Designing for Engagement: An Empathetic Educational Robot with Warm Speaking Tones and Interactive Non-Verbals

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ABSTRACT

This paper presents the design of an educational robot that leverages empathetic and friendly speaking tones, along with energetic and interactive non verbal communication to enhance student engagement. The robot, designed with a focus on emotional resonance in educational environments, incorporates advanced voice modulation and non-verbal cues. This approach aims to improve student-robot interaction, fostering a conducive learning atmosphere.

Keywords: Educational Robot, Empathetic Design, Human-Robot Interaction, Voice Modulation, Non-Verbal Communication, User Engagement, Robot Programming, Misty Robot Platform

1 Introduction

The advent of technology in education has not only introduced new methods of instruction but also paved the way for innovative interactions between students and digital tools. Amid this technological revolution, educational robots have emerged as a prominent figure, finding applications in various fields such as teaching materials [1], learning companions [2], and more. However, the effectiveness of these robots in educational settings largely depends on their ability to engage and maintain students' attention. This paper hypothesizes that the use of empathetic and friendly speaking tones in a robot can significantly enhance student engagement. We aim to design a robot replicating this, that not only educates but also connects emotionally with students, facilitating a more impactful learning experience.

2 Design Philosophy

The core design philosophy for our robot, built upon the existing humanoid Misty robot platform, centers around creating an empathetic connection with students, complemented by high levels of engagement. The idea of humanizing technology is not new; previous studies have indicated that personal devices with human-like qualities can foster deeper connections with users [3]. Our approach is not to redesign Misty from the ground up, but to innovatively design upon its capabilities to enhance its educational impact. This design is guided by principles derived from educational psychology, suggesting that the pitch and tone of communication significantly impacts student receptiveness and engagement. Vocal nuances, caused by changes in pitch, tempo and tone, can substantially influence users' perceptions of a robot's emotional state and other characteristics [4,5]. Friendly and warm tones are hypothesized to create a more welcoming learning environment, encouraging positive student-robot interactions. On the non-verbal front we have cues such as gestures, facial expressions, and movements that are integral to effective communication and teaching [6]. In the context of our robot, these cues are designed to be lively and interactive, aiming to capture and retain student attention.

3 Application Scenarios and Storyboards

Illustration of scenarios through storyboards has been demonstrated to be an effective method to efficiently develop potential designs in HRI [7]. We separated the storyboards into two categories based on educational scenarios: (i) robot giving a lecture, (ii) robot

answering students' questions. Details for each category are provided below.

Scenario 1: The first scenario demonstrates the robot giving a lecture. We designed our robot to maintain eye contact with students as a way to keep them engaged. The robot's voice is modulated to maintain a warm and affectionate tone. Throughout the lecture we have implemented non verbal communication through our robot, be it with arm movement or with facial expressions. The robot is designed to actually turn to look at the class lecture board and point to it whenever it needs to emphasize something. This feature directs the students' attention towards the board whenever required. After this, the robot is made to re-capture the students' attention back upon itself by reinstating the eye contact. The storyboard shows the robot implementing this design.

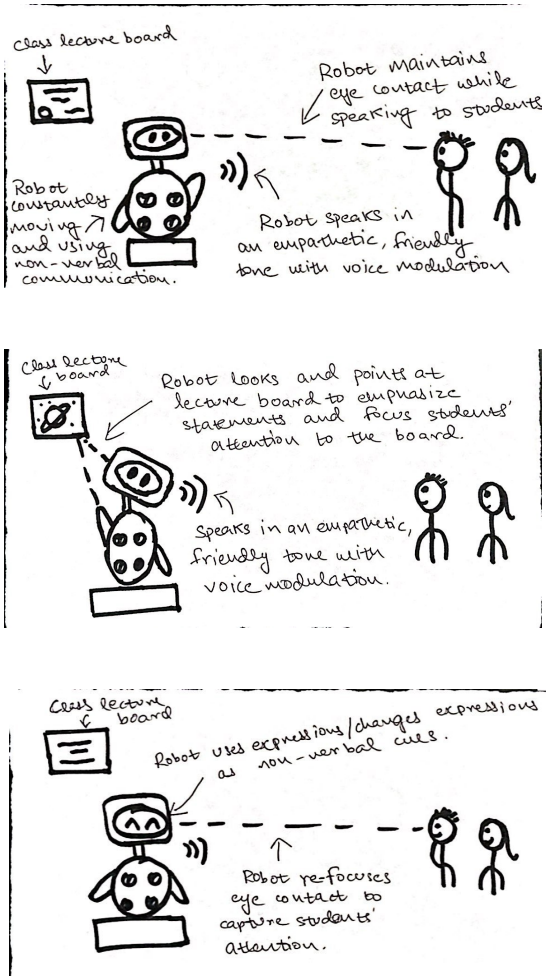

Figure 1: Illustration of Scenario 1.

Scenario 2: The second scenario demonstrates an all too common classroom situation. One where a student asks a question/doubt to their educator. In the case of our robot, we wanted this scenario to be handled in a seamless manner where the student feels heard, acknowledged and satisfied with the manner in which an answer is given. Initially while the student asks their question the robot maintains eye contact with them. Then, instead of robotically answering the question immediately, by design, the robot takes a few seconds to tilt its head and voice out that it is thinking. This is indicated with the use of a verbal note such as "Hmm" or "That's a good question!". Once the thinking phase ends in a few seconds the robot re-establishes eye contact with the student who asked the question and gives the appropriate answer. After the answer the robot waits to hear the student acknowledge the answer before moving on with the lecture. During this whole interaction the robots' movements, eye expressions and emotions in the tone of its voice are designed to show admiration and friendliness so the students feel welcome and heard when asking questions. The storyboard below illustrates this scenario.

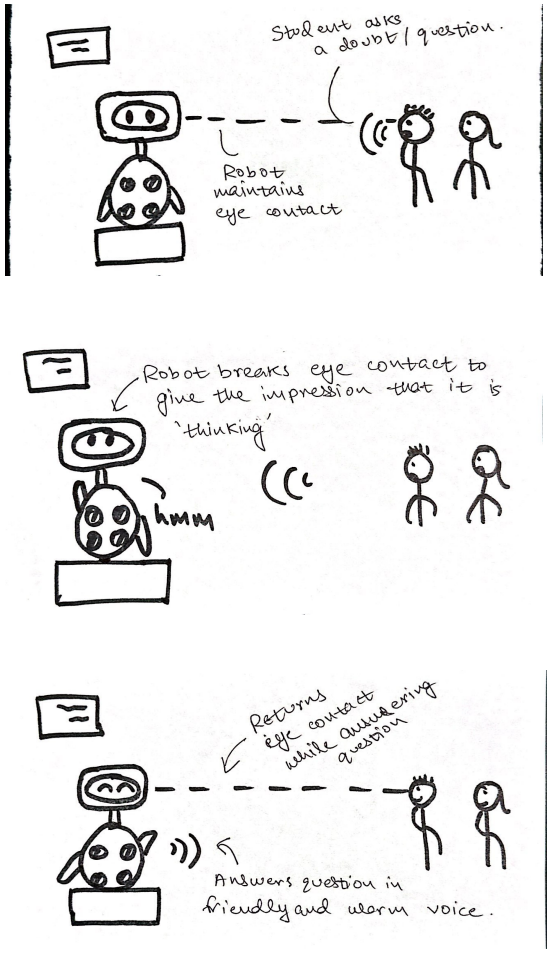

Figure 2: Illustration of Scenario 2.

4 Technical Implementation

We utilized the Misty robot to implement our design. This platform was chosen for its versatility, programmability and humanoid appearance[8]. Misty met our design objectives, as it allowed for specific hardware modifications and software customizations, which included voice modulation and movement features, along with a screen to showcase its 'face', which we used for non verbal communication. Our implementation was as follows:

We programmed the robot to exhibit Punctuation Sensitivity. It recognizes and appropriately responds to punctuation in text, guiding its speech intonation and rhythm. For instance, we ensured questions are met with a rising intonation, while full stops prompt a pause and a drop in pitch, effectively mimicking natural human speech patterns.

In terms of Enunciation, we placed a strong emphasis on clear and precise articulation[10], particularly for key terms and concepts. Our programming ensures that crucial educational words stand out, facilitating easier understanding and following of the robot's instructions or explanations by students.

For Pitch Variation, we adjusted the system to convey different emotions, keeping the speech engaging and lively. We designed it so that a higher pitch indicates excitement or enthusiasm, whereas a lower, more steady pitch is employed for serious or reflective topics. This variation avoids monotony and enhances the auditory experience[13].

We also took charge of Speech Rate Control, dynamically adjusting it to suit the specific part of the content being delivered. Complex explanations or instructions are delivered at a slower rate, while casual conversations or expressions of excitement are conveyed more quickly.

In terms of Tone Modulation, we carefully modulated the overall tone to ensure it is consistently warm and friendly. This was achieved through a thoughtful combination of adjustments in pitch, rate, and volume, fostering a welcoming and approachable auditory presence.

Regarding Energetic Gestures, we programmed the robot's gestures to be expressive and diverse[9], injecting enthusiasm and reinforcing key learning points. This programming was executed using the block programming features on the Misty dashboard, ensuring the gestures are both lively and relevant to the educational content.

For Eye Emotes and Movements[12], we utilized Misty's facial display and eye movement capabilities to exhibit a range of expressions[11]. We designed these to be engaging and responsive, coinciding with the spoken speech for coherence. This was achieved by synchronizing the code containing the emotes and expressions with the speech output.

Lastly, in Movement Dynamics, we choreographed the robot's movements to be fluid and purposeful, mirroring the energy of an enthusiastic educator. We used block programming to define specific parameters such as speed, direction, angular velocity, and movement duration. Additionally, we activated sensors to ensure the robot navigates smoothly around the demo area, avoiding obstacles and creating a dynamic, interactive presence.

Figure 3: Misty during a lecture

Figure 4: Misty answering a question

5 Conclusion and Future Work

The design of this robot represents a step towards more emotionally resonant educational technologies. By focusing on empathetic and friendly speaking tones, the robot has the potential to not only educate but also to emotionally engage students, fostering a more effective and enjoyable learning environment.

Currently, the robot's empathetic interactions are partly managed through Wizard-of-Oz techniques, involving some level of human control. This approach was crucial in the initial phase to understand and refine the empathetic communication strategies using the Misty platform.

Moving forward, our aim is to enhance the robot's autonomy, reducing the reliance on human operators. In order to do this we will need to devise programs and Machine Learning Algorithms to hear what students say, convert this from speech to text, parse this text as data and compute the appropriate response. We will also need to implement algorithms to make the robot perform a certain way in terms of non verbal interaction and movements when triggered by certain events.

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