhat robot personalities to detect student accents and speech speed. Because of this issue, students sometimes had to communicate more slowly. So, this impacted the effectiveness of communication between students and the robot.

The next limitation was found during the pre-study sessions. Students suggested incorporating physical features like hands for the Furhat robot to make it more engaging. However, due to current limitations, such features could not be provided for the main study. Instead, we managed to enhance the experience by adding a wig to the robot. Still this limitation could also be used for further exploration and development by improving the robot's capabilities and customization options according to the needs and preferences of users.

Another limitation identified during the main study was the Furhat robot's speech stopping mid-way while explaining the content. We could not resolve this issue throughout the study. However, it is important for developers to address this challenge and enhance the robot's communication capabilities in order to gain more effective interactions between robots and students. Additionally, research wise we had another limitation of participants for the main study phase. We had only four participants to interact with Astro luna robot personality as a teaching assistant. If we had more, we could gain more comprehensive insights into its impact in educational settings.

As this study designed the new personality using Big Five personality traits, future researchers could explore more about concepts such as the 16 personality traits identified

by Myers, (1962). Advanced research in this fold could offer a more comprehensive understanding of human-robot interactions and enable robot teaching assistance customized according to individuals' specific personality traits.

8. CONCLUSION

As we conclude, this study explored different robot personalities in enhancing student learning by focusing on Furhat robot personalities as teaching assistants. Throughout the pre-study and main study, valuable insights have been discovered into the effectiveness of robot personalities on student learning experiences. The findings from both the pre-study and main study highlighted several key points.

The 12 students who participated in the pre-study mostly perceived existing Furhat personalities more as companions than as effective teaching assistants by addressing issues regarding inaccurate information, speech interruptions, speech speed, and behavior. Most of the students had negative experiences regarding the Furhat robot's existing personalities. Therefore, the author of this thesis had to come up with a new teaching assistant personality, which was later introduced in the main study named Astro Luna.

This newly introduced personality provided positive results, with four of the participants finding it positive, engaging, and effective in enhancing learning experiences. Even though participants faced some challenges such as speech speed issues and stopping in mid-way sentences, Astro Luna was perceived positively by participants. The results of the main study suggested that Astro Luna can be used as a teaching aid due to its effectiveness in explaining specific subject matter in a way that any student can grasp the knowledge. For example, Astro Luna has the ability to explain theory in different ways, whether a student requests it in long form or short form, Astro Luna breaks it down in a way that is easy for the student to understand. This shows that Astro Luna's personality, including its way of teaching according to student’s expectations can be promising as a robotic teaching assistant in education.

Moreover, this research also found limitations such as accent detection, speech speed, and the absence of physical features for robots, which also suggests that future researchers and developers could address these issues and enhance the effectiveness of robotic teaching assistants. And also, future research could design and implement robot personalities based on 16 personality traits (Myers, 1962).

As this thesis contributes design implications as contribution to this thesis, it also contributes to the educational settings on the role of robot personalities in enhancing student learning experiences, it is also important to build such personalities by focusing on ethical considerations. By carefully examining the comparative experiences of students interacting with different robot personalities, the feedback found from this study highlighted

that both opportunities and challenges need to be addressed for future educational purposes. In furtherance, it is also important to continue exploring different innovative approaches and technologies by considering ethical considerations to maximize the potential of utilizing robotic teaching assistants in providing effective and enhancing learning environments.

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10. APPENDICES

a. Appendix 1 – Links

Consent form of pre-study

Consent form of the main study

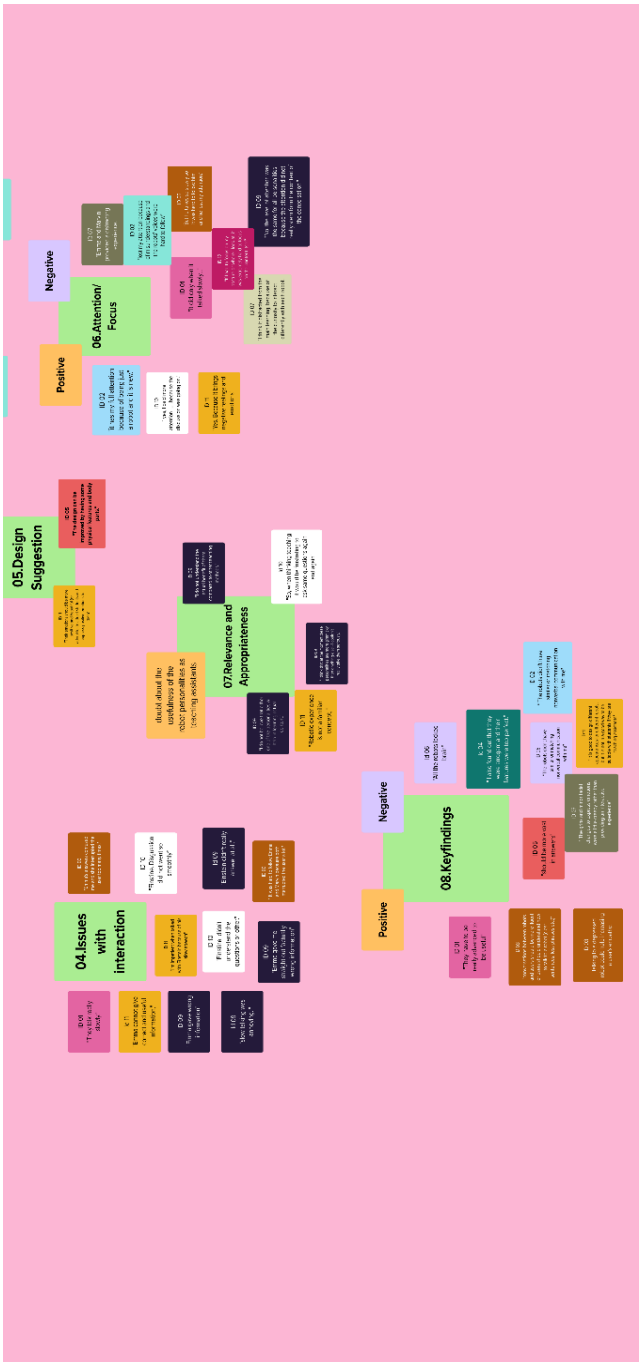
Affinity Diagram and Mural Task

Pre-study personality questionnaire

The main study survey questionnaire

Main study Interview Transcriptions

b. Appendix 2 – Pre-study Affinity Diagram analysis


05.Design Suggestion
04.Issues with interaction
06.Attention/ Focus
Negative
Positive
07.Relevance and Appropriateness
should about the usefulness of the code presentation as teaching material.
08.Keyfindings
Negative
Positive

c. Appendix 3 - Pre-study Mural Task

Task 01 : Robot Appearance Interactions (12 minutes)

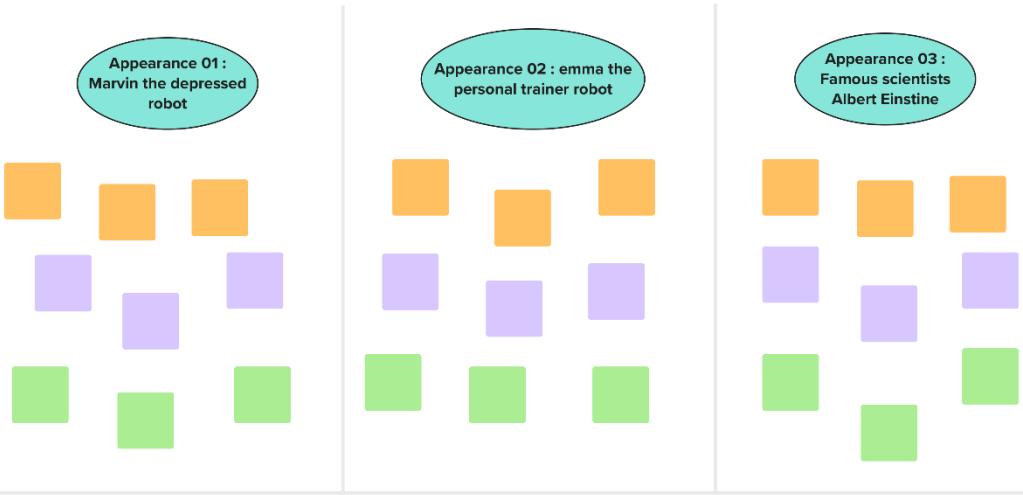
As the first task, you'll have the opportunity to engage with three distinct robot appearances of Furhat robot. Both of the groups should spend no more than 4 minutes interacting with each appearance.During the interactions, please approach the robot appearances as if they are your learning companions in the classroom.

1) First Appearance : Marvin the Depressed Robot.
2)Second Appearance : Emma the personal Trainer
3)Third Appearance : Famous Scientist Albert Einstein

Task 02 : Robot Appearance Interaction Emotional Response (8 minutes)

In this task, your goal is to reflect on your emotional experiences and the learning you gained from interacting with each appearance of the robot. Write your answers to the following questions according to the assigned color. All the questions must be answered for each appearance.

- Question 01 : How did the robot's appearance influence your interaction experience?
  - How does the appearance make you feel?
  - Did it enhance or hinder your engagement with the robot?
- Question 02 : Did the appearance effectively convey the intended emotion?
  - Based on the robot's design and expression, did it successfully communicate the intended emotion? Explain why or why not.
- Question 03 : In your opinion, how does the emotionally expressive appearance of this robot contribute to its role as a learning companion in the classroom?
  - Do you believe this appearance helps students to learn and stay engaged with their studies? why or why not?



Task 03 : Design or Upgrade Task (If you have no time to complete this task do it as your home work)

As the last task, you have the opportunity to design a brand-new robot appearance from scratch or enhance an existing one. This means you can create a fresh design or improve upon an appearance you've interacted with earlier. Make sure to think of the robot as a valuable learning companion and design its appearance accordingly.

1. Make a hand-drawn sketch of a preferred robot appearance. Consider how this design can contribute to a positive and engaging learning environment (for example: consider factors like color scheme, and facial expressions when designing the robot.)
2. Take a clear photo of your robot sketch and upload the picture to Mural.
3. In comparison to the robot appearances you interacted with, what key differences do you see in your sketch? How does your design approach differ?

d. Appendix 4 – Pre-study Personality Questions

1. For each robot personality (Einstein the science teaching assistant, Emma the physical health teaching assistant, and Marvin the depression expert), please rate the following aspects on a scale of Strongly Agree to Strongly disagree.

*

	Strongly Agree	Agree	Neutral	disagree	Strongly disagree
I felt at ease during the interaction with Einstein	○	○	○	○	○
I felt at ease during the interaction with Emma	○	○	○	○	○
I felt at ease during the interaction with Marvin	○	○	○	○	○
Einstein's personality aligns with its role as a teaching assistant	○	○	○	○	○
Emma's personality aligns with its role as a teaching assistant	○	○	○	○	○
Marvin's personality aligns with its role as a teaching assistant	○	○	○	○	○
Einstein's personality has the potential to positively impact students' learning outcomes.	○	○	○	○	○
Emma's personality has the potential to positively impact students' learning outcomes.	○	○	○	○	○
Marvin's personality has the potential to positively impact students' learning outcomes.	○	○	○	○	○

2.Please describe your emotional response to the personalities of Einstein, Emma, and Marvin. Did they make you feel comfortable, engaged, indifferent, or something else? Please describe your feelings and reactions for each personality.

3.Please put in order the three robot personalities from most preferred to least preferred teaching assistant based on your interaction experience.

I. Emma the physical health teaching assistant
II. Einstein the science teaching assistant
III. Marvin the depression expert

4.Please share why you gave the order in the question above.

5.In your opinion, give 3 main takeaways or key findings from your interactions with different robot personalities as teaching assistants?

6.Please share whether you felt more engaged or distracted during the interactions compared to your typical or usual experiences in a class room, and explain why you felt that way.

7.Did the personality of each robot influence your level of attention during the interaction? Why?

8.After interacting with the different personalities of the robot, choose which term best describes them

1. Learning Companion
2. Teaching Assistant

e. Appendix 5 – Main study Survey Questions

1.On a scale of 1 to 5 , how interested are you in learning about astrology (1= Extremely Interested to 5= Not interested at all).

2.On a scale of 1 to 4 , how familiar are you with the basics of astrology? (1=Not familiar at all to 4=Very familiar).

3.What is your preferred method of learning a new subject?(ex: reading books , interacting with teacher etc).

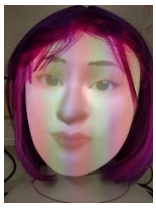
4. How comfortable are you with using technology for learning purposes?

5.On a scale of 1 to 4 , how familiar are you with social robots? (1= Not familiar at all to 4 = very familiar).

6.How open are you to the idea of using a social robot (*an artificial intelligence (AI) system that is designed to interact with humans and other robots*) as a teaching assistant for astrology studies?

7.If you were to use a robot for learning activities, what characteristics would you prefer? Provide at least 3 characteristics. (ex: informative, friendly, interactive, funny etc.)

8 Please select the face that you would prefer as your astrology teaching assistant from the options below.


Option 1


Option 2


Option 3

9.Do you think having a robot teaching assistant would enhance your engagement with astrology studies? (Yes,No,Maybe)

10.Are there any specific astrology topics or areas you are particularly interested in exploring with the help of robot? (example zodiac signs ,planetary influence etc).

11.Would you be interested in enrolling in the main study to explore astrology with the assistance of the Astro Luna robot personality? If yes, please leave your email address below.

f. Appendix 6 – Main study Exercise sheet Questions

1.What is Astrology

2.Put the zodiac signs in correct order from 1 – 12 by writing the corresponding number to each sign.

I. Aries
II. Taurus
III. Cancer
IV. Scorpio
V. Capricorn
VI. Pisces
VII. Libra

VIII. Leo

IX. Gemini

X. Sagittarius

XI. Aquarius

XII. Virgo

3.What is a birth chart?

4.How many houses in astrology?

5.What represents following houses

I. 1st house

II. 2nd house

III. 5th house

IV. 10th house

g. Appendix 7 – Main study Interview Questions

1. How did you feel when you first interacted with Astro Luna? (were you curious / scared? Why?)
2. Did Astro Luna capture your attention during the lessons?
3. Can you recall any specific information / concept that astro luna taught you during the lesson?
4. Do you feel that this new character helped you better understand astrology?
5. In what way did astro luna enhance your learning? (did it make the study more memorable?)
6. How did the experience of learning from astro luna robot compare to traditional teaching methods?
7. Did the new personality character help clarify any complex concepts?
8. Are there any changes in your perspective after engaging with the robot?
9. What type of improvements could be made to enhance the learning experience?
10. If there's a scale from 1- 10, how would you rate effectiveness of this new personality character as a teaching assistant?