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THE NOVA FINANCIAL LAB



Using Gamification to Overcome Common Behavioral Biases and Increase Financial Well-Being

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About Us



The Center for Advanced Hindsight is an applied behavioral science laboratory at Duke University that creates and tests interventions to help individuals improve their financial, mental, and physical wellbeing.



The Institute of Consumer Money Management conducts and provides funding for research and studies that promote positive spending behaviors and consumer asset building. ICMM is committed to promoting financial literacy in our community and across the United States.



NOVA LABS

NOVA Labs is a digital platform from the producers of the popular PBS science series that engages middle and high schoolers in science games and interactives. Labs participants – more than 10 million to date – take part in real-world investigations by visualizing, analyzing, and playing with the same data that scientists use. Each Lab focuses on a different area of active research. But all of them illustrate key concepts with engaging multimedia content, guiding participants as they investigate scientific questions, and explore solutions to current problems.



Thought Café is an award-winning animation, design, visual effects and vr/ar studio located in Toronto, Canada

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Executive Summary

Having good financial well-being, which looks different for everyone and depends on what makes you happy, is an essential component of overall well-being, yet many adolescents and young adults don't feel adequately prepared to make good financial decisions in the real world. Not only are financial literacy levels low, but their effects on everyday financial decisions aren't adequate to overcome biases that often result in suboptimal in-the-moment financial choices. In light of these issues, the NOVA Financial Lab was designed to provide a safe and feedback-rich environment that allows players to experience making financial decisions in contexts that encourage balancing current and future well-being.

This document serves as the report for the research conducted on the NOVA Financial Lab from February 2022 to May 2023. In this report, we summarize two main research lines: 1) research conducted via a survey linked on the main page of the website and 2) within-game data gathered on decisions and learning outcomes across the three mini-games. We find that, for each mini-game, we see benefits of repeat play on performance across games, and that participants are more accurate at responding to the survey questions after playing the games, as compared to before. Learning objectives were supported by data showing increases in optimal performance for each game, and in survey data showing better understanding of behavioral biases and tools to overcome them. Our findings offer support of serious games as effective methods for teaching financial well-being and helping adolescents and emerging adults balance the life choices that provide immediate and long-term financial security, and personal happiness. Though geared toward adolescents, the Financial Lab includes information relevant to anyone making financial decisions, regardless of their age.

KEYWORDS: Behavioral science, financial literacy, financial education, gamification, serious games, game-based learning, randomized control trial

Background

Financial well-being, which can be defined as “a state of being wherein a person can fully meet current and ongoing financial obligations, can feel secure in their financial future, and is able to make choices that allow them to enjoy life” (Consumer Financial Protection Bureau, 2017), is an essential component of achieving a high quality of life. For example, our general sense of well-being is predicted by our level of financial well-being (Netemeyer, et al. 2018), as low levels of financial well-being can lead to a variety of stressors which can create new, or exacerbate existing, problems in mental and physical health (American Psychological Association, 2015).



Financial well-being is an essential component of achieving a high quality of life.

But, as we found in our initial report, as critical as financial well-being is to our overall health, most people lack even basic financial knowledge needed to make optimal financial decisions (Lusardi, 2019; Lusardi & Mitchell, 2011).

Even *with* good knowledge of financial information, applying it in the real world - where decisions are not made in a vacuum - reveals how difficult it is to translate conceptual knowledge into good behavioral choices (Gelb-Bicknell et al. 2022). The decision-making environment has also changed dramatically in the past few decades, with new technology spurring changes in how money can be made and used, as well as new products (and variations of products) available to consumers for almost any given kind of expense. To add to this complexity is a changing economy with an uncertain future, a future our emerging adults are soon to face head-on.

Therefore, the NOVA Financial Lab was created to be a space where young adults could practice various financial skills – such as budgeting, paying off debts, and investing in their retirement – in a safe environment with feedback embedded to help improve decisions over repeated play.

Objectives of the NOVA Financial Lab

1. Provide a free, online financial education resource for adolescents and young adults.

Many adolescents and young adults around the world don't have experience learning how to make financial decisions, especially in complex environments that mimic the real world. Therefore, one objective of the Financial Lab was to provide a free, online environment where users can learn how to develop habits to overcome the behavioral and cognitive biases that often get in the way of making good financial decisions, while also learning about these biases explicitly in videos and through feedback in the games.

2. Serve as a stand-alone resource or supplement to a financial education course or lesson plan.

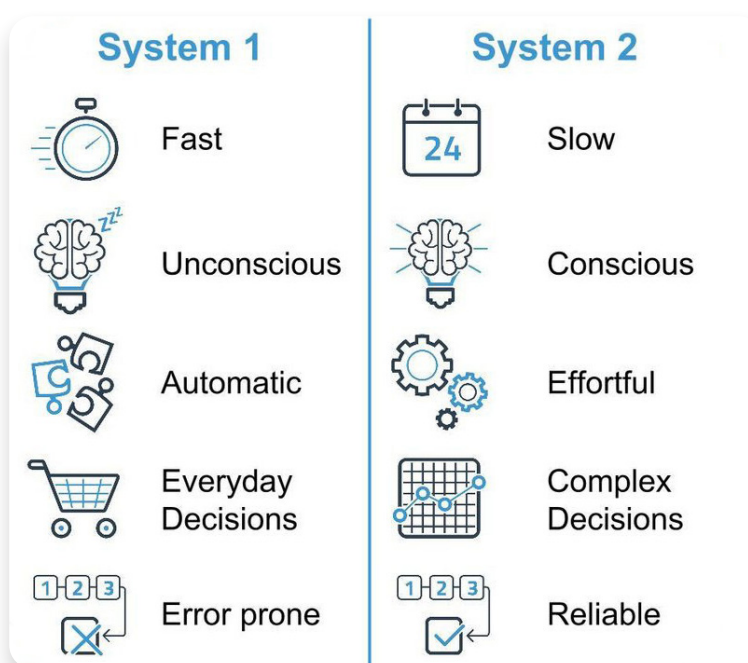
In addition to the three mini-games, we created the NOVA Financial Lab to be a multi-component resource for teachers and educators of financial well-being and financial decision-making to use alongside their curriculum lessons, although the Financial Lab can also be a resource in itself as a stand-alone lesson plan. In that vein, NOVA created an Educator Guide that provides a broad overview of the Financial Lab and of the three mini-games, as well as links to a series of educational videos teaching various concepts of behavioral science related to financial decision-making. Finally, our built-in research survey includes questions related to financial literacy and specifically tests learning of the major biases taught in each game.

3. Offer a novel way to teach behavioral science concepts within a highly interactive financial decision-making game environment.

Perhaps the most unique aspect of the NOVA Financial Lab is the inclusion of cognitive and behavioral biases as central to learning how to develop good spending and saving habits over time. Before diving into the mini-games, players are taught about two fundamental aspects of behavioral science which are key to understanding why we often fail to make choices that maximize our well-being: one is the difference between System 1 and System 2 processing and the other is the knowledge- or intention-behavior gap.

TWO FUNDAMENTAL ASPECTS OF BEHAVIORAL SCIENCE

System 1 vs. System 2 is the idea that we have two different decision-making systems in our brain: one that utilizes a rational, logic-based approach to decision-making – the one we all not only aspire to be but assume we are using most of the time – and another one which is more automatic, guided by emotion and intuition, and is characterized by impulsive decision-making. Behavioral economists have referred to these two systems as personalities to help put them in perspective. System 1, or our automatic and emotionally-guided system, is our Homer Simpson brain, while System 2 could be ascribed to a personality akin to Spock from Star Trek. These two systems operate simultaneously and oftentimes compete for behavioral expression. Behavioral economists argue that it is System 1 that tends to control many of our everyday choices, especially when dealing with complex environments or when our self-control resources are depleted.



https://www.researchgate.net/figure/System-1-vs-System-2-Thinking-upfrontanalyticscom-nd_fig3_335840928

The intention-behavior gap is the idea that, despite knowing how, or even wanting to make decisions that benefit us in the long-run, we often don't choose the best option, whether that's in the area of physical health or financial health. We know it's important to exercise and eat well, yet many of us end up being more sedentary than we hoped and less healthy in our food choices. We also fail to save

money when we can and we are overly optimistic about our future spending (and saving) habits, often leading to increased debt and lower financial well-being over time. These habits also follow us into adulthood and throughout our lives, so learning how to overcome some of these habits can help us build more optimal ones.



Brief Overview of Games and Within-Game Learning Objectives

In the [NOVA Financial Lab](#), the player is responsible for taking care of their pet's financial needs and responsibilities. The pet acts as a playful metaphor for the player's financial needs in the real world—it has debts, needs for short-term and long-term savings, non-essential and essential expenses, and preferences. Furthermore, the pet is the player's only financial responsibility, meaning that all in-game income is solely to be used on the pet.

This game is composed of three mini-games—Shoppportunity Cost, Budget Buster, and Exponential Potential. Shoppportunity Cost focuses on instilling a habit of considering opportunity costs when making spending decisions. Budget Buster focuses on developing mental accounts (for essential expenses, nonessential expenses, and savings), and strategies for using them effectively. Exponential Potential helps the player develop strategies for paying off debt and investing. We focused on these three topics due to their relevance to financial behavior. Each game teaches players about particular behavioral pitfalls in managing their money, but also provides tools for managing their financial behaviors. Whereas the games provide important information to increase financial literacy, they also emphasize how to engage in healthy financial behaviors. Each game is designed to be played multiple times so that the player can reinforce desired behaviors.



The player chooses either a cat or a dog as their avatar for each of the games. The first game (Shoppportunity Cost) deals with immediate spending, the second (Budget Buster), medium-term budgeting, and the final one (Exponential Potential), long-term debts and investments. Prior to playing each game, the player watches an instructional video that introduces relevant behavioral concepts and how to play. After each game, the player watches another video that discusses how to overcome the behavioral biases that are featured in the game.

Bones the Dog



Cash the Cat





Shoppportunity Cost

In Shoppportunity Cost, the objective is to maximize your pet's happiness by considering opportunity costs of present and future options. In this mini-game, the player is responsible for maximizing their pet's happiness on a trip to a music concert. They visit multiple "stores" in which they are required to make one purchase at each store for things that the pet will need for the trip. During the game, they make repeated purchasing decisions in which they need to trade off monetary and hedonic considerations, and opportunity costs. Each potential purchase gives the pet a certain amount of utility, or "happiness points," but the player only has a limited budget and cannot revisit stores. These happiness points determine the final score.

Shoppportunity Cost has a single learning objective:

🎯 **LEARNING OBJECTIVE:** Attend to opportunity costs in order to balance present and future well-being when making financial decisions

During the game, players learn that they cannot buy the most expensive option, which always provides the greatest amount of utility or 'happiness points', at every stop. However, the relative amount of happiness always varies over stops for each of the monetary choice values (\$10, \$20, \$30). Therefore, the trick is to try and figure out what a good value is, based on the number of hearts the pet gets for the purchase, and choose more expensive options sparingly when the pet's happiness value is maximized. But as in life, you don't know what the next stop will bring, and any choice you make will affect the availability of future buying options. As we mentioned in the first paper, every decision involves tradeoffs, but those tradeoffs are often ignored. When carrying out financial decisions, people tend to neglect future, alternative options that they are giving up (called opportunity costs). **Opportunity cost neglect** represents a failure to retrieve a relevant reasoning principle when it is needed (Corbin et al., 2015) – which in the case of in-the-moment spending decisions boils down to "money spent on








something now is money that can't be spent on something else later." Therefore, we created this mini-game to give players the ability to experience opportunity costs, while making explicit the connection between present or moment-to-moment spending and future consequences.

As a way to explicitly show the cost of money already spent, in between rounds the player is shown an "Opportunity Cost Map," in which they are faced with their past decisions as well as their upcoming decisions. As they spend more, future decisions are crossed out, demonstrating how one's spending in the present can reduce one's future options. If the player runs out of money before they visit the last store, they lose the mini-game because they cannot pay for transportation home from the concert. Thus, the player must juggle the goals of making their pet happy and having the money to visit each store. The mini-game is designed such that (much like in real life), considering opportunity costs when making purchasing decisions leads to a better outcome at the end of the game. Thus, the game is meant to prove the value of attending to future opportunity costs and instill a mental habit of considering these costs when players make decisions outside of the game, helping players to make less impulsive, and higher quality spending decisions.

Opportunity Cost Map

Thanks for purchasing Black Pants + Red Glasses!

It looks like you've lost the opportunity to buy item(s) in the future.

	—	—	\$30
	—	—	\$30
	\$10	\$20	\$30
	\$10	\$20	\$30
	\$10	\$20	\$30
	\$10	\$20	\$30
	\$10	\$20	\$30

You have \$50 left to spend for the rest of your evening.



After each decision, players are shown an "Opportunity Cost Map" that shows their past decisions, future potential decisions, as well as the opportunities they will miss out on due to their previous spending.



Budget Buster

In this mini-game, the player is responsible for managing monthly spending on essential expenses and non-essential items, collecting savings, building credit, and handling expensive emergencies and windfalls in income. This game is designed to help players break free from habits of either budgeting with overly narrow mental accounts or failing to budget at all. Players are meant to adopt three broad mental accounts for non-essential spending, essential spending, and savings. To encourage this habit, all decisions are framed by these three distinct accounts and players are scored on their ability to assign monthly expenses to the correct account.

Here, the learning objectives are twofold:

🕒 **LEARNING OBJECTIVE 1:** Develop three broad mental accounts for essential expenses, non-essential expenses, and savings in order to assist with budgeting

People tend to treat spending and earning inconsistently, separating and categorizing these decisions under separate mental “accounts.” This mode of thinking can lead to a range of behaviors considered irrational from a neoclassical economics perspective, such as maintaining inflexible budgets (Thaler, 1999). For example, a family may allocate \$600 of their monthly income to groceries, \$100 for outings, \$80 for gas, etc., and prevent themselves from using money from one account to go toward the expense of another. Yet, budgeting that includes earmarking and partitioning money can reduce unwanted spending behavior (Cheema & Soman, 2008; Soman & Cheema, 2011), making it a potential remedy to the worryingly low amount of savings that many Americans—especially low-income Americans—set aside (Wilcox, 2008; Jeszeck et al., 2015).

Still, budgeting with a large number of mental accounts has disadvantages. For example, maintaining

elaborate mental accounting budgets can make people give up on budgeting entirely (Ariely & Kriesler, 2017). To avoid these issues, Ariely and Kriesler (2017) recommend implementing a broad mental account for non-essential items in order to limit spending. This recommendation is consistent with a popular budgeting rule to use 50 percent of post-tax income on essential expenses, 30 percent on non-essential expenses, and 20 percent on savings (Whiteside, 2020).

LEARNING OBJECTIVE 2: To treat money as fungible by adjusting mental account budgets if necessary and attending to absolute rather than relative savings and costs

Because money is fungible, dollars are mutually interchangeable and should theoretically be treated with equal value. Mental accounting can violate the principle of **fungibility** (i.e., the value of money is the same regardless of where it comes from or what it is being spent on) by evaluating financial activities under separate accounts with inconsistent preferences. This leads to a number of irrational behaviors, including the underconsumption of goods within a mental account. However, many negative behaviors associated with mental accounting are not directly caused by spending budgets. One behavior Thaler (1999) notes is that people tend to treat money differently depending upon the way it is acquired, whether through work, gifts, or otherwise. As further proof, one study found that when people received windfall money, they tended to spend that money on an expense they rated similarly on a scale that ranges from “serious” to “frivolous.” Tax returns were more often spent on paying bills, while winnings of an office football pool were more often used for eating out (O’Curry, 1997). People also tend to treat money differently depending upon the method of payment. Most notably, people spend more when they use a credit card than when they use cash (unlike cash, credit cards charge users in one large sum after the purchase, separating payment from spending and reducing the salience of overspending; Thaler, 1999).

Additionally, people tend to treat savings in relative rather than absolute terms. It is theorized that individuals gain transaction utility based on the perceived value of a “deal,” with larger transactional utilities for larger deals (Thaler, 1999).

Whereas mental accounting budgets are encouraged in this game, it also uses a number of strategies to penalize players for violating fungibility. Players will receive windfalls and emergencies that force them to be flexible with their budgets in changing circumstances and to treat all forms of earnings (income, windfalls) equally. If they fail to use windfalls to balance out unanticipated spending in other months and instead treat them as “fun” money, they may end up overspending on non-essential items. If they refuse to use money from one account to go toward another and instead treat credit card debt as “future” spending, they may go into credit card debt. Both errors would hurt their final score, as players are graded on their credit score.

Finally, players must assess “deals” at the beginning of each round to practice ignoring transactional utility. In each deal, they are shown two distinct discounted non-essential items and must buy both items but can only use one discount. In order to score points, they must choose the discount with the higher absolute savings for their essentials account overall (e.g., 25% off of \$100) rather than the relative savings (e.g., 50% off of \$40).

In total, the mini-game is designed to teach players the advantages of flexible mental accounting budgets in mediating self-control and increasing savings while also training them to recognize violations of fungibility in order to improve spending decision quality.



Exponential Potential

In Exponential Potential, the player must strategize the best way to pay off their pet's long-term debts and invest in retirement savings. In this mini-game, the player is responsible for their pet's long-term debt and investment payments. Given a constant portion of fixed monthly income over 35 years, the player must decide how this money should be distributed to maximize net worth at the end of the time horizon. After the player sets the allocation for each account, they finalize their decision and watch their pet's accounts change over time on a dynamic graph before being scored on the pet's final net worth. If a debt is paid off before 35 years have passed, the mini-game pauses and allows the player to re-allocate that monthly portion to another account. One playthrough of this mini-game has multiple rounds to allow the player to learn from past performance and develop better strategies.

Because past graphical interventions that aim to improve accurate exponential growth predictions have shown varied results, we decided to avoid emulating such a goal. Instead, this game is designed to instill an intuition about the power of interest rates and time horizons on debts and investment growth. Scoring based on strategy for the highest net worth, rather than prediction of the final net worth, is meant to emphasize this behavioral goal. Furthermore, the player is not primed with any strategies before playing the mini-game, providing them with the chance to test out theories and learn the optimal payment strategy (maximize deposits in the account with the highest interest rate) through practice. However, players are shown a comparison between their performance and "optimal" performance as they play, allowing them to gain immediate feedback on how their strategies are playing out and make in-game adjustments. After the mini-game is completed, a short video explains various debt and investment payment methods with their benefits and costs, concluding with the optimal strategy.

The learning objectives are again twofold:

- ③ **LEARNING OBJECTIVE 1:** Overcome exponential growth bias by grasping the powerful, non-linear effect of interest rates over time to develop a debt payment and investment strategy based on interest rates

People tend to underestimate both the returns on long-term investments and the losses accrued by debt. Both of these miscalculations stem from **exponential-growth bias**, the tendency to anticipate linear growth when an exponential interest rate is given. The bias is more pronounced in longer time-horizons. One experiment found that the vast majority of college student participants underestimated exponential growth or expected it to be linear, which led them to underestimate the cost of waiting to save. Those researchers also found that highlighting exponential-growth savings motivated undergraduates and employees to save more (McKenzie & Liersch, 2011).

Incomplete understanding of interest leads to harmful investing and debt payment strategies that keep people from building wealth. In theory, the optimal strategy is to put all funds toward the debt or investment with the highest interest rate, thereby minimizing interest payments or maximizing savings growth. However, Amar et. al (2011) found instead that people tend to pay off their smallest debts first and distribute investment money evenly across all accounts they have access to, regardless of interest rates. In a subsequent experiment by the researchers that asked participants to allocate money to a number of debts with varying interest rates, people performed somewhat closer to the optimal strategy when given extra information that highlighted the actual dollar amount of debt accumulating from interest.

- ③ **LEARNING OBJECTIVE 2:** To make investment allocation and debt payment decisions independent from the default and minimum payment options.

In order to provoke status quo bias, this game has built-in **defaults** for each debt and investment option that are far from the optimal choice (similar to the minimum payment option provided by credit card companies). If the player declines to change their pet's monthly allocations, the pet will make minimum payments on all debts and put the rest of their money into a low yield savings account. Furthermore, if a debt is paid off before 35 years have passed, the player can decline to re-allocate the money to another investment or debt and allow it to accrue in their pet's savings account. To increase their score, the player must overcome status quo bias within the game in order to allocate money to the highest interest option.

TRANSLATING LESSONS INTO REAL-WORLD BEHAVIOR

After each mini-game, we also offer players the chance to translate insights from the game into real-world behaviors. For example, one post-game pop-up in Budget Buster provides players with an actionable step they can immediately take to overcome an early barrier to long-term saving habits:

Budget Buster



Make a commitment to put at least 20% of the money you have into savings at the end of every month! Add a reminder to your phone now!

Aim for a goal of having at least \$500 in savings for emergencies!

Developing concrete plans to implement a new behavior increases the likelihood that this new habit of mind will stick (Duckworth et al., 2018). Furthermore, providing such suggestions immediately after the mini-game increases the chance of follow-through by acting as a “just-in-time” intervention.

Assessing Impact of Games

After carefully developing the games, our primary question became whether playing the three mini-games (Shoppportunity Cost, Budget Buster, and Exponential Potential) would achieve the [learning objectives set-out at the beginning](#). We hypothesized that by playing the games, participants would be able to both recognize and overcome the following common behavioral biases related to money management: opportunity cost neglect, exponential growth bias, and suboptimal mental accounting/non-fungibility of money. We relied on both objectively measured gameplay data as well as self-reported survey data to assess the impact of the games on participants' financial literacy. Below, we provide a brief overview of each of these assessment methods.

GAMEPLAY DATA

By playing each of the three mini-games, anonymized data on game-performance was collected automatically in the back-end. Automatic data collection has the advantage that it is (1) objective, meaning that the participant cannot lie about their performance, and (2) that the act of measurement doesn't influence a participants' gameplay performance. For the purpose of this report, we consider the following metrics for each mini-game:

Shoppportunity Cost	Budget Buster	Exponential Potential
<ol style="list-style-type: none">1. Number of hearts at the end of the game (our measure of happiness)2. Number of stores the participant got to before running out of cash3. Grade	<ol style="list-style-type: none">1. Number of deals correctly chosen2. Total savings amount3. Final Credit Score4. Final Happiness Score5. Grade	<ol style="list-style-type: none">1. Total net worth2. Grade

Data used for this analysis was collected between February 9th, 2022 and December 2nd, 2022.

SURVEY DATA

To complement the gameplay data, we also relied on self-reported survey data to measure improvements in financial literacy as part of a randomized controlled trial. On the NOVA [Financial Lab homepage](#), participants can find a yellow box, titled “Play for Research”. The box also features the Center for Advanced Hindsight’s logo.



Upon clicking on the “Play for Research” box, participants are re-routed to a Qualtrics survey hosted by Duke University. Participants are randomly assigned to either complete the survey and then play the three mini-games afterwards, or to play the three mini-games and complete the survey after gameplay. The surveys are identical; participants merely answered them at different points in time. Participants that didn’t click on the “Play For Research” box on the NOVA Financial Lab homepage, but instead, directly preceded to the games, were presented with a pop-up at the end of gameplay that gave them the option to participate in the survey (these participants were included in the analysis with the caveat that they were not randomly assigned).

Using the following decision-making scenarios, the survey assessed whether participants can overcome the following three behavioral biases related to money management by playing the three mini-games:

Opportunity Cost Neglect

- Following Frederick et al. (2009), participants were told to imagine they had received money from their parents, and were then asked to make a hypothetical purchasing decision between a more expensive and a cheaper product.

Mental Accounting

- Participants were asked to make a hypothetical decision about whether they would drive to a nearby store to purchase the same calculator for a lower price or not (see Tversky & Kahneman, 1981).
- Participants were asked to make a hypothetical decision about a soda purchase (see Thaler, 1983).

Exponential Growth Bias

- Participants were asked to allocate \$400 towards paying down three credit cards with varying levels of debt and interest rate (see also Reyna et al., 2017).

In addition, the survey also collected information on demographics (e.g., age, gender), as well as participants' confidence in their decision-making and knowledge about the three behavioral biases related to money management: opportunity cost neglect, exponential growth bias, and suboptimal mental accounting / non-fungibility of money.

Data collection took place between September 15th, 2022 and May 2nd, 2023. Pre-registered hypotheses can be found on OSF: <https://doi.org/10.17605/OSF.IO/ZYP59>

ADDITIONAL RECRUITMENT METHODS

As voluntary participation in “Play for Research” was originally rather low, we additionally recruited 18–23-year-old participants through the Interdisciplinary Research Center (IBRC) at Duke University between February 3rd and February 16th, 2023. The IBRC is open to students and community members. In addition, we also promoted the games and the research among students that are part of the Young Enterprising Women Mentoring Forum Program between March 1st and April 30th, 2023.

Results

ENGAGEMENT

Gameplay Engagement

Within the 10-month time-period in question, Shopportunity Cost was played 17,929 times, Budget Buster 9,186 times, and Exponential Potential 13,693 times. Removing duplicate data entries leaves us with:

Table 1. Gameplay engagement

GAME	PLAYS	PLAYERS	PLAYERS > 1 ROUND
Shopportunity Cost	17824	7208	3304 (45.8%)
Budget Buster	6927	4500	1363 (30.3%)
Exponential Potential	8462	3354	1459 (43.5%)

In order to assess players' learning, we restrict our dataset to those players who've played each mini-game at least twice.

Survey Engagement

Out of the final dataset of 536 respondents, 142 respondents took the survey before playing the three mini-games, while 394 respondents took the survey after playing the three mini-games¹.

1. The majority of survey respondents who took the survey after playing the games weren't randomized to do so. This means that they didn't click on the "Play For Research" button on the NOVA Financial Lab homepage, but instead, opted to complete the survey presented to them in a pop-up window after playing the games.

PRE-GAME QUESTION RESULTS (NOVA QUESTIONS)

When asked whether they can (will be able to) afford most things they want / need now (in the future), 8,068 respondents reported on average being moderately confident in being able to do so. As the table shows, players were slightly more confident in affording essential things, both now and in the future. Interestingly, we also observe a more positive outlook on future financial well-being, with confidence in being able to afford things they want in the future, as compared to presently.

Table 2. How confident are you in the following statements?

FINANCIAL WELL-BEING COMPONENT	AVERAGE CONFIDENCE LEVEL: 1 (NOT AT ALL CONFIDENT) - 5 (EXTREMELY CONFIDENT)
I can afford most of the things I want now.	3.09
I can afford the things I need now.	3.55
I will be able to afford most of the things I want in the future.	3.39
I will be able to afford the things I need in the future.	3.61

When asked why they think people have a hard time sticking to their money goals, 6,632 participants answered. Among the six statements provided, respondents thought that it was *somewhat true* that people don't put enough effort into sticking to their goals, while they thought that it was almost *very true* that people prioritize what they need or want now and don't think as much about their future.

Table 3. Why do you think people have a hard time sticking to their money goals?

WHY DO YOU THINK PEOPLE HAVE A HARD TIME STICKING TO THEIR MONEY GOALS?	AVERAGE ANSWER: 1 (NOT AT ALL TRUE) - 5 (EXTREMELY TRUE)
They prioritize what they need or want now and not think as much about their future.	3.84
When buying something, they forget to consider what else that money could be spent on.	3.75
They spend more than they planned due to unexpected expenses.	3.69
They don't know enough about money or the financial system.	3.50
They are overly optimistic about their future spending/saving behaviors.	3.42
They don't put enough effort into sticking to their goals.	3.30

SURVEY DEMOGRAPHICS

Overall, 20.9% of survey respondents identified as female, 19.2% as male (with 54.3% not opting to respond to that question), with an average age of 23.9 years (min = 9, max = 80). The survey respondents were 15.5% White, 8% Asian, 8.4% Multiracial, 5.4% Black, and 4.9% Hispanic / Latine, with 54.9% opting not to answer this question. Average and median subjective social socioeconomic status were both rated at a 5 on a 1-10 scale, thus neither being at the top nor being at the bottom of a ladder representing Americans who are best (worst) off in society. The respondents reported an average monthly income in the past 6 months of \$2,736 and an average weekly spending amount of \$218.



Shoppportunity Cost Results

Gameplay

As a reminder, at the beginning of the game, participants are told that they are getting ready to go to a concert and they want to bring their pet. In addition, they are being told that they will now need to buy a disguise for their pet as well as tickets, transportation, and anything else to make this the most memorable night possible. Participants are given \$110 and 7 rounds of play (=7 stores) to purchase all necessary items, go to the concert, and make it back home. If they run out of money on the way, the game ends. At each store, participants will need to purchase something, and items either cost \$10, \$20, or \$30. Participants made it to anywhere from 4 to 7 stores before running out of cash, with an average of 6.6 stores (SD = 0.78).

Our results show that in only 17% of playthroughs, a \$30 item was purchased in the first store. We also find that there is an association between the number of stores one visits before running out of cash and whether a \$30 item was purchased in the first store, $\chi^2(3, N = 13,920) = 2473.4, p < 0.001$. This means that 91.5% of those who only made it to four stores before running out of cash, purchased a \$30 item in the first store, while it is between 9.7% and 38.5% for those who made it to five stores or more.

All participants who only made it to 4 stores before running out of cash, made three \$30 purchases, and one other purchase. This number sharply declines: Of those making it to 5 stores before running out of cash, only 23.1% made three \$30 purchases, and of those making it to 6 or more stores before running out of cash, nobody made three \$30 purchases. Instead, the majority of those making it to 5 stores before running out of cash (57.3%) made two \$30 purchases, while the majority of those who made it to 6 (47.3%) / 7 (47.5%) stores before running out of cash, made merely one \$30 purchase.

Our results indicate that, on average, the more rounds of Shoppportunity Cost a player completed, the more hearts they had at the end of the game, the more stores they were able to get to before running

out of cash, and the higher their final overall grade was (p 's < 0.001). This indicates that players learn and do better by playing the game. For example, after the first round of gameplay, players, on average, scored 82.8% on their game. This increases to 84.9% after the second round of gameplay (2.5% increase; p < 0.001), and to 86.5% after the third round of gameplay (4.5% increase; p < 0.001).

Survey

As we reported in our first paper, research shows that merely mentioning the money that someone could save by abstaining from a purchase (or buying cheaper version) changes decision-making. For example, a series of experiments demonstrated opportunity cost neglect by varying whether money saved was kept implicit or made explicit in the purchase of a CD. In the researchers' first experiment, willingness to purchase a \$14.99 CD fell from 75 percent to 55 percent when the "not buy" decision was changed to "keeping money for other purchases." In another experiment where participants chose between a \$299 iPod, a \$399 iPod, or neither, purchases of the cheaper iPod rose from 37 percent to 73 percent when subjects read the explicit opportunity cost that buying the cheaper iPod would mean "leaving you \$100 in cash." The researchers also found that participants were more likely to imagine alternative items they could buy instead when opportunity costs were explicit, and they demonstrated these effects under incentive compatible conditions (i.e., when real money was at stake; Frederick et al., 2009).

Following Frederick et al. (2009), participants were asked to imagine that they had just received \$250 from their parents for their birthday, and that they had been wanting to buy wireless headphones or earbuds. They were then presented with two options:

1. Buy the headphones / earbuds they want for \$250

-OR-

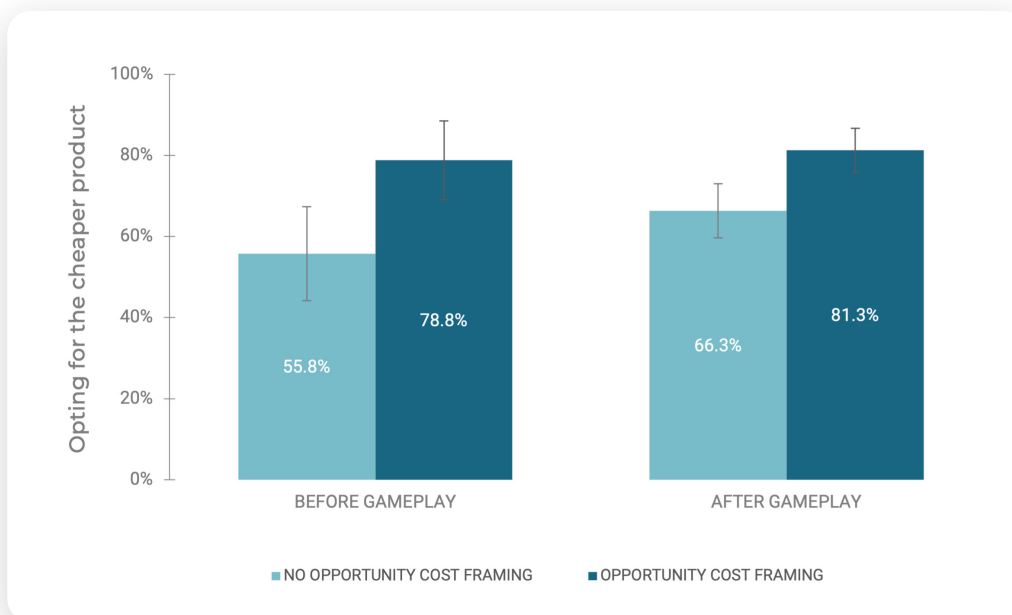
2. Either:

- a. Buy an okay set of headphones/earbuds that don't do everything they want for \$175, or**
- b. Buy an okay set of headphones/earbuds that don't do everything they want for \$175, leaving them with \$75 that they can save for other things.**

Participants were randomly assigned to either see option 2a or 2b, with option 2b explicitly mentioning the opportunity cost of going with the cheaper set of headphones / earbuds.

Overall, we find that exposure to the opportunity cost framing (vs. not) increases the likelihood of opting for the cheaper product (80.7% vs. 63.9%; $p < 0.0001$). This is not only the case for those that completed the survey before playing the games (78.8% opted for the cheaper product with exposure to opportunity cost framing vs. 55.8% without exposure; $p < 0.05$), but also for those who completed the survey after playing the games (81.3% with exposure vs. 66.3% without exposure; $p < 0.01$). While we find that the gap between opting for the cheaper product when exposed to the opportunity cost framing (vs. not) declines slightly from pre-game survey (23 percentage points) to post-game survey (15 percentage points), the gap doesn't disappear. This means that playing the game slightly increases participants' understanding of opportunity cost; however, when participants are reminded about the opportunity cost of their decision-making, they make better choices.

Figure 1. Opportunity cost framing increases likelihood of opting for the cheaper product



Lastly, participants who completed the survey after playing the game (vs. before playing the game) reported a higher knowledge of what opportunity cost is, with 57.1% saying that they know what an opportunity cost is (vs. 34.5%; $p < 0.001$).



Budget Buster Results

Gameplay

Our results indicate that, on average, the more rounds of Budget Buster a player completed, the more deals they were able to correctly identify, the higher their final credit score was, the higher their pet's final happiness score was, and the higher their final overall grade was (p 's < 0.001). At the same time, the more rounds of Budget Buster a player completed, the lower their total savings amount was at the end of the game ($p < 0.001$). Yet, the overall conclusion remains unchanged: players learn and do better by playing the game. For example, after the first round of gameplay, players, on average, scored 80% on their game. This increases to 88.1% after the second round of gameplay (6.13% increase; $p < 0.001$).

Throughout the gameplay, players experience unexpected windfalls and emergencies. With their windfalls, players have the option to buy a non-essential item or save their windfall in either their checking or their savings account. Out of all windfalls, 37.7% of them were put towards savings, 32.5% of them were put in the checking account, and 29.8% were used towards purchasing a non-essential item. There is little variation across rounds played.

When an emergency occurs, players have the option to pay it using money in their checking or savings account, or use their credit card. Out of all emergencies, 36.9% were paid for using a credit card, 31.8% using money in the checking account, 21.3% using money in the savings account, and 10% used a mix of checking account, savings account, and/or credit card. Again, there is little variation across rounds played.

Survey

Purchasing-Decision 1

Following Tversky & Kahneman (1981), participants were asked to imagine that they are about to purchase a jacket for \$15 (\$125), and a calculator for \$125 (\$15). The calculator salesman informs them that the calculator they wish to buy is on sale for \$120 (\$10) at the other branch of the store, located 20 minutes drive away.

Participants were randomly assigned to either read the scenario with the large (small) numbers, while keeping the savings by driving to the other store constant at \$5.

Overall, when asked whether the participant would drive to the nearby store to purchase the same calculator for a lower price, we don't find a difference in willingness to drive between participants who took the survey after playing the game (42.9%) vs. before playing the game (44%; $p > 0.1$).

However, those who took the survey before playing the game are affected by the size of the numbers in the scenario. When large numbers are used, 29% are willing to take the trip, while 57% are willing to take the trip when small numbers are used ($p = 0.06$). The preference for driving to the other store is stable for those who took the survey after playing the game (41% are willing to take the trip with large numbers vs. 43% with small numbers).

Purchasing-Decision 2

In another scenario – following Thaler (1983) – participants were asked to imagine that they are lying on the beach on a hot day. A friend gets up to make a phone call and offers to bring back a soda from the only nearby place where soda is sold: a fancy resort hotel (a small, run-down grocery store).

Participants were randomly assigned to either read the scenario with the fancy resort or the small, run-down grocery store, while keeping everything else the same.

Overall, when asked how much the participant is willing to spend on a soda of their choice, we don't find a difference in willingness to pay between participants who took the survey after playing the game (\$7.2) vs. before playing the game (\$5.41; $p > 0.1$).

While we find that the willingness to pay between the fancy resort and the run-down grocery store is larger when participants are asked before playing the game (\$1.35) than when asked after playing the game (\$0.40), the differences are not statistically significant ($p > 0.1$). Yet, this finding suggests that playing the game elicits more stable preferences and willingness to pay amounts across contexts than before playing the game.

Budgeting Knowledge

When asked about what percentage of one's income they think they should be putting towards essential expenses, non-essential expenses, and savings each month, participants who completed the survey after playing the games (vs. before playing the games) exhibited a higher percentage of correct answers (p 's < 0.01).

Table 4. Percent of participants who correctly answered the budget allocation question for...

	BEFORE	AFTER
Essential expenses	36.4%	56.2%
Non-essential expenses	18.2%	41.9%
Savings	9.1%	43.8%

This clearly shows that participants remember what is being taught in the games.

Yet, participants who take the survey after playing the games (vs. before playing the games) don't report a difference in confidence in their ability to manage their money ($p > 0.05$). They also don't exhibit a smaller likelihood to discount the future ($p > 0.1$; see Reyna et al., 2017).

Budgeting Knowledge

When asked why people have a hard time sticking to their money goals, participants who took the survey after playing the games (vs. before playing the games), were more likely to agree with the following two statements (p 's < 0.05):

1. When buying something, they forget to consider what else that money could be spent on.
2. They prioritize what they need or want now and don't think as much about their future.

This shows that the Shopportunity Cost game had the biggest influence on participant's beliefs. It's also consistent with the highest rated statements by players within the gameplay dataset (see table 4 above).



Exponential Potential Results

Gameplay

Our results indicate that, on average, the more rounds of Exponential Potential a player completed, the higher their total net worth was, and the higher their final overall grade was (p 's < 0.001). This indicates that players learn and do better by playing the game. For example, after the first round of gameplay, players, on average, scored 82.5% on their game. This increases to 87% after the second round of gameplay (5.45% increase; p < 0.001).

This is also consistent with our goals for difficulty level in the games; we wanted it to be relatively easy to get a good score, but difficult to achieve an excellent score.

Survey

Participants were asked to imagine that they had \$400 this month to pay towards their credit card debt. They have three credit cards with debt that needs to be paid off (there is no minimum payment for any of the cards.):

- » Credit card 1 has an interest rate of 8% and a balance of \$1,000.
- » Credit card 2 has an interest rate of 12% and a balance of \$200.
- » Credit card 3 has an interest rate of 6% and a balance of \$50.

They were then asked to allocate their \$400, so they would spend the least amount of money in the long run (see also Reyna et al., 2017).

We find that participants who take the survey after playing the game (vs. before playing the game) are not more or less confident in their allocation of the \$400 toward their credit card accounts ($p > 0.1$). This translates into action: We find that participants who take the survey after playing the game (vs. before playing the game) are equally likely to misspend on their overall credit card debt, as well as on their first/second/third credit card account (p 's > 0.1).

Lastly, participants answered two more questions concerning compound interest:

1. "Suppose you owe \$1,000 on a loan and the interest rate you are charged is 20% per year compounded annually. If you didn't pay anything off, at this interest rate, how many years would it take for the amount you owe to double?" Answer options were (1) Less than 2 years, (2) 2-4 years, (3) 5-9 years, (4) 10 or more years, or (5) Don't know.

Participants who took the survey after playing the game (vs. before playing the game) didn't display higher knowledge in compound interest (51.4% correct answers vs. 50%; $p > 0.1$).

2. "Which would you rather have: (1) \$1 million today, or (2) Start with a penny on day 1 and double your money every day for 30 days (e.g., Day 1 = \$0.01, Day 2 = \$0.02...etc.)"

A higher percentage of participants who took the survey after playing the game (vs. before playing the game) answered the question correctly: 76.9% vs. 58.5% ($p < 0.01$). Yet, participants who took the survey after playing the game (vs. before playing the game) are not more confident in their answer ($p > 0.1$).

Finally, 35.5% of participants who completed the survey after playing the game (vs. 29.6% before playing the game) reported knowing what compound interest is ($p > 0.1$).

Conclusions and Takeaways

CONCLUSIONS

This project empirically evaluated whether playing three mini-games (Shoppportunity Cost, Budget Buster, and Exponential Potential) can teach young adults financial literacy skills, and in particular enable them to both recognize and overcome the following common behavioral biases related to money management: opportunity cost neglect, exponential growth bias, and suboptimal mental accounting / non-fungibility of money. To do so, we analyzed data on over 6,000 young adults' gameplay performance as well as self-report survey data collected from over 500 persons.

Overall, we found that – before being exposed to any educational content – people recognize that the reason behind a lot of money mismanagement is that we tend to prioritize what we need or want now and don't think as much about the future. That is, participants unknowingly recognize the concept of present bias.



Before being exposed to any educational content, people recognize that the reason behind a lot of money mismanagement is that we tend to prioritize what we need or want now and don't think as much about the future.

Opportunity Cost: The more rounds of Shopportunity Cost a player completed, the more participants' understanding of opportunity cost increased – from a self-reported 34.5% to 57.1% – and thus, the better they did (= the more stores they were able to get to before running out of cash). Thus, by playing the game, players achieved the learning goal of balancing present and future well-being when making financial decisions. However, when asked to make a hypothetical purchasing decision between a more expensive and a cheaper product in a survey, participants that were reminded about the opportunity cost of their decision, made better choices.

Mental accounting: The more rounds of Budget Buster a player completed, the more deals they were able to correctly identify, and thus, the more participants' understanding of mental accounting increased. Thus, by playing the game, players achieved the learning goal of treating money as fungible and attending to absolute rather than relative savings and costs.

Players of Budget Buster also achieved their second learning goal by developing three broad mental accounts for essential expenses, nonessential expenses, and savings in order to assist with budgeting. Furthermore, our survey data suggests that playing the game elicits more stable preferences and willingness to pay amounts across contexts than before playing the game.

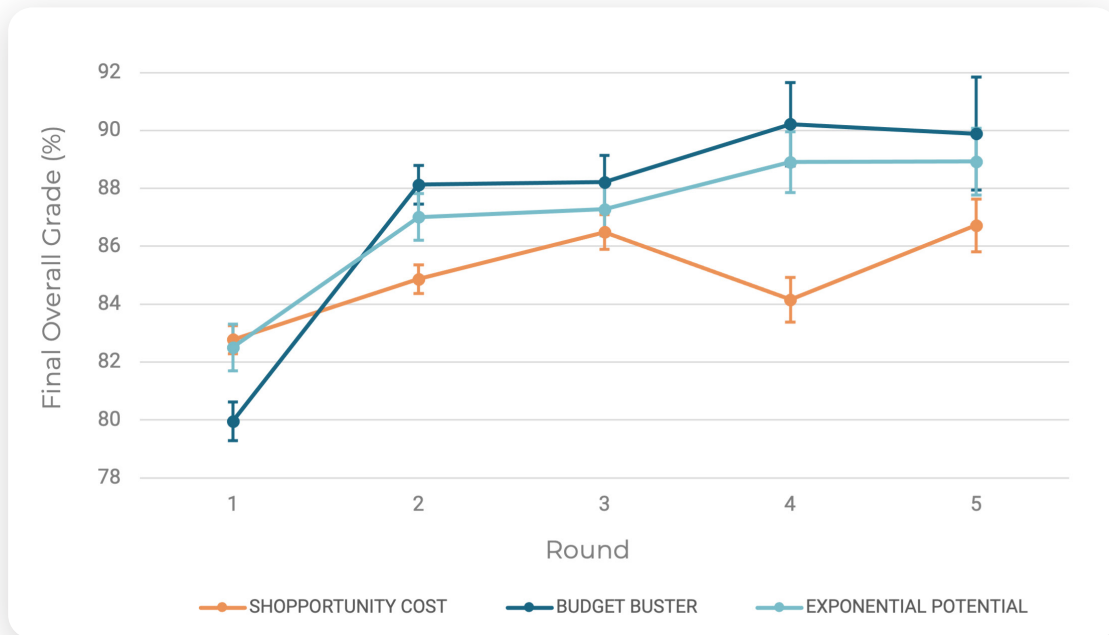
Exponential growth bias: The more rounds of Exponential Potential a player completed, the better they did, meaning that they were able to overcome exponential growth bias by grasping the powerful, non-linear effect of interest rates over time to develop a debt payment and investment strategy based on interest rates (see Learning Goal 1) instead of the default and minimum payment options (see Learning Goal 2). However, when asked to allocate \$400 towards paying down three credit cards with varying levels of debt and interest rate in a survey, we find that participants who took the survey after playing the game (vs. before playing the game) are equally likely to misspend on their overall credit card debt.

TAKEAWAYS

When asked how much they agree with a set of statements about the game (on a scale from 1 to 5), participants agreed that they liked the games ($M = 4.32$), that they learned something about managing money ($M = 4.08$), that they learned something about biases that can make it difficult to manage money ($M = 4.06$), that they would play the games again ($M = 3.98$), and that the games were easy to understand ($M = 3.92$).

In addition, another notable finding was that, on average, players show improvements on their final overall grade the more rounds they play. However, we observe the biggest improvements between rounds 1 and 2. Starting in round 3, scores started to plateau.

Figure 2. Player Scores Over Rounds



To summarize, we find that playing three mini-games (Shopportunity Cost, Budget Buster, and Exponential Potential) can teach young adults financial literacy skills, and in particular enable them to both recognize and overcome the following common behavioral biases related to money management: opportunity cost neglect, exponential growth bias, and suboptimal mental accounting / non-fungibility of money.

LIMITATIONS

This evaluation contains notable limitations. Firstly, the assessment of learning takes place while playing each of the three mini-games (from one round to the next) as well as right after playing the games (survey-based). This means that we are able to conclude the effectiveness of playing the three mini-games on financial literacy skills in the short-term, but we are not able to make any claims about long-term effects.

There were also practical and logistical limitations for our survey data. Due to the fact the NOVA Financial Lab was made available to the public in mid-February, 2022, while the underlying survey link of the “Play for Research” box was not available until September, 2022, we were unable to collect the initial bulk of user data through our survey.

Lastly, there are minor discrepancies in conclusions when considering the gameplay data versus the self-report survey data. This means that *how* the questions are phrased could influence our conclusion regarding the magnitude of “learning.” At the same time, the survey questions themselves may not accurately capture the behavioral biases of opportunity cost neglect, exponential growth bias, and suboptimal mental accounting / non-fungibility of money.

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