Thesis Project Portfolio

A Financial Literacy AI-Enabled Voice Assistant System for Educational Use

(Technical Report)

Financial Democratization, the Rise of Fintech, and the Need for Financial Literacy

(STS Research Paper)

An Undergraduate Thesis

Presented to the Faculty of the School of Engineering and Applied Science
University of Virginia • Charlottesville, Virginia

In Fulfillment of the Requirements for the Degree
Bachelor of Science, School of Engineering

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Department of Engineering Systems and Environment

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Sociotechnical Synthesis

Knowing how to properly engage in financial activities such as borrowing money from a bank or investing in the stock market is important to building wealth and increasing ownership of assets. With access to credit and investing at an all-time high due to major deregulation of the United States financial sector and financial technology (fintech) increasing avenues to engage in financial activities, it is pertinent to ensure everyone has proper access to financial literacy resources to mitigate the risks of borrowing and investing. Vulnerable groups such as the elderly, poor, and marginalized communities have lower rates of financial literacy and are more likely to be victims of financial institutions (e.g. predatory lending). It is important to support these groups as they pursue wealth building and financial democratization increases in the United States. The following technical and STS theses will discuss the in-depth importance of financial literacy and provide potential solutions to shrink the financial literacy gap.

The technical thesis proposes a solution to teach financial literacy to K-12 students in the United States through an artificial intelligence-driven virtual voice assistant. Students can call a phone number and go through a ten-minute lesson of their choice based on the six financial literacy benchmarks for each grade level set by the Jump$tart National Standards for Personal Finance Education: employee and income; spending and saving; investing; credit and debit; risk management and insurance; and financial decision making. These lessons can be incorporated into personal finance courses throughout a student's progression in school. The three stages of this project consisted of writing the lesson plans, building the lessons using Google Dialogflow's chatbot software and telephony integration, and conducting a system evaluation to ensure the voice assistant was both effective and robust. By providing an interactive way to learn financial

literacy throughout a student's schooling, this voice assistant will be able to help them receive holistic, long-term financial education that will aid them in their adult lives.

The STS thesis explores how the positive relationship between increased access to the financial markets and greater risk for vulnerable groups to be victims of financial institutions creates a need for financial literacy for all. The thesis delves into lessons learned from the deregulation and democratization of the financial markets, the social construction of fintech, an analysis of financial literacy research, and future applications of financial literacy.

As banks became more unified and powerful from deregulation in the past fifty years, this led to both positive impacts such as an increase in homeownership and negative impacts such as an increase in predatory lending and the Financial Crisis of 2008. Fintech continues this trajectory of financial democratization and many of the same risks apply to borrowing and investing using fintech. Financial literacy is essential to combating these risks so everyone can safely engage in financial activities and build wealth.

I would like to thank Tariq Iqbal and MITRE, specifically Jennifer Kuczynski and Jyotirmay Gadewadikar, for supporting my team throughout the project.

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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 Financial Literacy AI-Enabled Voice Assistant System for Educational Use

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***Abstract*—Financial literacy is crucial for saving money, avoiding debt, establishing strong credit, and many other skills that help build wealth throughout an individual's life. A very large percentage of Americans from various demographics and backgrounds do not have the basic financial and economic knowledge to sustain themselves financially. Our proposed solution to tackle financial illiteracy is by ensuring students are taught the foundational expertise at a young age so that they make wise financial choices by the time they reach adulthood. We have developed a virtual voice assistant that will improve financial literacy by offering lessons that will cover all topics within the National Standards in K-12 Personal Finance Education educational curricula. Data was collected and analyzed in order to assess the effectiveness, robustness, and engagement of the voice assistant. While further analysis on engagement should be conducted, the bot met baseline goals of effectiveness and robustness which can further be improved through more intent training and testing on potential users.**

***Index Terms*—financial literacy, voice assistants, education, conversational mapping, artificial intelligence**

I. Introduction

Financial literacy refers to the skills, information, and tools that enable people to make individual economic decisions and achieve their objectives. Studies show that only 57% of adults in the United States are considered financially literate [1]. Financial literacy is often referred to as financial competence, particularly when combined with access to financial products and services [2]. This is extremely valuable as it equips one with the knowledge to manage and utilize money effectively. With the growing and complex nature of the American financial system, the need for a call to action to improve the national financial literacy levels is more imperative than ever. Many Americans are tasked with paying off their cars, homes, or student loans. In 2019, about 42% of adults in the United States said they had a budget and used it to keep track of their spending [3].

If taught at a young age, personal finance would help one prepare to make major financial decisions after high school. Results have shown that about 1 in every 5 American teenagers lack basic financial literacy skills [4]. After high school, students often follow various paths, such as attending college or joining the workforce immediately. A personal finance education delivered in high school would increase the likelihood of young adults having a better understanding of financial topics. Currently, personal finance and economics classes are offered in most high schools; however, only 21 states require high school students to take a personal finance class before they graduate [5], and these classes are seldom taught in middle and elementary schools. Even high schools struggle to find teachers and resources to adequately prepare their students since a large percentage of American adults themselves lack a sufficient level of financial understanding; a little more than half of adults are considered financially literate [6]. If nothing is done to improve the financial literacy rates in the U.S., many Americans will continue to struggle with managing their money, which is crucial to ensure financial stability and well-being for many. Without this basic knowledge and skill set, students will be more prone to making irresponsible financial decisions, resulting in severe consequences like unpaid debt, bankruptcies, and foreclosures [7]. We intend to implement a virtual voice assistant that will guide students through various lesson plans outside of the classroom to achieve higher financial literacy rates; this will help to introduce these important skills to students at a young age and prepare them to make future financial decisions.

Our plan of developing a virtual voice assistant includes lesson plan creation, cloud platform implementation and system evaluation. Through this, we intend to create a dynamic collaboration between education and technology to gradually build knowledge among students. Our goal is to help students build off of their foundational knowledge and practice their financial literacy skills at a reasonable pace. This will prepare them to tackle more advanced concepts and set them up for economic success in the future, allowing them to be financially independent.

Data from 100 calls — 50 for each lesson — were used in the assessment of the voice assistant. This data was analyzed in order to determine how effectively the assistant achieved the goals laid out for it. The four primary goals for the assistant were: effectiveness of the voice assistant, robustness of the system, engagement of the conversations, and robustness of parameters. The voice assistant yielded strong results, meeting thresholds for all goals, but still showing room for improvement in areas. The Kindergarten Spending and Saving average conversation duration was within the expected duration range while the Fourth Grade Credit and

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Debit average conversation duration was longer than the expected duration range. Additionally, the assistant was able to correctly detect the users' speech on the first attempt 81.8% of the time and longer interactions were usually due to misunderstanding user input. Understanding a wider range of possible responses through increased testing and training for the voice bot will improve the system's ability to handle any user input.

II. Prior Work

Voice assistants and their educational role have been examined in regards to their existing uses, as well as their future potential throughout various levels of education. A 2021 study found that voice assistants are known to be popular for simple everyday tasks such as asking what the weather is like and playing music but seem to be less used within the realm of education [8]. Nonetheless, the markets for A.I. and chatbots, which are the backbone of technology for voice assistants, are growing in size and beginning to garner interest in classrooms [9]. Other current and educational applications for voice assistants include language learning [10] and teacher-to-student communication [11], which have received overall positive feedback from students. Studies have also been conducted to test future voice assistant capabilities, like the ability to improve web page information accessibility [12], assist students with autism in the classroom [13], and ease the responsibilities of teachers for online classes [14]. While these studies offer insight into the educational uses of voice assistants, they do not explore the technical methodology of developing a voice assistant and implementing it onto a cloud platform. This is crucial to advancing the capabilities of virtual voice assistants for future use in various learning environments. For this reason, we explore the process of building a voice assistant, specifically an assistant that addresses financial literacy.

In their 2019 study, Reyes et al. [15] walk through the methodology used to create a virtual voice assistant in an educational setting. The voice assistant was developed using Google Dialogflow, with the purpose of allowing undergraduate students to access learning material for a course about artificial intelligence. Through their data gathering phase, a foundational knowledge of the course itself was established through literature review, with subsequent questions that were formed and grouped into categories for developers to structure the content. The conversational flow was another area of focus, as it defines the interactions between the voice assistant and the user. Two types of conversational flows were identified: linear [16] and nonlinear [17]. Linear flows represent the basic question and answer steps, while nonlinear flows allow for a more diverse structure and focus heavily on suggestions. Gadewadikar and Vatatmaja reconfirmed the importance of the stochastic nature of human conversation and reinforced that voice assistants must then follow a nonlinear approach in conversation to best reflect this [18].

In addition to choosing the right type of conversational flow, visualizing and mapping out each flow is imperative. To facilitate this process, decision trees were utilized to construct the framework of the voice assistant [15], with nodes that are assigned conditionals that activate when a user's query matches the response stored in the node; these nodes were translated as intents in Dialogflow. This study details the methodology of building and implementing a virtual voice assistant on Google Dialogflow; however, there is much to explore in regards to content generation for students, such as different modes of passing on knowledge. This could come in the form of independent learning, direct interactions between teachers and students, etc. Building an effective assistant is an interactive process with an emphasis on training, testing, and tuning, otherwise known as the three Ts of conversational AI [19]. By continuously performing the three Ts, the assistant can become more conversational and realistic.

In collaboration with MITRE, a team from the Massachusetts Institute of Technology established the functional, non-functional, and technical requirements of the virtual voice assistant. We utilized the work above as foundational knowledge to design our own voice assistant in a more specific realm of financial literacy and generate lesson plan content tailored for kindergarten to twelfth grade students.

III. Methodology

The creation of the prototype was divided into three main components: lesson plan content generation, cloud platform implementation, and system evaluation.

A. Phase 1

For lesson plan content generation, the first task was to determine the recommended standards for students to be considered financially literate. The National Standards in K-12 Personal Finance Education provided benchmarks for students in the following topics: employment and income, spending and saving, investing, credit and debt, risk management and insurance, and financial decision making [2]. The National Standards was used to tailor each lesson plan to the students' expected level and personal progress. Benchmarks were provided for kindergarten, fourth, eighth, and twelfth graders and lesson plans were created for each benchmark of the first standard for all six units.

B. Phase 2

For the second component, the next task was to choose a public cloud platform that would best fit the project's scope. The three initial candidates included Amazon Web Services [20], Microsoft Azure [21], and Google Cloud Platform [22]. Google was chosen for its user-friendly capabilities, specifically with Google Dialogflow CX being the most useful platform that Google Cloud offered. Some advantages of Dialogflow included an interface with a visual conversational flow builder, easy to understand documentation, and multiple platforms for telephone integration. The first set of lesson plans were imported into a platform called Voiceflow [23]

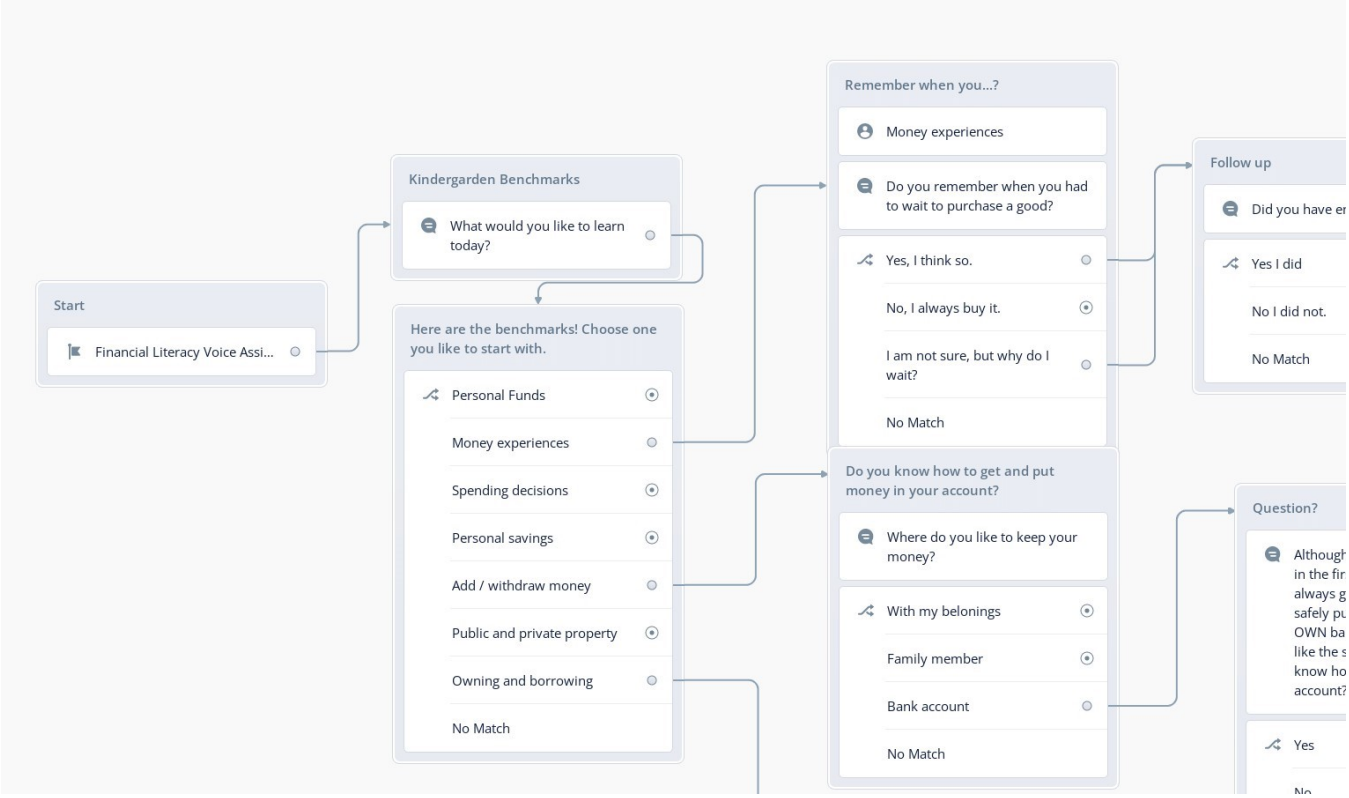

Fig. 1. An example kindergarten lesson mapped out in VoiceFlow.

to visualize the conversational flows of the first few lessons before they were transferred to Dialogflow, along with the remainder of the lesson plans (See Fig. 1). The initial flows built out in Voiceflow helped to show the complexity of each lesson plan, as well as the different routes that diverged from each topic. It also enabled us to clearly list out all the options of user responses for each prompted question and how each response would transition into the next segment. Once each lesson plan was completed in Google Dialogflow, the project was assigned an agent called "Finance Guru", which served as our chatbot. To implement a lesson, a new flow was created. Each flow had a start page that greeted the user and listened for a response before continuing on with the lesson. As the lesson progressed, each question that the agent prompted was given its own page, with an entry fulfillment that acted as the agent's response when the page was activated. On each page, there were routes that represented the different response options of the user. Some routes were as simple as a "yes" or "no", while others represented more complicated responses.

Additionally, every route required an intent or something that represented what the users wanted to do during the conversation with the agent. While Dialogflow provided default intents, we added our own intents with personalized training phrases, which made our voice assistant more compatible with various user inputs and made the conversations more natural and personable. Once Dialogflow matched the user's response to an intent to the intent, another fulfillment was activated, so the agent could respond to the user - usually confirming or dissenting the user's answer.

The final step to create a page was to create the transition, which connected the current page to either a new page or a new flow. Each page was connected to a new page that represented the next question in most cases. For routes where the user said the incorrect answer, the transition connected again to the same page, creating a loop so that the agent repeated the question for the user to try again. In a more simply structured lesson plan, the flow consisted of each page connected to one other page, with an option to loop back for every question. However, some lesson plans that contained more complex structures had flows in which certain pages could connect to two or more pages, with routes that diverged from each other. Finally, each flow ended with an "End Flow" page, which signaled to Dialogflow that the flow should be terminated.

The team utilized the CX Phone Gateway [24] (Google's built-in telephony service) and AudioCodes [25] (a third-party telephony service compatible with Dialogflow) to allow users to access the various lesson plans via telephone. CX Phone Gateway provided the most conversational voice options but failed to store important data from the phone calls. On the other hand, AudioCodes had fewer conversational

TABLE I
KEY VARIABLES WITH THEIR ASSOCIATED METRIC TO EVALUATE THE PERFORMANCE OF THE VOICE ASSISTANT SYSTEM

Goal	Metric	Reason
(1) Effectiveness of the voice assistant in delivering the content of the lesson plans	Lesson duration: track conversation length of new conversation against some baseline	See if lessons are running longer or shorter than expected. This can show room for improvement of the language our lessons use.
	Page duration: Track page durations normalized to each interaction to be able to compare all interactions together	See if certain pages need to be trained more or if language at a certain page can be improved.
	Lesson duration standard deviation: spread of duration for each conversation	Track if a lesson has inconsistent call times.
(2) Robustness of the voice assistant's understanding of the users' interactions	Intent/Match detection confidence value: an AudioCodes-provided metric indicating how confident the AI is in its matching of user intent to trained intents	See if we need to train a given page more.
	Number of repetitions: Average number of times the bot repeated itself throughout the course of delivering a lesson plan	See if we need to train a given page more.
(3) Level of engagement from the voice assistant	Conversation completeness: if a conversation made it to the end of the lesson	See if users are sticking with conversation.
(4) Overall strength of the parameters	Parameter extraction accuracy: this can be measured by looking at the repetitions in lessons that use parameters (e.g. Kindergarten Spending and Saving lesson)	See if more parameter training needs to be done.

options but provided abundant data during each phone call. Because of this, the final product used the CX Phone Gateway, but all testing, data collection, and evaluation was done through AudioCodes. Additionally, the dialogue was framed in Speech Synthesis Markup Language (SSML), a language that allows for more customization of the bot's speech. This allowed for the addition of pauses and emphasis to increase the conversationality of the bot.

C. Phase 3

For the third and final phase, a system evaluation approach was used to test the effectiveness of the voice assistant. The major goals of the evaluation infrastructure were to understand the (1) effectiveness of the voice assistant in delivering the content of the lesson plans, (2) the robustness of the voice assistant's understanding of the users' interactions, (3) the level of engagement from the voice assistant, and (4) the overall strength of the parameters. The specific metrics used are shown in (See Table I).

AudioCodes was then used to collect real-time data on the phone calls; the software provides its own text-to-speech bots and its own speech-to-text software, using Dialogflow on the back end to process the users' words to return a response. AudioCodes is directly integrated into the conversation, so Dialogflow and AudioCodes send information directly back and forth during each interaction, and AudioCodes logs this data. Data is organized with each row representing an individual interaction with the assistant (e.g., the user answers a question asked by the voice assistant), and the metrics listed above are provided both directly and indirectly. Data is exported from AudioCodes and parsed in JavaScript to provide a cleaned dataset in the form of a JSON file. The JavaScript code takes in a file as input, iterates through each interaction, and tracks and stores the metrics (See Table I). This dataset is then converted into a CSV, and an R script is used to provide visual and numeric analysis on the system.

IV. RESULTS AND DISCUSSION

In order to conduct our analysis, a dataset of summarized conversations were used and a dataset of the individual interactions. The summarized dataset tells a better story for the overall performance of the virtual assistant, whereas individual interactions dataset allows for a more detailed analysis into the strengths and weaknesses of the system. Two key lesson plans were analyzed: Kindergarten Spending and Saving and Fourth Grade Credit and Debit. Data from 50 calls was collected for each lesson via AudioCodes.

A. Goal 1: Effectiveness of the Voice Assistant

The Credit and Debit lesson shows a right-skewed distribution for complete conversations with most incomplete calls being much shorter (see Fig. 2). This is expected, as this lesson was more complex, leading to longer conversations and more errors with the voice bot. The complexity also caused more incomplete phone calls. The Spending and Saving lesson was much more normal around the mean with a lower incompleteness rate, which was expected due to the lesson plans' simpler format (see Fig. 2). Two single sample t-tests were performed on the total conversation duration for complete conversations against expected means of 620 seconds for Credit and Debit and 360 seconds for Spending and Saving. These expected durations are based on the duration of a perfect call with no repetitions or errors, simulating the ideal lesson length. The Credit and Debit

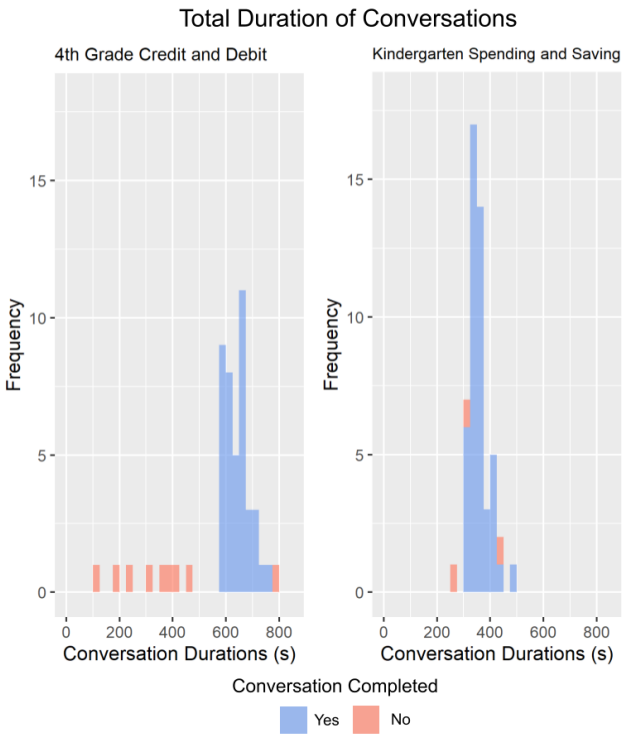

Fig. 2. Histograms of the total durations of both lessons

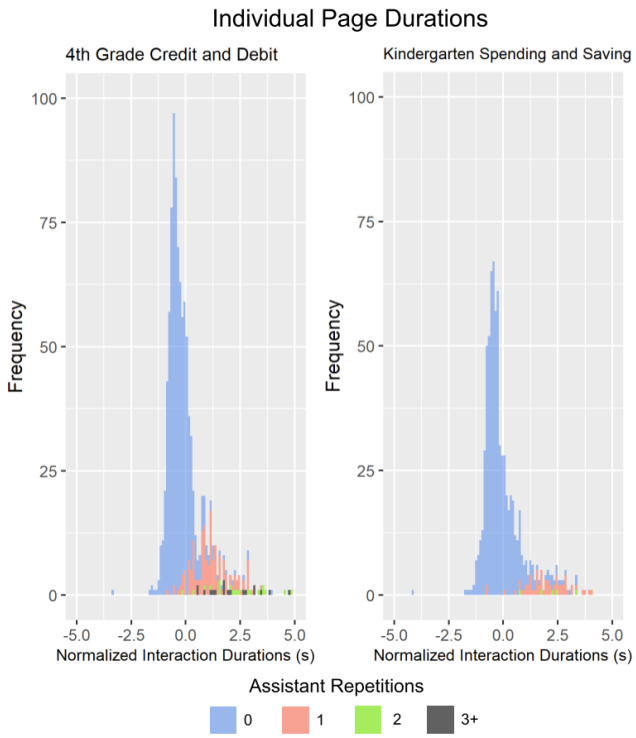

Fig. 3. Histograms of the page durations of both lessons

data had a mean of 642.9 seconds and was higher than the expected mean at a 99% confidence level (p-value < 0.01). The Spending and Saving data had a mean of 358.5 seconds and was not significantly different from the expected mean. This shows that the Credit and Debit lesson could be less effective at delivering the content than needed. Looking at the spread of conversation lengths, the Credit and Debit data had a standard deviation of 46.5 seconds while the Spending and Saving data had a standard deviation of 36.0 seconds. The spread should continue to be tracked as the bot is improved since we want future lessons to be tighter around the mean, indicating more consistent performance from the assistant.

B. Goal 2: Robustness of the System

An important metric to measure the robustness of the system is the duration of each interaction (question) throughout the lessons. This is important to measure because it indicates if the user is struggling on a certain question within the conversation. We normalized the lengths of each individual interaction while grouping the interactions by each question. Grouping the interactions by each question is necessary before normalizing, as it allows us to compare page durations across all questions, no matter the length of question or how open-ended the question is. The lengths of each singular interaction across all conversations were grouped and graphed as described to visualize the robustness of the system (See Fig. 3).

The vast majority of interactions with no repetitions remained near the mean, which indicates good system performance by the voice assistant in terms of its ability to consistently deliver the questions to the user and have the user understand and respond in a timely manner. We can also see that many of the interactions that went beyond the mean were a result of the assistant repeating the question, whether it was due to misunderstanding the user, or the user answered incorrectly. This is important because it shows that longer interactions can be attributed to pages being repeated. Our system should be able to handle misunderstandings better and be able to understand the user on the first try without any repetitions. The assistant was able to correctly detect the users' speech on the first attempt 81.8% of the time. This shows a need to better train the intents of each page and incorporate stronger error handling so our bot can be more robust to unknown inputs. In order to increase this confidence, we can increase the number of training phrases in responses to its questions so that it is able to handle a wider range of possible responses. The Credit and Debit data shows an average interaction confidence of 87.3% for complete conversations and 83.8% for incomplete conversations. The Spending and Saving data shows an average interaction confidence of 88.8% for complete conversations and 89.3% for incomplete conversations. These results indicate that the bot's confidence level has no impact on whether or not a conversation is complete, showing that its ability to understand

user input is not a large factor in increasing conversation completeness.

C. Goals 3 and 4: Engagement of the Conversations and Robustness of Parameters

The best data available that gives potential insight on engagement of users is the rate of incompleteness for the lessons. For the Spending and Saving data, 6% of the calls were incomplete while for Credit and Debit, 18% of the calls were incomplete. Incompleteness rate can be attributed to other factors, such as errors in the system. An opportunity to better measure engagement is adding a survey at the end of a lesson. The Spending and Saving conversation used parameters to increase the conversationality of the lesson. The bot was built to pull out certain keywords that the user gave and incorporate them into the conversation. This lesson saw an average repetition rate of 1.6 repetitions per conversation (for reference, the Credit and Debit lesson had 5.6 repetitions per conversation). This low level of repetitions shows the robustness in error handling of the Spending and Saving lesson, including the bot's ability to understand parameters.

V. Conclusion and Future Work

Smart technologies such as virtual voice assistants have the power to change how students learn. In this paper, we have presented a model that focuses heavily on two main lesson plans, with each being from a different category and age group of the National Standards. This model aims to improve financial literacy for students in kindergarten to twelfth grade. Our experimental results indicate that our current voice bot has a good baseline for our goals of effectiveness and robustness with room for improvement via more bot training and improved language used in the lessons. A future area of improvement for testing is adding a survey to our lessons so we can better track the engagement of users.

Usage of this technology in an educational setting is still fairly new, which means there is access to limited data. Future work for progressing the prototype will require several iterations of user testing in order to acquire this data. Given the addition of more lesson plans and users, a more thorough analysis of the effectiveness of the prototype on a student's educational experience can be performed as well. A student perspective would be extremely valuable due to the knowledge gap between the team developers and student users. This could also indicate changes to be made in the pace of the voice, type of voice, and the appropriate vocabulary for each grade level. The data collected from this will highlight issues in the prototype to be addressed, thus ensuring the prototype fits the user's needs more adequately.

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We would like to thank MITRE for supporting the project.

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A Research Paper submitted to the Department of Engineering and Society

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In Partial Fulfillment of the Requirements for the Degree
Bachelor of Science, School of Engineering

Matthew L. Thompson

Spring 2022

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

Advisor

Sean M. Ferguson, Department of Engineering and Society

Financial Democratization, the Rise of Fintech, and the Need for Financial Literacy

Introduction

Americans have seen a huge wave of financial democratization in the last fifty years through the deregulation of the financial markets, the strengthening of the private banking sector, and the growth of the financial technology (fintech) industry. With increased advocacy to expand access to credit and ways to invest, there has been a surge in consumer fintech services in the past decade. Despite this, there lacks adequate financial literacy education infrastructure to help inexperienced borrowers and investors learn responsible strategies and navigate through financial markets. Breaking down the barriers of entry to investing is a step in the right direction but without the proper education, many dangers threaten vulnerable groups, such as the elderly, poor, and minority communities, as they engage in financial practices. To understand the complexity of this issue, this paper will delve into lessons learned from the democratization of the United States financial markets, analyze the social construction of fintech, and discuss the need for financial literacy as the fintech industry grows.

Impact of the Deregulation of Financial Markets

Before the Financial Crisis of 2008, the United States financial system went through major deregulation in an attempt to increase financial democratization. This had both positive and negative implications and the lessons learned from this period should be kept in mind as fintech increases people's ability to engage in financial activities. In the past fifty years, financial service providers and the government have increased opportunities for people to obtain credit via loans and credit cards. In 1977, the Community Reinvestment Act was passed by President Jimmy Carter to combat redlining by encouraging banks to increase lending within low- and moderate-income communities (Berry, n.d.). In 1999, the Gramm-Leach-Bliley Act was passed

by President Bill Clinton to promote financial integration for consumers and investors by deregulating past laws within the financial industry, allowing for more consolidation of companies within the financial sector and creating a more unified banking system (Mahon, n.d.). This period of deregulation provided more autonomy to banks and gave the financial industry the power to expand. Many believe this deregulatory mindset led to poor supervision of large banks and was a major driver of the Financial Crisis of 2008 (Born, 2011).

As the private financial sector became more deregulated, companies began to introduce new products and services to consumers. Factors such as the introduction of credit scoring, risked-based pricing, and general-purpose credit cards have not only allowed consumers to gain access to more credit but have increased information about borrowers for lenders. These developments create advantages for prime borrowers who can receive competitive rates but disadvantage vulnerable subprime borrowers, as they are more likely to be victims of the financial markets they engage with. A major risk is predatory lending to vulnerable groups such as the poor, elderly, and minority communities due to asymmetrical knowledge between lenders and borrowers (Smith, 2004).

Government and traditional financial institutions have shaped the way people live their lives not only directly but indirectly by fostering a public sentiment that everyone has the right to engage in financial activities. This sentiment helped to lay the foundation for the explosion of the fintech industry. Just as the deregulation of the financial markets and expansion of the financial sector has led to greater inclusion for all to engage in financial activities, fintech has continued this trajectory by providing more vehicles for individuals to gain access to credit. Prime examples include Klarna and PayPal, which offer loans through their “buy now, pay later” (BNPL) payment models (Klarna, 2022; PayPal, 2022). While companies preach that BNPL

reduces financial barriers for all, some of the same risks of borrowing from traditional banking institutions apply. Low-income users who overuse these services could find themselves in similar situations as victims of predatory lending. The lessons learned from the past within the public and private sectors should be considered as usage of fintech expands, especially as more vulnerable groups engage with these new technologies.

Promises of the Stock Market: From Past to Present

The sentiment to democratize financial markets for all was not just limited to access to credit but also impacted the growth of the consumer investing industry. The 1990s were the heart of a public push for the democratization of the stock market with stories of people like Warren Buffett building wealth. This created the narrative that Wall Street stood for the middle class instead of just the elite (Erturk et al., 2007). Before the boom of fintech, however, investing in the stock market was only easily accessible to upper-middle- and upper-class individuals. Then, Robinhood disrupted the investment industry. In 2013, Robinhood was founded with a mission to "democratize finance for all" (Robinhood, 2022). Robinhood allows its users to easily access financial markets by permitting any United States citizen over the age of eighteen to invest on its platform. It has revolutionized how consumers invest and has significantly lowered the barrier of entry to be able to trade in the stock market. Tan (2021) reports that around 20% of trading activity can now be attributed to retail investors, a significant proportion that shows how the accessibility of the stock market increased due to innovation within this sector.

In December of 2020, a group of investors on the Reddit channel "r/WallStreetBets" caused a short squeeze of GameStop stock to lash out against large financial institutions (Aharon et. al, 2021). Melvin Capital and other financial firms shorted GameStop and a wave of retail consumers flooded GameStop with buy orders to push up the price. Artificial intelligence

algorithmic trading was triggered to buy this stock because of this, resulting in the price to spike from under $50 per share to over $350 per share in less than one month. As a result, Robinhood was forced to temporarily stop the trading of this Reddit-influenced stock and Melvin Capital had to be bailed out after facing huge losses (Tan, 2021). Robinhood provided a gateway for frustrated consumers hoping to make quick profits to misappropriate the platform in a way that goes against responsible and established trading methods.

Some accuse Robinhood, a gatekeeper of the financial markets for many retail investors, of backing the wishes of big finance at the expense of consumers but Robinhood claims the spike in the trading of GameStop stock caused shortages in its trading warehouse which forced them to shut down trading. Regardless, a common theme emerged: average consumers are frustrated with Wall Street and by using fintech as a vessel, they have more influence on America's financial system than ever before. By using Robinhood in an unintended way through risky and irresponsible volatility trading rather than classic and risk-averse trading, consumers have shown they have significant market power in the industry. Retail investors have demonstrated that wealthier classes and traditional financial institutions are not the only groups that have the power over the stock market and they will continue to shape the trajectory of fintech and the financial industry.

Analysis of the Social Construction of Fintech

Pinch and Bijker (1984) laid the foundation of research for the Social Construction of Technology framework. The framework explains that technologies are molded by their stakeholders, known as relevant social groups, where each group shapes the technologies in different ways. Through interpretive flexibility, users from various groups can perceive and utilize the technology differently and sometimes in ways that are not originally intended. The

following section synthesizes the research previously presented in this paper under the social construction of technology framework by discussing fintech's relevant social groups: government and traditional financial institutions, entrepreneurs, and consumers.

Government and Traditional Financial Institutions

Traditional financial institutions and government policies have laid the foundation for fintech by creating a market signal for financial democratization. Through the implementation of various policies and growing infrastructure that allowed people to access credit and invest in assets, they not only directly created a more inclusive system but spurred public sentiment to provide equal opportunities for all to engage in financial activities. Many see fintech as a direct competitor of classic financial institutions due to its disruptiveness. However, through machine learning analysis, Kowalewski and Pisany (2020) have found that within developed countries, fintech startups are more likely to be created when strong banking groups are present. This paper argues that there exist mutual interests between the demands of a bank and financial innovation, providing more investment opportunities for startups to thrive. Access to funding is essential and the presence of strong banking systems in America potentially accelerated the growth of the industry.

Entrepreneur Influence on Fintech

With the increased sentiment for financial democratization, entrepreneurs saw this as an opportunity to bring equalizing solutions to society. Zavolokina et al. (2016) analyzed the media to track factors that influenced the growth of the fintech industry and found that there was a spike in articles on fintech after 2010 that heavily mentioned financial institutions, start-ups, and IT companies. This indicates that innovation and entrepreneurs played a role in driving the fintech industry. The rise in IT companies from the dot-com bubble set up the initial environment

for innovation and once the financial crisis hit, these companies were able to fill that gap. Additionally, the romanticization of Silicon Valley and startup life helped to spur a rise in entrepreneurship that drove financial innovation.

Fintech innovations have provided more ways to borrow and invest. New fintech companies built around the "buy now, pay later" payment model offer more flexible financing for users and have established themselves as microlenders with some advantages over credit cards and traditional loans. Other companies like Robinhood aim to decrease barriers to investing and are revolutionizing the markets by making retail investors more influential and relevant. Entrepreneurs have played a huge role in shaping the overall financial industry and have revolutionized how the average consumer engages in financial activity.

Consumer Influence on Fintech

Consumers have influenced the financial industry in two ways: by creating the demand for the innovation of fintech and by using fintech as a vessel to influence financial markets in ways that have never been done before. A 2017 Bain & Company study found that consumer preferences for "mobile, fast, and comfortable solutions" were a major driver in fintech development (Kowalewski and Pisany, 2020, p. 2). Consumer preferences heavily influence the trajectory of the markets and because of this, they created an environment that allowed entrepreneurs to revolutionize the industry. As this demand gets satisfied through entrepreneurial and IT company innovation, more opportunities for consumers to access financial markets are created. With more access, consumers have influenced the market in new ways. The Robinhood saga showed that through the misappropriation of fintech, the average consumer has more power than ever to change the course of investing.

The Need For Financial Literacy

As history has shown, the democratization of finance in the United States creates risks for vulnerable groups, such as the elderly, poor, and minority communities. With the rise of fintech, these dangers pose similar threats to vulnerable groups as they engage in financial activities through new financial technologies. While many made money from the GameStop short squeeze, those who invested too late lost much of their investment. Those who were educated in proper investing strategies knew the risks of this speculative bubble but those who were investing with minimal educational background did not. Financial literacy can help fintech users to understand the risks of their activities so they can more safely engage in financial activities.

Erturk et al. (2007) discuss that the promises of financial democratization can only come to fruition if three conditions are met: wealth effects of people are predictable, people meet a certain level of financial literacy and financial services competence, and risk and return can be calculated for financial technologies. Data used in this paper shows that while countries like the US and UK have higher levels of financial literacy compared to the rest of the world, there are huge disparities between social classes. The data also showed that certain social classes had overconfidence in their financial knowledge when asked to calculate a basic interest return problem. The groups with the most incorrect responses had the lowest response rate for the "I Don't Know" option. This overconfidence can potentially lead to irresponsible financial decisions and financial targeting.

Efficacy of Financial Education, Training, and Counseling

The risks of engaging in financial activities can be mitigated with the three branches of financial literacy: financial education, training, and counseling for vulnerable groups (Smith, 2004). In 2003, financial questions were added to the Survey of Consumer Finances to measure

the relationship between financial literacy and financial behavior (Mandell and Klein, 2009). A Financial Practices Index was created based on four variables: cash flow management, credit management, savings, and investment practices. A positive correlation was found between financial literacy and this index, indicating that financial knowledge can positively impact financial behavior.

Financial education aims to teach general topics in personal finance in more of a classroom setting. A 2007 study on retirement preparedness showed that retirement seminars have a positive wealth effect but mainly for those with a lower wealth and education baseline (Mandell and Klein, 2009). Mandell (2006) used data from Merrill Lynch and the Jump$tart Survey of Financial Literacy to analyze the impact of high school financial literacy education on financial behavior. The data showed that there is no impact of high school financial literacy education on the financial abilities of high schoolers in the short run. He also discusses a smaller study in a Midwestern district with a highly regarded financial literacy program. Students were tracked up to five years after the program and no impact was found on financial behavior. One issue with these high school studies is people are not usually put in a position where they need extensive financial knowledge until many years later. Based on current financial education studies, the data does not show a strong impact of traditional classroom financial education on financial behavior.

Financial training applies financial education to real examples and aims to teach specific skills to reach a certain goal. A 2001 study of fourteen nonprofits in the American Dream Policy Demonstration showed that for each additional hour that its low-income participants were trained in a savings seminar, they contributed more to their IDAs, subsidized savings accounts for low-income households (Collins, 2010). One thing to note is individuals who received more

education might be more motivated to succeed and therefore are probably naturally more likely to engage in positive financial behaviors. Collins (2010) discusses opportunities to make a larger difference in individuals' financial behaviors if their motivations and characteristics are analyzed so they provide better placement in the seminar type. Financial training benefits both consumers and lenders by lowering the risk for all parties. It can also be one of the most effective ways to combat financial distress and predatory lending, potentially providing more promising opportunities to teach financial literacy than financial education does.

Financial counseling encompasses financial advice, information, and training for people in financial distress or financially vulnerable individuals. A 2003 study on the impact of credit counseling on credit usage and payment behavior showed that one-on-one counseling sessions had a positive impact on credit behavior by boosting credit scores, improving delinquency, and helping with other credit characteristics (Smith, 2004). Those with worse baselines were especially helped. A 2001 Freddie Mac study found that pre-purchase counseling helped reduce delinquency rates for potential homebuyers, further supporting that counseling has a positive impact on financial behavior and activity (Mandell and Klein, 2009). Financial training provides measurable and immediate benefits for borrowers while counseling improves one's awareness of the dangers of borrowing and investing. Financial education has controversial data regarding its efficacy but many still believe that it provides long-term benefits and boosts opportunities for all.

Role of Nonprofits and Government in Financial Literacy Infrastructure

Collins (2010) highlights that nonprofit organizations are the primary providers of financial literacy services for low-income adults. Because these organizations are not driven by the need to return profits to shareholders and investors, they inherently provide unbiased services to consumers. Nonprofit organizations work outside of many pressures of the market and it

allows them to better meet the needs of people who are underserved by the market. The Jump$tart Coalition for Personal Financial Literacy is a non-profit organization that sets financial education standards and helps to implement financial learning within schools and other educational stakeholders (Jump$tart, 2018). Through various initiatives, they have shown to be an altruistic stakeholder in financial education. Nonprofits play a huge role in teaching financial literacy to individuals and could provide new financial literacy programs within the fintech industry moving forward.

The government has also played a role in spurring the nonprofit financial literacy sector. The Community Reinvestment Act of 1977 incentivized financial institutions to support nonprofit organizations that have a focus on boosting consumer financial literacy. Government-sponsored financial organizations Fannie Mae and Freddie Mac required individuals to receive financial counseling before approving mortgages that fell below certain guidelines, leading to the growth of nonprofit financial counseling (Collins, 2010). With the infrastructure of financial literacy already in place within nonprofit organizations and government programs, their financial education, training, and counseling should incorporate a focus on how to safely engage in fintech to teach the risks of borrowing money and investing. This way, more vulnerable populations will not face the risks of predatory lending and losing investments due to unknowingly engaging in irresponsible trading practices. They would also be able to better engage with these technologies using their intended purposes, build wealth, and fight against the cycle of poverty.

Other Opportunities for Increased Financial Literacy

Financial literacy should be taught at a young age to ingrain it within their mindsets for the rest of their lives. Even though the efficacy of financial education in a traditional classroom

setting is questionable, there is promising data on one activity that has been shown to have a positive impact on the financial behavior of individuals: the stock market game (Mandell, 2006). Several studies have shown that students who play the stock market game have much higher financial literacy scores than those who do not. However, the stock market game rewards high volatility and risky investments, and Jump$tart data shows that students who participate in the stock market game have poor money management. Despite the downsides of the stock market game, the positive correlation between participation and higher levels of financial literacy shows that gamifying aspects of the financial markets within a low-risk space can increase the engagement of its participants and increase the retention of financial knowledge among students. Financial training modules can also be incorporated into these programs to allow individuals to truly learn financial skills and realistically apply them. This long-term education and training would make financial literacy easier to retain as compared to a single class on personal finance.

Another opportunity to improve financial literacy among students, highlighted by Tanase (2015), is the integration of financial education and training within the curriculum of everyday school subjects. American youth have significantly low levels of financial literacy, especially low-income students, and Tanase (2015) argues that math curricula could be a vehicle for social justice if it was restructured to incorporate more financial literacy. If teachers engage students with more real-world applications of the subject, that kind of thinking would be second-nature to students and would empower them with more skills to succeed in the real world. Students would still learn the same baseline skills in math while also applying them to financial literacy. This could make the curriculum more engaging, as mundane subjects would seem more applicable to the real world. While teaching financial literacy as a one-time course or high school program

might not have a major impact, incorporating it into the curricula of standard school subjects could be a way to increase the efficacy of financial education and training for students.

As fintech revolutionizes the financial markets, products can be designed in ways that teach financial literacy while being used. Way and Wong (2010) delve into the assumption that applying technology to finance will automatically increase financial literacy for the intended users. They argue that with an increase in demand for financial education technology, entrepreneurs continue to churn out products without fully analyzing the motivations behind its users. Many fintech companies fail to consider behavior theory in their design. Way and Wong (2010) argue that if companies analyze end-user behavior, more meaningful and effective products can be created. If the government and companies incentivize the incorporation and usage of training modules in fintech products, this could help teach users financial literacy so they can engage with the technologies more effectively.

Discussion

As the relevant social groups influence the fintech industry and the financial industry as a whole, there is one major takeaway: consumers have more influence on financial markets than ever before because of a major push to democratize finance for all. Fintech can help level the playing field by giving more access to low-income households to engage in activities that have traditionally only helped the wealthy. By analyzing the lessons learned from financial democratization before the rise of fintech, many of the risks of engaging in financial activities can be avoided as consumers continue to incorporate fintech into their everyday lives. Financial literacy is more important now than ever before and without financial literacy promotion to go along with the growth of fintech, new risks are posed to financially vulnerable populations in America.

Financial education, training, and counseling are the three components of financial literacy. Financial education can provide awareness that there are ways to build wealth, financial training can help everyone learn how to engage in responsible ways to build wealth, and financial counseling can help keep low-income households on the right financial track. Teaching financial literacy early on through education and training can be a key part of ingraining safe financial practices within the minds of everyone. Proposed solutions include incorporating gamified financial education and training models within school curriculums, including more applied financial problems in curricula so people can retain long-term financial literacy knowledge, and incentivizing the incorporation of financial training modules into fintech platforms so users can learn financial literacy as they engage with the technologies. Greater financial literacy will allow people to effectively engage in financial activities and equip more vulnerable populations with the tools necessary to combat the risks of borrowing and investing as fintech becomes more widely used.

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Financial Literacy Voice Virtual Assistant

Understanding the Stakeholders of Financial Education Technology to Aid in Product Design

A Thesis Prospectus
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Presented to
The Faculty of the
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In Partial Fulfillment of the Requirements for the Degree
Bachelor of Science in Systems Engineering

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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Introduction

Robinhood, a name that has connotations of financial democratization, was an app created to allow the average citizen to easily access financial markets. Just as its name implies, it significantly lowers the barrier of entry for the common person to invest their money and has the apparent goal of giving every user an easier path to potential financial freedom. However, in more recent events, claims that Robinhood stood for Wall Street rather than the people were made when the app shut down trading of Gamestop and AMC stocks after the stocks spiked in response to a public fight against Wall Street. Robinhood is just one of many financial technology (fintech) platforms that preaches the democratization of finance. Other fintech companies, such as Klarna and PayPal offer services that allow users to access credit and advertise their ability to reduce financial barriers for its users. Fintech companies across the board claim to give people the opportunity to grow their wealth but what is advertised might be different than their true impacts. More technology is not always better, especially if the financial education of its users does not meet certain standards and if the true intentions of its creators conflict with their publicized values.

This brings up many questions about the mutual growth of financial technology and pushes to increase financial literacy for all. How has the push for the democratization of finance and the growth of accessibility to technological systems impacted the abilities of individuals to access financial markets and to learn about financial literacy? What are the motivations of groups behind technologies that aim to level the financial playing field and how are they continuing to push for societal fairness? While some platforms claim they were created to level the financial playing field, this paper aims to delve into the relationship between these companies, their stated goals, their apparent actions, and their relationship with stakeholders.

This first part of this paper will delve into the project of designing and implementing a financial literacy virtual voice assistant for K-12 students that aims to teach students baseline curricula based on age. The second part of this paper will discuss the social construction of financial technology and its relevant social groups to explore the underlying motivations behind all stakeholders and to understand more effective financial technology design.

Technical Topic

The Rise in Demand of Financial Technology

The push for financial democratization for all is not a new topic in the United States. The 1990s the heart of a public push for the democratization of finance via investing. Stories of people like Warren Buffett building wealth created a narrative of Wall Street being for the middle class instead of just the elite (Erturk et al., 2007). With the boom of the internet, opportunities to create financial technology were created to combat the retention of financial markets within the wealthiest classes. Erturk et al. (2007) discuss the facade of stories like this and how these promises can only come to fruition if three conditions are met: wealth effects of people are predictable, a certain level of financial literacy and financial services competence is met, and risk and return can be calculated for financial technologies. Financial literacy is especially important. Robinhood, with its mission to "democratize finance for all" (Robinhood, n.d.), allows its users to easily access financial markets but it also makes the process of trading entertaining through its almost gamified design. On top of this, it allows users access to risky trading activities that only experienced traders should partake in such as trading on margin and trading options (Tan, 2021). While financial democratization via fintech can provide positive opportunities to retail investors, it creates a higher demand for financial education.

Technical Project Description

The project's team aims to support Ertuk's second criterion of the success of financial democratization: basic financial literacy for all. They aim to create a financial literacy voice virtual assistant that aids K-12 students with financial education. The goal of this platform is to allow users to learn about personal finances depending on their age group. The curricula will be designed based on the Jump$tart Coalition for Personal Financial Literacy *National Standards in K-12 Personal Finance Education* educational requirements (Jump$tart, 2019). By combining interactive technology with education, the platform aims to maximize user engagement and drive curiosity about the curriculum. The team's role in this project is to design the conversation flow between students and the assistant based on the given curriculum for each age group. Other tasks of this project include testing and validating the conversation flow, selecting the best software, building the product, and, as a stretch goal, developing an interface for teachers to track the progress of their students. The end date of this project is Spring 2021. Thompson's specific role in this project is to choose a voice assistant framework and associated cloud service, implement the conversation flows into the voice assistant software, aid in testing the core product, and make changes based on the results.

By educating youth on personal finance, the platform aims to enable users to grow up with the knowledge necessary for effective saving, borrowing, and investing. The long-term impact of this education will hopefully contribute to people's abilities to become financially independent. With the rise in financial technology that provides opportunities for all to access more channels to build wealth, financial literacy is an essential factor in allowing individuals and households to be knowledgeable in how they spend and save, and with the advancement of technology, platforms such as this project are possible.

STS Topic

Applying Behavior Theory to Financial Education Technology Stakeholder Analysis

With a rise in the popularity of financial technology, does more technology necessarily lead to a positive impact on society from a financial perspective? Way and Wong (2010) delve into the assumption that applying technology to finance will automatically increase financial literacy for the intended users. They argue that with an increase in demand for financial education technology, people continue to churn out products (e.g. games, simulations, interactive tutorials) without fully analyzing the motivations behind its users. Behavior theory, a crucial part of ensuring the efficacy of products, is left out of many implementations of financial technology. Way and Wong (2010) argue that if end-user behavior is analyzed in conjunction with consumer financial behavior, more meaningful and effective products can be created. In addition, the behaviors and motivations of other stakeholders in financial education technology must be understood to analyze the impact of current solutions.

Understanding The Social Construction of Financial Technology and Markets

In order to delve into the behaviors and motivations of financial education technology stakeholders, this paper reviews scholarship on the social construction of financial technology. Relevant social groups include policymakers, citizens from underprivileged communities and educational systems, and entrepreneurs.

With current United States Secretary of Education Miguel Cardona calling for more financial literacy within America's youth as a recent example (Reinicke, 2021), there has been a governmental push to increase the financial literacy of its citizens with the presumption that this will give them a better opportunity to increase their wealth and quality of life. This has created a

market demand for governmental agencies, for-profit organizations, and non-profit organizations to create products to fill this gap.

With this market signal, the motivations to create financial technology and financial education platforms can be diagrammed as a spectrum from purely altruistic-driven motivations to purely profit-driven motivations. The Jump$tart Coalition for Personal Financial Literacy is a non-profit that sets financial education standards and helps to implement financial learning within schools and other educational stakeholders (Jump$tart, 2018). Through various initiatives, they have shown to be an altruistic stakeholder in financial education. Returning to Robinhood, while their mission claims to be more on the altruistic side of the spectrum, their features and actions sometimes put them more on the profit side (e.g. the ability to trade high-risk options with no financial background). Tan, 2018, argues that Robinhood's behavior of shutting down volatile stock trading during the Gamestop and AMC stock price spikes is a complicated issue that not only exposed the downsides of its controversial 'payment for order flow' revenue source and attracted allegations of working with Wall Street's best interests, but showed how providing the opportunity for all to trade can create opportunities for the abuse of trading algorithms (from irresponsible trading techniques). This multifaceted issue shows the complications of the democratization of finance and gives insight into the agendas of fintech companies. While technologies such as Robinhood do not abandon their mission to democratize finance, it is important to be critical of the imaginaries that drive their creation and perpetuation.

From a citizen side, stakeholders include parental altruists and members from underprivileged communities. Erturk, 2007, discusses the increased public demand for financial education since the 1990s while Tanase and Lucey, 2016, delve into studies that show people do not always act in their best financial interests and studies that discuss correlations between poor

parental education on finances, low household income, and lower rates of financial literacy. With this parental altruism point of view, technologies that are designed to increase financial accessibility might not necessarily align with the motivations of the users they are designed for.

Each of these actors funnels into a streamlined demand for financial technology with various purposes and agendas. The fintech industry is overall profit-driven but when it comes to financial education technologies, truly impactful companies should revolve around core values to end disparities in financial knowledge to effectively employ their mission. Entrepreneurs supply the demand that the government and citizens create for financial education. On a more granular level, the sub-group of stakeholders is a subset of citizens who are not exposed to the same opportunities for education. For some products, it is the motivations of this group that must be understood to effectively launch a financial education platform. Developers need to understand how to utilize available resources to make financial education meaningful to the end-user to allow technology to strive for societal fairness. This takes time but is completely necessary to ensure baseline financial literacy for all is achieved. More research on the societal construction of financial technology and financial education technology could aid stakeholders in understanding how to design more impactful future financial technologies.

Future Research

Future research on the social construction of financial technology and its impact on financial literacy education includes (but is not limited to):

- Researching how the government (state and national) has specifically incentivized financial education, financial education technology, and financial technology as a whole (specific laws, grants, agencies, etc.)

- Past public and government figureheads in the movement of financial literacy and their direct impacts
- Comparison of for-profit and non-profit financial education, financial education technology, and financial technology companies (actions, behaviors, investors, other stakeholders) to see if trends exist between profit structure and agendas of the companies
- Further analysis on said financial education technology companies' implementations in underserved communities and their true impact on financial literacy baselines. Citizens from underserved communities are one of the most important stakeholders as many of the standards and technologies created for financial education are aimed at allowing them to break out of the cycle of poverty.

Next Steps

The next steps for the technical project are:

- Choose technologies based on the requirements of the platform. Google Cloud and Google Dialogflow is the most likely choice. (November 2021)
- Start approval process with the University of Virginia's Institutional Review Board for the Social and Behavioral Sciences to be able to test the product with Charlottesville schools (November 2021)
- Collect and analyze data to aid in design using public and private datasets and hopefully self-collected qualitative data (November 2021)
    - For self-collected data, approval is needed to conduct human studies
    - For private datasets, the team is leveraging connections and has reached out to potential partners to provide this data
- Design a minimum viable product based on analysis (December 2022/January 2022)

- Test and modify the platform (February/March 2022). It might be the case that the virtual voice assistant might not be the best way to make an effective financial education platform. Testing will show if this is the case.

The team is currently on track. Major hurdles currently include collecting all of the necessary data to begin product design and gaining approval to conduct human trials. Every team member is working on this and specific tasks will be delegated after this step. Testing is the most important step to developing the team will work to put together a minimum viable product that can be implemented as soon as possible.

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