Mountain Directed Energy Wayfinder (D.E.W.)

Robots in Schools: How Innovation Attempts to Solve Problems in Education

A Thesis Prospectus
In STS 4500
Presented to
The Faculty of the
School of Engineering and Applied Science
University of Virginia
In Partial Fulfillment of the Requirements for the Degree
Bachelor of Science in Computer Engineering

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May 9th 2023

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On my honor as a University student, I have neither given nor received unauthorized aid on this assignment as defined by the Honor Guidelines for Thesis-Related Assignments.

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Overview:

Computer engineering takes the hardware component of electrical engineering and combines it with the software of computer science such that engineers in this field possess knowledge relating to both software and hardware. Robots are just that, a combination of hardware components and software programming with some mechanical engineering added in that serves a specific purpose. The purpose of a robot that I am interested in is how a robot can impact learning, and how learners who are taught by the robot perceive the robot. This will be accomplished through teaching people backgammon with a robotic coach. Readers will learn if robots have a place in education, how robots affect education outcomes, and perceptions of robots in learning environments.

Positionality:

My background is that I grew up in a Washington D.C. suburb and went to a magnet school located in Loudoun County. I am currently enrolled as an undergraduate in the School of Engineering and Applied Sciences at the University of Virginia and am studying Computer Engineering. I grew up in an upper-middle class family and took advantage of the school programs and advanced classes available in my school district. Additionally, I am abled and have not identified as disabled.

Problematization:

The research gap that I will be addressing is how robots fit into education. There is a lot of research on how digital tools, such as canvas, IXL Learning, and other educational software augments learning and the perceptions of users on those tools, but not tools that utilize digital and analog mediums, i.e. robots. The software implementation of educational tools has been successful in addressing the difficulties of teaching by delivering more personalized learning as

class sizes increase, but robotic tools have been left unexplored. In a classroom, students, teachers, robot technicians, school administrators, and parents will have to explore how robots can augment a student's education, and whether robots either positively or negatively impact student learning.

Guiding Question:

How does having a robot in the classroom augment student learning, and what are the users' perceptions on the robot?

Projected Outcomes:

My research aims to identify how robots augment education and the perceptions of robots, and in doing so create a possible inroad to further research and development of robot educational systems. This research can anticipate how robots fit into education curriculum, potentially changing education to be more effective. Teachers, students, and robotics companies will be impacted by the outcomes of this research.

Technical Project Description:

The anticipatory project that I will complete in my Capstone will be a robotic back gammon player. This will be a physical Backgammon player instead of a digital one, meaning a robot will actually move the pieces instead of a digital representation. I find that when I interact with a physical artefact rather than a digital one, the learning that I experience is greater, and this report will attempt to determine how well other people learn backgammon and their overall perceptions of the robot.

This project can be split up into 3 parts: image processing, game decision, and piece movement. Since the robot is playing on a physical board, there has to be some way for the robot to "read" the board and determine the location of all the different pieces. This will require a

camera, as well as a software controller to interpret the image from the camera and determine the location of the pieces and the roll of the die. This allows the robot to decide about where to move the piece in the game decision logic. This can be accomplished by using a machine learning model to determine the best move at any backgammon position. Lastly, there must be a way to move the pieces around the board as well as roll the die. That will require a specialized grabber to move pieces around and pick up and roll the die for each new roll. The backgammon will likely have to be modified such that it is easier for the robot to move pieces around. That is the general overview of the project.

Preliminary Literature Review & Findings:

In my preliminary findings, I discovered that a lot of the research of educational robots occurred in Europe and East Asia, and most of the research was focused on early education. The fields that robots were studied in include learning English (Zeng-Wei, 2016), mathematics (Ekström, 2022), and healthy sleeping habits (Bindsbergen, 2022). Studies were conducted on how robots taught older individuals as well, but that research is in the minority. Many of the studies determine that using robots as an educator is an effective form of education, and that the major limitation that robots have in education is cost of the development and the maintenance of robots as educating tools (van den Heuval, 2022). Additional research was conducted on perceptions of users who interacted with the robot. Some studies utilized Activity Theory as a method to study robots and the role that they played in an educational environment, and how robots took on multiple roles in the classroom. However, this theory is difficult to understand, and I will use a different theory to guide my analysis. The most interesting study that I found was about telepresence robots. This type of robot is utilized when a student is no longer able to be physically present in a classroom but still wants to participate in that environment. These

students and their classmates perceived the robot as an extension of the absent student, using the appropriate pronouns and other language to describe the robot as the student (Thompson 2021). The role that robots can take in teaching special education students has also been studied, with robots being an effective teacher of life skills for special education students (Reardon, 2019). Robots can take on many different roles within the classroom, and perceptions of the robot change with each role it assumes.

STS Project Proposal:

STS is science, technology, and society, and broadly, it studies how humans interact with technology. Robots have always been a visible part of the technological landscape, with videos from Boston Dynamics and other groups depicting the cutting edge of what robots are capable of and in doing so exposing society to how robots are able to be used. Robots have been used as deep ocean explorers, security guards, and in manufacturing, but one aspect that I want to explore how robots can be utilized is in education. When you take a robotics class, you are often integrating directly with robots and their development; you are acquiring knowledge from directly interfacing with the robot to learn how to program a robot. But what I want to explore is how robots have been adapted to education in non-robotics class settings. How are robots used in mathematics class to augment learning, and what are the perceptions of that robot by all the actors involved? These are the types of questions that I want to explore, and this is an STS project because it discusses robots (the artefacts) and how they are utilized to augment education and the perceptions of those robots in the classroom. This interaction between robots and education can follow how computers and other similar technologies were placed into the classroom to augment learning, and thus I believe is an interesting topic to study through the STS perspective.

The main ecosystem of knowledge that I will borrow from while writing this STS report is educational studies. When talking about a modern classroom, there will be students that have disabilities within them. If robots have the capability to assist students with disability in creating a better learning environment or learning process, then that research topic should be present in current disability studies. Additionally, that is why I believe that robots would also be present in education research, as robots are extremely visible in the current technological landscape, and I am sure educational researchers have studied the impact of robots in the classroom on student learning. The primary authors that I will reference will probably be educational researchers who focus on the impact of technology on education.

The approach that I will use to investigate the topic is Affordance Theory. This theory is focused on human computer interaction, more specifically the connection between perception and action (Gaver, 1991). When an artefact is situated in an environment, users perceive those artefacts as capable of doing certain a set of certain actions. Then, there is a set of actions that the artefact can perform. For example, a kiosk has a light flashing 'ATM' next to it. In the United States of America, this artefact would be perceived as being able to accept and dispense cash. If the machine is an ATM, then the machine will be able to perform that perceived action. But what if that ATM is out of cash, or has some other problem that inhibits the artefact's acceptance or dispensation of cash? Then the artefact can not perform an action in its set of perceived actions. In affordance theory, this type of disconnect between perceived action and true action is called a false affordance. There are also perceptible affordances, where the perceived action can be performed, and hidden affordance, where the artefact can perform an action which is not perceived. Affordance Theory provides a strong basis to understand how the shape of the robot and the environment in which the robot is situated will affect the use and perceptions of the robot

in education. The perceived actions of a robot in a mathematics classroom differs greatly from the perceived actions of a robot in the library, yet the actions of the robot will be to assist students' learning, independent of environment.

My anticipated method for accomplishing this research is to perform literature analysis of articles performing experiments of robots in education. For each paper I will list the possible actions each robot can perform, then the actions the participants attempted to perform with the robot. I will classify these perception action pairs into affordances, and then use these affordances to depict how current robot assisted teaching is perceived and how future development of robot assisted teaching should be directed.

Barriers & Boons:

One of my potential blind spots is that I am not currently within the robotics field; meaning I don't know the possible limitations of robotics and how they can be applied. However, I do have a background in education, where I have tutored and taught classes at camps. The reason why I selected the approach of a literature review is that I currently do not have a robot to perform actual research with. My capstone, which will be completed in December 2023, will be about building a robot with the expressed purpose of assisting education, but I do not currently have a working model. Additionally, my previous STS experience was limited, as during my 2000 level STS class my professor was no longer able to teach just halfway into the semester. The way that I can overcome these difficulties is to familiarize myself with current robotic technology and the scope of what they are able to do. Additionally, I can read up on more commonplace STS techniques aside from those discussed in class to broaden that knowledge. I can also integrate some of my research from my capstone into this paper later as well.

References

Bindsbergen, K. L. A. van, Hoek, H. van der, Gorp, M. van, Ligthart, M. E. U., Hindriks, K. V., Neerincx, M. A., Alderliesten, T., Bosman, P. A. N., Merks, J. H. M., Grootenhuis, M. A., Litsenburg, R. R. L. van. (2022). Interactive Education on Sleep Hygiene with a Social Robot at a Pediatric Oncology Outpatient Clinic: Feasibility, Experiences, and Preliminary Effectiveness. *Cancers*, *14*(15), 3792. https://doi.org/10.3390/cancers14153792

Ekström, S., & Pareto, L. (2022). The dual role of humanoid robots in education: As didactic tools and social actors. *Education and Information Technologies*, *27*(9), 12609–12644. https://doi.org/10.1007/s10639-022-11132-2

Gaver, W. (1991). *Technology Affordances*. 79–84. https://doi.org/10.1145/108844.108856

Reardon, C., Zhang, H., Wright, R., & Parker, L. E. (2019). Robots Can Teach Students With Intellectual Disabilities: Educational Benefits of Using Robotic and Augmented Reality Applications. *IEEE Robotics & Automation Magazine*, *26*(2), 79–93. https://doi.org/10.1109/MRA.2018.2868865

Thompson, P., & Chaivisit, S. (2021). Telepresence Robots in the Classroom. *Journal of Educational Technology Systems*, *50*(2), 201–214. https://doi.org/10.1177/00472395211034778

van den Heuvel, R., Jansens, R., Littler, B., Huijnen, C., Di Nuovo, A., Bonarini, A., Desideri, L., Encarnação, P., Lekova, A., & de Witte, L. (2022). The potential of robotics for the development and wellbeing of children with disabilities as we see it. *Technology & Disability*, *34*(1), 25–33. https://doi.org/10.3233/TAD-210346

Zeng-Wei, H., Yueh-Min, H., Hsu, M., & Wei-Wei, S. (2016). Authoring Robot-Assisted Instructional Materials for Improving Learning Performance and Motivation in EFL Classrooms. *Journal of Educational Technology & Society*, *19*(1), 337–349.