EMBEDDED ARTIFICIAL INTELLIGENCE ROBOT FOR FINANCIAL LITERACY

AN ANALYSIS OF THE SOCIAL IMPLICATIONS OF ARTIFICIAL INTELLIGENCE IN EDUCATION

A Thesis Prospectus
In STS 4500
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The Faculty of the
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Bachelor of Science in Your Major

By
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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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A THESIS PROSPECTUS: EMBEDDED ARTIFICIAL INTELLIGENCE ROBOT FOR FINANCIAL LITERACY AND AN ANALYSIS OF THE SOCIAL IMPLICATIONS OF ARTIFICIAL INTELLIGENCE IN EDUCATION

With the usage of artificial intelligence (AI) systems rapidly growing on an international scale, it is increasingly important to truly understand the implications of such systems. Nearly a $100 billion industry, the global AI market is expected to expand at a compound annual growth rate (CAGR) of over 38% by 2030 (Grand View Research, n.d.). To address the growing demand for such systems and corresponding need for related research, my senior project, including a technical capstone project and technical paper and a related Science, Technology, and Society (STS) written thesis paper, will address the ethics, practicality, and implementation of artificially intelligent systems used in education.

The former project will involve the logistics and practice of implementation, including building an AI system for financial literacy educational usage, embedding the system into a humanoid robot, and testing with human subjects. The latter project will involve researching and reporting on the societal implications of such projects, especially regarding potential bias in AI systems and the competency of the existing research on the subject matter. The two projects are tightly coupled, as the latter investigates the social consequences of the former in an effort to understand whether or not implementing these systems on a large scale is an appropriate course of action. These projects are to be carried out over the course of the 2022-2023 academic year, as detailed below in Figure 1. This prospectus serves to detail the existence and scope of the problems addressed by each project, the objectives and methods of the work, and their anticipated outcomes.

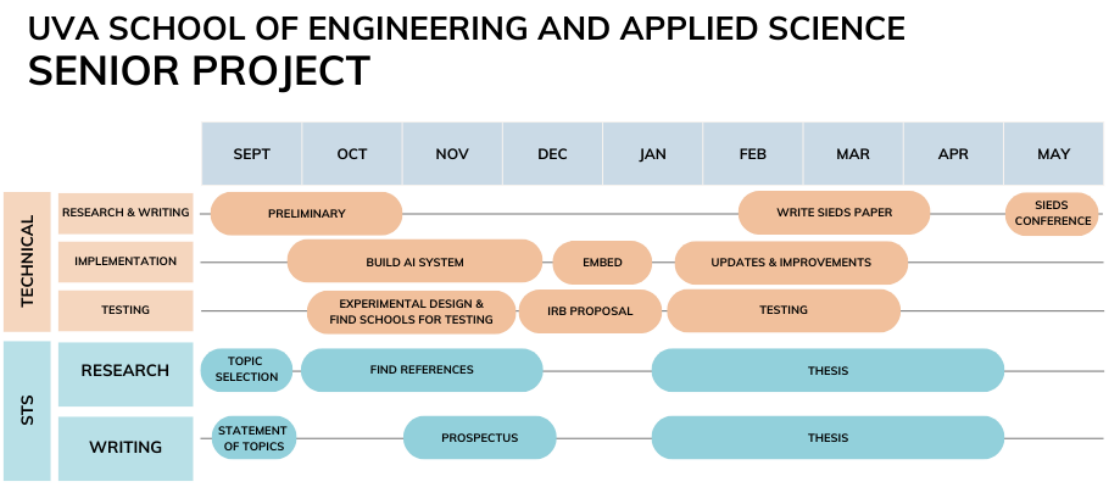

Figure 1: Gantt Chart: This image details the anticipated timelines for both my technical and STS projects, including research, writing, implementation, and testing for the former and research and writing for the latter (Howle, 2022).

TECHNICAL PROJECT: EMBEDDED AI ROBOT FOR FINANCIAL LITERACY

My technical project regarding embedded AI for financial literacy education is under the advisory of Tariq Iqbal, an Assistant Professor of Systems Engineering and Computer Science at the University of Virginia (UVA) School of Engineering and Applied Science (SEAS). The team tasked with carrying out the project consists of five undergraduate students in the school's Systems Engineering department – Qinyuan Jiang, Shirley Lesham, Pulkit Rampa, Lucas Zak, and myself, Sophia Howle. This project, sponsored by the MITRE corporation, is to be carried out by the beginning of April 2023.

PROBLEM AND SIGNIFICANCE

The significance of this project lies in the rapid development of artificial intelligence. Already raking in $51 billion in revenue by 2021, the AI software market was projected by Gartner to grow an additional 21.3% over the subsequent year. Over $6 billion of the 2021

revenue came from AI virtual assistants, in which category my technical project falls under. A virtual assistant AI system is one that assists users or automates tasks that were previously only able to be completed by humans (Gartner, n.d.). In this case, the task at hand is teaching financial literacy lessons to grade school students.

However, a 2021 Gartner study found that the maturity of AI systems lags behind the swiftly increasing interest levels. The research shows that despite experimentation with AI being commonplace, organizations encounter difficulties when it comes to integrating these systems into their standard operations. This lag is primarily attributed to an inability to connect investments into AI back to business value. Nonetheless, both interest and implementation continue to grow across virtually all fields of business.

While the presence of technology in grade school education is somewhat of a contentious debate that continues to be researched, educational entities in the U.S., both educators and policymakers alike, have historically prioritized investments in integrating technology into educational methods (Blackwell et al., 2014). Therefore, there has been an increase in the use of AI tools in education in recent years, as expected (Su & Yang, 2022). While various tools and related research exist, the niche intersection of AI, education, and financial literacy has yet to be widely explored and implemented - hence, this technical project was created.

OBJECTIVE

As the field continues to grow and expand, across many fields as well as education, there is an increasing demand for systems that can be implemented in schools. The MITRE has indicated a strong enough public interest to sponsor and employ UVA SEAS to develop a new tool. The objective of this project is to create a system adequately equipped to teach financial literacy lessons to grade school students, to test the system and make appropriate adjustments,

and to use the experimental findings to determine if the system's implementation provides a benefit to students.

METHODS

Thus far, the aforementioned project has involved creating an AI virtual assistance system designed to guide elementary school students through lesson plans about various financial literacy topics, based upon the National Standards for Personal Finance Education (Council for Economic Education, 2021). The topics that have lesson plans developed as of the end of December 2022 are: (1) credit and debit, and (2) saving and spending. Next, our team will embed this system into a humanoid robot using Choregraphe software to convey the lessons with both verbal and non-verbal cues, creating a system better equipped to capture users' attention. The humanoid robot(s) being embedded with our system are NAO robots, provided to us by UVA SEAS, as seen in Figure 2: NAO Robot with Children. The system will then be tested, pending approval from the Institutional Review Board, in elementary schools nearby to UVA. This testing will serve as an experiment aimed at determining how the embedded AI system performs amongst children when compared to existing traditional methods of education, such as guided worksheets. The metrics across which the system will be tested are as follows in Figure 3: Technical Project Metrics Tree. Adjustments will likely be made according to the experimental findings. Finally, the aforementioned work and resulting recommendations will be detailed in a paper submitted to the 2023 Systems and Information Engineering Design Symposium (SIEDS) and presented at the SIEDS conference, pending approval from the corresponding committee.

Figure 2: NAO Robots with Children: The robots that will be used for embedding the AI system for our technical (Howle, 2022).

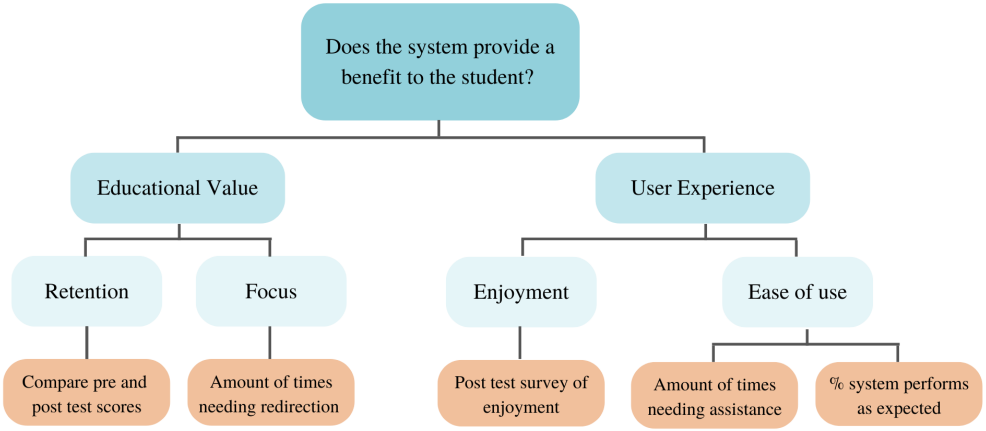

Figure 3: Technical Project Metrics Tree: This diagram shows the breakdown of the objective of our technical project, the associated metrics, and the data that will be collected to measure these metrics (Howle, 2022).

ANTICIPATED OUTCOME

I anticipate that the testing with elementary school students will find a need for improvements to the system, and therefore, the system will be deemed inadequate for widespread implementation in its *current* state. Once improvements have been made, the system could be re-tested and re-evaluated for its benefit to students. However, depending on the findings of my related STS project, as detailed in the following paragraphs, I may recommend waiting to implement this system even if it shows a benefit to students within our experiments. This is because our experiments do not test for potential harm - only for educational benefits.

STS PROJECT: AN ANALYSIS OF THE SOCIAL IMPLICATIONS OF AI IN EDUCATION

The thesis paper will be written under the advisory of Catherine Baritaud, Senior Lecturer in the STS department within UVA SEAS. This project will entail research and findings on how artificial intelligence in education (AIEd) systems similar to that of the technical project described above imparts effects on society, particularly regarding their ethics and potential for harm. The research will seek to answer the question of whether or not embedded AIEd systems should be implemented on a large scale based on their social implications for various stakeholders. In doing so, I will fulfill the Technology and Social Relationship Model (TSRM), an STS framework, by identifying the stakeholders and determining whether or not they stand to benefit or to experience harm from the implementation of such systems (Carlson, 2009). Additionally, I plan to apply actor network theory (ANT), another STS framework, to address questions such as: *Is there potential for bias in these systems? How will such bias implicate marginalized groups? Are these implications properly considered or addressed before such systems are implicated?* (Guilherme, 2017).

PROBLEM AND SIGNIFICANCE

The significance of this research lies in the contentious nature of the accelerating development of widespread AI systems. Many advocates against widespread AI warn of the potential for embedding subconscious bias into these systems, and therefore reinforcing and amplifying existing structures of inequity (Kantayya, 2020). Racial and gender bias towards children in modern education is pervasive and well documented, meaning AIEd systems are particularly at risk of perpetuating these biases (Anokam et al., 2022). According to 2018 research by Marri & Sonu, there exists specific "hidden curricula" within existing financial literacy lessons. These lessons require understanding and/or acceptance of neoclassical economics, which largely fails to acknowledge the complex history of economic inequality. Furthermore, these hidden curriculum aspects

Meanwhile, some research shows that humanoid AIEd systems have been found to better facilitate engagement and retention (Robotical, n.d.). As a result, Americans' views towards AI systems have shown to be extremely divided, with many expressing concerns about the promise of an increased AI presence in daily life and others simply not understanding what these systems entail, as seen in Figure 4: American Attitudes towards AI. Moreover, there are relatively minimal amounts of research regarding AIEd compared to the level at which it has been implemented. A 2021 study by researchers Aslan and Zhang found only 40 comprehensive, empirical journal articles written prior to 2020 regarding AIEd from a search of three major databases. Yet, 92% of academic institutions have implemented such systems (University of the People, n.d.).

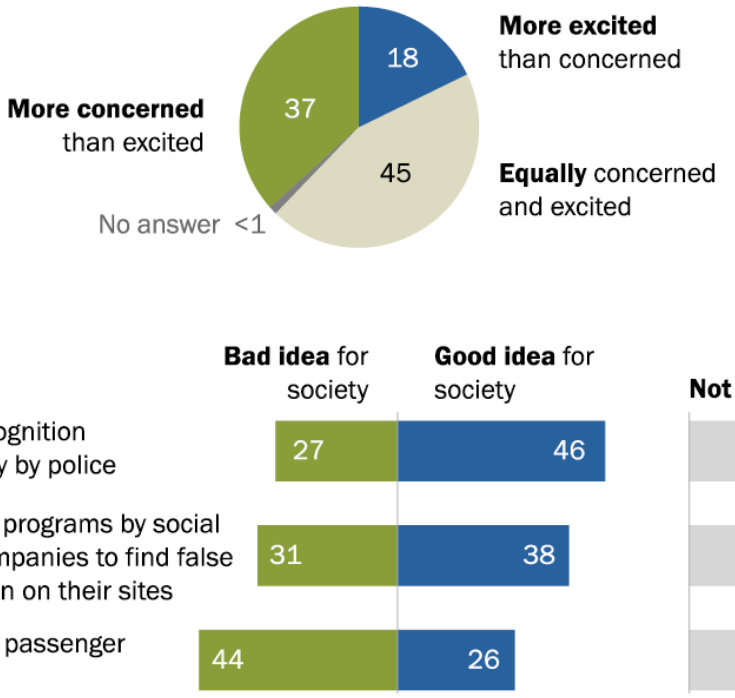

Figure 4: American Attitudes about AI: Gartner forecasts worldwide artificial intelligence software market to reach $62 billion in 2022 (Pew Research Center, 2021).

OBJECTIVE

The objective of the STS thesis is to investigate a problem in a way that involves the larger environmental, social, or ethical contexts of engineering and/or technology. The issue I am investigating is that of rapidly accelerating AIEd without proper research. The broader context involved is that of the social implications of these technologies. In doing so, I will seek to synthesize existing research to address the current gap in order to provide better context about the implications of AIEd to better allow citizens to make informed decisions about their support, or lack thereof, and elected use of these systems.

METHODS

Thus far, the process of developing an STS thesis has involved: (1) choosing a topic related to my technical project - in this case, AI in financial literacy education, (2) declaring this

topic in a Statement of Topics paper, (3) identifying sources to support my research and declaring them in an annotated bibliography, and (4) finalizing both my technical and STS projects within this Prospectus. The remainder of this project will involve the researching and writing of the thesis paper itself.

ANTICIPATED OUTCOME

I anticipate that this analysis will reveal a need for adjustments to existing and future systems, as the existing research will likely be deemed inadequate compared to the potential consequences. Even if the research only shows the *potential* for harm to students, rather than guaranteed harm, the recommendations should reflect the worst case scenario in order to prevent any irreversible harm to marginalized groups. Further, I anticipate that the research will also reveal a need for more research - in which case, I will seek to highlight the areas in which supplementation is needed.

STS FRAMEWORK

An important aspect of the STS thesis paper is to contextualize the broader systems at play. In researching and analyzing the issue of AIEd's social implications, I will apply two STS frameworks: (1) ANT and (2) TSRM. The former theory involves the intertwined system of behaviors, social practices, and material objects that dictate what technologies are adopted and how. In this case, there are a multitude of actors within the network of AIEd, including the AI systems themselves (the material object), the education system (a social practice), and the laws, guidelines, and regulations implemented by policymakers (another social practice). This theory indicates that, just because AIEd systems are developed does not mean that they will be adopted accordingly (Johnson, n.d.). The latter theory helps explore why or why not the technology could be adopted by analyzing the ways the various human actors stand to benefit and/or suffer from its

adoption (Carlson, 2009). AIEd will or will not be implemented according to the amount of pros and/or cons for each stakeholder and the influence wielded by that group.

IS AI APPROPRIATE MEANS OF EDUCATING CHILDREN?

AIEd is a complex, multi-faceted topic that can impact many different stakeholders and social systems in different ways. Through both the personal experience of implementation and the data provided by experimentation, my technical project will aid in uncovering the reality of whether or not embedded AI systems are appropriate means of educating young students by answering the question of whether or not there is a benefit to the student. Through extensive research, my STS project will provide similar insight into the suitability of AIEd, but rather by answering the question of whether or not there is a potential for harm to the student. After exploring the advantages and disadvantages - both logistically and socially, I will make a recommendation about future widespread implementation of such systems based on the research, experience, and data gained over the course of the paired projects.

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