

21st Century Skill Building with Web-based Games

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Abstract: Financial knowledge has a tangible impact on an individual's ability to make positive financial decisions in their life. It has been estimated that the difference between the 75th and 25th percentile of the financial literacy index is equivalent to approximately an 80,000 euro difference in net worth and has significant impact on financial decisions made throughout one's working life and into retirement. The need for quality financial education is clear, but many studies show that personal finance classes offered today do not seem to have significant impact on the financial literacy of the students who take them. One hypothesis of this paper is that traditional instruction methods, which do not force students to exercise the financial tools they need to be fluent with as adults, hinder their ability to improve their financial literacy. We also argue that analysis of game interactions may be a more effective assessment mechanism than traditional academic tests. There is a growing body of evidence that the immersive elements of particular styles of games can have a significant impact on learning outcomes. This paper offers a potential starting point from which an immersive game, which leverages real world financial decision-making as its main mechanic, can be born. We will discuss the underlying design of such a game and how it lays the foundation for a game that could achieve financial literacy outcomes. Such outcomes would empower students with the skills to make positive financial choices in their lives and better achieve personal financial goals.

1 INTRODUCTION

In 2005 at Kenyon College in Gambier, Ohio, David Foster Wallace gave a commencement speech which began with a joke where one fish asks, "How's the water?" to which another fish replies "What is water?". This is an apt metaphor for the role that finances and financial concepts play in our lives. Some people are aware of them and their ubiquity, while others are less conscious of finances and their impact. However, regardless of awareness, finance is a topic that permeates modern day life. The vast majority will be forced to manage liabilities such as credit cards, student loans, and mortgages throughout their life. They will make financial decisions in the midst of interest rate data, depreciation schedules, and tax-favorable savings vehicles. Their understanding of the financial system will have a real, measurable impact on how well they are able to navigate that world and the success they are able to find on the other side of those decisions.

One study by van Rooij, Lusardi, and Alessie on financial literacy in the Netherlands found that the dif-

ference between the 75th and 25th percentile of people on the financial literacy index is approximately €80,000 in net worth, close to \$100,000 USD at the time of this writing (van Rooij et al., 2012). Other analyses of the current literature by Mandell have concluded that "results suggest that financial knowledge is related to self-beneficial financial practices". Mandell also notes that "25 percent of undergraduate college students have four or more credit cards and about 10 percent carry outstanding balances between \$3,000 and \$7,000." The imperative of financial education is not lost on educators. They see the difference education makes and understand that they must arm students with the knowledge they need to handle these commonplace scenarios.

The term "21st Century Skills" is used to describe the wide-ranging body of skills, knowledge areas, and core competencies required to succeed in 21st century society and workplaces. There is still debate as to exactly how to define and categorize the skills exactly. However, most frameworks include financial literacy among the required competencies, including The Partnership for 21st Century Skills Framework.

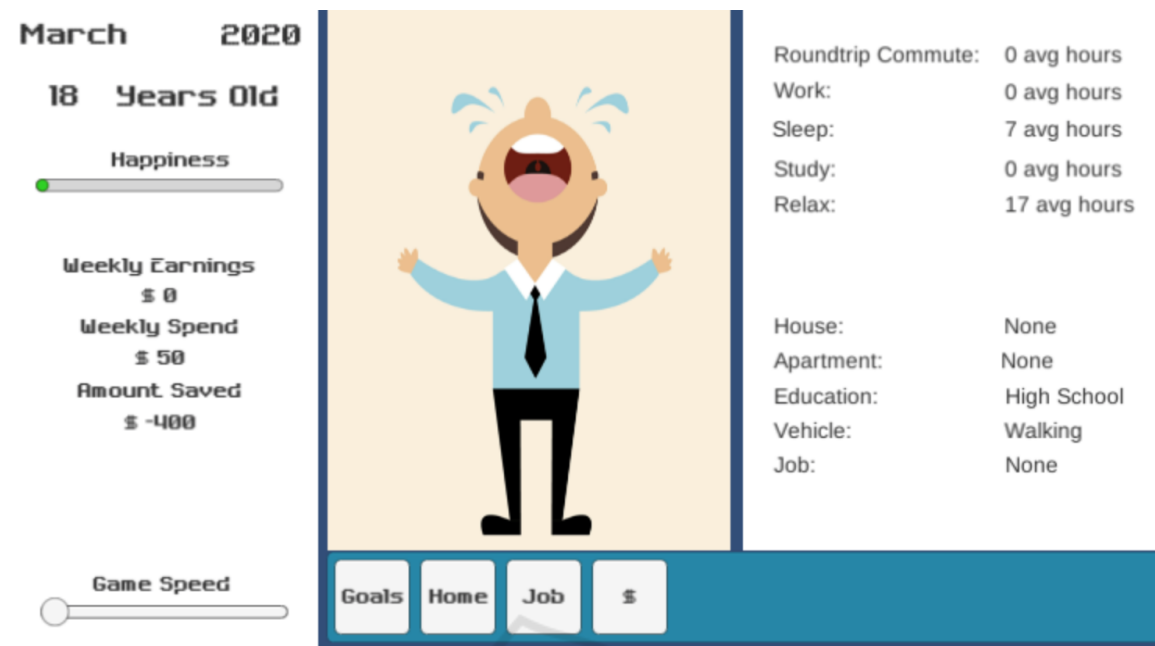


Figure 1: Simulation Screen. The left panel shows the current weekly status with a slider to adjust simulation speed. The center panel is a visual representation of their current level of happiness. The right panel provides details about their quality of life. The buttons on the bottom enable them to make life choices.

While there are multiple organizations pushing educators to adopt different 21st Century skill frameworks, P21's conceptualization of 21st Century skills is more detailed and more widely adopted than any of the alternatives (Dede, 2010). To further define this set of skills, we can also look to The Jump\$tart Coalition for Personal Financial Literacy, which defines a set of financial literacy standards in their publication of "National Standards in K-12 Personal Finance Education" (k12, 2015). It is from here that we can find more granular definitions of financial skills to focus on building and assessing.

With regard to assessment, one interesting finding by Mandell (Mandell, 2009) on financial literacy acquisition is the observation that personal finance courses in college and high school don't have a strong impact on the student's long term financial literacy as assessed by traditional testing, but they do have a positive impact on some areas of financial behavior. This suggests that assessment using traditional multiple choice and short essay questions may not be the most effective way to measure the long term impact of a financial literacy intervention.

It is the responsibility of educators to adapt and create new content and pedagogies for ensuring the success of students. Educators do not need to train the next generation of students how to use the latest technology, but as Marc Prensky says, they do need to move away from the "old" pedagogy of teach-

ers "telling", to the "new" pedagogy of kids teaching themselves with a teacher's guidance (Prensky, 2008). Game-based learning is one of the pedagogical approaches that fit this vision (Malone, 1980; Gee, 2003). It is the intent of this paper to propose that educational games are an appropriate activity for K-12 classroom instruction and that they are potentially a very effective medium for teaching financial concepts and increasing desired financial literacy learning outcomes.

In this paper we present an initial version of a game to teach students to make effective financial decisions in their lives. Fig. 1 shows the initial screen after the student starts the game when they are 18 years old with no job and no housing.

2 RELATED WORK

There is a rich body of existing research on educational games ((Malone, 1980; Gee, 2003; Mandell, 2009; Kafai, 2006; Allery, 2004; Habgood and Ainsworth, 2011) and the game this paper proposes leverages many of these general educational game design concepts. Habgood discusses the value of intrinsically integrated games which fully engage the student and in which the learning is intrinsically embedded within the structure of the game itself. As the player explores the gaming world they are also explor-

ing the conceptual world of the learning domain, and their interactions with the game correlate to deepening their understanding of these educational concepts (Habgood and Ainsworth, 2011). This type of gameplay seems ripe for financial skills as it puts their application at the forefront of the game strategy rather than as an ancillary detail, thus encouraging more interaction with the skills.

Understanding what makes a game effective is important in design. Gunter proposes a unique rubric (RETAIN) for scoring educational games on their ability to engage learners and affect learning outcomes using the following six weighted factors: relevance, embedding, transfer, adaptation, immersion, and naturalization. (Gunter et al., 2008). This work informed many of the choices made during the game design phase and informs many of the proposed improvements to be made to the gameplay experience in the future. In particular the initial game focuses heavily on some of the highest weighted factors of naturalization and adaptation, forcing players to synthesize the multi-faceted financial impact of their decisions on concepts that they are already familiar with from everyday life. Sweetser and others have also proposed models for evaluating player enjoyment in games (Sweetser and Wyeth, 2005; Sweetser et al., 2012) and this is an active and important area of research in educational games.

Another important concept in game-based learning is the difference between instructionist and constructionist games. Kafai, in discussing technological literacy (Kafai, 2006), argues that fluency in a domain is more than just being able to recall definitions and solve standardized problems, it requires the ability to use these skills and concepts to impact the world in significant ways. For technological literacy this entails building computational artifacts, for financial literacy it corresponds to making effective life choices in a real or a game-based context. By leveraging constructivist principles this game hopes to empower learners to develop and transfer in-game skills to the real world.

The importance of feedback cycles in gameplay has been well-documented. Linehan notes that effective games provide players with a variety of different rewards whose effects on the player are easily evaluated (Linehan et al., 2011) and computer games are well-suited to deliver because they can continuously monitor the player's interactions with the game and estimate which rewards are most effective, educationally. While this particular type of dynamic feedback cycle was deemed out of scope for the initial game, providing clear visual feedback to reinforce positive behaviors certainly plays a role in guid-

ing learners through their decision-making as they explore the simulation game space. All of this existing research was taken into account when determining the exact pedagogical design goals of the pilot game.

3 PEDAGOGICAL DESIGN GOALS

The overall goal of this project is to merge learnings from existing research around educational game effectiveness, traditional game design, and personal finance education to create an education experience that effectively teaches students the 21st century finance skills outlined by The Partnership for 21st Century Skills Framework and further detailed in "National Standards in K-12 Personal Finance Education".

In particular we focus on the following "Spending and Savings" skills:

- Spending behaviors and habits affect personal satisfaction.
- Use income to meet current obligations and future goals.
- Every spending and saving decision has an opportunity cost.

The game is purposefully designed as an "intrinsically integrated game" as described by Habgood which means that it "delivers learning material through the parts of the game that are the most fun to play". The results of their studies provide strong evidence to support the benefits of such a game, with the children exposed to the intrinsic game making the most learning gains of any group in the study (Habgood and Ainsworth, 2011).

Another design goal of this project is to engage students in a way that they identify as the main character. This is achieved in the few ways. First, by forcing the learners to choose their own financial goals, they can take ownership of helping the character achieve those goals. We also build some ownership specifically by avoiding common ownership pitfalls as described by Shirts including "assigning attitudes and values along with the role", "determining consequences with a model which the participant feels is inappropriate or inaccurate", or "making the choices obvious so the consequences have little meaning." (Shirts, 2013). Fig. 1 shows the initial screen shot from the simulation phase when the player has no job and no housing. It accurately captures the mood of many students as they transition from high school to college or a working life.



Figure 2: Welcome screen and First Life Goal Screen. The player is given a general overview of the goal of the game and must start by choosing life goals which cannot be changed during the game play.

As stated earlier in this paper, traditional college courses on personal finance do not seem to have a significant impact on financial literacy, but they seem to have some impact on financial behavior (Mandell, 2009). We propose that the reason finance courses do not impact literacy in the same way that they impact behavior is the lack of application. By creating an intrinsic game where students must set goals and employ financial skills to achieve them they will have more grounded learnings that carry with them into real world scenarios. We also hypothesize that such a game can be used for assessment as a better proxy for real world outcomes than existing financial literacy assessment, which is typically exam-based.

By leveraging these design insights in the pilot game we hope to see students applying many of the stated 21st Century finance skills in conjunction with each other. It was important to ensure that the game was not simply one in which the student grinds out the maximum amount of money to win, but instead makes choices and uses financial tools to achieve their personal experiential goals while maximizing their average and final happiness.

4 INITIAL GAME DESIGN

Each game can be completed in a few minutes and we assume that each user will play the game multiple times. The game¹ is divided into three phases as follows:

- pregame phase is where the player selects their personalized life goals for the game,

¹The initial version of this game can be played at <https://21centurygames.github.io/>

- simulation phase is where they make decisions that effect the quality of their life,
- endgame phase is where the salient results of their simulated life are summarized.

4.1 Pregame

In the pregame screens shown in Fig. 2, the player is given a light narrative of what's to come, priming them for the decisions they will need to make on the next screen. Once they have started the game they are immediately asked to set some life goals for their avatar. The current version has only two types of goals:

- living style (urban, suburban, rural)
- education (BA, MA, PhD)

There is purposefully little direction here as to the importance of this selection and its impact on the game to encourage players to select goals that map to their own goals rather than choosing goals to influence any in-game objectives. One of the goals of the game is to help player explore the consequences of real-life decisions. In particular, getting a higher level of education increases the opportunities for employment and the potential for a higher annual salary. Likewise, living in the country results in a fewer job opportunities or longer (and possibly prohibitive) commute times. The commute times can be ameliorated by purchasing a car, but this requires savings. These consequences are not explained in the pregame screens; players will discover these consequences when they look for a job and see how their income compares to their expenses.

4.2 Simulation and Player Agency

After selecting their goals the simulation begins and the player is shown the Simulation Screen in Fig. 1. The simulation screen can be divided into 4 sections. A fluctuating data section on the left, an avatar section in the middle, a decision result section on the right, and an action section along the bottom. In the fluctuating data section the player can see the current date and the avatar’s current age, as well as what things happens as time passes. The amount they earn and spend impacts how much savings they have. Their overall happiness monitor ebbs and flows as they make decisions in the game and attempt to achieve their financial goals. In the avatar section a simple avatar reflects the current mood of the player as shown in Fig. 3. The image changes in concert with the happiness bar to provide an emotional indicator to the player as to how they feel about their situation.

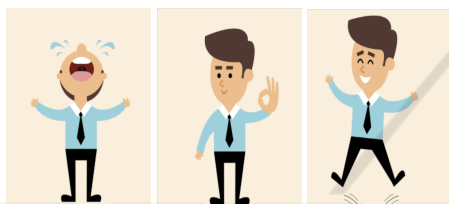


Figure 3: Three visual levels of avatar satisfaction. The sad figure indicates life threatening situations such as homelessness or working/commuting with no time to sleep. The happy figure indicates that the avatar’s lifegoals have been achieved.

In the decision result section the player can see the current state of their choices, some features are directly in their control and some indirectly. For example, they can choose to own a vehicle and live in a certain place (direct choices). This section will also show things like time spent commuting (an indirect outcome of their transportation choice, home location choice, and work location choice).

Finally, the action section consists of a series of buttons that allow the player to make their in-game decisions about where to live, what jobs they want to have, and what items they want to purchase. They can also control the speed of the game, slowing down gameplay to make a handful of decisions and then speeding it up to see how those decisions impact their avatar over time.

The simulation ends when the avatar passes away. The precise time of death for the player’s avatar is based on the latest statistical data about average lifespans in the United States (nat, 2006), wealth is not factored in to the lifespan calculation, though it might be more accurate to include poverty as a negative impact factor on lifespan.

4.3 EndGame

When the avatar’s simulated life is over, the game displays a summary screen which the player can use to judge whether they have lived a successful life. A sample screen is shown in Fig. 4. The summary screen currently shows average and final happiness as well as the number of goals met, but does not indicate how much money, if any, they had saved. After playing the game a few times, it becomes clear that the goal is to meet your goals and attain the highest average and final happiness.

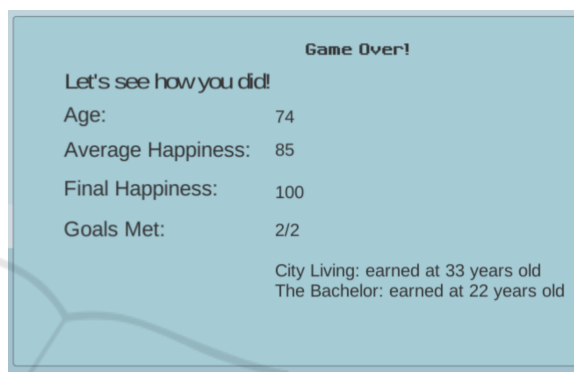


Figure 4: Summary Screen showing results of the simulated life.

5 GAME ARCHITECTURE

We decided to use an industry standard game engine, Unity3D, to encourage future improvements to the game’s visual aesthetic. By using a fully featured game engine we have the flexibility to take the underlying simulation code and map it to any number of visual representations. For this initial pilot the visuals are simple, but the path to future UI enhancements is straightforward using the Unity framework. Each object in the simulation has a corresponding display object that is 2D for this pilot game, but to create and integrate 3D objects would not alter the backing simulation in any way.

Under the hood the simulation leverages a consistent interface pattern, which allows future developers to register new types of game objects and integrate them easily into the simulation. The most prevalent example of this is that each game object implements its own “onTick” function that is called each time the simulation moves forward in time. This allows each game object to manage its own simulated state. What that means for development is that each object’s simulation can be made as complex or simple as desired without altering the rest of the system.

The final major architecture choice that enhances our ability to improve upon the game design is the use of Unity3's scriptable objects. By designing object templates it is trivial to test many variations of the game using new values. It is possible to have people not familiar with the underlying code generate these objects and put them into the game. This is an effective way to test difficulty levels when tuning the game for general use or for a particular player demographic.

6 CONCLUSIONS

The existing research shows that there are key strategies that can be employed in game design to enhance learning outcomes and keep players engaged with the game content. There are also many standards bodies designing skill-based outcomes to be used assess students abilities to learn new skills for which there is no standard curriculum. However, since current assessments of financial literacy are not strongly impacted by traditional teaching methods it is reasonable to apply findings in effective educational game design research to 21st century financial literacy skills in an attempt to give students alternative ways to exercise financial skills and potentially to evaluate financial literacy. The pilot game designed is one such attempt that can be iterated upon with user feedback to approach achieving those outcomes.

7 FUTURE WORK

In the future our plan is to run a pilot study to assess the effectiveness of this approach in producing positive learning outcomes, and to expand the scope of the game play to include additional 21st Century Skills

7.1 Gameplay Tuning

A critical phase of game development is the playtest phase. This helps to tune many of the nuances of game mechanics. Allowing the designers to adjust and tweak small things like the cost of items, scoring mechanisms, and game tempo. It can also result in larger changes like redesigning the user interface. Since the game has yet to enter this phase of development it should be expected that there are many improvements to be made which are not yet known and will be discovered through playtesting and user feedback.

It is important to consider the balance of traditional playtesting and expected learning outcomes. That is one area where having the financial skills as an

integrated game mechanism helps ease some of this tension. One does not need to sacrifice educational content to increase playability. Also, in terms of balanced gameplay, a financial game is unique in that it can draw much of its data from the existing markets that are naturally balanced. Using up-to-date salary, housing, and commercial goods pricing data ensures the proper balance but also increases the realism of the game and the likelihood that skills are transferable outside of the game.

The biggest area where the game, in its current state, feels to be lacking is the level of immersion. This is probably the most challenging part of designing a game around an abstract concept such as finance. With other simulation games like SimCity, the visual construction integrated into the gameplay experience effectively immerses players in the game. With abstract simulations there is no natural immersion so it is up to the game designer to determine how to incorporate the gameplay elements in an immersive way. The game could, in theory, be played inside of a robust excel spreadsheet. It is paramount that playtesting phase garners feedback in how to make the game more immersive to keep players engaged long enough for learning to take place.

7.2 The Challenge of Assessment

A valid assessment of skills is paramount to understanding the educational value in playing this game. It is not clear from the literature exactly what financial literacy assessments were used in evaluating financial literacy claims discussed by Mandell, but if financial courses are not significantly impacting financial literacy scores but are, however, positively impacting some financial habits of individuals then it is not an unreasonable conclusion that we may be evaluating based on the wrong criteria. Using a more traditional pre-test and post-test method may still be a reasonable approach but more investigation would be necessary to ensure that we do not fall into the same trap of evaluating literacy skills as having not improved despite observing the positive application of those skills (which is the true intent of the instruction).

Since the game itself requires players to exercise financial skills and understand financial concepts it is possible that the results a player achieves in the game can be a reasonable proxy for skill and knowledge acquisition. Let's take a look at the three granular financial concepts targeted by the game and how gameplay could be used to evaluate them.

The players ability to increase the happiness of their avatar requires an understanding of how "spending behaviors and habits affect personal satisfaction".

The richer and more complex the spending and life-action options that are made available to the player, the more connections to this skill they will be forced to make. Assessing the players' final happiness scores as well as how quickly they are able to leverage spending and habits to get such scores will indicate a mastery and understanding of that skill.

Similarly, achieving goals is a main mechanism of the game and the primary way to build in-game happiness. Thus, measuring how quickly players are able to achieve certain in-game goals is a very good proxy for their development of the skill of "using income to meet current obligations and future goals".

The last piece of understanding, where "every spending and saving decision has an opportunity cost" is not as directly integrated into the game mechanics as the first two. The game does require certain milestones to be met before some actions are available, for example needing a bachelors degree before getting access to certain jobs. Players are forced to make the trade-offs between spending money on education to access those jobs and saving money for items like vehicles to help them commute faster to jobs. As a matter of course players engage with these decisions and players who do well in the game are those who are able to manage opportunity costs appropriately. One way in which using gameplay results as an assessment of this skill could be correlated more strongly would be giving the players differently balanced games and seeing if they still make the same trade-offs. Players who do well in all versions of the game could be said to understand this financial concept.

While the assessment of skills and understanding is one thing, an open question remains as to the transferability of in-game skills to real life. Using more longitudinal observations of players real life financial activities would allow for even stronger evidence that the game itself and the virtual application of real financial tools is an effective method for teaching and evaluating the understanding of those tools.

7.3 Feature Enhancement

There are many future improvements that would be interesting to explore in this field. The decision to pursue any of these should be informed by the initial results of the pilot study. However, some possible areas of exploration that likely make sense are:

- The usage of closed loop feedback systems to keep learners in the zone of proximal development.
- Using socio-economic status starting situations to build empathy for others as well as to be able to better reflect the student in the avatar.

- Using existing data and statistics to more accurately simulate market conditions and provide a more realistic experience for the players.
- Include more immersive game elements, both aural and visual, to make the student more engaged with the content.
- Leaning on the RETAIN model, including more immersive game elements, both aural and visual, to make the student more engaged with the content.
- Focusing on improving the transferability of in-game skills (another improvement born of the RETAIN model).

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