Interactive Desktop Study Buddy Robot: Stubie

Jongwon Lee
Indiana University
leejojo@iu.edu

Colette Clouse
Indiana University
coleclou@iu.edu

Ayesha Kazi
Indiana University
kaziaye@iu.edu

Abstract

An electronic device while studying is a double-edged sword in the aspect that it helps students study but it can distract students as well. In this research, we designed and created a robot study mate, Stubie, using an Arduino that implements the Pomodoro method, interactive emotions, and a rewarding system. Our research revealed that students demand functional features from a study buddy robot, and we believe a robot can be their study buddy if the robot provides relevant features. Our design focused on setting up the mental model that the student is studying which will help the students focus. Regarding ethical concerns, our prototype of Stubie did not store the data that can be generated with the sensor to reduce any privacy concerns from students, such as feeling that they are under surveillance for how long and what time they study.

Keywords— Human Robot Interaction, Robot Ethics, Robot in education

1 Introduction

Using electronic devices such as a laptop and a smartphone while studying can be helpful because it provides technological functions such as timers and search functions. However, electronics can be more distracting than beneficial. For students that prefer to study with a companion, but sometimes get distracted, a robot study mate will meet their needs. Moreover, students can quickly lose motivation when studying or doing classwork, leading to burnout.

We are interested in the following questions:

- What motivates students to study?
- How can students study more efficiently?
- Why do people like to study with friends?
- What kinds of tasks can be automated with a desktop assistant to ensure students have effective study sessions?

Our measures of success and evaluation criteria are as follows:

- Does the user understand how to use the robot without being explained? (Affordance)
- Does the user get motivated to go through multiple cycles of the study session?
- Does the user treat the robot friendly?

2 Background

We were interested in the effects of social settings on studying efficiency and how a desktop robot can embody the characteristics of social studying. Lu et al. adopt the self-determination theory (SDT), which emphasizes the importance of the user's innate psychological needs, such as relatedness, as the design principle for their study partner robot. They claimed that satisfying such psychological needs will motivate learners and improve the learning output (Lu, 2018). Thus, we designed a robot that is friendly, interactive, motivating, and rewarding to fulfill their psychological needs. As discussed in Human-Robot Interaction (HRI), emotional responses in robots strengthen the bond between users and robots. Mimicry is the simplest way to program emotions (Bartneck, 2020). Because of time constraints and limited resources, we designed our robot to mimic what it looks like to complete a study session. We were also interested in how we can design the robot to familiarize students and let students detect the affordances (relation between an object and the user which makes it clear how to use it, (Gibson, 1966)) of the robot. Moreover, Michaelis and Mutlu emphasize that face design is the key to motivating users and connecting socially with their robot (Michaelis, 2017). Thus, we focused on the digital facial design to make our robot serve as a better companion. Nonverbal cues in HRI are necessary as a "social glue" to build a bond between the robot and its user (Bartneck, 2020). Instead of using mechanical body movements in response to the presence of a user, we focused on visual cues acknowledging the student, like timer speed and facial expression. Bethel and Murphy defined 5 main approaches to nonverbal expression in social robots: body movement, posture, color, orientation, and sound (Bethel, 2010). Each approach has values that elicit a certain feeling, so the purposeful choice of each value is essential to develop an effective HRI system.

In our research of study methods, we found two approaches that could be implemented with a social robot. The first approach is the cognitive one; the techniques include SQ3R (Survey, Question, Read, Recite, Review) and SOAR (Select, Organize, Associate, Regulate). These techniques take advantage of the memory system by encouraging students to interact with information after their initial interaction with it (Jairam, 2014). SQ3R and SOAR are helpful for retaining information from textbook readings and lectures with presentation slides. The other approach is the Pomodoro technique which practices time-based studying by breaking up sessions into 25-minute studying followed by a 5-minute break. Francesco Cirillo developed this technique to "enhance focus", track productivity, and reduce anxiety linked to the abstractness of time (Cirillo, 2009). By breaking up study sessions into short, uniform units of time, students are able to stay focused while tracking their progress with Pomodoro units.

3 Design research methods

Our empirical research focused on how robots are used in academic settings. We also addressed how physical form affects the HRI system and found that faces, round edges, soft materials, and animal-like forms build trust and connection (Michaelis, 2017). In terms of studying, working on different subjects in a study session is helpful in improving information retention (Winerman, 2011). In our research of study methods, we found the Pomodoro technique to be the easiest to adopt and most applicable. Pomodoro sessions provide flexibility for students to focus each session on a subject, then switch for the next 25 minutes. We also planned to design the robot to be able to suggest study topics. Based on Bethel and Murphy's review, the design should combine calming characteristics like blue colors to inhibit distraction (Bethel, 2010). It should also have happy accents to mimic the feeling of finishing a study session and getting a break. We can use yellow because it is viewed as a joyful color. In terms of body movements, they should elicit positive emotions so the user stays motivated to continue building positive study habits. Quick movements convey elation, which is the feeling we want to mimic when students get a break. By combining movements, in our case represented with glasses movement, with happy facial expressions, the robot can give students positive feedback after each Pomodoro session.

For our primary research, we surveyed university students (N=11) to understand their emotions and motivation while interacting with a robot and their design preferences. The questions and results can be found in the appendix. We found that most students believe rewards (physical or virtual) will motivate them to study, and slightly fewer students believe facial expressions would help with studying. We asked what features students prioritize from a Studying Buddy Robot among 3 choices: a companion for psychological reasons, 27.3%, motivation by rewards, 27.3%, and functional purposes such as task and time management, 45.5%. We asked if a Studying Buddy Robot, assuming it fulfills your desired features of a studying buddy, can replace a human studying buddy. Out of five scales of answer choices, 63.6% of the students believed it will depend on the features, 27.3% believed it will somewhat replace, and 9.1% believed it will unlikely replace. These results showed that most students were positive about studying with a robot instead of a human study mate. Also, students care significantly about the features the robot can provide.

We conducted another survey with university students (N=10) to understand their outer design preferences. Survey respondents generally liked the softer shapes/textures of Keepon and Blossom and disliked the faceless aspect of Blossom. Students disliked the high-tech look of Kuri because it looks mainstream and cheap.

The robot's design will reflect the responses by including a cartoon-like face so users connect with it without falling into the negative part of the Uncanny Valley. The robot is intended to accompany students to their desks while working, so it will need to be relatively small in size. Because of the size constraints, we will have to limit bulky hard-

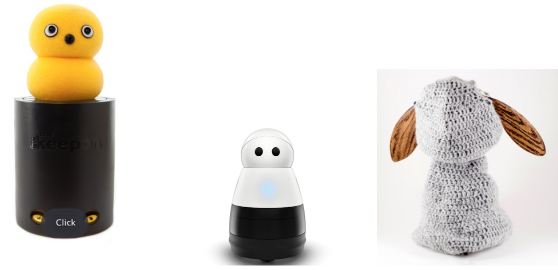

Figure 1: Keepon, Kuri, Blossom

ware components and only include necessary features.

4 Design

4.1 Context of Use

Stubie (Study+Buddy, pronounced: stu:bi)'s purpose is to improve the user's study habits. In our research, we found that studying in uniform periods of time with consistent breaks is the most effective way to retain information. Based on our surveys, most students do not practice this method. As stated earlier, Stubie promotes the Pomodoro technique, which is traditionally 25-minute studying followed by a 5-minute break. The incorporation of structured study sessions with breaks helps information retention and reduces burnout when working. Stubie is designed to sit on a student's desk, and there is an ultrasonic distance sensor to detect the user. When the student is sitting within 100 cm of Stubie, it will smile at the student and the study time passes normally. When they are not detected, the study timer moves slower to encourage the student to stay on task. Our context of use video is available in the appendix.

4.2 Prototype Design

We incorporated human features like eyes and a mouth because the anthropomorphization of robots strengthens the human-robot relationship. Stubie's main purpose is to provide comfort and happiness to students so studying does not have to be lonely. Both digital designs change visually between study and break mode.
In our secondary research, we found that the HRI system is strengthened when the user is directly involved with designing and building their robot (Mubin, 2013). Instead of creating a robot that looks the same for everyone, we added accessories in the second design for people to customize their Stubie.

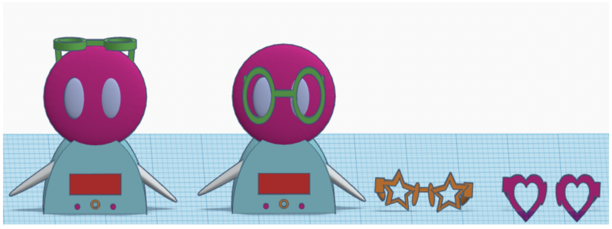

Figure 2: Prototype - Customizable Glasses

Figure 3: LCD displays in chronological order.

For our final design, we focused on timer functionality and customization. Stubie is an owl-like robot to pace studying and provides companionship for students. We chose the owl because it fits in the schema of academics. There are 4 modes that are signified on the LCD screen and physically illustrated by the position of the glasses: welcome, study, break, and achievement (Figure 3). On the achievement screen, a "O" is added to signify an additional Pomodoro session was completed.
Similar to the digital designs, the owl wears glasses on his face while studying. We believe this will form the mental model for the student that they are studying, and be more focused. Stubie's emotions are conveyed through the eyes. There are three states: focus, happy, and neutral (Figure 4).
Our physical prototype includes a backpack to hold the power bank connected to the Arduino. Stubie is designed to switch out the backpack designs and the glasses easily with command strips (Figure 5). These features strengthen the bond between the user and Stubie, but this is not the only goal of the design.
Our goal is to improve the way students study, but it takes weeks to form a habit. We kept the functionality simple with the timer because the relationship between the student and Stubie is more

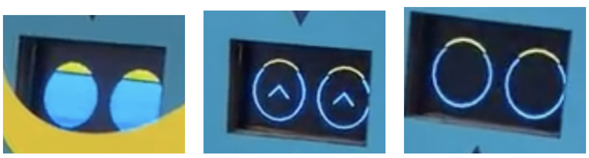

Figure 4: OLED eye states from left to right: focus, happy, and neutral

Figure 5: Two backpack designs and removable glasses

important. When the student is able to have a direct impact on the aesthetics of their robot, the HRI system is strengthened (Mubin, 2013). The ability to customize and accessorize keeps the student interested in Stubie; therefore the student continues using him, and ultimately increase the amount of time the student studies.

5 Discussion

5.1 User Evaluation

During the Demo Day, students in the Human Robot Interaction at Indiana University had a chance to use Stubie. During the demonstrations, we were interested in affordance, whether it is motivative, and feedback on the outer design. Because we had one button, students asked if they could press the button which naturally started the study timer. They understood the timer was going down, glasses were on and the eyes changed to the focusing mode. Most of the students gave feedback that Stubie will motivate them to study more and be focused while studying. They also reacted positively to the outer design which implied they treated Stubie as a companion. Moreover, students realized Stubie's eyes changes to smiling and neutral but our Arduino ultrasonic sensor was not accurate and responsive enough for the students to realize it is intended to check the distance with the student.

5.2 Reflection in the Design Process

From the research on HRI-based robot design, we concluded that the robot's design should inform the user of its functionality. We changed the design as simple as possible so the user will clearly understand how to use the robot and understand our intentions in using it. Setting up the mental model that the student is studying by putting Stubie's glasses on when the study starts was another important concept of our design.

5.3 Ethical Statement

Privacy is a primary ethical concern when adopting a robot as a service provider. Usage of the information collected by robots should meet the informed privacy policy. Calo argues robots can infringe on privacy by robots serving as direct surveillance, new points of access, and social agents (Calo, 2011). Stubie does not use a camera for the version we are working on, but it uses an ultrasonic sensor to sense if the student is sitting at a desk. We will only be using that information to know if the student is on the desk or not and will not store the data that can be generated with the sensor and inform this policy to the users.
Objective welfare such as respect and recognition can be expressed by Stubie as well by showing positive facial expressions whenever it recognizes the student completing study sessions. However, studying with friends or parents may not provide this recognition, and rather be indifferent or negative about the student's studying progress. We believe we need to take objective welfare into account to improve the result of a service robot project because people will design the robot to have more interactivity and motivation. Moreover, service provider robots do not necessarily replace human service providers but rather help them. In this sense, Stubie can be part of the study group instead of conceiving as a replacement for a human studying mate.
We apply Riek and Howard's HRI principles that aim to address ethical concerns regarding human dignity (Howard, 2014):

- The emotional needs of humans are always to be respected.
- The human's right to privacy shall always be respected to the greatest extent consistent with reasonable design objectives.
- Human frailty is always to be respected, both physical and psychological.

We are concerned with our robot being misused as a surveillance and a time tracker. We address this by designing our robot as friendly as possible and having interactive facial expressions so that students will treat the robot as a companion instead of a tool. We respect users' privacy. We will not be storing or using data that may be invasive to students' privacy. There will be no pressure if the student feels frailty. We address this by our robot only having reward systems and no punishment related to students' study progress.

5.4 Future Research

We recommend future research on adding extra features such as lighting, database-server interactions, and physical rewards. We initially wanted Stubie to function as a lamp, but we did not have the time and resources available for it. We believed the study light turning on and off according to the Pomodoro study or break time and the presence of the student was crucial. Incorporating databases and servers for keeping track of study hours and providing reports will motivate students to study. Lastly, we wanted physical rewards, such as candies, provided after each session. We did not have time for this and had technical issues as well. The current version rewards only emotionally, showing smiling eyes and increases the Pomodoro by one each study session. We had technical issues with slowing down the speed of study time reduction according to the presence of the student based on the ultrasonic sensor. Attempts like optimizing the Arduino code, finding a different sensor, or using an Arduino with higher performance are recommended.

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