Work in Progress: Fostering Empathetic Engineers by Practicing Contextual Listening – A Case Study

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***Abstract*— This work in progress research-to-practice paper proposes an approach that can encourage students to think about defining problems in socio-technical terms. One of the main goals of engineering curricula is to foster the ability of students to define a problem and propose an engineering solution. Students engage in an analysis of the criteria and constraints of a given event which leads them to develop a problem statement that they propose a solution for within a given time frame. The paper suggests that developing the skill of contextual listening is a pillar to socio-technical thinking. The work is based on a theoretical model of empathy in engineering developed by Walther, Miller, and Sochacka [1]. This model conceptualizes empathy as a skill and a professional way of being. One of the skills for empathic communication is contextual listening which is different from basic listening. The paper will present a study which a student undertook over the span of a semester to implement contextual listening through a hands-on project. The project addresses the nursing shortage currently present in US hospitals. Through the interviews the student practiced contextual listening to understand the needs, workloads and challenges that nurses face on a daily basis. The student also conducted a literature review to check if themes identified through the interviews are also present in the literature. The paper will present the results of the literature review, the interviews and the lessons learned about teaching and practicing contextual listening.**

Keywords—contextual listening, socio-technical thinking, engineering education, empathy, design.

I. Introduction

Basic listening "refers to hearing or paying attention to the verbal and nonverbal messages of any speaker" and "is framed as a dyadic process of speaking (output) and hearing/receiving information (input)"[2]. Whereas contextual listening is defined as "A multidimensional, integrated understanding of the listening process wherein listening facilitates meaning making, enhances human potential, and helps foster community-supported change. In this form of listening, information such as cost, weight, technical specs, desirable functions, and timeline acquires meaning only when the context of the person(s) making the requirements (their history, political agendas, desires, forms of knowledge, etc.) is fully understood" [2].

This paper will present a study which a student undertook over the span of a semester to implement contextual listening through a hands-on project. The goal was to interview medical professionals in order to understand their daily work schedules, tasks, and the environment that they operate within. The perception of using robotics to aid medical professionals in their daily activities was also investigated. The paper will present the interview questions, the themes that emerged and a literature review on the prevalence of robotic applications in aiding nurses. The paper will demonstrate how the interview process can be a vehicle for exercising contextual listening.

II. Interviews

In order to understand the circumstances and the environment of their project, the student developed four main questions which are listed below. The goal of this step was to establish the context of their design process. Over the duration of a month, four registered nurses (RNs) and two doctors were interviewed over the phone. Interviews targeted local individuals in the tri-state (NJ-NY-PA) area as the project aims to aid local areas around Lewisburg, PA.

1. *Can you please tell me about your daily work schedule and what tasks you are required to complete as part of your job? Please describe your work environment.*
2. *What is your opinion on robotics in a hospital/retirement home/household environment?*
3. *What are some of the needs of the area you currently work at? What are some areas for improvements in these facilities that you have seen or would like to see?*
4. *What are some current uses of robotics currently in your facility, if any?*

Five major themes were obtained from the interview and are summarized in the sections below.

A. Theme1: The need for assistance in delivering supplies such as medications to the different rooms.

In the interviews, several nurses indicated a shortage of staff in most hospitals. This results in over-exertion of the nurses or needs of patients being delayed. Delivering supplies to patient rooms is a task nurses need to do and occurs on a daily basis. With medication delivery, the process requires six "rights" of medication that the administration needs to go through, and the nurse staff serves as the last point of verification. In short, the cycle of medication delivery is as follows. First, the doctors order the medications and then the pharmacy verifies the dosage. Then, the order appears on Pyxis software where the nurse verifies if the medication and dosage are right for the specific

patient. At this point, if the nurse sees something out of the ordinary, she can contact the doctor directly and make sure if the medication was labeled for the right patient. Once medication and dosage are verified for the patient, each nurse goes to each individual patient's room to deliver the medication. There the nurse asks the patient for their name, date of birth, and to scan their wristband barcode before giving them the medication. It was expressed that this entire process takes a lot of time, and that simplification or aid would be highly appreciated.

B. Theme 2: Providing emotional support to the patients

Multiple nurses described how their job did not just entail monitoring heart rates and tracking other vitals of the patient. Due to COVID-19, many nurses had to take on a larger role of emotional support as patient's family members were not allowed to visit, a precaution to limit the spread of COVID-19. During this time, nurses had to take on the roles of family members to provide reassurance while patients were healing and as they passed away. This took a big toll on nurses as they were being stretched to their max capacity and had to go through a lot emotionally with the patient itself. A nurse described how it wasn't easy to see an individual who you took care of physically and emotionally to pass away, if not in front of their own eyes.

C. Theme 3: Bilingual assistance needed in the hospitals

Another topic that came up during the interviews was that not all patients know how to speak English. Every patient has the right to request a translator in a hospital. In the cases where the nurse is not able to speak the language that the patient would like to converse with, the hospital tries to find another entity who is able to do so. This person could be a doctor or another department staff member. This can cause a lot of inconvenience especially if it takes some time to find an interpreter for the patient.

D. Theme 4: Prevalence of robots is low

Through interviews, we found only one robotic application that directly interacted with the nursing wards. This robot specifically would deliver food items from the basement to the main levels of Mount Sinai Hospital. Most other robotic applications worked directly in the operating room. Many interviewees expressed the need for assistance and the vast area where robotics could be applicable in assistance.

E. Theme 5: Medical Imaging comparison through automated robotic process

One of the interviewed doctors noted how at their hospital there is currently no medical software that effectively and efficiently compares brain imaging of patients. Brain image comparisons are crucial as multiple sclerosis patients develop new scars on the brain and skull over time and therefore, MRI scans need to be taken numerous times and compared to assess the patient's condition. Doctors are required to manually compare each MRI scan to one another which can take a lot of time and isn't as reliable as needed. An automated system that could complete these comparisons would serve to be very beneficial to both the doctor and patient. The themes discovered from the interviews conducted clearly show the need for robotic assistance in hospitals, whether they were directly in the ward or the assistance for doctors. Robotics is a continuously developing area of engineering innovation. It has made its presence in various fields, including automation and education. For numerous years now, the medical field has taken a big hit due to the presence of the nursing shortage in US hospitals, as shown in a number of studies [3-7]. As a result of this depreciation, hospitals are having a harder time satisfying the needs of their patients. Along with staffing shortage which already provides stress for individuals working in the field, nurses are possibly exposing themselves to infection throughout their daily interactions with patients regardless of wearing any protective gear i.e., PPE. As mentioned in a study published by in the Association of Anesthetists journal the proximity to patient's airway is a factor that can cause the nurse to be infected through aerosol transmission [8]. This direct exposure can lead to illness in the hospital nursing staff, causing depreciation of number and therefore further straining the shortage present.

The use of a robotic application in a hospital setting could ease the load on nurses while aiding patient wellness, allowing a nurse to concentrate on the more important tasks such as giving immunizations and medication to the patient. Robotics can also limit the exposure a nurse would have from daily interactions with patients by helping out in various tasks and maintaining distance to limit aerosol transmission from patient to the nurse. This would help alleviate stress and protect the nurse form possible exposure to infection. The paper aims to review the current robotic applications and research designed to aid the medical field through analysis of current literature present and assess the situation of the field through conducting interviews of individual currently working in the field.

III. LITERATURE REVIEW

Reviewing the literature, we found out that medical robotics is applied in different areas of the medical field: (1) to aid nurses, (2) to provide comfort and socialize with patients, and (3) to assist with daily needs in the hospitals. A number of studies have shown examples on the ways robots can assist nurses and help around the hospital.

A. To Aid Nurses

One of the tasks of the nurses during the day is to deliver meals and other personal items to the patients. This can add up to 6 trips to the patient's room every day. In an attempt to reduce this burden on the nurse, a line-following robot was designed to carry out food delivery. A group of researchers at Kanagawa Institute of Technology designed a tray robot that follows guidelines, and it can be located either on the ground or ceiling of the hospital. This robot would aid nurses, as they would not need to walk around the floor delivering items to the patient. Instead, the patient would place their items on their designated tray and then the robot would store the tray rack located in the hospital ward. The robot goes back and forth between the rack and the patients. In all, this robot uses a line trace control algorithm to complete tray carrying tasks [9].

B. To Provide Comfort and Socialize with Patients

A number of robotic applications aim to provide comfort for a patient in a hospital setting or a household setting. It was observed that in such settings the gender representation of the robot played an important role in the perception or in the interaction with the human. For example, a study was conducted where a group of researchers from the College of Education/Educational Psychology from the University of Washington evaluated how people perceived humanoid robots/androids created for household application. Results displayed participant willingness to include the robotic devices in household activities by assigning tasks and human roles to them. Though the participants were shown videos of robot-human interactions in a home environment, when asked which tasks they could envision robots completing, participants stated both home chores and job roles not included in a domestic environment. The responses included jobs such as receptionist, librarian, or doctor's assistant and chores such as washing dishes, laundry, cleaning, ironing, and lifting heavy objects. The participants acknowledged their reluctance regarding the robotic devices engaging in social environments, as this would cause confusion amongst other individuals of whether they were "machine or organic" [10]. They also voiced how they would not be pleased with the robotic device physically interacting/embracing the human in a close manner, including hugging. This could lead to a false idea of the device displaying humanlike emotions. The humanlike characteristics such as clothing, voice, and morphology brought surface to possible gender issues that might arise. Participants stated that a feminine form was more inviting and created a warmer environment to create more conversation, whereas a masculine form would create safety issues to arise. Comfort level approached significance especially when talking about gender impact on robot perception. Lastly, female participants also felt less comfortable with in-home robots compared to the male participants [10].

Another study conducted by the University of Auckland showed the progress of social interaction with a healthcare robot Charles who is able to take blood pressure readings using a monitor. In this application, two age groups interacted with Charles, and the attitudes and reactions they had before and after their interactions were monitored. Charles is capable of basic human-robot interaction (HRI) and communication through an emotional 3D face with speech and blood pressure measurement of the patient. Through this study, no significant difference was seen between age groups in all aspects except for a small trend where older participants were less comfortable with the BP measuring that the robot was doing. The researchers observed that gender had a large influence on the participants' attitude, therefore showing that gender issues will need to be considered in design for robots in the future [11].

Furthermore, an investigation was conducted on how gender, occupational roles, and personality play a factor in user acceptance for social robots. For this, the robot performed two roles to show potential usage of a social robot at home. Through the study, it was shown that participants liked the robot to match stereotypes for gender-occupational role, i.e., male and female robot for specific roles, (less strong effect on outcome) and personality-occupation role, i.e., introvert and extrovert for specific roles, (stronger effect on outcome) combinations. This clarified that gender and personality did not monotonically influence the user acceptance of the robot as much as how role stereotypes affected the acceptance outcome. Through these results, designers can gain better insight on how to reduce the wide gaps present in robot designs and can approach designing robots with a direct focus on what aspects they should consider [12].

To provide comfort to patients, a social robot, "Dr. Arash," was designed by Ali Meghdari, Minoo Alemi, Mobin Khamooshi, Ali Amoozandeh, Azadeh Shariati, and Behrad Mozafari at the Center of Excellence in Design, Robotics and Automation (CEDRA) in Iran for use in pediatric hospitals. This robot is able to interact with the children and move in various areas around the hospital. Dr. Arash is there to answer children's questions, motivate, entertain, help relieve physical suffering and distress, and enhance cooperation with clinical staff [13].

C. To Assist with Daily Needs in the Hospital

A study done by Zeashan Hameed Khan, Afifa Siddique, and Chang Won Lee showed the evolution of robotics in the healthcare field and the potential that robotics could aid the management of COVID-19. Aspects such as person-to-person contact could be limited with robotics and therefore help with mitigation of the pandemic [14].

There have been many other examples where robotics have been implemented. For efficiency purposes, there needs to be an appropriate task allocation algorithm present for multiple robots in a hospital delivery service environment. The article "Performance Analysis of Scheduling Multiple Robots for Hospital Logistics" talked about two multi-tasking allocation (MTTA) algorithms. Both of these algorithms were tested through simulations and compared via pre-established criteria. Through the comparison, it was seen that MT-COM, a combinatorial search method which searches for all combinations of paths for each robot and the robot-path pair associated with the least cost chosen for the task, is the better option as the robot fleet size increases. The paper further states that recommended hospital fleet size is derivable and future research will further explore the MTTA task binding problem [15].

Another article, "Medical robots with potential applications in participatory and opportunistic remote sensing: A review," talked about the design, use, and maintenance of such technologies in the realm of healthcare, assistive robotics, and rehabilitation. This review focused on areas where the core had sensory data collection and analysis issues present, leading to further talk on the new advancements in the technology as well as the variety of mobile sensing applications. This article discusses numerous subjects, including sensor-fusion, kinematics and many others based on literature that is already present. Safety monitoring, security, privacy, and evolutionary optimization were also discussed. Mainly, this article dives into optimal design and maneuvering of surgery and many other medical assistive robots. Throughout the article we were able to see that detachable drives, networked intelligent mobile devices, and robots play crucial roles in improvement in medical and

healthcare services. Another topic that was discussed was prosthetics and exoskeletons that were aided by parallel robots, as well as microrobots and control strategies. Lastly, managerial topics to aid incorporation into healthcare was discussed along with future research directions of such technologies [16].

Another example would be the IWARD ("Intelligent Robot Swarm for Attendance, Recognition, Cleaning and Delivery") Robot Team, which is a team of service robots that are being applied to a hospital environment and was presented in the "Co-operative robot teams in a hospital environment" article [17]. The article introduces different scheduling and distribution patterns for different applications, including central and distributed scheduling. This article further presents an adapted approach towards the hospital environment scenario. The only downfall is that the scheduling accounts for power state and equipment of a robot for each task and therefore isn't the same task distribution problem as is known. This article discusses task allocation issues but also introduces the IWARD approach for scheduling incoming orders. Currently, the approach has been implemented and high efficiency has been noted. Further evaluation is planned [17].

Lastly, another article, "Design and Simulation of an Automated Guided Vehicle through Webots for Isolated COVID-19 Patients in Hospitals," talked about an automated guided vehicle (AGV) that can transport 8 kilograms and follows the desired path with a built-in system that avoids collision. This AGV collects medicine, food, and other necessities from the nursing station to the isolated COVID-19 patient. The isolated wards are divided into two halves and take the shortest path while going from one place to another without duplicating the path so there is avoidance of coronavirus spread. Patients are able to grab food and necessities when a robot stops by their room. This hospital environment with isolated wards and COVID-19 was depicted using Webots. In total, four robots were used, two robots taking care of one half of the wards and the other taking care of the other half. Though this proposed system is cost effective, some issues may arise if there is less light which can cause diversion from the path. The use of a camera or speech recognition could help with this issue and personalize the patient experience [18].

Through the various articles that were analyzed, we can see the use of medical robotics in different areas around the hospital. There is still much more that can be done and therefore the need for robotics in the medical field is still present.

IV. DISCUSSION

Based on the several articles reviewed and interviews conducted, we can see that there have been some efforts in the field of robotics to provide assistance to the medical field but much more can still be done. The literature review showed the use of medical robotics in different areas around the hospital and how numerous factors such as gender, occupational roles, and personality affected the perception and interaction the human experienced with the robot. Mostly through the review, gender took the lead for the factor that affected the human-robot interaction directly. Such factors are important to be considered while developing robotic applications as human perception is what primarily dictates an application to be accepted in a healthcare environment, where individuals look to get cared for and feel better at the end of the visit. It was also seen that different algorithms and basic line following robot principles can effectively help nurses with basic tasks such as delivering food and personal belongings.

V. CONCLUSION

Through this project the information gathered from the interviews allowed the student to identify areas of inquiry that weren't as prominent in the literature. It allowed the student to practice contextual listening by understanding the conditions and the daily challenges that the nurses operate within. Individuals in the medical field can clearly see the disparity present between medical robotics and aiding hospitals in other areas than the operating room. With the current shortage of staff in nursing wards, nurses are expected to take long shifts where they are responsible to care for numerous patients. With the numerous tasks they are assigned to complete and the worry of contracting an infection, nurses are put in an unfair position which can cause distress. Any possibility of contracting a virus at the workplace can dictate the ability for hospitals to deliver adequate care. This is because contracting infection can decrease the number or nurses present at work which can lead to hospitals having an even harder time then they are now with satisfying the needs of their patients. Through the interviews, multiple themes were identified that could be addressed that would help alleviate some of the stress provided to the nurses. With further development in medical robotics, we can aid with effort to decrease the contraction of viruses by hospital nursing staff. This will benefit both the nursing staff and the hospitals directly.

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