Utrecht University

MASTER THESIS HUMAN-COMPUTER INTERACTION

Data Visualization in Higher education Financing: Aiding Student Loan Decisions

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Abstract

This study has investigated the impact of data visualization on decision-making and financial self-efficacy in student loans. Interviews have revealed a simplistic decision-making process of students when taking out a student loan, primarily focusing on the present gains while neglecting the future consequences. Due to the multitude of factors influencing student loans and the inadequacy of current tools in illustrating the impact of each variable, a new data visualization tool called StudentViz has been created to assist students in making informed student loan decisions. StudentViz allows students to add various loan plans based on certain inputs and visually compare the important characteristics of each loan plan to gain a better understanding of the future consequences of loan decisions. An insight-based evaluation in combination with interviews has revealed that StudentViz supports the exploration of the effects of different factors, for example interest rates. Moreover, users of StudentViz scored high on financial self-efficacy indicating they believe they have the capacity to make informed student loan choices, but further research is necessary for definitive conclusions. All in all, StudentViz provides students with a deeper understanding of the repercussions of specific loan decisions, potentially empowering them to make more informed choices.

Contents

1 Introduction

Many students find it necessary to borrow money for tuition, rent, school supplies, food, leisure activities and other expenses. Student loans have been around for a while. The first student loans were offered in 1840 to students attending Harvard University [48]. Recently, the total student debt amount has been increasing rapidly. While the American student loan debt surpassed the $800 billion mark in 2010, it is now nearing $2 trillion [8], with the average federal student loan standing at $37.574 [1]. The United Kingdom has the highest average student debt, where students are expected to graduate with an average debt of £50,000 [83]. American student loans account for the second largest form of debt after mortgages [75]. It is estimated that 3 in every 10 households acquires a student loan to pay for college. Repaying student loans will take most people a long time: Americans who are 50 years and older hold nearly a quarter of the total student loan debt, indicating that student debt is a multi-generational problem [50]. The rise in student debt is also present in the Netherlands, where the total student debt increased by almost €14 billion between 2015 and 2022, which is an increase of more than 100% in recent seven years [12].

More students are attending college, and students are also staying in college for longer periods than before [64]. In addition, tuition costs have increased resulting in more students needing to borrow money for college [124]. For example, law school tuition in America has increased by 60% in the last 15 years [103]. The increase in the average student loan is also reflected in the expected payment-to-income (PTI) ratio, which is defined as the ratio of required debt payments to disposable income [15]. Artavanis et al. showed in their study that 30.3% of American students participating had an expected PTI ratio above 10%, which is considered very high [15]. This may cause long-term financial troubles for graduate students.

In the Netherlands, the increase in student debt can partly be explained by policy changes implemented in 2015 [119]. Until then, students received grants which were converted into gifts when a student graduated within 10 years. Following September 2015, the finance system for higher education underwent a transition towards a loan-oriented approach, leading to a rise in the number of students requiring loans and an increase in the average loan sums [119]. In order to prevent the heavier reliance on student loans from becoming a barrier to accessing higher education, the Dutch government

implemented various measures aimed at minimizing the impact of student loans on students' future disposable income. Student loan terms were made more lenient. These measures included extending the maximum repayment period from 15 to 35 years, adjusting the minimum monthly repayment based on household income, and temporarily setting the interest rate at 0% for the years 2017, 2018, and 2019 [5]. Furthermore, if a loan cannot be repaid within the maximum repayment period, the remaining debt will be forgiven. Despite their good intentions, these measures may have contributed, at least partially, to the rise in Dutch student debt observed in recent years [119]. The American government implemented similar measures. Individuals who earn below a certain threshold can apply for one-time debt relief. Eligible borrowers can get a full or partial discharge of loans up to $20,000.

While the implementation of more lenient loan terms may have eliminated potential barriers for students entering higher education, these measures could also have unintended and undesirable consequences. A significant concern is that these relaxed loan terms may encourage students to borrow more than necessary, resulting in greater debt burdens than strictly required. Findings from a comprehensive survey conducted among Dutch higher education students revealed that excessive borrowing is indeed a valid concern. Among students with a student loan, 54% utilized a portion of their loan for savings, 36% stated that they could still manage financially if they borrowed less, and 31% determined their monthly loan amount by simply opting for the maximum available [4]. These findings suggest that students' loan size decisions are not solely based on the actual amount of money needed for their higher education studies, and that Dutch students are structurally overborrowing [119].

Students may have a lesser understanding of the influence of a loan on one's future disposable income. According to Van der Werf and Warnaar, when obtaining a consumer loan, the borrowed sum is frequently tailored to a particular purpose, such as purchasing a car or funding home improvements [118]. In such instances, the majority of borrowers have typically predetermined the precise loan amount prior to applying for the loan. However, determining the loan amount for a Dutch student loan is not as simple. Unlike other types of loans, Dutch students do not request a specific total loan amount. Instead, they request a monthly loan amount. Frequently, students make this decision at the start of their studies, when they are unsure of their actual financial needs to cover their expenses. This uncertainty complicates the process of determining the precise monthly borrowing amount in advance

[119]. In addition, students often do not know exactly how many years they will study since there is always a chance of getting delayed or choosing a different career path that takes longer. Moreover, students make loan decisions when they do not know exactly what career they will pursue and what their future income will be. Lastly, throughout the accumulation and repayment of a student loan, the interest rate associated with the loan can change once every year, and during repayment once every five years. This fluctuation in interest rates has the potential to significantly influence the effect of outstanding debt on the disposable income of students, even long after they have completed their studies [119].

In conclusion, there are a lot of unknown variables that can impact how certain student loan decisions affect someone's future financial situation. It is therefore important that students receive proper support in deciding on the size of the loan. Section 1.1 will explore the diverse range of consequences of having debt, stressing the importance of considerate decision-making. Next, available tools will be discussed in section 1.2 to identify strengths and points of improvements. How data visualization can be used to aid decision-making is discussed in section 1.3.

1.1 Consequences of student debt

The rising student debt can have multiple negative effects on the borrowers. This section will elaborate on the wide range of negative effects and stresses the importance of minimizing debt as much as possible. Section 1.1.1 will elaborate how having a debt postpones the time at which individuals own a house. Section 1.1.2 shows the big impact of having a debt on one's mental health. The relation between student debt and academic performance is discussed in section 1.1.3. How certain life choices are affected by having a debt is explained in section 1.1.4. Lastly, section 1.1.5 will explain that student debt does not only have negative consequences but that it also offers opportunities.

1.1.1 Home ownership

Mezza et al. studied the impact of student debt on home ownership [78]. Improving on previous studies related to debt and home ownership, Mezza et al. account for an extensive amount of confounding factors ranging from *unemployment rate, average weekly wages and house prices at the state level*,

to more personal factors like *Age at final school exit* and *Highest degree attained*. Results show a 1 to 2 percentage point decrease in home ownership for every 10 percent increase in student debt immediately upon college exit. Although the precision of the estimates decreases over time, there is little indication of the effect diminishing throughout the 60-month window after exiting college. In a more recent study, Mezza et al. rephrase the relation between student debt and home ownership as: "*$1,000 increase in student loan debt accumulated before age 23 (representing an approximate 10% increase in early-life borrowing) causes a decrease of about 1.8 percentage points in the home ownership rate students by their mid-20s*" [77]. This implies that a young adult's entry to home ownership would be delayed 1 year for every increase of roughly $3000 in student debt. Young adults who have recently graduated are often the group that wants to transition from renting a home or dorm room to owning their first home. Student debt can cause individuals to rent for a longer period of time, costing them even more money that otherwise could be invested into mortgages.

1.1.2 Mental health

Many studies have investigated the relationship between stress resulting from personal indebtedness and the development of mental health problems. A considerable portion of this research has employed extensive quantitative surveys among students to assess whether a correlation can be observed between student debt and various objectively measurable indicators of mental health [83]. Most studies find that students with higher financial concerns tend to have worse mental health attitudes [27]. An interesting finding found across multiple studies is that, in relation to the impact on mental well-being, the perceptions of student debt are more important than the actual levels of debt [83, 27]. Some studies found that levels of perceived stress are also related to feelings of shame.

A mental health survey conducted in 2021 including 2300 high-debt graduated students even revealed that one in fourteen participants experienced suicidal thoughts at some point during their repayment period because of their debt [67]. This is an increase compared to 2019, where in the same survey one in fifteen respondents experienced suicidal thoughts. The effect is moderated by the Debt-to-Income (DTI) ratio. Individuals with a DTI of more than two, indicating the debt amount is more than two yearly salaries, were more likely to experience suicidal thoughts than participants with a

DTI below two [67].

1.1.3 Academic performance

Higher amounts of debt are associated with higher levels of perceived financial stress [72]. This effect is consistently found throughout research in different study domains [22]. Baker et al. showed that higher financial stress was negatively associated with Grade Point Average (GPA) [17]. In their research, students' GPAs were asked twice, with a one-year interval between assessments. Initially, students with higher student debt levels exhibited significantly lower GPAs compared to those with less debt. Furthermore, within the span of a year, students with higher debt experienced a notable decrease in their GPAs, whereas the GPAs of students with lower debt remained consistent. The authors argue financial stress may reduce cognitive resources and academic engagement of college students and therefore negatively impact academic performance.

In addition, some students are taking on excessive employment during the academic year as a result of increasing living costs and the need to reduce debt, which is a significant concern [83]. High rates of employment during college are associated with worse academic performances and an increased rate of drop-out [16]. Moreover, the type of employment is often not in their field of study and therefore does not contribute to their future career.

1.1.4 Life choices

Studies have shown that student debt affects some important choices students have to make, for example, what major they want to follow. In a study by Morra et al., 54% of students indicated choosing a higher paying speciality as it will make you more money and will pay off your debt faster [81]. The remainder of the participants indicated choosing a certain speciality since its duration is shorter so they can start paying off their debt earlier. A study by Grayson et al. also showed that medical students with high debt choose more high-paying specialities [49]. Interestingly, the high-debt students placed more value on the anticipated higher income compared to low-debt students. Another study found that graduates with student debt were less likely to choose low-paying public interest jobs [103]. Graduated lawyers with high student debt are more likely to accept higher-paying jobs in the private sector compared to lawyers with lower student debt [103]. This shows that student

debt actively affects students' educational choices. It is not desirable for students to choose a career direction simply because it allows them to pay off their debt quickly, instead of choosing a direction because of personal interest.

Student debt also impacts marriage. Students with higher debts marry less often, and later compared to students with lower debts [46]. Furthermore, data concerning marriage expectations provides evidence of a correlation between educational expenditures, debt levels, and anticipated marital status. Students with a higher debt also expect to marry at a later time. This is because a lot of individuals want to be financially stable before committing to a marriage. The effect is larger for women than for men [103].

1.1.5 Student loans offer opportunities

Although there are many negative consequences of having debt, borrowing money to finance education is still considered a good investment that may lead to better job prospects [23]. A student loan enables students to learn certain skills that may be beneficial in their working career. Since a student loan provides individuals with the opportunity to invest in themselves, it is commonly referred to as 'good debt' [19]. Therefore, this section is not meant to demote individuals to go to college and take out a loan for it. Rather it urges students to be cautious about borrowing large amounts of money without good consideration. Considering all the negative consequences of having debt, it is crucial to minimize the debt burden and strive for its timely repayment.

1.1.6 Minimizing debt

The most practical approach to minimize debt is to borrow only what is truly necessary. This raises the question: how does one decide upon the optimal size of their loan? To make an informed choice, factors like current income, expenses, interest rates, the chance of dropping out, chances of being delayed during study, duration of the loan, the maximum amount of debt, and future earnings should all be considered. Since there are a lot of variables involved, it would be beneficial to visually present how these variables interact with each other and contribute to the final expected debt, and how repaying the debt impacts future disposable income. This way, students can get tailored

advice about the size of their student loan, so that ideally they should be able to pay all their expenses while still minimizing their debt.

Several interventions can help, such as policies, finance training, or financial advisors. This thesis will primarily focus on technological possibilities. This research aims at designing, building, and testing new technology to address the consequences described above. The next section will discuss several existing online tools that students can use to make student loan decisions.

1.2 Current available tools for student loans

This section will discuss tools that are already available for students. It is important to analyze what strengths the existing tools have and how they can be improved. Section 1.2.1 will discuss publicly available that are not created by government institutions, while section 1.2.2 will discuss two examples of tools created by the American and Dutch governments. How all the data in the tools is computed is discussed in section 1.2.3. Lastly, the limitations and challenges of the current tools will be discussed in section 1.2.4.

1.2.1 Non-government student loan tools

Several publicly available non-government tools exist [9, 7, 6]. In general, these tools mostly focus on repayment of the loan. Basic calculations based on the total debt amount, repayment period, and interest rate are made. These tools take into account certain regulations that apply to student loans based on nationality. For example, both The Netherlands and The United Kingdom cancel the remaining debt at the end of the repayment period if an individual is not able to repay it. One of these tools, called the UK Student Loan Calculator, includes some data visualization techniques such as line charts and pie charts to visualize the course of repayment and the proportion of interest on the entire debt paid [9]. This is displayed in Figure 1.

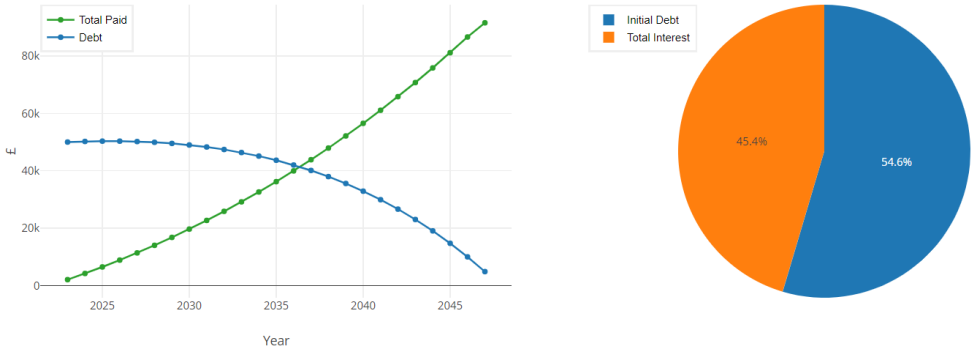


Figure 1: A line chart and a pie chart used in a publicly available tool for students. The line chart shows how the total debt decreases slowly in the beginning while the total paid amount increases more rapidly, indicating that the interest at the beginning is at its highest. The pie chart shows the proportion of total interest on the initial debt. Image from [9]

Another tool (Student Loan Payment Calculator) merely provides a simple bar chart displaying how the total debt progresses over time [7]. This is based on the total debt, repayment period, and interest rate. It also provides a textual description of the total debt in the form of: "The total lifetime costs of your student loans would be $X paid over X years.". This is a quick and understandable way to communicate the total cost of the loan, especially since the total amount paid and the number of years are displayed in a distinct color, as is displayed in Figure 2.

The total lifetime costs of your student loans would be $35,583 paid over 10 years.

Figure 2: A textual description of the total debt including interest. The total debt and the number of years are highlighted in a different color. Image from [7]

A tool called the Student Loan Calculator is meant for calculating American private student loans [6]. If a federal student loan is not sufficient, students can apply for an additional private student loan. This tool includes both a requirement analysis and a monthly repayment plan. Students fill in the costs of tuition, renting a room, and certain fees. Subsequently, they fill in their income based on scholarships, grants, financial contributions, and

federal student loans. Income is subtracted from expenses to estimate the size of the private student loan. The distribution of income and expenses is presented in a doughnut chart, which is displayed in Figure 3. A doughnut chart is similar to a pie chart, except the middle is cut out to display additional information. The doughnut chart automatically updates whenever changes are made to the income or expenses.

On the next page of the tool, information is shown regarding the repayment of the loan. A monthly repayment amount is estimated based on the loan type, loan amount, interest rate, repayment term, and years until graduation. The repayment is again displayed in a doughnut chart, showing the proportion of accrued interest on the total repayment amount.

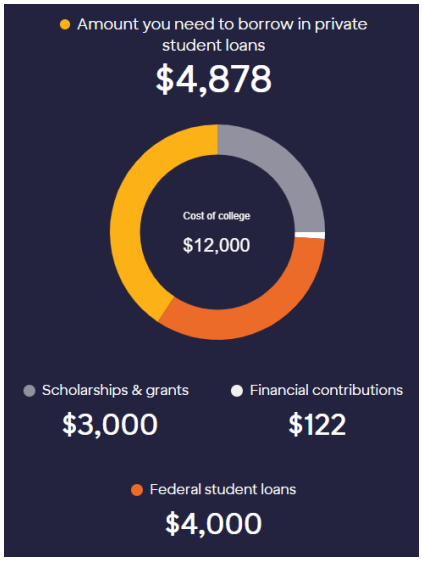


Figure 3: A doughnut chart displaying the distribution of expenses. In addition, it shows how much the user is short and therefore needs to borrow. Image from [6]

1.2.2 Overview of government loan tools

The review of the government tools is not exhaustive. Rather the American and Dutch tools will be discussed. The US example is discussed to show the relevance of the problem beyond the Netherlands. Later, this thesis will focus more on the Dutch tool and how it can be improved.

1.2.2.1 US government tool The American government provides students with a tool they call loan-simulator [3]. A simple calculator is available to calculate college expenses during a certain period. However, this only takes into account tuition costs, ignoring all the other costs like rent, social activities, school supplies etc. Students are left on their own estimating how much daily expenses they will have, how much they will earn during that time, and thus how much they should borrow.

The repayment part is more sophisticated. Once the student has acquired a rather simple estimate of the total debt, the student is provided a textual description in the format of: "If you borrow the amount above, we estimate you will pay about $220 per month over 10 years on a standard plan". The tool includes one visualization element: a line graph that shows how the total debt is expected to decrease throughout the years, with the time in years on the horizontal axis and the total debt amount on the vertical axis. The repayment data is mapped to a line graph. Figure 4 shows an example of this graph. When hovering over the graph, additional information regarding the outstanding debt, interest paid, and the total amount paid is displayed. A strong feature of the American tool is that it considers the expected salary rise. The U.S. Department of Education and U.S. Department of Treasury analysis expect that the salary of borrowers increases by 5% on average per year [3]. Most other tools do not take this into account.

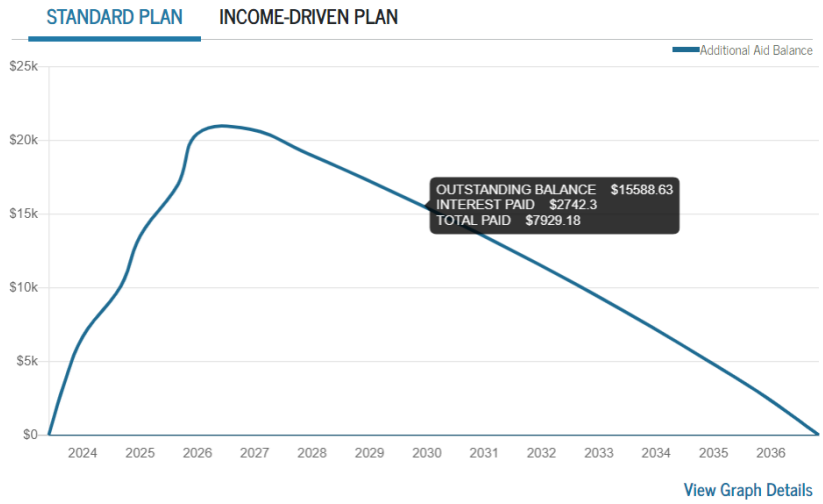
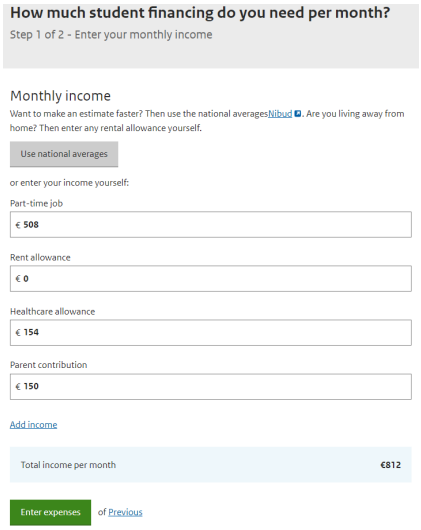


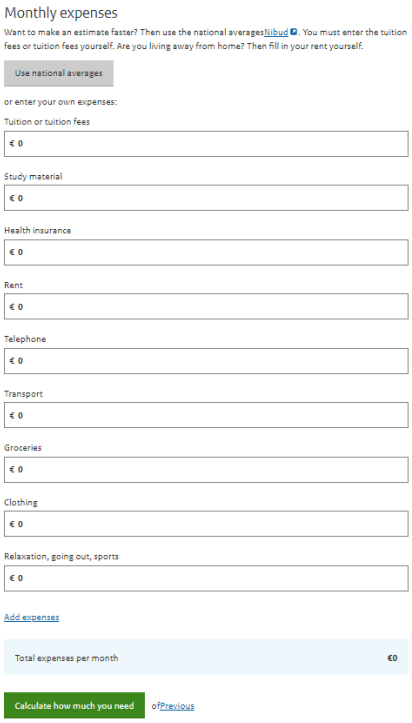
Figure 4: A line chart used to visualize repayment schedules in a tool created by the American government [3]. Hovering over the chart reveals additional information about the amount of debt paid.

1.2.2.2 Dutch government loan tool: DUO In the Netherlands, student loans are handled by the Dienst Uitvoering Onderwijs (DUO). DUO has provided students with a tool to calculate how much they should borrow (DUO-tool hereafter) [11]. Students fill in their income, which is divided into four categories (part-time job, parental contribution, healthcare allowance, and rent allowance). This interface is displayed in Figure 5. There is an option to add your own categories. Next, students need to fill in their expenses, also based on some predetermined categories (tuition, study material, healthcare insurance, rent, phone, transport, groceries, clothing, and leisure activities). Again, students can add other categories themselves. This is displayed on the right side of Figure 5. The suggested loan amount is calculated by simply subtracting the total income from the total expenses. For example, a total income of $1000 combined with total expenses of $1500, will result in a suggestion to borrow $500.

The DUO-tool offers some small features regarding repayment of the debt. On a separate page, a simple line graph is shown to display how the total debt decreases over time (Figure 6). Beneath, numerical data of the total



(a) The first stage of the DUO tool provided by the Dutch government. Income can be filled in based on certain categories.



(b) The second stage of the DUO tool provided by the Dutch government. Expenses can be filled in based on certain categories.

Figure 5: The income and expenses page of the DUO-tool. Both images are translated to English. Images from [5].

debt and repayment amount each month is shown. On the top, the total debt, interest rate, and annual income can be edited. The graph will adapt to these changes accordingly.

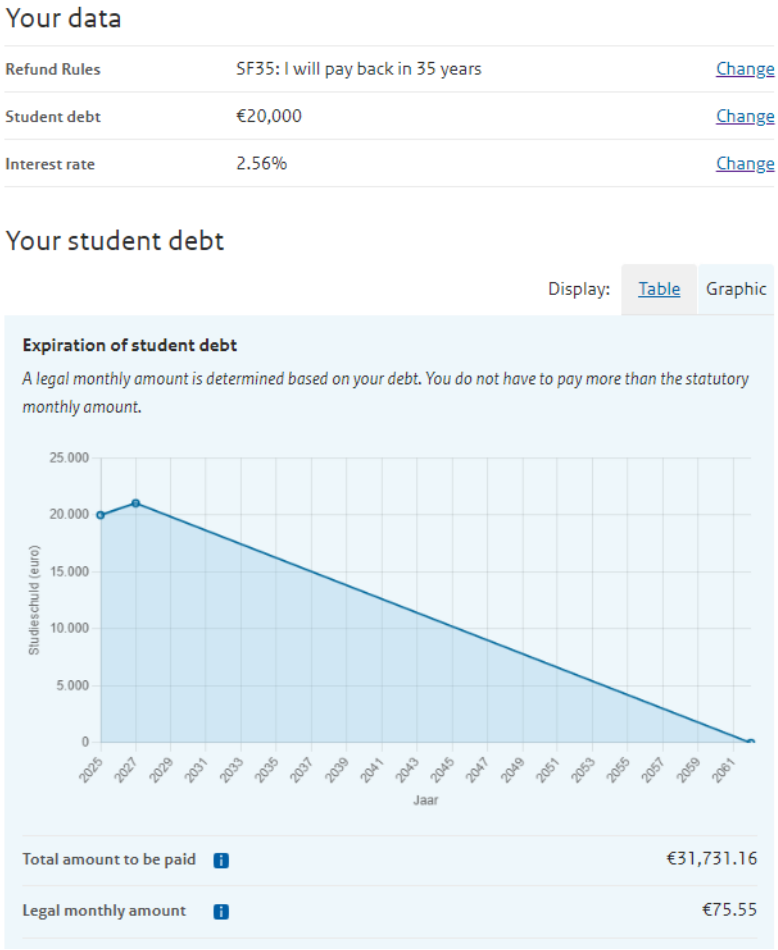


Figure 6: The line chart used in the DUO-tool. Image from [5]

1.2.3 Algorithms used

To understand how to effectively map data to visual outputs, we first need to understand what data is relevant to show and how this data is computed. The tools mentioned above will be analyzed, revealing what algorithms are used to compute the data. The data can roughly be divided into "requirements",

"total debt amount" and "repayment". The requirement is the suggestion the tool makes about how much the student should borrow. Total debt amount refers to how the final total debt is calculated. Repayment refers to the estimate of the monthly repayment amount.

The American loan-simulator only provides a simple calculator for the costs of tuition. This essentially only multiplies the number of years in college with the yearly tuition costs. However, the American education system is a bit more complicated since students can apply for or get offered a college grant, which pays a part or sometimes the entire tuition costs. In addition, it is not uncommon for American students to apply for a loan at a private bank, which has its own rules and regulations. Therefore, we will only focus on the loan-simulator tool which analyzes federal loans. Federal loans can be subsidized or unsubsidized. Subsidized loans are for undergraduate students with financial needs. This is the case when the cost of attendance exceeds the sum of expected family contributions and other financial aid such as grants or scholarships. Subsidized loans do not accrue interest during college. Unsubsidized loans are for both undergraduate and graduate students, and are not based on financial needs.

The total debt amount is calculated based on the time period of the loan and the interest rate. The monthly loan amount is multiplied by the number of months of the loan. What students often do not realize, is that interest often already accumulates during the loan and not only when repayment starts. In the Netherlands, the yearly interest rate is 2.56% (or 0.21% monthly). The following formula is used to convert yearly interest rates to monthly interest rates: $(x\% + 1)^{1/12} - 1$ where x is the yearly interest rate. During study, the monthly interest rate is added each month to the total debt amount. In America the interest rates are higher. The yearly interest rate for subsidized and unsubsidized loans for undergraduate students is 4.99% for the academic year 2022-2023 and is increased to 5.50% for the academic year 2023-2024. For graduate students the yearly interest rate is even higher: 6.54% for the academic year 2022-2023 and 7.05% for the academic year 2023-2024.

The monthly repayment amount depends on the total debt, the repayment period, and the interest rate. The initial monthly repayment amount is calculated by dividing the total debt amount by the number of months available for repayment. During repayment, the interest is added each year when one makes yearly payments, and each month if one makes monthly payments. The interest is paid on top of the repayment amount. Therefore,

often the repayment amount stays constant while the interest that is added on top will decrease over time. For example, the repayment amount might be 120$ each month. The interest is added on top of that and starts at 20$, putting the total repayment amount on 140$. As the total debt decreases, so does the interest. After a year the repayment amount is still 120$, but the interest has decreased to 10$, making the total repayment amount 130$.

Alternatively, some individuals prefer an income-driven repayment plan in which a certain percentage of one's disposable income is paid. The possible downside of an income-driven plan is that you might pay more interest, making small payments due to low income might be beneficial for your budget, but you end up spending more of your money on interest. Lastly, individuals with higher incomes can choose to repay a fixed higher amount each month. This way, the debt is repaid quicker and less interest will be paid.

In the Netherlands, the repayment amount is based on one's salary. This is called carrying capacity. It is meant to protect individuals who are unable to repay their student debt due to low income. If you are single without children, the disposable income threshold is 100% of the minimum wage in the reference year. In all other cases, it is 143%. The carrying capacity is 4% of one's income above the disposable income threshold. If the provided amount is insufficient to settle the debt within a span of 35 years, the remaining portion will be forgiven.

1.2.4 Limitations and challenges of current tools

The existing tools available are limited in their ability to aid students in making optimal student loan decisions. This section will elaborate on what aspects could be improved. It is important to identify the weaknesses in existing solutions in order to understand points of improvement.

1.2.4.1 Not including all relevant variables The tools discussed above do not include all relevant variables or the uncertainty in variables. For example, chances of being delayed during study or even dropping out of college are not included in any tool, even though it can have a big impact on the repayment of the debt. Being delayed one year means one extra year of borrowing money resulting in a higher total debt. Dropping out of college means more uncertainty about future income. Besides, in The Netherlands, some

grants will be converted back to loans if someone is unable to finish a study within 10 years.

The probability of future salaries is not communicated. Students are asked to estimate their yearly salary themselves without any more information. It would be advantageous for students to have access to the likelihood of specific salary ranges based on their chosen field of study.

Furthermore, the tools act as if interest rates are a constant. In the Netherlands, for instance, the interest rates on student loans can change every year and every five years during the repayment period. Ideally, students should be able to explore the effect of different interest rates.

Finally, the tools do not illustrate how repayment affects future disposable income. This aspect is of utmost significance to showcase as it can significantly influence one's quality of life. How much of one's monthly disposable income is required to repay the loan is important information, especially when this will last 35 years.

1.2.4.2 No adequate requirement analysis The main limitation of the tools not created by government institutions is that they solely focus on the repayment of the loan. Decisions regarding income and expenses and therefore the size of the loan are not taken into account. The tools treat the total debt amount as a static number that can not be influenced by the decisions of the user, focusing only on what repayment plan would be most beneficial. These tools unfortunately do not stimulate users to explore how their debt can be minimized.

Other tools resort to very basic requirement analysis, only taking into account the costs of tuition for example. This completely neglects other costs like rent and leisure activities. The US loan-simulator tool asks users themselves to estimate the total debt at the end of their study or to enter the average debt of students based on what state they attend college. It might be hard for students to make these estimations without any support. The DUO-tool on the other hand offers a more elaborate requirement analysis, forcing students to think about their monthly income and expenses.

1.2.4.3 Limited interactivity A limitation the DUO-tool are that income and expenses are separated from the total debt amount and repayment part, as they are displayed on different web pages. This way, students are not able to interactively see what impact certain changes in income and expenses

have on the total debt amount and repayment of the loan. This is done better in the Student Loan Calculator tool [6]. The doughnut charts react immediately to changes in income or expenses. This allows for easy comparison and enables to user to investigate the consequences of minor changes.

In addition, the line chart used in the DUO-tool does not offer any interaction. Hovering over the line chart does not show more detailed information on for example the total debt amount at a specific point in time. This would be valuable information to display to users.

1.2.4.4 Impact of decisions All the tools discussed in section 1.2 do not facilitate exploring the impact of certain decisions. For example, when wanting to see the impact of borrowing 50 euros less each month on the monthly repayment of the loan, users need to remember each alternative. No side-by-side comparisons can be made between the two situations. This makes it harder for students to identify the precise relations between all the variables included. Comparing different loan plans side-by-side gives users more insights in the consequences of certain decisions.

1.2.4.5 Biased decision-Making Van der Werf et al. argued that the DUO-tool created by the Dutch government leads to biased decision-making since it only focuses on the benefits of the loan and the fact that by default the monthly loan amount remains the same until it is terminated [119, 5]. To address this, van der Werf et al. studied different types of interventions that informed students about the future impact of their student loans and how easy it is to adjust them. The goal of these interventions was to urge students to recalibrate their monthly loan amount based on their needs. The field study, performed in 2019, contained almost 50.000 Dutch students.

Students were randomly assigned to one of five conditions: control, total debt, monthly repayment, plain letter, and plain email. Participants in the total debt and monthly repayment condition were provided with detailed and personalized information regarding their existing debt and projected debt at the time of graduation. The information was presented in a combination of text and visualization. An example of the visualization is shown in Figure 7. Participants in the monthly repayment condition received additional information about their expected future monthly repayment and at what age the entire loan would be repaid. Participants in the plain letter and plain email condition only received a link to the website of the DUO-tool with some

explanation of how to use it. The control group did not receive anything.

Results showed that students who received the most detailed personalized information about the future costs of their student loans were more inclined to recalibrate their loans. More specifically, these students were more likely to decrease their monthly loan amount to a larger extent. This study shows the importance of providing students with detailed information about the future impacts of student loans, instead of solely focusing on the current benefits of the loan [119]. This could counter overborrowing and reduce biased thinking of students when they apply for a student loan.

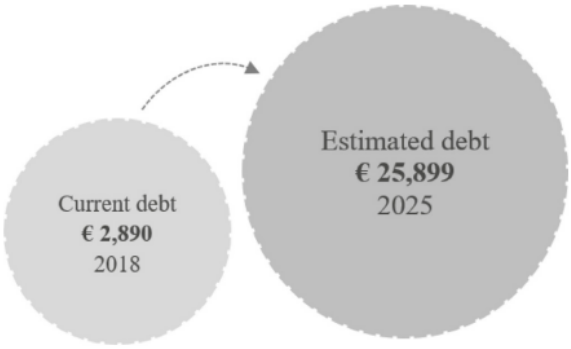


Figure 7: An example of visualization of expected debt used in van der Werf et al. [119]

1.2.4.6 Numeracy and financial literacy Most information in the tools is conveyed to the users as numerical data. This could be troublesome for individuals with low numeracy. Numeracy, also called mathematical literacy, is the understanding of ratio concepts, notably fractions, proportions, percentages, and probabilities [21]. Individuals with low numeracy have a hard time understanding relationships between numerical data and how certain data is computed. In addition, people with low numeracy often overestimate risk probabilities [125], and are more susceptible to other factors like mood states, framing effects, and feedback from others [44]. Importantly, people with lower numeracy are less likely to infer the meaning of numbers [90].

Levels of numeracy are relatively low in the general population [117]. A national survey performed in 2010 showed that 30% of the general American

population cannot transform 20 in 100 into a percentage, and a staggering 75% cannot transform 1 in 1000 into a percentage [43]. Although high numeracy is associated with higher education, also highly educated people can be less numerate [66].

Skagerlund et al. showed that numeracy was the strongest predictor of financial literacy [107]. Financial literacy is the knowledge of financial concepts such as inflation, interest rates, and risk diversification. Financial literacy is becoming more important since individuals have been getting more responsibility regarding mortgages, retirements, but also student loans [70]. Financial literacy is correlated with better financial decision-making. Research has shown that many individuals around the world are financially illiterate based on measurements of financial literacy [69]. These measurements contain basic questions about financial concepts like borrowing, investing, and protecting resources (e.g. risk management techniques or insurance) [57].

Mainly presenting information in numerical format may lead to lesser comprehension in students with lower numeracy and financial literacy. One way to resolve this issue is by presenting the information in another format. Data visualization presents data visually rather than numerically and is extra helpful for individuals with low numeracy [70]. Data visualization can help shift information processing to the perceptual system [70]. This allows individuals, also with low numeracy, to better understand relationships between data and make meaningful inferences. Effective data visualization can aid both individuals with high and low financial literacy in financial decision-making, especially when there are multiple variables influencing one another. The next section will elaborate more on the advantages and challenges of data visualization.

1.3 The potential of data visualization in student loan decision-making

This section will discuss data visualization and how it may be used to support students in student loan decisions. Section 1.3.1 will provide an explanation of data visualization and outline the advantages it provides. Next, section 1.3.2 will show the relationship between data visualization and self-efficacy. A simple example of data visualization regarding student loans is presented in section 1.3.3. Finally, the challenges of designing an effective data visualization tool are discussed in section 1.3.4.

1.3.1 Advantages of data visualization

Compared to numerical data, data visualization can reduce cognitive overload and allow for easier comprehension of data. One major advantage of data visualization is the huge amount of information that can be rapidly interpreted if presented well [123]. Data visualization maps data to visualization techniques. Colin Ware defines it in his book as: "A graphical representation of data or concepts" [123]. It allows the processing of a lot of data at once, in stark contrast to the limitation of reading handfuls of data. Anscombe quartet demonstrates this in a nice example [14]. The top of Figure 8 shows 4 sets of 11 coordinate values. Seeking patterns within each set, or comparing values of different sets takes a lot of time, and progressively becomes more difficult. In addition, these tasks exhaust memory capacity, resulting in new numbers or patterns displacing ones that were previously seen [41]. The cognitive overload resulting from large amounts of numerical data can lead to worse comprehension of the data.

Due to the constraints in the symbolic processing of numbers, viewers tend to rely on summary statistics as an alternative, which condenses data sets into a single set of numbers. In Figure 8, these statistics like means, standard deviations, and correlation coefficients are the same for each data set. This may lead individuals to believe that the individual numbers are also similar [14]. However, these statistics summarize larger sets of numbers by generalizing and making assumptions about their underlying patterns, which can result in multiple sets of numbers producing the same statistics [41]. In this case, relying solely on the statistics may lead to individuals acquiring false beliefs. In contrast, when the four sets of numbers are translated into scatterplots (bottom of Figure 8), the differences between the sets are immediately visible.

The decision about the size of a student loan is influenced by a lot of variables. To make an optimal decision, a lot of data need to be taken into account. As the example above shows can data visualization help users understand large amounts of data. Using data visualization in student loans has a lot of potential in aiding decision-making. Unfortunately, as we have seen in the existing tools discussed in section1.2, not much data visualization is used and many important variables are neglected. The following section will underscore the significance of data visualization by examining its influence on self-efficacy.

	x	y	x	y	x	y	x	y
	10	8.04	10	9.14	10	7.46	8	6.58
	8	6.95	8	8.14	8	6.77	8	5.76
	13	7.58	13	8.74	13	12.74	8	7.71
	9	8.81	9	8.77	9	7.11	8	8.84
	11	8.33	11	9.26	11	7.81	8	8.47
	14	9.96	14	8.10	14	8.84	8	7.04
	6	7.24	6	6.13	6	6.08	8	5.25
	4	4.26	4	3.10	4	5.39	19	12.50
	12	10.84	12	9.13	12	8.15	8	5.56
	7	4.82	7	7.26	7	6.42	8	7.91
	5	5.68	5	4.74	5	5.73	8	6.89
Mean	9.00	7.50	9.00	7.50	9.00	7.50	9.00	7.50
Stdev	3.32	2.03	3.32	2.03	3.32	2.03	3.32	2.03
	R	0.82	R	0.82	R	0.82	R	0.82

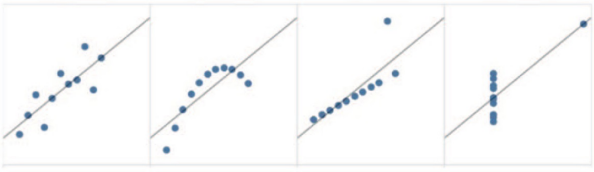


Figure 8: The value of visualization. Visualization techniques can reveal patterns in data that are difficult to see when only using raw data. Image from [14]

1.3.2 Data visualization and self-efficacy

Using visualization techniques, individuals can make better inferences from data by improving decision accuracy and judgment accuracy and decreasing response time [97, 89]. As a result, effective data visualization can increase self-efficacy in individuals [61]. Self-efficacy refers to individuals' beliefs in their own capacity to successfully complete a task or meet a goal [18]. "Self-efficacious individuals generally consider complex tasks as challenges to overcome, establish a deep interest in their tasks, set challenging goals and remain committed to meeting them, and recover rapidly from problems and disappointments" [29]. When applied to finance, financial self-efficacy is the perceived ability to complete financial tasks and meet financial goals. Individuals with higher financial efficacy are more motivated to master financial challenges. Therefore, financial self-efficacy promotes positive financial behavior such as investing and saving [29].

Improving self-efficacy in students can be very beneficial regarding their student loans. In a longitudinal survey, Shim et al. found that individu-

als with greater financial self-efficacy at the end of the study perceived less difficulty in paying off their student loans [101]. Furthermore, they discovered that the perceived difficulty of repaying a loan was directly linked to the actual repayment difficulty, and this perceived challenge, in turn, was connected to stress specific to the loan. Another study has shown that financial self-efficacy is related to help-seeking behavior [65]. Improving financial self-efficacy in students via data visualization may decrease the difficulty in paying off the loan and promote coping behavior for financial stress like help-seeking.

1.3.3 Example of data visualization in student loans

One example of data visualization being used in student loans is the study by Vidermanova et al. [120]. Their study aimed to explain to prospective students how interest works. Loans without interest are easy to understand. Each month the repayment amount is subtracted from the total debt until the debt reaches 0. When interest is involved, it becomes more complicated. Each month, the interest is added to the total debt amount after which the repayment amount is subtracted from the total amount. The interest is a percentage of the total unpaid debt amount. Therefore the interest is the highest at the beginning of the loan and slowly decreases. To visualize this trend for prospective students, Vidermanova et al. used a line graph to visualize the schedule of repayments [120]. The visualization schedule for the first two months used in their study is shown in Figure 9 (right). The Figure shows how the total debt first increases due to interest, and subsequently decreases due to repayment. The graph shows that the repayment consists of two parts: interest and amortization. The amortization part represents the real reduction of the total amount owed [120]. Figure 9 (left) shows what happens in the first month in more detail. Most of the repayment consists of interest, and only a small portion consists of amortization. The distinction between interest and amortization is made by using different colors for each part.

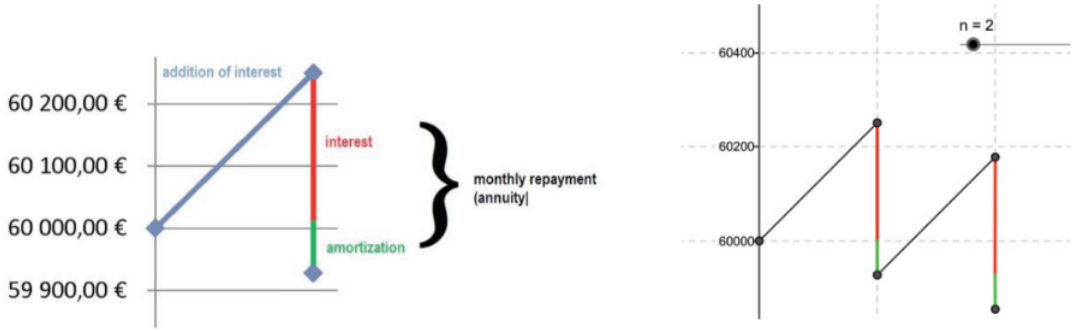


Figure 9: The left graph shows how debt decreases per month in more detail, differentiating interest from amortization. The right graph shows how the debt progresses during the first two months. Images from [120].

Participants of the study found the visualization helpful, saying that it helped them better understand how interest works in loans, and how it progresses over time [120]. Some even indicated that the visualization taught them more than school did, again showing the importance of data visualization. The study concludes that using line graphs while making a visual distinction between interest and amortization increases understanding of repaying a loan. This study shows that even a simple visualization technique can improve the comprehension of loans in students. The next section will explain why designing effective visualization can be challenging.

1.3.4 The challenge of designing effective visualizations for student loan decisions

Choosing suitable visualization techniques based on the type of data is important since unsuitable visualization techniques can have opposite effects than intended, such as an increased response time and lower decision accuracy [32]. Therefore, it is very important to conduct thorough literature research before designing a system. Taking out a student loan involves a lot of different variables, some more important than others. Furthermore, a wide variety of visualization techniques is available. Identifying which variables are essential to showcase and understanding how specific visualization techniques influence user behavior are critical aspects in the development of a useful tool. This study aims to investigate how data visualization can be properly utilized to aid students in student loan decisions. The next section

will elaborate on the research questions and the structure of this study.

1.4 Research questions

This study's central research question is: *How can data visualization be used to support financial loan decision-making in higher education?* This question is divided into two subquestions.

1. *RQ1:* How do students make their loan decisions and what factors do they consider?
2. *RQ2:* How can a visualization tool support students to make more informed student loan decisions?

First, a literature review is conducted to understand how individuals make personal financial decisions and what data visualization techniques are often used in this area. Next, interviews with students are conducted to understand their decision-making process when taking out a student loan, and to identify important elements to include in a tool. Based on this, a new data visualization tool is created and evaluated to investigate how data visualization affects loan decisions and the financial self-efficacy of students.

2 Literature review

In this literature study, relevant studies regarding visualization, decision-making, risk communication, uncertainty, financial behavior, and visualization techniques will be discussed. Section 2.1 will discuss the psychology behind financial decisions. More specifically, how individuals evaluate gains and losses, how financial scarcity impacts these perceptions, and how this affects their financial behavior concerning loans. Section 2.2 will discuss best practices for visualizing data that is prone to uncertainty. It is important to convey uncertainty in an understandable way for students since a lot of variables present in student loans have some degree of uncertainty. Next, section 2.3 will discuss visualization techniques that can be applied to time-series data. This is relevant to show the build-up and repayment of the debt over time. This also includes how to visualize certain events happening at specific points in time. How uncertainty and time-series data are combined will be discussed in section 2.4. This section will discuss studies about the visualization of personal investment decisions. Section 2.5 will discuss visualization techniques that focus on displaying part-to-whole relationships. This is important since proportions are present in loan decisions in several ways, for example, the proportion of interest compared to the total future income, or the proportion of interest on the total debt amount. Lastly, section 2.6 will discuss some more complex visualization systems to evaluate their benefits for non-experts.

2.1 The psychology of financial decision making

This section will elaborate on the psychology behind financial decisions. This is important since it explains how individuals see financial gains and losses and how it affects what choices they make. This section provides evidence that future negative aspects of student loans might be neglected since attention is too much focused on the present. Section 2.1.1 will explain loss aversion. Loss aversion shows how individuals see losses and gains in different ways. This is important to understand since it impacts decisions about the future, which will be explained in section 2.1.2 about temporal discounting. Temporal discounting is important since it shows how individuals are often focused on the present while neglecting potential risks in the future. In student loans, this may lead to overborrowing. Section 2.1.3 will discuss

how financial scarcity is related to temporal discounting and how it affects decision-making. Students often experience financial scarcity when taking out a student loan, and this enhances temporal discounting. Lastly, section 2.1.4 will explain how individuals evaluate risks and how they often overestimate their capabilities. This shows that students might underestimate all the risks involved in student loans.

2.1.1 Loss aversion

Student loans can be seen from two perspectives. On one hand, they can be regarded as a short-term benefit since individuals receive monthly funds that they can use as they wish. On the other hand, the total debt amount grows each month, representing money that must eventually be repaid. Consequently, a student loan can also be seen as a long-term loss. This section will explain how the way the student loan is perceived can influence decision-making. Loss aversion is also important to understand since it impacts temporal decisions, which is explained in section 2.1.2.

Individuals do not evaluate gains and losses in the same way. Kahneman and Tversky explained that a loss has more influence on choices than a gain of the same magnitude [59]. The imbalance of gains and losses is depicted in Figure 10. The objective value (gaining or losing x amount of money) is displayed on the horizontal axis. The subjective value (how one feels towards the objective value) is displayed on the vertical axis. In the graph, the line in the losses domain is steeper than the line in the gains domain. This indicates that "the disutility of losing a given amount of money is significantly greater in absolute value than the utility of gaining the same amount" [68]. For example, for most individuals, losing $10 is worse than it is pleasurable to gain $10. Loss aversion is a very famous and consistent finding in psychology literature. Loss aversion was first described by Kahneman and Tversky in the prospect theory, for which Kahneman received a Nobel prize [59].

Haricnk et al. found loss aversion in anticipated attitudes towards amounts of at least $40. However, the reverse pattern is found in small amounts of for example $1: people expected that the intensity of their emotions following losses would be lower compared to the intensity experienced when gaining something of equal significance [52]. Mcgraw et al. suggest that loss aversion is most likely to be observed when individuals can directly compare gains and losses [74]. It is important to understand loss aversion since it influences how individuals make financial decisions, as is explained more elaborately in

the next sections.

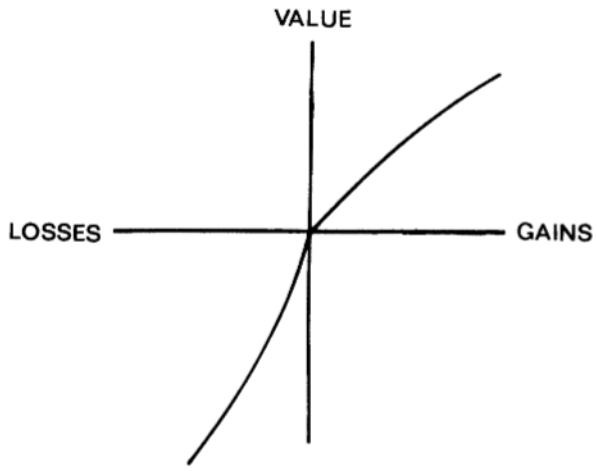


Figure 10: The imbalance of gains and losses visualized. Image from Kahneman et al. [59].

2.1.2 Temporal choices

This section will show that there is a difference between gains and losses in temporal decisions, and how this shifts individuals' attention towards the present. Temporal decisions are decisions in which the timing of costs and benefits are spread out over time [68]. A key characteristic of building up debt is having an immediate gain while postponing the losses into the future, and can therefore be considered temporal decisions [13]. Temporal discounting is the tendency to value immediate outcomes more strongly than delayed outcomes [54]. When asked to choose between immediate $100 or $110 in a year's time, most people will choose the immediate option [13]. One reason is the opportunity cost: the $100 could be invested and end up with more than $110 [96]. Secondly, the future is uncertain. For example, due to inflation the $110 may be worth less, or one might die before receiving the check [13]. This is related to loss aversion since people might see these situations as a loss, which is evaluated more strongly than gains. In addition, the majority of individuals tend to hold the belief that even though they may currently face financial constraints, they anticipate having more resources in the future. Consequently, they perceive immediate access to money as more

advantageous than receiving it at a later time [127]. Lastly, present bias may cause people to be impatient and want immediate gains above any rational thinking [51].

Overall, humans tend to discount future gains more than future losses [113]. With losses, alternatives to choose from are in the format of: "pay $100 now or pay $110 dollars in a year's time". Where high temporal discounting is seen with gains, this effect is less evident in losses. This asymmetry is called the sign effect: "People are quite anxious to receive a positive reward, especially a small one, but are less anxious to postpone a loss" [68]. Tanaka et al. argue that loss aversion could be a source of the sign effect: the aversion to potential losses can lead individuals to discount delayed losses less than delayed gains [113]. In other words: since people evaluate losses more strongly, people are more likely to postpone a loss even though it results in a higher loss, whereas with gains, people are more likely to choose the immediate option.

The sign effect shows that individuals are more susceptible to immediate gains than long-term losses. This is exactly what happens with loans, individuals receive immediate gains while building up a long-term loss. Being more susceptible to immediate gains may cause individuals to make choices based on the short term, while those choices may not be beneficial for the long term. In loans, this might cause individuals to borrow more than they need since they are more focused on the positive immediate effects than the long-term negative effects.

2.1.3 Financial scarcity

This section shows how financial scarcity impacts temporal discounting, and how it further shifts attention to the present. Financial scarcity is defined as the subjective perception or experience of having inadequate financial resources to fulfill one's needs and demands [54]. Financial scarcity can lead to the accumulation of debt, which is the case for a lot of students. A result of financial scarcity can be a 'scarcity mindset', in which individuals have a strong focus on immediate outcomes of decisions and actions. In addition, it increases temporal discounting by shifting attention to current financial concerns. Because of that shift of attention, financial scarcity leads to a preference for short-term optimal options rather than long-term optimal options [54]. This could result in a tendency to delay due payments instead of making immediate payments. For instance, individuals may be more in-

clined to choose installment payments rather than paying in full upfront. In both scenarios, having scarce resources at present results in decisions that yield positive outcomes in the short term but have more significant negative consequences in the long term [54].

Concentrating one's attention during challenging situations is typically an adaptive strategy as it facilitates problem-solving and resolution of the immediate issue [42]. Individuals who experience financial scarcity are more likely to direct their attention on the most pertinent characteristics of the choice, and therefore are less susceptible to irrelevant framing cues [100]. However, the shift in attention could also lead to tunnel vision, neglecting important information about future consequences [115]. Therefore, Hilbert et al. argue that the shift in attention due to financial scarcity increases temporal discounting and therefore leads to sub-optimal decision-making in which future problems are disregarded [54].

While some students acquire a student loan not out of necessity but out of the desire to have more money to spend, most students who have student loans experience financial scarcity: they are required to borrow money to pay for their expenses. This may lead to an increased focus on the short-term benefits of student loans. The Dutch loan system enhances short-term thinking by making monthly payments to the students. Each month students eagerly wait for the day they receive their monthly payment, focusing even more on the immediate benefits instead of the long-term situation. This structure is understandable however, giving students large amounts of money at a time, like once every year for example, is bound to cause problems.

2.1.4 Loans and risks

Financial risks are often underestimated, causing potential risks to be neglected. Individuals take economic risks with personal loans and mortgages since the ability to repay the loan is not certain [45]. Risk-taking is mediated by risk perception, risk attitude and risk propensity. Risk perception refers to the subjective construct created by individuals. People are more influenced by perceived risk than by objective risk [30]. Risk perception is important for understanding financial decisions [45].

Risk perception consists of an assessment of the degree of uncertainty, controllability and confidence in these estimates [106]. Risk perception is prone to many biases, of which overconfidence is one of the most studied ones [108]. People often believe that their knowledge is more accurate than

it really is, think that their abilities are above average, and are extremely optimistic about the future. Due to their excessive self-assurance, individuals often have a tendency to underestimate the genuine risks involved and overestimate their capacity to overcome unexpected challenges [45]. Research has shown that increased risk perception lowers risk-taking behavior [28]. Therefore it is important when lower risk-taking is desired, to focus on increasing accurate risk perception of individuals.

Risk propensity is the general tendency to either take or avoid risk [44]. It is a personal trait that remains relatively stable during a lifetime. Decision-makers who are averse to risk tend to pay more attention to negative outcomes, leading them to overestimate the likelihood of experiencing losses compared to gains. As a result, they demand a higher probability of gains to be willing to tolerate the risk of failure. On the other hand, decision-makers who are inclined towards risk-taking are more prone to focus on and assign greater significance to positive outcomes. Therefore they tend to overestimate the likelihood of experiencing gains compared to losses.

Individuals often display financial overconfidence [76]. This often displays as being unrealistically optimistic about future events. Research has shown that students, especially males, are often overconfident about their student debt situation and future repayment difficulty [40]. Overconfidence can cause increased risk-taking, resulting in higher debts and more repayment difficulties. Therefore, it is important to properly emphasize the risk involved in student loans.

Overall, this section has shown that individuals are more susceptible to immediate gains compared to future losses. This causes the sign effect where individuals discount future gains more than future losses. This causes a shift in attention to the present while neglecting possible risks in the future. Financial scarcity amplifies this effect even more. In addition, students tend to overestimate their ability to pay off debt. Therefore, it is important to stress the risks involved in taking out a loan. Different visualization techniques are available to communicate this risk to students. Section 2.2 will discuss how risk can be presented to users and how certain visualization techniques impact the risk perception of humans.

2.2 Visualizing risk and uncertainty

This section will discuss how risk and uncertainty can be visualized and what formats are best understood by users. This is important since some factors in loan decision-making are uncertain and can have a large impact on future repayments. For example the chance of completing your study in the allocated time. There is the possibility students will be delayed in their studies, resulting in a longer period of borrowing money. This will increase the total debt and is therefore important to visualize to users in an understandable way. Furthermore, the interest rates can change every year, which also has a huge impact on the repayment of the loan.

Most data is prone to uncertainty [88]. It is therefore important to communicate this uncertainty effectively to make informed choices [58]. However, understanding even the most commonly used communications of uncertainty can be challenging for both novices and experts because of the abstract nature of probabilities [20]. Effective data visualization can help improve understanding of risk and uncertainty and decision-making in a range of contexts such as the weather, healthcare, and everyday decisions [86]. Uncertainty can be distinguished into different types. Aleatoric uncertainty refers to the randomness that is inherent in a process and therefore cannot be reduced. Epistemic uncertainty comes from a lack of knowledge that could theoretically be reduced if more information is given. Ontological uncertainty refers to the uncertainty about how accurately a model describes reality, which can only be described subjectively [111]. The risk of not completing a study or being delayed, and the uncertainty of interest rates are both aleatoric uncertainty since it is inherent to the process.

Section 2.2.1 will discuss three uncertainty visualization theories. These theories explain how certain visual elements can impact risk perception in humans. These theories are applied in some visualization techniques which will be discussed. The theories are more focused on the interaction between visual elements of risk and risk perception in humans than the psychology of loans and are therefore mentioned in this section instead of section 2.1. Lastly, section 2.2.2 will discuss a study where future repayment difficulty is visualized per career path.

2.2.1 Uncertainty visualization theories

Gerd Gigerenzer proposed the frequency framing hypothesis [47]. This hypothesis states that human decisions seem flawed when provided with confusing information like probabilities communicated as percentiles (e.g. 20% chance). In contrast, individuals can make rational choices when information is in a format they can understand easily such as frequencies or ratios (e.g. 1 out of 10). According to Gigerenzer, percentiles fail to align with how individuals experience probability in real-world situations, resulting in the occurrence of errors [47]. Instead, representing probability as a frequency is considered more intuitive, as we have greater familiarity with such ratios through exposure (e.g. I have hit a traffic jam here 6 out of 10 times. I will try a different route next time.). Research has found probabilities more time-consuming and error-prone compared to frequencies [121].

The frequency framing hypothesis is applied in for example icon arrays (top-right of Figure 11). There is a substantial body of research indicating that icon arrays are highly effective in conveying a single probabilistic value, surpassing textual descriptions of probabilities and frequencies in terms of communication efficacy. A notable advantage of icon arrays is their ability to alleviate the cognitive load by enabling viewers' visual systems to effortlessly compare the denominator and numerator in a frequency probability format [86]. This technique applies the frequency framing hypothesis, presenting information in frequencies rather than percentiles [47].

When visualizing a continuous variable with a lot of possible outcomes, often a probability density plot is used. An example of a probability density plot is shown at the bottom of Figure 11. This plot maps probability to height [86]. Nonetheless, users might encounter challenges in accurately determining the precise density for a given value, as it requires them to visually calculate the area beneath the curve [60]. Kay et al. created the quantile dot plot as an alternative to the probability dense plot, which is shown in the middle of Figure 11. Quantile dot plots have undergone testing in numerous empirical studies, revealing their ability to decrease the variability of probabilistic estimates in comparison to density plots [60]. Additionally, quantile dot plots have been found to enhance the recall of distributional data [56], and are more advantageous for decision-making involving risk, surpassing interval and density plots, as well as textual descriptions of uncertainty [37]. Quantile dot plots also apply the frequency framing hypothesis, favoring frequencies over using percentages.

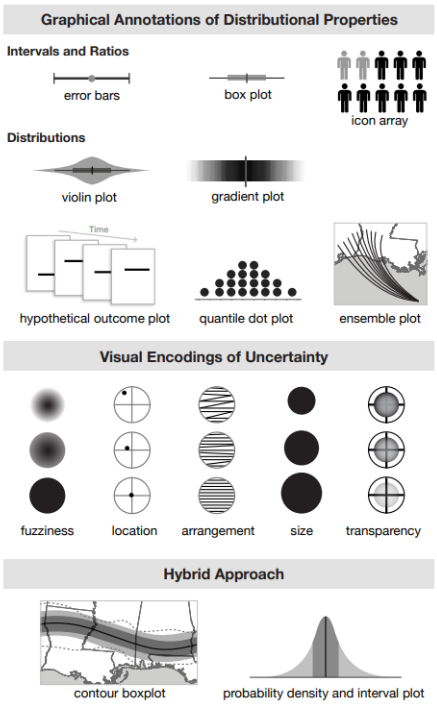


Figure 11: Different approaches of visualizing uncertainty. The top displays visualization techniques that use graphical annotations to visualize uncertainty. The middle part shows visual encodings that apply the theory of visual semiotics of uncertainty. Certain metaphors that are intuitive to understand are used to display uncertainty. The bottom combines graphical notations with visual encodings. Image from [86].

The theory of visual semiotics of uncertainty by MacEachren et al. argues that uncertainty encoding techniques that utilize visual metaphors for uncertainty are more intuitive for users [71]. These metaphors can consist of techniques like color saturation and out of out-of-focus using blur. According to this theory, features that elicit a sense of uncertainty in viewers are suggested to be more impactful compared to features that lack associations with uncertainty. MacEachren et al. found that fuzziness, location, value arrangement, and transparency were highly intuitive [71]. These visual encodings are displayed in the middle part of Figure 11. An example of using blurriness to visualize uncertainty is using a blurred point on a map. This

makes it not possible for users to pinpoint the exact location, preventing them from making overly precise judgments when uncertainty is high.

The theory of why visual metaphors aid decision-making is based on natural mapping. Natural mappings propose that it is possible to present information in a manner that closely corresponds to how individuals intuitively perceive and understand the data. The idea is that when visual representations match how people think about the data, they will save cognitive effort which can be used to complete the task more effectively [71]. In contrast, a large discrepancy between how the information is presented and the person's internal model causes the person to first transform the visual elements to match their mental representation [91]. This transformation uses some of the limited mental capacity, which results in less mental effort being available for the task.

The data visualization theory proposed by Padilla et al. states that when visual boundaries like error bars are employed to represent continuous data, individuals tend to perceive the data as categorical due to the presence of these boundaries [87]. Individuals often believe that the data inside the boundaries is categorically different than data outside the boundaries. The boundaries often cause individuals to forget that there is a distribution of possible values. When a hard boundary is depicted in a plot, viewers tend to infer that the creator of the plot are emphasizing the significance of the specific value assigned to the boundary [87]. It is understandable that viewers would attach meaning to the boundary value, especially when there is limited information provided about how the visualization was created. Therefore, Padilla et al. advise to be cautious using visual boundaries, and if they are included, explicitly explain what the boundaries mean.

An example of boundaries being utilized to convey uncertainty is used by Flood et al. [39]. A visualization was created to depict the American Federal Reserve's before and after 2007, the start of the financial crisis. Mathematical models made predictions about the progression of the Federal Reserves. This is visualized in a line chart with boundaries that represent confidence intervals (Figure 12). Different confidence levels are displayed with different colours. The left chart compares the realized historical data (black line) with the confidence intervals of the model estimates. The right chart shows the models' forecast of the Federal Reserves with confidence intervals. As Padilla et al. suggested, the meaning of all boundaries is explicitly mentioned inside the chart, minimizing ambiguity and chances of wrong interpretations [87],

[39].

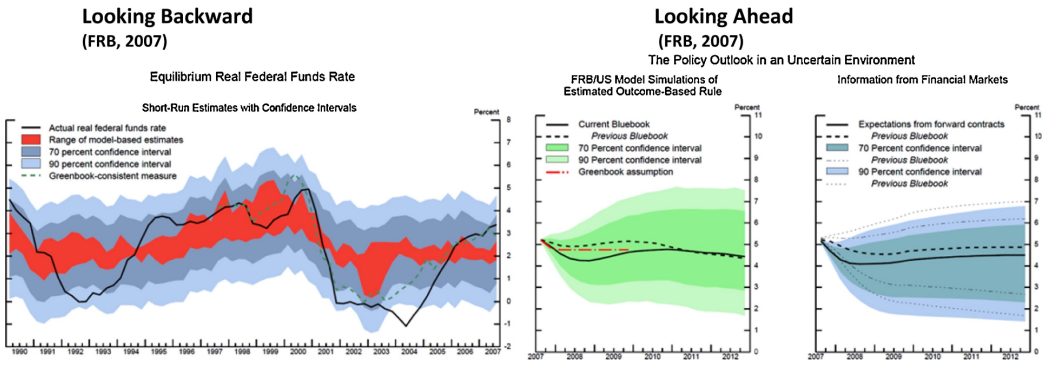


Figure 12: Uncertainty in the Federal Reserves visualized with boundaries that represent confidence intervals. Image from [39].

The examples above display the uncertainty and risk of one specific alternative. Another possibility is to display multiple alternatives simultaneously, where some alternatives are inherently more risky than others. Regarding student loans, this might be a scenario where the user gets delayed in their study and therefore needs to borrow for a longer period. In that case, no specific uncertainty visualization techniques need to be used. The risk is portrayed in the attributes of the alternative like the total debt amount, instead of using visualization techniques. Whether it is best to display uncertainty using specific visualization techniques, or by displaying multiple alternatives, depends on the task and the preferences of the users. Concerning student loans, it remains uncertain whether students may prefer evaluating multiple options. Conducting interviews with students is essential to address this question.

2.2.2 Repayment visualization of student cohorts

This section will discuss a study that shows a way of visualizing uncertainty in future salary can be displayed and compared between different career paths. Some college institutions faced accountability measures that could. These are applied to avoid supporting enrollment in institutions where poor outcomes can be expected, and therefore probably will struggle with repayment of student loans. Matsudaira and Turner proposed a method whereby a program's qualification for offering federal aid to students would

be tied to certain benchmarks for income and loan repayment [73]. Programs would be required to have a positive loan repayment rate (LRR). The LRR is defined as the percentage change in the aggregate student loan balances of a repayment cohort three years after entering repayment, compared to the cohort's initial aggregate balance. It uses the following formula: $LRR = 1 - \frac{Cohort\ balance\ in\ year\ 3}{cohort\ balance\ at\ repayment\ entry}$. A positive loan repayment rate (LRR) signifies that, on the whole, borrowers managed to meet their interest payments and decrease their loan principal by at least $1. Conversely, a negative LRR indicates that the cohort's balance has increased during this period [92].

Restrepo and Turner created a visualization tool to explore differences between programs and institutions. This tool included box plots showing the distribution of LRR for different undergraduate programs. A distinction is made between public and for-profit institutions. For-profit institutions focus mainly on earning revenue through tuition and fees paid by students. The box plots are shown in Figure 13. Plotting multiple box plots in the same graph allows for quick comparisons between different career directions and types of institutions.

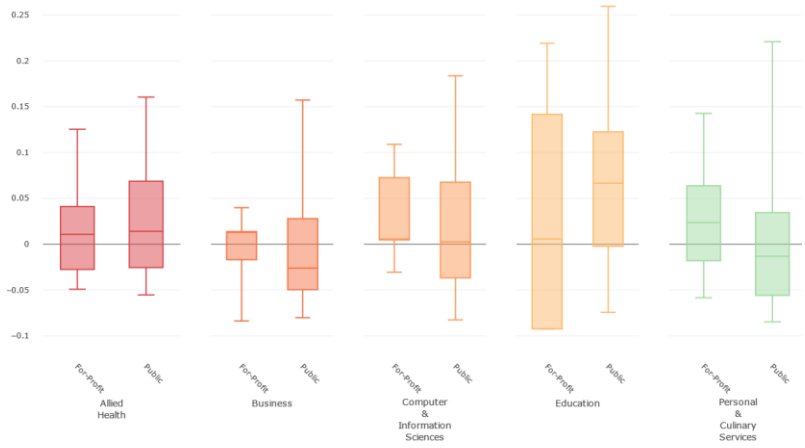


Figure 13: The Loan Repayment Rate (LRR) distribution of different cohorts visualized with box plots. Image from [92].

In a support tool for student loans, displaying multiple box plots might not be the best technique. First of all, in The Netherlands interest rates are way lower than American interest rates. Therefore, almost all studies will have a positive LRR. The main intention of the boxplots used by Retrepo and Turner is to visualize whether career directions have in general a positive

or negative LRR. In addition, the tool is meant for students who are about to take out a loan or want to recalibrate their loan. These students most likely have already chosen and enrolled in a study, and students recalibrating their monthly loan amount are most likely not interested in other study fields. Therefore it would be more beneficial to let the users choose their career direction and display their expected salary distribution and/or LRR. This could be done with a box plot, but quantile dot plots may be more effective since they present the data in frequencies [86].

2.3 Visualizing financial time series

This section will discuss visualizations of time series information. Time series data is data with time attributes that change over time [35]. In loans, time series data is present in two ways: the build-up of debt over time and the repayment of the loan. First, the most common visualization techniques used in time series data are discussed in section 2.3.1. Section 2.3.2 will discuss visualization techniques used in the stock market. This is useful since it uses time series data, and because it is impacted by specific external events. The same goes for student loans, where repayment is heavily influenced by for example changes in interest rates. As will be discussed, these external events can be visualized in different ways.

2.3.1 Common time series visualizations

Line graphs have been very popular for visualizing time series data [122]. By displaying the temporal changes of values using slopes, they easily allow people to identify trends and other patterns. Another option is using a scatterplot, which is essentially a line graph where all the lines connecting the dots are omitted. Scatter plots also provide overall representations of the trend for a time series [102]. To select which one is more appropriate, the characteristics of the data need to be analyzed. When the data contains a large amount of noise, scatterplots show the trend more clearly compared to line graphs. This is due to the many disturbing lines between the noisy data [122]. Otherwise, line charts are often preferred.

When multiple elements should be visualized on the same time frame, with approximately the same scale, stacked area charts can be used to show

how different elements progress in time, and the relationship between the different elements. Elesser et al. used stacked area charts to show the loan status of students throughout the years (Figure 14) [33]. The information in the figure is easy and intuitive to interpret. However, one problem with stacked area charts is that the fluctuations across the layers will accumulate. Fluctuations in lower layers of the chart will affect the appearance of the layer above them, making them look more volatile than they actually are. This is especially the case when there are a lot of different layers with a lot of fluctuations [112].

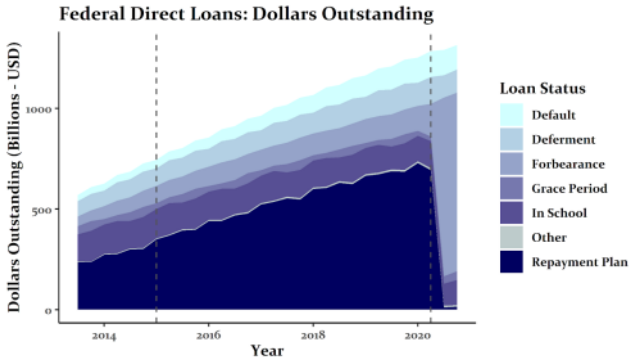


Figure 14: An area chart showing how different loan statuses progress over time. Image from [33]

For displaying the debt build-up in student loans, a stacked area chart would be very suitable. There are only two elements to visualize, the monthly debt accumulation and interest. The problem with fluctuations in area charts will not arise since the monthly debt amount is relatively stable, and the interest on top of the total debt amount is a percentage that can change only once every five years. Using area charts, the relation between the interest and the total debt amount is visualized easily and understandably. One limitation of area charts is that only one alternative can be displayed. When the focus of an application lies in comparing different alternatives, regular line charts displaying each alternative in the same graph might be more appropriate to use. Whether students would prefer visualization of different loan plans, or one loan plan needs to be investigated.

2.3.2 Stock visualization

In the stock market, line charts with the stock price on the vertical axis and time on the horizontal axis are very common. The stock market is heavily influenced by event data like news, earnings releases and announcements [109]. Some charts include visualizations of these events to improve understanding of specific changes in the chart. A sudden price drop can be explained when it is accompanied by negative news about the company behind the stock. One option is to plot visual elements on top of the price chart. One example of this is displayed in Figure 15. In this example, the alphabetical characters represent certain types of events that are known by the user. One limitation of this approach is that it is not scalable to very big time frames or a large event density due to occlusion [109].

Figure 15: Line chart of stocks with alphabetical characters plotted on top that represent certain events. On the top chart, the characters represent events that are known by the user. On the bottom chart, explanations are given in an adjacent panel on the right. Image from [109]

.

An alternative is displaying the events in a separate graph that has the same time frame as the line chart and is aligned with it. This way, the price information of the stock will not be occluded with event visualizations. An example is shown in Figure 16. This method allows for more events to be displayed but takes up more space. In addition, it takes more effort to associate the event with specific changes in the stock price. Therefore,

choosing the right event visualization depends on the event density [109]. Graphs with low event density are better of at plotting the events directly into the chart while graphs with high event density

Figure 16: A line chart of a stock with the events plotted in a separate window below. Image from [109]

In student loans, certain events can also impact the situation of students. Changes in interest rates and monthly loan amounts for example can both have an impact on the build-up and repayment of the debt. It would be beneficial to display these events directly on a chart to visualize to the students what influence these events can have. These events will probably have a low density. Interest rates during repayment can only be changed once every five years. The monthly loan amount will probably not change often during the study. Research showed that 49% of Dutch students never changed their monthly loan amount [4]. Of the students that did change the monthly amount, 82% of them changed it between one and four times per year. Therefore, visualizing these events directly on top of the line chart could improve the comprehension of the effects that these events can have.

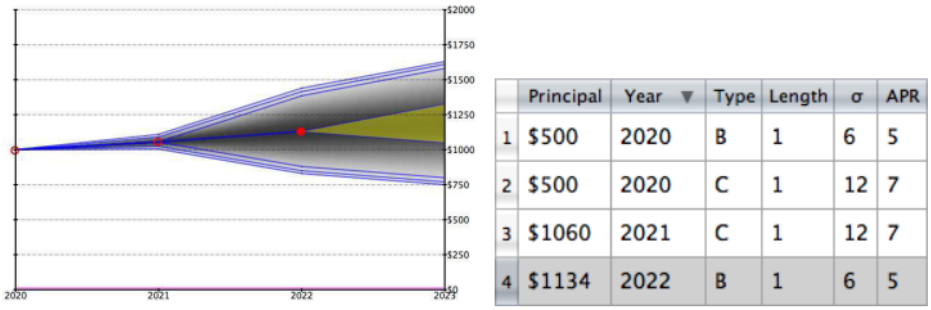
2.4 Investment visualization

This section will discuss visualization tools that are used in studies that focus on investments. These tools include financial time-series data and

risk factors, which we have previously discussed. It is interesting how this financial risk is visualized to users and how it allows users to plan their financial investments. Both loans and investments need to show how money progresses over time, and how it is impacted by certain risk factors. Two investment tools are discussed to evaluate how risk and time-series data are visualized.

2.4.1 FinVis

FinVis is a visual analytics tool supporting the interpretation of return, risk, and correlation of personal finance decisions [95]. It allows users to compare different portfolio options by visualizing the expected returns. FinVis shows each investment simultaneously in two ways: a table of all investments and a corresponding visualization. The goal of FinVis is to improve the diversification of portfolios. It shows how combining different investment alternatives impacts the risk involved. Users can choose certain investment options. The user has the freedom to modify the investment option, principal, and start year as many times as desired as they are all editable and subject to alteration. The table and visualization are displayed in Figure 17



	Principal	Year	Type	Length	σ	APR
1	$500	2020	B	1	6	5
2	$500	2020	C	1	12	7
3	$1060	2021	C	1	12	7
4	$1134	2022	B	1	6	5

Figure 17: The table and visualization that are displayed to users in FinVis. Image from [95].

The risk, also called the uncertainty of future outcomes, is displayed in two ways. First, the total risk of the combined investments is displayed as a Gaussian gradient. The darker area of the gradient represents the more probable outcomes. Secondly, the risk of each individual investment is also displayed so the user can see what the impact is on the total risk. When a single investment is selected, a yellow gradient represents its risk (left of Figure 17).

The total risk is divided by the blue lines, as can be seen in the left of Figure 17. Each subsequent investment has the risk displayed closer to the center (the blue boundaries of each subsequent red dot are not displayed on top of each other but beneath each other). This way the impact of single investment decisions on the total risk can be derived from the graph.

Rudolph et al. found that FinVis improved decision-making [95]. Expected returns of the portfolio of students using FinVis were compared to the results of students using a baseline model. This baseline model contained all relevant information but used no visualization techniques. An example of the baseline model is displayed in Figure 18. Results showed that FinVis resulted in significantly higher expected returns for the same amount of risk compared to the baseline model. Questionnaires showed that FinVis students were more confident in their decisions. In addition, students spent more time with the FinVis tool and modified the combination of investments more often. This suggests that the FinVis tool allows students to explore more options, resulting in improved personal financial decision-making [95]. These results suggest that including the visualization lowers cognitive costs and therefore allows individuals to analyze more alternatives without resorting to suboptimal heuristics.

	Year ▼	Expected Net Wealth	−2σ	+2σ	Funds Available
1	2020	$1000	$1000	$1000	$0
2	2021	$1060	$1021	$1099	$0
3	2022	$1134	$841	$1427	$0
4	2023	$1190	$761	$1619	$1190

Figure 18: The baseline model used by Rudolph et al.[95]. All necessary information is present, but no visualization techniques are being used.

The visualization in FinVis uses a line chart with events displayed on top of it: each subsequent investment is displayed with a red dot. The uncertainty is projected with boundaries and color gradients, where the darker colors are the more probable outcomes. This technique could also be applied to visualize the repayment period for students. The red dots in the chart are intuitive to understand and can be used to visualize for example changes in interest or changes in salary. The boundaries could be used to project uncertainty in future salary. Individuals with higher salaries can repay more

each month and therefore minimize the accumulation of interest. Similar functionality as in FinVis could be applied, enabling users to pick a specific salary and highlight it inside of the boundaries in the line chart. This way, users see what repayment situations are most probable and how they progress over time.

2.4.2 PortfolioCompare

A tool similar to FinVis is PortfolioCompare [98]. This tool aims to compare different portfolio alternatives, each with a different distribution of funds. It aims to facilitate efficient risk comparison of diverse portfolios for users. Risk is implemented as standard deviations of future returns. Users can use interactive slider bars, as is shown in Figure 19, to create new portfolio options. Each slider corresponds to the amount of a specific fund. Once satisfied, users can add the portfolio to a 'basket'. All portfolios in the basket will be compared. The comparison will be visible in two displays: the Risk/Return display and the Return Variability display.

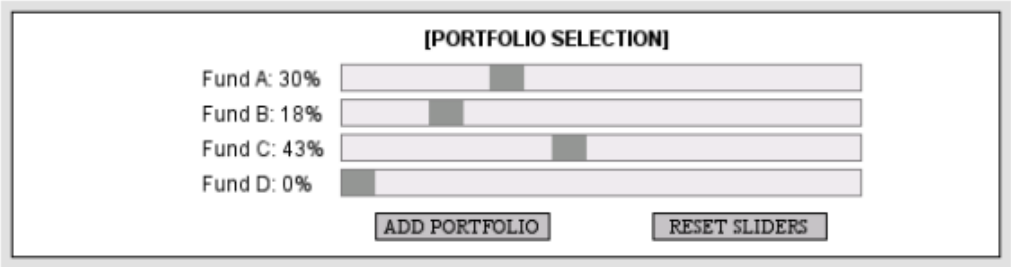


Figure 19: Interactive sliders enable users to create a portfolio with a certain distribution of funds. Part of the Portfolio-Compare tool by [98].

The Risk/Return display consists of a scatter plot in which the horizontal axis represents risk and the vertical axis represents return (Figure 20). As the properties of the portfolio are changed, the dot in the scatter plot is continuously updated. The dot also incorporates a trail as a visual indicator, enabling users to easily discern the direction of change in risk or return as the investment proportions vary. Studies have shown that motion can express relationships and that it increases the perception of causality [98, 79]. Once the user has decided on the proper proportions of investments, the portfolio can be added to the basket. Once it is in the basket, the dynamic dot in the

graph becomes static and is given an ID number. The display allows users to compare return and risk for all the portfolios in the basket, as well as compare new dynamic portfolios to all the static portfolios.

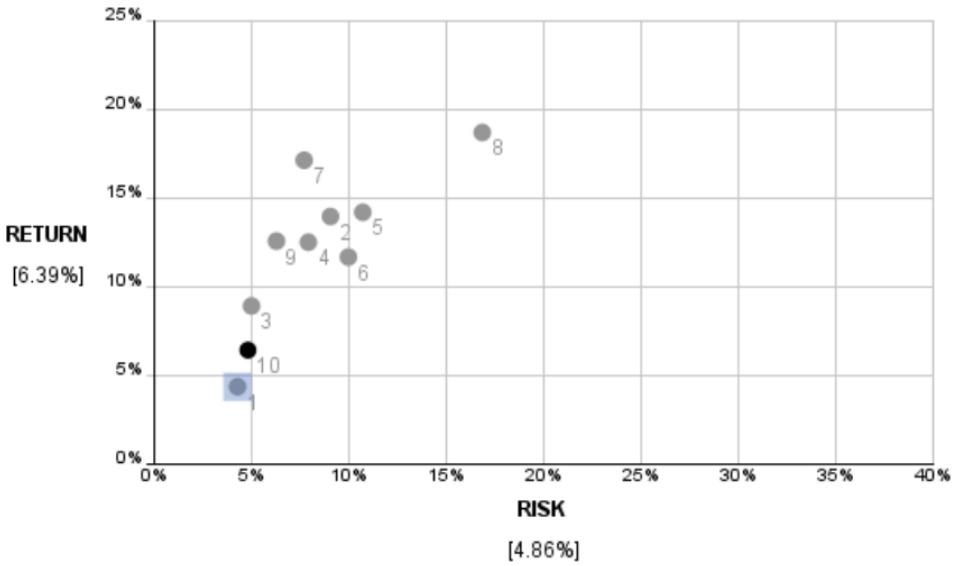


Figure 20: The Risk/Return graph used in PortfolioCompare. Image from Savikhin et al. [98]

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The Return Variability display allows users to select certain portfolios from the basket. It will show the variability of the expected return of the selected portfolios. This is done with distribution bars, where blue bars represent potential upside risk and the red bars represent potential downside risk. In addition, transparency is used to represent different levels of risk. Different transparency levels represent the return falling within the 68%, 95% and 99% probability. The boundaries are explicitly explained to prevent ambiguity. The Return Variability display is shown in Figure 21.

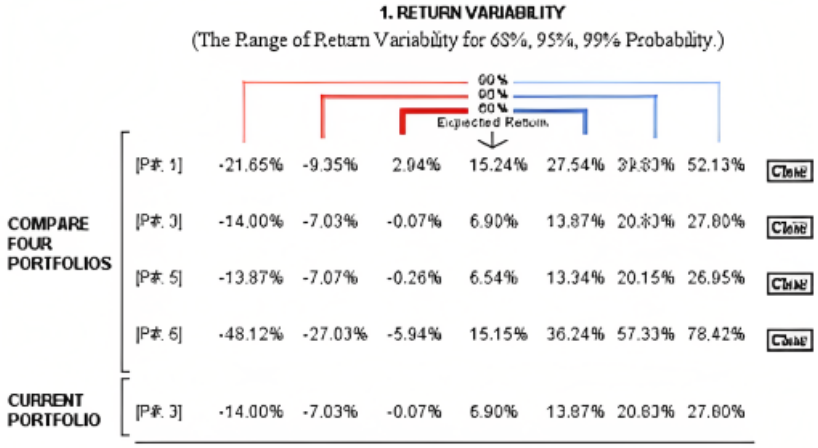

Figure 21: The Return Variability graph used in PortfolioCompare. Image from Savikhin et al. [98]

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The experiment compared PortfolioCompare to a baseline model with the same functionality but with textual explanations instead of graphical explanations. Participants were asked to use either PortfolioCompare or the baseline version and select the portfolio with the highest return after 5 minutes. This was repeated for 9 rounds in order to allow learning. After the experiment, participants were presented with a risk preference questionnaire that aimed to measure subjective risk tolerance. Results show that PortfolioCompare assisted users in choosing a portfolio that aligned better with their risk tolerance. In addition, PortfolioCompare decreased the cognitive load of users, which was measured by the time spent on the task. Although solely lesser time spent on the task does not have to indicate a decreased cognitive load, the fact that performance was equal between the two conditions does indicate that the most probable explanation is a reduced cognitive load [98] Furthermore, in both conditions, the time spent on the task decreased as the rounds progressed. This indicates that the exploratory nature of the task facilitated learning and therefore continued to improve decision-making [98].

Using the Risk/Return scatterplot and the Return Variability distribution bars in the PortfolioCompare tool did support individuals in choosing portfolio options that were more in line with their personal risk tolerance, and it reduced the cognitive load. The distribution bars can be interesting to visualize the distribution of expected future salaries or expected future

repayments for students. When using distribution bars, it is important to explicitly explain what the boundaries mean and to use colors that have high contrast for easier comparisons [98].

While FinVis implements the risk directly inside the graph with boundaries, PortfolioCompare implements it as a separate graph. FinVis uses time-series data where the investment amount is plotted against time. It makes sense to incorporate the risk inside the graph since it is easy to infer how the risk varies over time. PortfolioCompare does not show how the risk varies over time, but instead shows the uncertainty of the end results. Therefore it makes sense to visualize the uncertainty in the end results in a different graph.

All in all, FinVis and PortfolioCompare use different techniques to visualize the risk of financial data. The boundaries and color gradients used in FinVis might be used to visualize the impact of expected salary (and therefore monthly repayment) on the progression of debt over time. One problem with this approach is that the progression of debt is influenced by a variety of variables like the interest rate, monthly loan amount, and duration of the loan. If students would prefer to see the impact of all these variables, it might be better to be able to compare different loan plans. Using boundaries with color gradients in every loan plan would make the graph very cluttered and hard to interpret. Whether students would prefer to see and compare alternatives or focus on one specific alternative needs to be investigated.

2.5 Visualizing financial proportions

This section will investigate the best ways of visualizing proportions. Proportions show how certain parts are related to the whole [104]. In student loans, proportions occur in different places. For example, the proportion of interest on the total debt, some category of expenses on the total amount of expenses, and the monthly repayment amount on total income. These valuable insights need to be visualized to students understandably. Different visualization techniques will be discussed.

2.5.1 Circular charts

Common methods of visualizing part-to-whole relations are pie charts and doughnut charts. Pie charts are often favored by the public, but criticized by domain experts [104]. The pie chart is criticized as being inefficient since

the data can be read from different sources: angle, length of the arc, and the area of the segment. Although previous research suggested that comparisons of the angle were the most used, Siirtola et al. show with eye tracking that all three methods are used almost evenly for information extracting [105].

Spence and Lewandowsky argue that despite the criticism from experts, practitioners of display graphics persist in using pie charts and practitioners generally know what works and what does not [110]. Siirtola et al. argue that this discrepancy between experts and practitioners is due to the pie charts often being misused [105]. For example, pie charts should not have more than seven slices, should not have a separate legend (requiring eye movement between slices and labels), and should not use 3D effects [105]. These rules are often violated. Evidence exists that when these rules are followed, pie charts result in higher interpretation accuracy and clarity in participants compared to bar charts or icon arrays [114].

Research has shown that length is easier to estimate than an angle. Estimating an area has even worse precision [26]. Therefore, visualization techniques that solely use length, like bar charts, are sometimes favored by researchers since they were assumed to be more accurate [25]. However, this precision holds primarily when extracting quantitative data from the charts, also called absolute estimations. However, pie charts are often not used to make absolute estimations, but rather part-to-whole estimations [105]. In these proportion estimations, pie charts perform as well as bar charts. In fact, pie charts are often favored by the public [25]. This shows that the type of task is crucial in determining the best visualization technique. For example, difficulties in analyzing and interpretation arise when different pie charts are being compared with each other [63].

Doughnut charts are very similar to pie charts, except the middle of the chart is cut out. The advantage of this is that it allows for additional information to be displayed inside the hole. The disadvantage is that extracting data based on angle becomes harder. Siirtola et al. compared pie charts to doughnut charts in terms of time needed to extract data and accuracy. In addition, the study investigated the effect of the size of the holes [105]. Results showed that doughnut charts where the hole has a radius of 50% of the pie radius, are slightly faster and more accurate to extract data from than pie charts and doughnut charts with different size holes.

2.5.2 Rectangular charts

Besides circular charts like pie charts and doughnut charts, rectangular charts are also common in visualizing proportions, the most popular one being bar charts. Stacked bar charts use length to decode the size of elements. Stacked bar charts hold an advantage over pie charts when multiple charts need to be compared. When comparing different stacked bar charts it is important that the elements are ranked in the same order. Comparing differently ordered stacked bar charts leads to lower accuracy and a higher response time [55]

Treemaps are less popular than pie charts and bar charts in showing part-to-whole information. Treemaps are more often used to visualize hierarchical data such as organizational structures [24], but can also be used to display proportions. In that case, often rectangular treemaps are used that encode the size of elements in an area. An example of a rectangular tree map (right) is shown next to a stacked bar chart (left) with the same distributions in Figure 22. As discussed, estimating area is less accurate than estimating length. Unsurprisingly, research has found treemaps to be inferior compared to pie charts and stacked bar charts [62]. They yielded less accurate estimates and longer response times in participants. The authors argue that rectangular should not be used to visualize part-to-whole relationships.

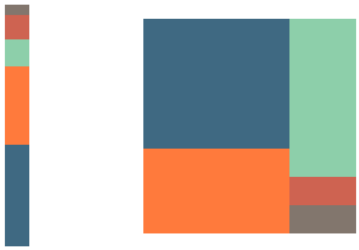

Figure 22: A tree map (right) next to a stacked bar chart (left) with the same distributions. Image from [62].

As discussed, what chart is most suitable depends on the situation. Proportions are present in student loans in several ways: the distribution of the monthly expenses divided into several categories (comparing it to the expenses division of the average student), the proportion of interest on the total amount of debt, and the proportion of monthly repayment compared to the disposable future income. When different loan plans, and therefore different proportions need to be compared, bar charts are more suitable. Otherwise,

pie charts or doughnut charts are more suitable since they are favored by the general public.

2.6 Complex systems

Until now, mostly simple visualization techniques (e.g. pie charts, line charts and bar charts) and simple tools (e.g. FinVis and PortfolioCompare) have been discussed. These techniques and tools are easy for non-experts to understand and use. However, more complex tools exist. These tools often convey more information but require more explanation to understand [116]. This section will discuss some of these more complex systems and explain how they work and whether they are suitable for students.

To visualize how certain elements flow through a system, Sankey diagrams can be used. Sankey diagrams illustrate quantitative information about flows, their relationships and their transformations [93]. Heileman et al. used Sankey diagrams to visualize the flow of students through a university system [53]. An example of a Sankey diagram used in Heileman et al. is displayed in Figure 23.

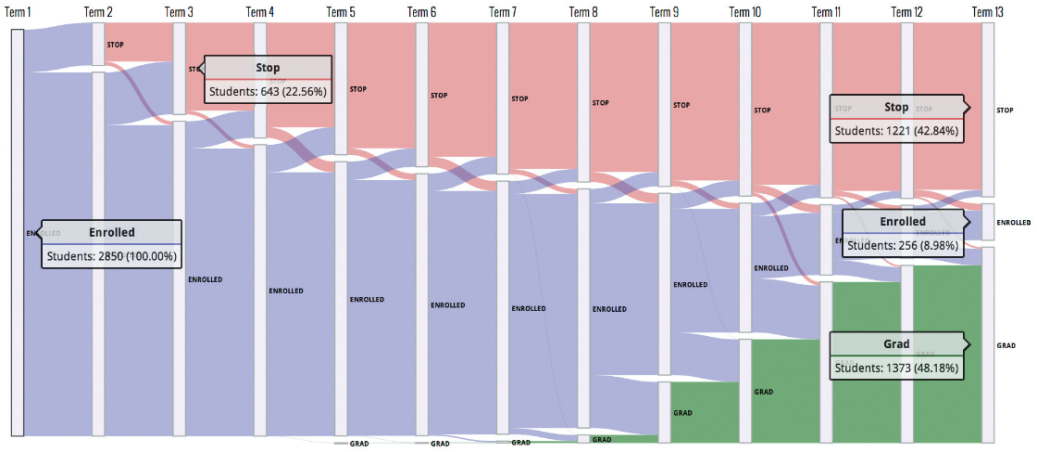

Figure 23: A Sankey diagram of the flow of a student cohort through a university system. Image from [53]

The diagram shows how students flow between the following categories: "enrolled", "stop" and "grad". These categories are each displayed with a distinct color. The flow is displayed by the lines between each category. For

example, between term 1 and term 2, it can be seen that a portion of the enrolled students flowed to stopped students, indicating that those students chose to stop their education. This diagram allows for detailed information to be displayed. Another variation used in Heilman et al. is shown in Figure 24. Here, more detailed information is shown regarding the field of study. Within each category, the distribution of different fields of study can be read. The increase in the information displayed is accompanied by an increase in the difficulty to read the diagram.

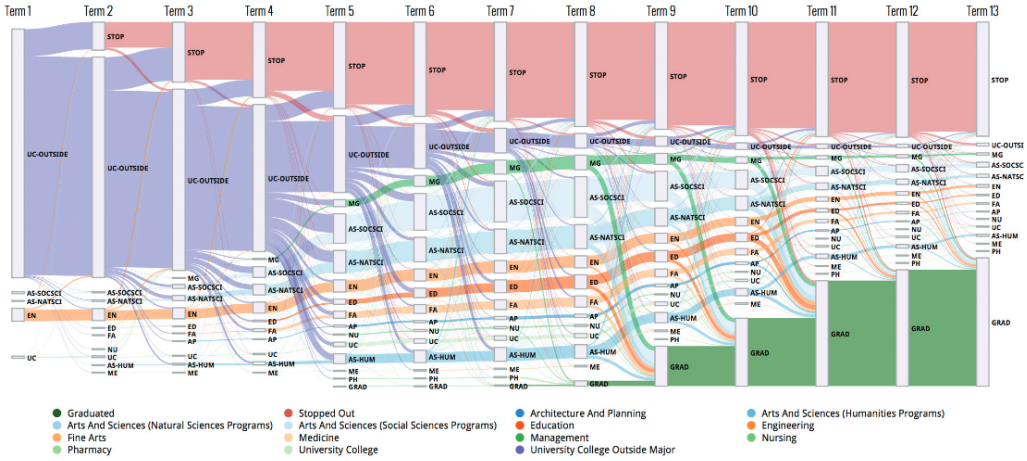

Figure 24: A Sankey diagram with more detailed information about the field of study is displayed. Image from [53]

A Sankey diagram could be used to portray the chances of dropping out of college or being delayed. For this purpose, a simpler Sankey diagram like the one in Figure 23 would suffice since students that are exploring the best loan conditions are probably not interested in other fields of study. Instead of displaying one cohort of a university, the average of all cohorts within a field of study should be displayed. It remains the question if a Sankey diagram really adds new insights compared to displaying the chances of dropping out or getting delayed with for example an icon array. The flow between each term might not be very relevant for prospective students. In addition, all this extra information can cause cognitive overload, which is exactly what we aim to decrease using data visualization. All in all, the additional information that can be displayed with a Sankey diagram does not outweigh the additional effort required to understand and use the diagram.

Another more complicated visualization technique is used in Regshock. Regshock is a tool designed for financial agencies to support the exploration and evaluation of financial regulation measurements [84]. Regshock consists of a so-called Risk-island view, which is displayed in Figure 25. A network layout algorithm is used to compute the nodes in the Risk-island view. Nodes close together form an island, indicating that these financial entities have similar risks. Such a visualization technique could also be used in student loans. Different combinations of variables such as expected salary, delay in study and monthly repayment amount could be visualized as nodes. Nodes with similar risks would form an island just as in Regshock. The risk could for example be based on the Debt-To-Income (DTI) ratio, where a higher DTI corresponds with a higher risk. The problem with this approach is that it would not be intuitive for students to understand that type of visualization without extensive explanation. Regshock is developed for domain experts in network finance. This is in stark contrast with the target audience for the student loan tool, which consists of young adults that are by no means domain experts. Therefore, it is important to only include visualization techniques that are understandable for a large population.

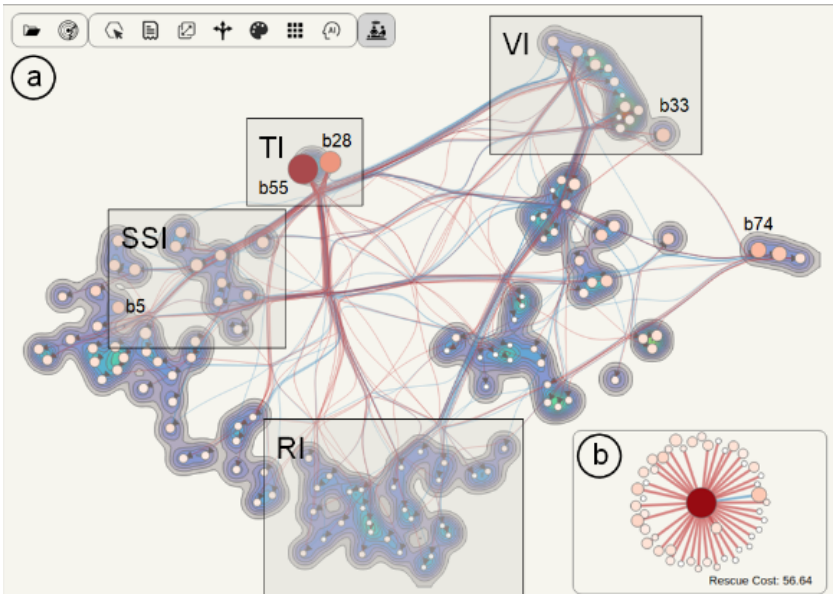

Figure 25: The Risk-island view used in Regshock. Nodes represent financial entities, which can be grouped based on risks to form islands. Image from [53]

2.7 Conclusion

Because of the lack of literature specifically about the visualization of loans, the literature review has visited many aspects that are in some way related to loans. Section 2.1 has discussed psychological topics that are related to loans. This enables predictions about the decision-making process of students when taking out a student loan: namely that they might be too focused on the present while neglecting important risks of the future. However, it is important to validate these predictions. The exact thought process of students when taking out a loan, and whether that is influenced by existing tools, remains unknown.

Different visualization methods of displaying time-series data are discussed in 2.3. The most suitable technique to display the progress of debt over time depends on whether one or multiple alternatives are displayed. An area chart clearly shows the build-up of debt and interest over time. A regular line chart can display multiple loan plans to easily make comparisons between the plans. Section 2.2 discussed risk and uncertainty visualization

techniques. It is important to investigate whether students want to compare different loan plans, or want to investigate one loan plan at a time that incorporates some kind of visualization of the risk and uncertainty. How risk and uncertainty are used in investment tools is discussed in section 2.4. Again it is important to know the preference of visualizing a single loan plan or comparing multiple to know whether the techniques used in FinVis and PortfolioCompare can be applied to student loans.

How proportions can be displayed is discussed in section 2.5. Pie charts and bar charts perform similarly on part-to-whole estimation. Bar charts are preferred when different loan plans are compared with each other. Lastly, some more complex systems are discussed in section 2.6. Because of the broad target audience, complex systems are not preferred. The next section will discuss interviews that aim to answer questions resulting from the literature review. For example, how do students decide on the size of their student loan and would they prefer to compare different loan plans?

3 Pilot study

3.1 Motivation

The main research question of this thesis is: *How can data visualization be used to support financial loan decision-making in higher education?*. To answer this question, it is crucial to fully understand the current decision-making process of students. Based on the literature review, there is an indication of a simplistic decision-making process of students. However, when designing a new tool, this indication should be validated. One purpose of the interviews is to ask students about their decision-making process at the moment they took out a loan. The factors they took into account, and the ones that are neglected are of great value. Moreover, prior encounters with student loans, existing tools, and the associated challenges and struggles can offer insights and points of improvement for developing a new tool. Lastly, it is important to investigate whether students prefer to compare different loan plans or focus on one loan plan in more detail at a time. This has implications for decisions regarding what charts are appropriate, how risk and proportions are visualized, and whether techniques used in investment tools can be used.

In the interviews, the critical incident technique is used. The critical incident technique is about identifying specific incidents or situations that are considered critical [38]. Recognizing and analyzing into these occurrences provides valuable insights into both the incidents themselves and the individual's encounter with them. In this thesis, participants are asked to go back to the moment they decided on the size of their student loan. They are asked to narrate their thought process at the time and especially focus on factors that frustrated them and therefore could be improved. Frustrations could be elements that were unclear or information that was missing at the time. By narrating these frustrations, important points of improvement are revealed. The leading objectives of the interviews are listed below.

- What factors do students consider when applying for a student loan? This gives insight in the decision-making process of students. Before creating a tool to support decision-making, it is essential to understand the existing decision-making process.
- What tools have students used and are they satisfied with these tools?

This gives more insights in the popularity of tools, and allows for identifying strengths and weaknesses of other tools.

- What support do students need to make better student loan decisions? This identifies what information and functionalities students want to have, and are therefore important to include in the tool.

Answering these objectives should give more insight into the decision-making process of students and their experiences and frustrations with student loans. These insights will be taken into account when developing a new tool. The complete list of all interview questions can be found in the Appendix (Section 8.1).

3.2 Methods

3.2.1 Procedure

Participants were welcomed to the study. At first, an information sheet was provided which included a brief description of the entire study, in addition to contact information. The rights of the participant were listed and an explanation of what will happen with their data was provided. The information sheet can be found in the Appendix (Section 8.5). On average, the interviews lasted around 15 minutes. After reading the information sheet, participants were presented with the informed consent form, which was mandatory to sign in order to proceed with the interview. The informed consent is included in the Appendix (Section 8.5). The interview started after the informed consent was signed and the audio recording was started. The interviews were conducted in a quiet room with only the participant and experimenter present. During the interview, snacks and drinks were provided to participants as a reward for participating. After all questions were answered, the audio recording was stopped and the participant was thanked for their time. Participants did not obtain any financial compensation.

3.2.2 Data analysis

All interviews were recorded using a mobile phone's voice recording feature, after which they were manually translated from Dutch to English and transcribed. The transcribed data was entered into an Excel sheet. This way, the content of the interviews could be easily analyzed to discover themes

in the data. First, the transcribed data was re-read to get a sense of the whole picture, as is advised by the procedure of content analysis [34]. The next step was to quantify the frequency of themes per question. For each interview question, answers were aligned below each other in the Excel sheet to observe themes. Once a theme was observed, the frequency was counted to see whether the theme is broadly shared between participants. The most frequent themes were analyzed in more detail and reported in section 3.3.

3.2.3 Particpants

Convenience sampling was used to recruit participants [36]. The only criterion to participate was that participants should possess experience with student loans: either actively using one currently or having utilized a student loan in the past. This criterion was necessary since the interview asked about personal experiences with student loans. Recruitment continued until a saturation point was reached where new interviews yielded no additional crucial information [126].

A total of 12 participants have been interviewed (6 males, 6 females), with a mean age of 22.58 ($SD = 2.1$). Ten had a Dutch nationality, one was German and one was French. Nine participants were still in college following a master's degree, of which all were actively using their student loans. The remaining three participants already completed their studies and had full-time jobs at the moment of the interview, and therefore had stopped borrowing. Various academic disciplines were represented among the participants, ranging from Arts and Society to Computer Science.

3.3 Findings

This section will discuss the most important findings of the conducted interviews. The experiences and awareness of participants with existing tools are discussed in section 3.3.1. Section 3.3.2 will explain the decision-making process of participants when taking out their student loans. Lastly, section 3.3.3 will discuss the frustrations and struggles of participants when taking out their student loans, identifying desirable functionalities for future tools.

3.3.1 Use of Tools

An interesting finding was the very low awareness of existing tools that can aid students in their student loan decisions. Out of the twelve participants, only two indicated that they had used a support tool. Both had used the DUO tool provided by the Dutch government, which is described in section 1.2.2.2 [11]. The DUO tool makes a simple calculation based on the income and expenses users fill in (p2: *"You had to fill in how much you earned and how much you spent and the tool would decide how much money you needed. Then based on this amount you could see some information about your student loan. It was pretty basic to be honest."*). When asked about their experiences with the tool, participants indicated it as satisfactory (p2: *"The information was not necessarily new to me, but it did force me to think about my spending at the time of moving out."*).

Participants also mentioned points of improvement about the DUO-tool. Primarily the lack of ability to compare various interest rates was highly unsatisfactory (p2: *"Nowadays I would include an interest calculator. The government really screwed us by increasing the interest. I believe almost all students thought the student loan was interest-free. This was not communicated clearly to students"*, p5: *"Also, there was no option to see the effect of changing interest rates. I believe I could only see how a 0% interest rate influenced my debt, which was nothing because it was 0%. Now it has been changed to 2.56%"*). In addition, one participant mentioned the tool did not have the option to fill in savings (p5: *"It did not ask about my current savings if I remember correctly. I did have a small amount in my savings account which I used to pay part of my costs."*).

The remaining 10 participants indicated that they were not even aware that tools existed. At the moment in The Netherlands, when a student applies for a student loan, a clickable link is displayed with a link to the DUO tool. Apparently, this pop-up is not sufficient to create awareness of the tool. An alternative could be to include the tool inside the DUO website when students are applying for a loan, instead of providing a link to a separate web page. This way, it could even be made mandatory to use the tool before applying for a student loan. However, this might lead to some frustration when for example students have already used an external tool or when they are simply not interested in getting better insight into all the future implications of a student loan.

3.3.2 Decision-making process

The decision-making process of the participants regarding the size of their student loans turned out to be rather simple. Out of the twelve participants, ten mentioned that they initiated borrowing when they transitioned from their parent's home to their student apartment (p12: *"At home I lived with my parents so they paid for groceries and stuff, but now I have to pay for it myself, and also my rent of course"*). The remaining two indicated they borrowed to be able to do fun activities.

But how exactly did participants decide on the size of their loan? Nine participants made a simple calculation of income and expenses. They decided to borrow the amount they estimated they came short each month (p11: *"I calculated everything: tuition, rent, bills, food... everything. I also factored in my part-time job earnings and my student grant. The money I was short I decided to borrow."*). The three additional participants opted to take out the precise sum needed to cover their rent. Their supplementary earnings, generated through part-time work or external contributions, covered their day-to-day expenditures (p4: *"... I just borrowed the amount of my rent, my side job earned enough to pay for my groceries and other stuff. "*). Calculating monthly income and monthly expenses is a logical thing to do when deciding on the size of your student loan since it will give you an estimation of how much extra money you need each month. However, participants treated their income and expenses as a static number that can not be changed. Not a single participant looked into the effects of making small changes to their income or expenses. Perhaps working a few extra hours on your side job, or saving on some expenses might save you a lot of money at the end of your loan. The other way around, taking more hours off from work might impact one's total debt and repayment not as much as one might think. Either way, it would be highly beneficial to be able to see the impact of certain decisions.

In addition, when describing their decision-making process, not a single participant mentioned future effects of the student loan like monthly repayment or the total debt. Two participants mentioned in hindsight they wished they would have thought more about the future effects of the loan (p10: *"I didn't take into account paying it off later, especially now the interest rates have gone up. I don't actually know how much I need to pay back each month, which is very weird now I think about it."*). The neglect of the future effects is in line with the psychological factors of loans described in section 2.1, which makes individuals more focused on the present gains while neglecting future

losses.

3.3.3 Struggles of Students

When reflecting upon their own decision-making process, several participants mentioned factors they wished they had taken into account when taking out their student loans. Five participants mentioned the changing interest rates as a factor they underestimated or completely neglected (p3: *"...but I did know that it could change. Interviewer: Would you like to have known how it impacted your situation? p3: I guess yeah. I was not aware of the exact implications of a changing interest rate. So although I knew it could change, I did not really know what that change meant for me."*). One participant mentioned the job market as an important factor, but also reflected on its usefulness (p11: *"I should've considered the job market after graduation and how that might affect paying off the loan. But then again, the market is constantly changing, so I'm not sure if analyzing the market 5 years ago would have helped me very much."*).

When participants were asked to design a tool themselves, 10 out of the 12 participants mentioned to include something to see the impact of changing interest rates. Comparing different interest rates was something that was mentioned multiple times (p4: *"Also something about how different interest rates impact your loan. Like, if the interest rate increases even further next year, how much will that cost me?"*, p6: *"It should take into account the amount of interest. I think I can speak for a lot of students when I say that no one really knew the impact of interest. The interest increase has a lot of impact on my loan, something I was not aware of when taking out the loan."*). Two participants mentioned the important factor that students are no financial experts and therefore are not familiar with the range of probable interest rates (p3: *"... and maybe something about how probable certain interest rates are because if you don't know the 'normal' interest rates, you can't really make a meaningful comparison between different interest rates. So maybe some combination of impact and probability."*, p5: *"... so like what is the difference between 1% and 2.5%. But in that case you would need to have some information about how probable certain interest rates are"*). This demonstrates that students also require financial information about interest rates, which provides them with a sense of the range of interest rates, allowing them to make more accurate predictions about the future.

3.4 Conclusion

The interviews have given insight into the use of tools, the decision-making process and the struggles participants encountered when taking out a student loan. The simplistic decision-making process aligns with the psychological aspects discussed in section 2.1. Students are often only focused on the immediate gain they get from the loan. This is problematic since the long-term consequences of a loan are forgotten. New developed tools therefore should properly indicate the long-term effects of a loan like the monthly repayment, total amount paid and how much interest will be paid.

The interviews also showed that participants would like to be able to compare alternatives, especially to investigate the effects of a changing interest rate. This indicates that visualizing different loan plans where each plan represents a certain level of risk might be more appropriate compared to using risk visualization techniques on one alternative, which was a question resulting from section 2.2. Furthermore, a line chart representing the multiple alternatives is favored over an area chart.

The pilot study has provided important insights in the decision-making process and and struggles of students when taking out a student loan. The next step is developing a new tool to aid students in making these student loan decisions. Especially the changing interest rates, the need for a probability indication regarding the interest rates, the ability to compare alternatives and the static view of income and expenses will be focused on when developing a new tool. The next section will showcase this tool and explain the functionality and design choices made.

4 StudentViz

This section will discuss the tool that is developed by the author (StudentViz hereafter). Section 4.1 will explain shortly what technologies are used to develop the tool. The design of the tool and all design choices are explained in Section 4.3.1.

4.1 Technologies used

The complete code is freely accessible on my GitHub account [10]. The tool is developed using a combination of the Svelte framework, and the d3.js library. Svelte is used for the reactivity of the tool. The d3.js library is used to create the visualizations in the tool.

4.2 Purpose

The purpose of StudentViz is to aid students in making student loan decisions. To make better loan decisions, it is crucial that students understand the relationship between current decisions and future consequences. StudentViz allows students to compare different student loan plans. The pilot study with students in section 3 indicated that students would like to compare different loan plans, with a special focus on the interest rates. Student loan plans are also affected by other variables like monthly loan amount, monthly repayment amount, duration of the loan, and duration between the end of study and the start of repayment. To make meaningful student loan decisions requires all these attributes to be taken into account. Multi-attribute comparisons between different loan plans requires certain visualization techniques.

Users of StudentViz can alter all these variables to their liking and see important information like total debt, final repayment date, and interest proportion. By adjusting the inputs, users can add and compare various student plans, allowing them to explore the impact of small changes over time. Each element of StudentViz is listed and explained below.

4.3 Design

4.3.1 Income and expenses page

StudentViz comprises three web pages: the income page, the expenses page, and the visualization page. Aligned with the DUO tool [11], the purpose of the income and expenses pages is to guide users in contemplating and inputting their income and expenditure patterns. The income page, depicted in Figure 26, is divided into a student grant section (left) and an income section (right). Within the student grant section, users can indicate if they receive a student grant and, if so, specify their education level and living situation. Based on this information, the student grant is incorporated into the monthly income. On the right side, users can input their income within predefined categories, such as side job, rental allowance, healthcare allowance, and external financial contributions. Users also have the option to include additional custom categories. Additionally, a button is provided to input the income of an average Dutch student, offering users a benchmark. Once users have completed entering their monthly income, they can proceed by clicking the "Go to expenses" button.

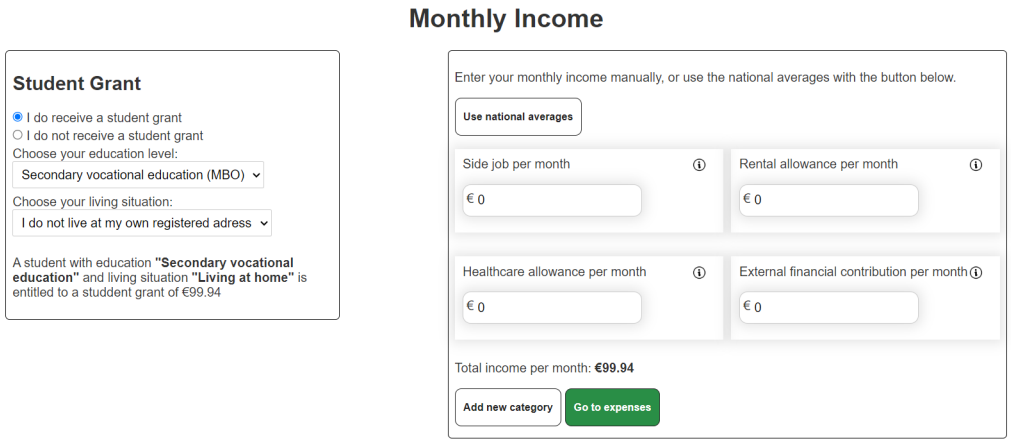

Figure 26: The income page of StudentViz. Information about a student grant can be entered on the left based on education level and living situation. Other income can be entered on the right using predetermined categories, or by adding categories yourself.

The expenditures page closely resembles the income page, with its em-

phasis shifting towards the user's spending patterns (see Figure 27). Users can input their monthly expenses within predefined categories such as tuition, study material, healthcare insurance, rent, phone, transport, groceries, clothes, monthly subscriptions, and leisure activities. Additionally, users have the flexibility to introduce new categories and input the spending patterns typical of an average Dutch student. Upon completion, users can proceed by clicking the "Next" button.

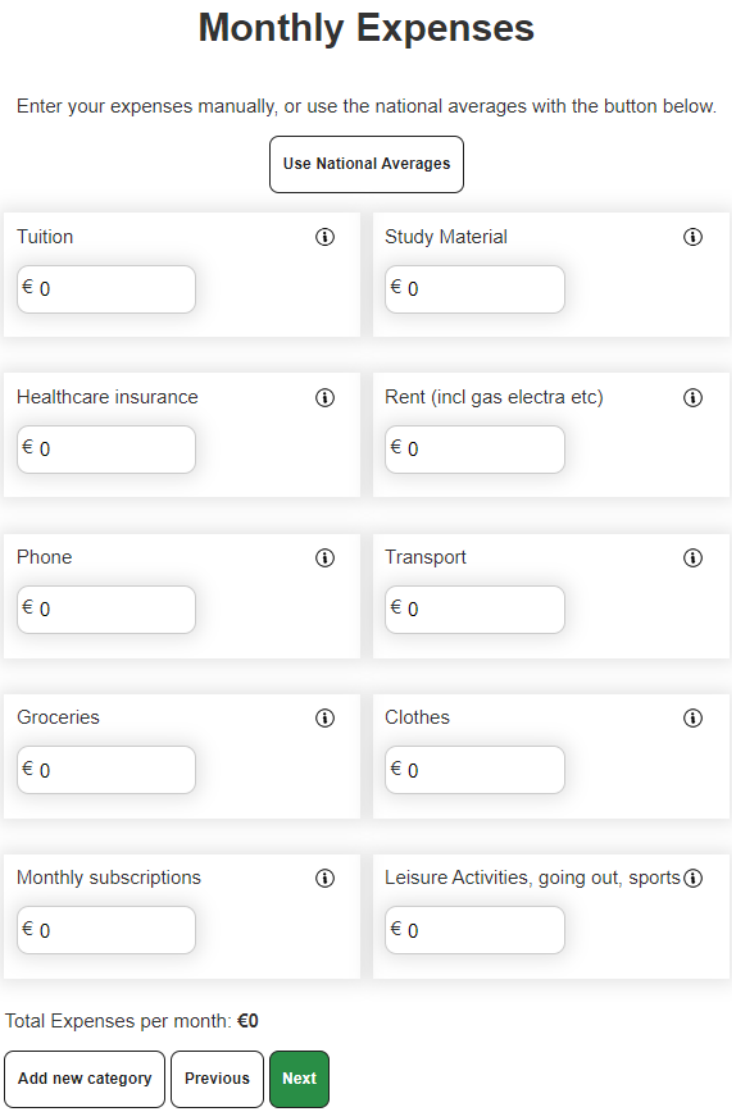

Figure 27: The expenses page of StudentViz. Monthly expenses can be entered using predetermined categories, or by adding categories yourself.

The income and expenses pages are included in this tool accord with the comments of the two participants that used the Duo-tool who indicated in section 3.3.1 that they liked the structure of it. It forced them to think about their income and expenses in a clear and understandable way. It also allows making a simple recommendation that can be used as a baseline for users to

explore alternatives. Therefore, the same structure has been implemented in StudentViz.

4.3.2 Visualization page

The final page is designed for interactive engagement, serving as the primary platform for users to observe how specific decisions impact their student loan plan and facilitating comparisons between various student loan plans. The visualization page uses a coordinated views approach. This means that multiple views are used to visualize the data. Furthermore, the views are coordinated due to specific mapping: changes in one view affect the others [99]. A coordinated views approach has been chosen since a loan plan is characterized by a wide variety of attributes. When evaluating various loan plans, the comparison primarily involves assessing the different attributes associated with each plan. Due to the diverse nature of the attributes, using a mixture of various visualization techniques could yield optimal results. Lastly, because of the mapping between different visualizations, the impact of certain decisions on certain attributes can be seen interactively. For example, altering the monthly loan amount automatically alters the monthly repayment amount. The different components of the visualization page are discussed below.

4.3.2.1 Input panel The input panel is placed on the left side (Figure 28). The total income and total expenses that the users filled in the previous pages are displayed on the top. Based on these numbers, a recommendation is given by simply deducting the income from the expenses. In case the income is higher than the expenses, no recommendation is given since there is no need for a loan. Below, information about the loan can be entered. The current debt, the monthly loan amount, and the duration of the loan can be altered here. Sliders are used to alter the monthly loan amount and the duration of the loan since these have a minimum and maximum value. Sliders limit the interaction needed to alter the values compared to numerical input fields. Since there is no maximum value of the current debt of a user, an input field is used which is incorporated inside the textual description. The textual description also includes the monthly loan amount and duration to ensure the inputs are understood correctly.

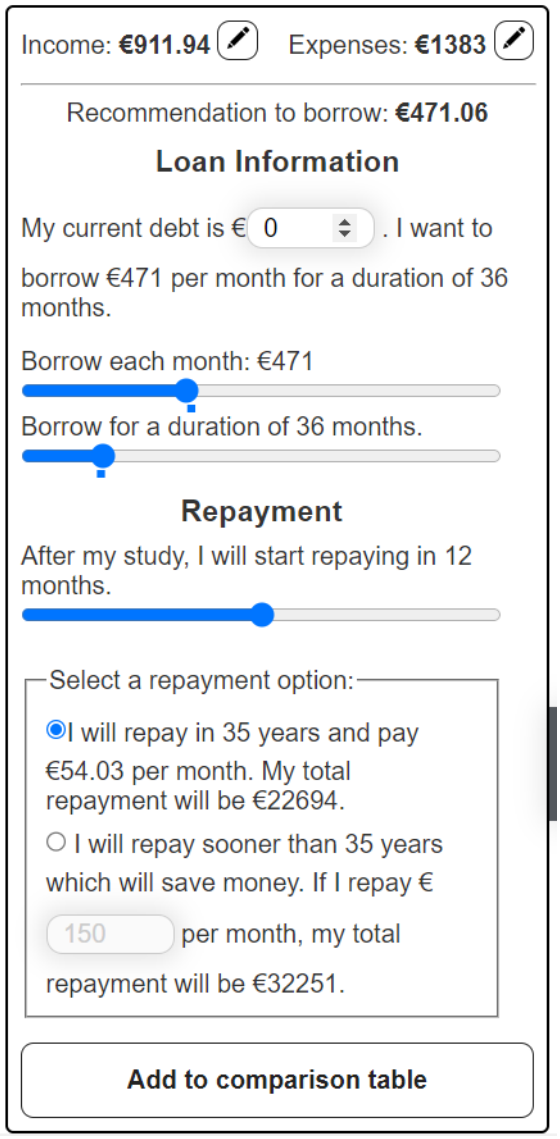

Figure 28: The line chart in StudentViz. It shows the progression of the total debt over time. Four different student plans are plotted inside the chart.

Beneath, repayment options can be entered. With a slider, the duration between the end of your loan and the start of repayment can be changed. This is a period where no repayment is required, but interest keeps building up. Beneath, two different repayment options can be selected with the use

of radio buttons. The first option is to repay the loan in exactly 35 years. In that case, how much you have to repay each month is calculated for you. The monthly repayment amount and the total repayment amount are mentioned inside the text of the radio button, and are automatically updated whenever input is changed. The second option is to repay sooner than 35 years. In that case, you have to specify your monthly repayment amount yourself. In case this specified monthly repayment amount is too low (which would result in a repayment term longer than 35 years), a red warning is presented to the user indicating the minimum monthly repayment amount for their situation (Figure 29)

On the bottom, a large button can be used to add different student loan plans. Each loan plan is visualized in the Interest Explorer, line chart, and comparison table which are discussed below. Each loan plan has a unique colour which is used to identify the loan plans in the different charts. Colorbrewer2 is used to select colors that offer excellent contrast and accommodate color blindness to the best extent possible [2].

Figure 29: A warning is displayed whenever the monthly repayment amount is too low.

4.3.2.2 Interest Explorer The Interest Explorer features a line chart that illustrates the historical interest rate data in The Netherlands from 2000 to the present. This decision is made because participants in the prior interviews revealed a lack of familiarity with interest rates, expressing uncertainty about distinguishing between high, medium, and low interest rates.

By incorporating historical data on student loan interest rates, the objective is to provide users with a clearer understanding of the range of interest rates. Showing this data in a straightforward line chart enables users to swiftly understand the range of previous interest rates.

Within the chart, a horizontal black line represents the currently selected interest rate. Positioned above the chart, an input field displays the numeric value of the chosen interest rate. Users have the option to adjust the interest rate by either dragging the black horizontal line vertically or by modifying the value in the input field. Once a loan plan is added, a horizontal line in the corresponding color of the loan plan will be plotted inside the Interest Explorer (Figure 30). By plotting the colored line inside the chart, the interest value can easily be compared to other loan plans and historical data. This way, users can see the effect of different interest rates, while also getting more insight in the probability of certain interest rates.

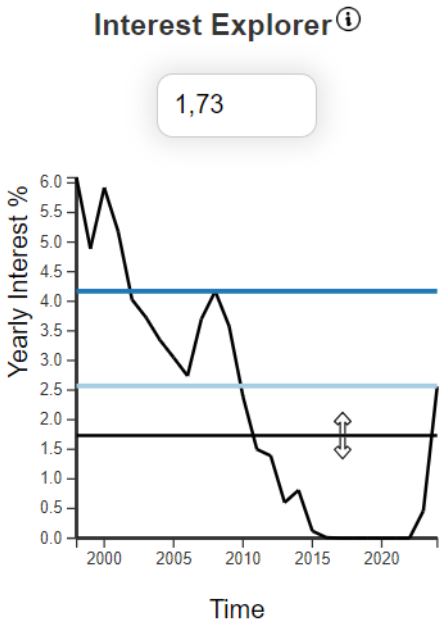

Figure 30: The Interest Explorer in StudentViz. Historical data of the interest rate on student loans is displayed in the chart. The two colored lines indicate interest rates of two loan plans. The black horizontal line indicates the interest rate of the current plan and can be moved to regulate the interest rate.

4.3.2.3 Line chart The line chart shows the progression of the loan over time (Figure 31). On the y-axis, the total debt at a specific moment in time is displayed. On the x-axis, the time is displayed. The black line in the chart indicates the progression of the loan plan based on the current inputs in the input panel and the Interest Explorer. After adding a loan plan, its progress will be visually represented by a line featuring the corresponding color associated with that specific loan plan. In the top right, a legend is displayed which shows what color corresponds to what loan plan. A line chart has been chosen because it is a widespread way of visualizing time series data, as discussed in section 2.3. Because of this, it is easy to interpret and it provides useful information about how the total debt decreases over time. It is preferred over an area chart since it easily visualizes multiple loan plans in a single chart. Furthermore, since the data has no noise and a lot of data points, a line chart is preferred over a scatter plot [122].

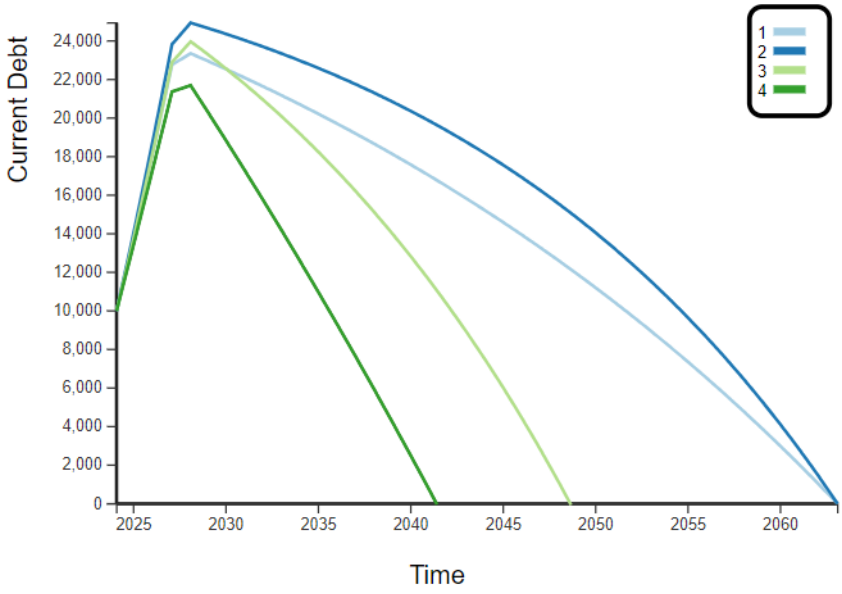

Figure 31: The line chart in StudentViz. It shows the progression of the total debt over time. Four different student plans are plotted inside the chart.

4.3.2.4 Comparison table The purpose of the comparison table is to compare the student loan plans in more detail. The comparison table uses

a tabular visualization technique, inspired by Dimara et al. [31]. This technique consists of a numerical table in which the cells are encoded visually. In the comparison table, the cells are encoded by length using bars. The tabular visualization technique allows comparisons of multi-attribute alternatives. Importantly, the tabular visualization is lossless: all attribute values can be visually retrieved without interactions beyond basic scrolling and panning operations [31]. This is useful for users as it is crucial to understand the precise implications of a loan plan rather than relying on estimations. For example, the difference in monthly repayment between two loan plans might be just a couple of euros. This small difference could have a large impact over time. Therefore, it is important that the exact values can be extracted from the table instead of estimates. Another reason why a tabular visualization technique has been chosen is the simplicity of it. It is very easy to understand how it works, which is very important considering the broad target audience. Figure 32 displays the comparison table containing five loan plans.

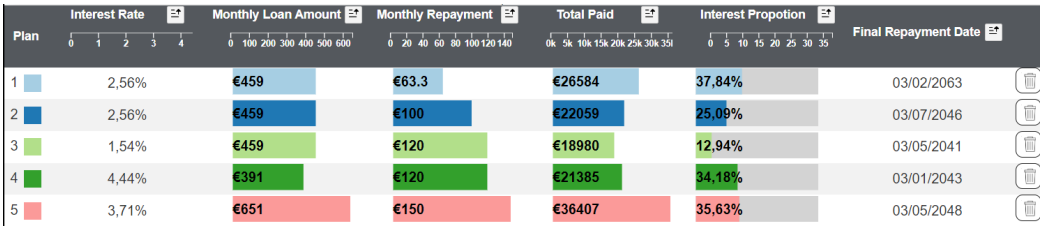

Figure 32: The comparison table used in StudentViz. It contains five loan plans.

Each student loan plan is presented as a row in the table. Each row portrays important information about that loan plan. For each loan plan, the following attributes are displayed in the table: the loan plan identification number, the selected interest rate, the monthly loan amount, the monthly repayment amount, the total amount paid, the interest proportion, and the final repayment date. The interest rate and the final repayment date are not encoded with bars as opposed to the other attributes. This choice is made because the chosen interest rates are also showcased in the Interest Explorer, allowing for more effective comparisons with the historical data. The textual representation of the final repayment date is opted for because it can more easily be compared using the line chart.

Once several plans are added to the comparison table, meaningful comparisons can be made. The bars allow for quick and easy comparisons between different loan plans. The bars automatically adapt accordingly whenever new loan plans are added. The loan plans can be sorted based on one attribute by clicking on the sorting button in the table header (top of Figure 32). For instance, if a user considers the interest proportion to be highly significant, loan plans can be swiftly sorted based on this criterion to eliminate certain options. Furthermore, study plans can be filtered based on one or more attributes. A scale is plotted in the table header beneath the attribute name. This can be used to specify a minimum and maximum value of that attribute. Study plans with an attribute value outside the filtered range will become greyed out. An example is shown in Figure 33, where a filter based on the total amount paid is applied.

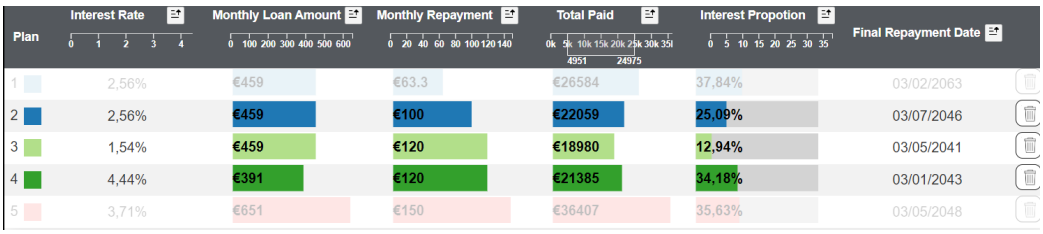

Figure 33: The filter option being used in the comparison table.

In summary, StudentViz aims to assist students in making informed decisions regarding student loans by facilitating comparisons of various loan plans. A coordinated views approach is implemented to visualize the wide variety of variables that are in play in student loans. The Interest Explorer allows users to compare the interest rate to previous interest rates by displaying the historical data inside the line chart. The line chart displays the progress of the loan plans over time. The tabular visualization is used to allow users to make multi-attribute comparisons between different loan plans. The following section will evaluate StudentViz to determine its effectiveness in supporting the decision-making process for students.

5 Tool Evaluation

This section will discuss the evaluation of StudentViz. The methods used will be discussed in section 5.1. Subsequently, the main findings of the evaluation will be discussed in section 5.2.

5.1 Methods

5.1.1 Participant recruitment

Participants were required to have some experience with student loans to be eligible to participate in this study. This means they were actively using their student loan or had a student loan in the past. Alternatively, they could also have displayed an interest in getting a loan without having experience with student loans. Convenience sampling, in combination with recruitment via WhatsApp was used. In addition, snowball recruitment was used. Participants were asked to forward the invitation to participate to friends and acquaintances. Participants were recruited until a saturation point is reached where new participants provided no more new insights [126].

A total of 11 participants, 3 males and 8 females, with a mean age of 24.7 ($SD = 2.3$) participated in the tool evaluation. All participants had a Dutch nationality. Seven out of the eleven participants were still in college, all following a master's degree. The other four participants already completed their studies and worked full-time. Six participants had borrowed in the past. The remaining five participants were actively borrowing at the time of the evaluation.

5.1.2 Measurements

The evaluation of StudentViz consists of three main measurements: a think-out-loud session, an interview, and a financial self-efficacy questionnaire. These are explained below.

5.1.2.1 Think-out-loud session The purpose of the think-out-loud session was to analyze the decision-making process of participants, and how it was affected by the visualization techniques when using the tool. Participants were asked to use StudentViz with the data of their own situation in mind. In case they have borrowed in the past, they were asked to take a

situation in mind when they were still borrowing. They were told that the objective was to use StudentViz and pick a student loan plan that fits their goal. Participants were asked to narrate their actions and thought processes as elaborately as possible while using StudentViz.

5.1.2.2 Interview The interview was semi-structured. There were leading questions that are listed below and in the Appendix (Section 8.4). There was room for follow-up questions or elaborations. The purpose of the interview was to gather participants' opinions about the tool. What do they think of the visualization techniques used? What could be improved? Also, participants were asked to explain their behavior during the tool. For instance, why did they use some elements more than others? This gives deeper insights into the effects of the tool on their decision-making process and their personal opinions of the elements in the tool.

1. Why did you choose this exact student loan plan?
2. What do you think of the Interest Explorer? (Was it easy to use? Did the historical data displayed increase your understanding of interest rates? Did you prefer dragging the horizontal line, or use the input?)
3. What do you think of the tabular visualization showing all the student loan plans? (Was it easy and understandable how to compare different student loan plans, sorting and filtering, use of colors?)
4. Were you inclined to explore the effects of different interest rates? Why or why not?
5. Were you inclined to explore the effects of different monthly loan amounts? Why or why not?
6. Did you have any frustrations or moments of unclarity when using the tool?
7. Overall, What should be kept and what should be dropped from the tool?
8. Do you have any final remarks or questions?

5.1.2.3 Financial self-efficacy questionnaire Financial self-efficacy is the perceived ability to complete financial tasks and meet financial goals [29]. Individuals with high financial self-efficacy perceived less difficulty in paying off their student loans compared to individuals with low financial self-efficacy [101]. To measure financial self-efficacy, a reflective five-item self-report scale was used [80]. The statements were slightly altered to measure the impact of the tool rather than the general self-efficacy trait. This is also done in other studies where the term 'investment' was changed into 'financial' to be able to use the questionnaire outside the investment domain [29]. For example: *"I am confident in my ability to make personal financial decisions"* became *"This tool makes me confident in my ability to make personal financial decisions"*. The statements are listed in the Appendix (Section 8.2). Answers were provided on a 7-point Likert scale ranging from "strongly disagree" (1) to "strongly agree" (7). The final financial self-efficacy score is the average of all items, with item 3 being reverse scored.

5.1.3 Procedure

At first, participants were welcomed to the study. The study took place in a quiet room with only the participant and interviewer present. The exact location of the room varied. Participants were presented with the information sheet that contained information about the study, the duration of the study and contact details. Next, the informed consent was presented to the participant. It was mandatory for the participant to sign the informed consent to proceed with the study. The information sheet and informed consent can be found in the Appendix (Section 8.5) Once the informed consent was signed a video was shown to the participant. This video explains the functionalities of the tool and how to use it. The video is 4 minutes and 35 seconds long. Next, the training session started.

During the training session, a short scenario was presented. The scenario was printed out on paper and given to the participant. The scenario describes a hypothetical student who wants to take out a student loan. The income and expenses of this student were provided. Based on this scenario, five simple analytical tasks were presented to test their understanding of the tool. The time of completion was measured using the stopwatch function on a mobile phone. The time was started when the participant completed reading the scenario and analytical tasks, and stopped when all analytical tasks were successfully completed. The scenario is listed in the Appendix

(Section 8.3). The analytical tasks are presented below. If the analytical tasks were completed successfully, the think-out-loud session was started. In case some mistakes were made with the analytical tasks, more explanation was provided to the participant. The participant was required to successfully perform the analytical task before continuing with the think-out-loud session.

1. Use the tool and fill in the income and expenses listed above
2. Using the recommended monthly loan amount, how much do you have to repay in total with a duration of 36 months, an interest rate of 2.5%, and a monthly repayment amount of €100?
3. How much less do you have to repay in total with an interest rate of 1%? (The other parameters remain the same)
4. Sort the alternatives from high to low based on interest proportion
5. Filter the alternatives on the interest proportion with a minimum of 0% and a maximum of 15%. How many alternatives are greyed out?

The think-out-loud session was started after the analytical tasks. Simultaneously, a screen recording is started. The screen recording captures both the participant's interactions with the tool and their voice. The participant was asked to narrate their interaction and thought process as elaborately as possible. Once the participant had finished using the tool, he/she was asked to pick the best loan plan for their situation. After this, the screen recording was stopped. Participants did get a minute to relax while the researcher wrote down the tracked data from the think-out-loud session. The tracked data included the number of loan plans added and the number of unique interest rates and monthly loan amounts explored by the user. Subsequently, a new audio recording was started and the interview began. When all interview questions were answered, the audio recording was stopped. Finally, the financial self-efficacy questionnaire was presented and some demographic information was asked. The procedure is graphically displayed in Figure 34, and was expected to last around 35 minutes.

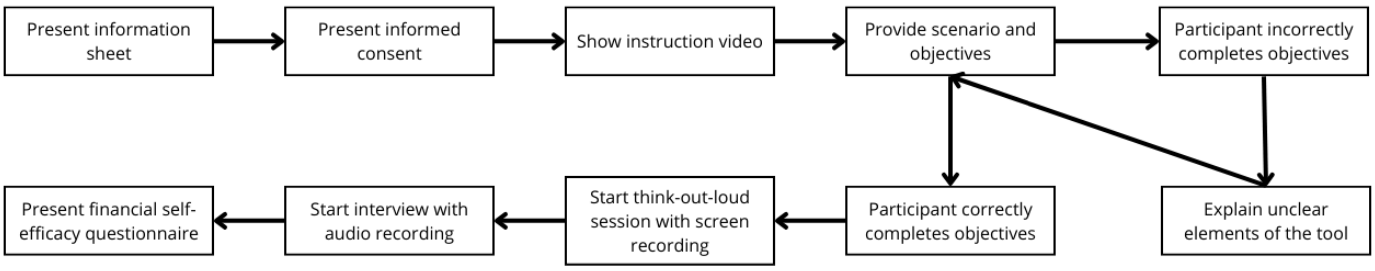

Figure 34: The procedure of the evaluation of StudentViz.

5.1.4 Data analysis

The think-out-loud session was evaluated by an insight-based evaluation [85]. Participants were required to think out loud about the insights they acquired when using StudentViz. We distinguish different types of insights. Singular insights are insights about a singular attribute of a loan plan (e.g. This loan plan has a monthly repayment amount of X). Second, comparative insights are observations about the relationship between different loan plans (e.g. how an increase in interest rate increases the monthly repayment amount compared to a previous loan plan). Insights about the functionality of the tool (e.g. moving this line causes the interest rate to change) were not evaluated in more detail since it is explained in the video and tested in the training session. In addition, important interactions with the tool were measured: StudentViz tracks how many loan plans, unique interest rates, and unique monthly loan amounts are compared. Lastly, the time of completion was also measured.

The think-out-loud sessions were recorded and manually translated from Dutch to English and transcribed. Next, all insights were annotated in the transcribed data. Of each reported insight, it is determined whether it is a singular or comparative insight. In singular insights, the attribute of what the insight is about, called the evaluation attribute, was noted. With comparative insights, we distinguished between alteration and evaluation attributes. The alteration attributes are the attributes that are changed by the user (e.g. monthly loan amount, duration of the loan, monthly repayment amount). Evaluation attributes are the attributes of the loan plans that are used to compare the plans. For example, a participant adds loan plan A as a base-

line. Subsequently, the monthly repayment amount is changed in plan B. The participant then compares the alternatives based on the interest proportion (e.g. *"I see when I start to repay more, my interest proportion decreases compared to plan A"*). In this example, the alteration attribute is the monthly repayment amount and the evaluation attribute is the interest proportion. The frequency of the alteration attributes indicates what users think is most interesting to alter and see the impact of, whereas the frequency of the evaluation attributes indicates what users think is the most important of a loan plan and impacts their decision-making process.

The interview recordings were also manually translated from Dutch to English and transcribed. It was analyzed with a content analysis approach, similar to the interviews in the pilot study (section 3) [34]. The transcribed data was entered into an Excel sheet. At first, the transcribed data was re-read to get a sense of the whole. Next, for each question, themes were identified and quantified. The frequency of themes indicated whether the theme is broadly shared between participants. The most frequent themes were analyzed in more detail and reported.

Finally, the financial self-efficacy score is assessed to give an indication how StudentViz is related to financial self-efficacy. The financial self-efficacy score is the average of all questions with question 3 being reverse scored. The score will range between one and seven, with higher scores indicating a higher financial self-efficacy score.

5.2 Findings

5.2.1 Scenario and analytical tasks

The average time of completing the scenario with the accompanying analytical tasks was 156 seconds ($SD = 22$ seconds). All participants managed to correctly perform the analytical tasks without needing additional explanation. This shows that the tool was understandable and easy to use after seeing the short introduction video. This was expected since the visualization techniques used in StudentViz were purposely made easy to understand because of the broad target audience.

5.2.2 Insights think-out-loud session

5.2.2.1 Singular insights During the think-out-loud session, participants mentioned on average 1.45 singular insights. Most of these singular insights were about the first loan plan that participants added. Four different evaluation attributes were mentioned a total of 20 times in the singular insights. The frequencies of all singular insights are displayed in Table 1. The most frequent attribute is the total amount paid, followed by the interest proportion and monthly repayment amount.

Table 1: The frequency of reported evaluation attributes in the singular and comparative insights.

Evaluation attributes	Total paid	Interest proportion	Monthly repayment	Final repayment date	Total
Singular insights	8 (40%)	5 (25%)	5(25%)	2 (10%)	20
Comparative insights	30 (48.4%)	15 (24.2%)	7 (11.3%)	10 (16.1%)	62

5.2.2.2 Comparative insights After multiple loan plans were added, most insights were comparative instead of singular. This is reflected in an average of 5.0 comparative insights per think-out-loud session. This shows that after multiple plans were added, the loan plans were mostly analyzed by comparing them to other loan plans and seeing how they relate to one another, instead of analyzing each plan individually. This is precisely the goal of StudentViz: not to concentrate solely on the features of one plan, but to explore the effects of alterations made to loan plans and compare them.

5.2.2.3 Evaluation attributes In total, 62 evaluation attributes have been mentioned in the comparative insights. The frequencies of each attribute are mentioned in Table 1, and displayed in Figure 35. The frequencies of the evaluation attributes show similar patterns to the singular insights. The total amount paid and the interest proportion have a high frequency, indicating that these attributes were most important when comparing loan plans and when analyzing single loan plans. The monthly repayment does

have a higher contribution in the singular insights compared to the comparative insights. The final repayment date is more frequently referenced in comparative insights than in singular insights, suggesting that users prioritize this information when comparing different loan plans rather than when analyzing a single loan plan.

The total amount paid and the interest proportion were the most important evaluation attributes when comparing loan plans. This might be because these attributes signify a certain level of desirability in the choice. Generally, the lower the total debt and interest proportion the better. Therefore, these attributes make it easy to compare the overall quality of different loan plans. The final repayment date is also mentioned quite some times, but not as frequently as the total debt and interest proportion. This could be due to the final repayment date not providing as accurate an indication of the loan's quality as the total debt and interest proportion do. An early final repayment date could also be the result of excessive borrowing in combination with large monthly repayments, still resulting in a high total debt. Hence, the final repayment date may be perceived more ambiguous evaluation criterion than the total debt and interest proportion, and might therefore be less frequently utilized when comparing different loan plans.

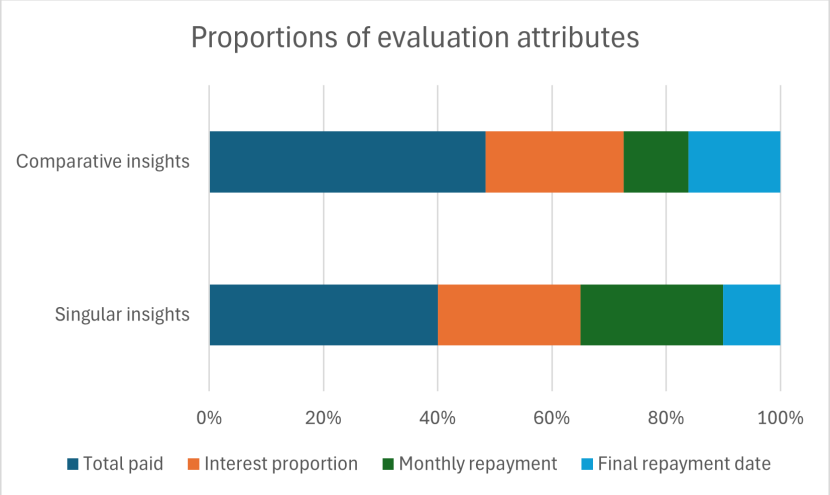

Figure 35: The distribution of evaluation attributes mentioned in the singular and comparative insights.

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5.2.2.4 Alteration attributes In total, 47 alteration attributes have been mentioned in the comparative insights. The frequencies of each attribute are reported in Table 2, and displayed in Figure 36. The findings indicate that participants expressed the greatest interest in observing the effects of altering the monthly repayment amount. The monthly loan amount and the interest rate have also been mentioned several times. The study repayment period and duration of the loan have only been mentioned a few times.

The monthly repayment amount is the alteration attribute with the highest frequency, indicating that participants were interested in how it impacts student loan plans. One possible explanation for this is the fact that all participants were either borrowing for quite some time already or were already repaying their loans. For students nearing the end of their loan period, repayment is a very interesting factor since it is the only factor they can control that can have a big impact on their total repayment amount. Participants who were already repaying their loans were asked to take a situation in mind when they were still borrowing. This might not be the best approach since some participants indicated it was hard to explore the effects of some decisions in hindsight.

Participants did display some interest in investigating the impact of various monthly loan amounts, but not as much as the monthly repayment amount. Students who have borrowed for some time generally know how much money they require each month, and might therefore be less inclined to see the effects of a different monthly loan amount compared to younger students. In an evaluation with younger participants, ideally, people who have not borrowed before but are interested in taking out a student loan, one might expect the monthly loan amount to be mentioned more in the alteration attributes.

The effects of different interest rates are also an interesting factor for participants. This is a big difference compared to the pilot study, where the impact of interest rates was not incorporated into their decision-making. This may be attributed to the combination of minimal effort required in StudentViz to observe the changes and the significant impact these changes can have. By merely adjusting a slider, substantial changes in the loan situation can be visualized.

Table 2: The frequency of reported alteration attributes in the comparative insights.

Alteration attributes	Study repayment period	Monthly loan amount	Loan duration	Interest rate	Monthly repayment	Total
Comparative insights	4 (8.7%)	8 (17.4%)	5 (10.7%)	8 (17.4%)	22 (47.7%)	47

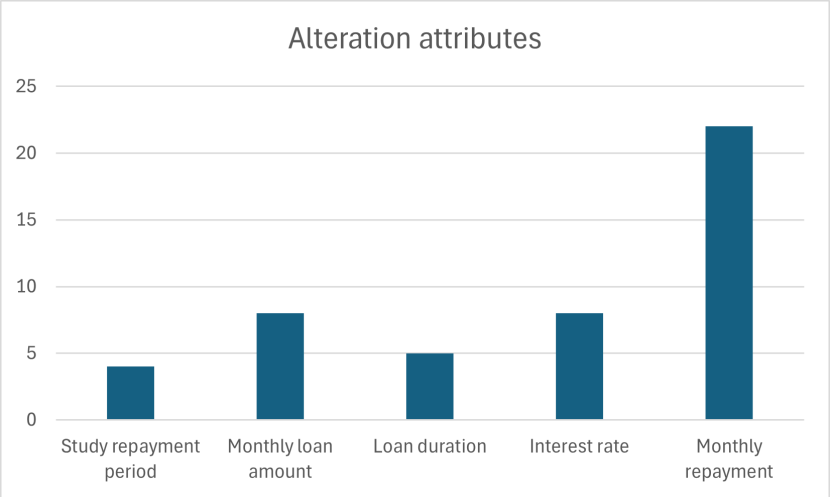

Figure 36: The distribution of alteration attributes mentioned in the comparative insights.

5.2.2.5 Conclusion The results show that the participants using StudentViz are very much interested in comparing loan plans. Users compared on average 6.0 different loan plans. This puts the focus on the future effects of the loan plans. The total amount paid and interest proportion are the most important attributes for participants when comparing different loan plans. Furthermore, the monthly loan amount is in several instances not perceived as fixed, rather, the effects of adjustments to it are explored. On average, participants explore the effects of 2.0 different monthly loan amounts. Similarly, the effect of different interest rates is often investigated. This is reflected in the fact that on average 2.5 unique interest rates are included in the loan plans.

A vast majority of the insights resulted from analyzing the comparison table. This is no surprise since it is the only element that holds important information like the total debt and interest proportion. The line chart also elicited some insights, mainly about the final repayment date.

5.2.3 Interview results

5.2.3.1 Decision-making process The data of the participant's explanations of why a specific loan plan was chosen confirm the findings of the insight evaluation. Participants often chose a loan plan that minimized the total amount paid and the interest proportion (p10: *"The monthly repayment of this plan is very high, but that does minimize the total paid and interest proportion. If I would repay less, more money would be thrown away to interest"*). In some cases, attributes like monthly loan amount or the final repayment date were also important (p7: *"I wanted some financial freedom, so the monthly loan amount was important, but also how fast I would be done with repayment."*. The focus of participants when selecting the optimal loan plan was mostly on the future negative aspects of the loan. This is a huge contrast compared to the pilot study, where loan plans were solely based on the current needs of the student. This indicates that StudentViz encourages users to also take into account the future effects of a student loan.

5.2.3.2 Interest Explorer When questioned about their encounters with the Interest Explorer, the outcomes varied. Some of the participants enjoyed it and utilized it frequently. (p6: *"Nice to see since it fluctuates a lot. It has changed a lot in recent years. I do expect it to change in the future, also because I put some money into savings, it is good to see the impact of the interest rate. It differs around 20k from my highest loan plan, so that is good to see"*, p3: *"I really liked it. The arrows on the line indicate that you can move it. Also very insightful."*). Participants mentioned it was insightful because of the very big impact it can have (p2: *"But because it fluctuates quite a bit, you see very big differences"*). These participants were inclined to explore the effects of different interest rates (p6: *"I looked at three interest rates: the current situation, one higher and one lower, in combination with different repayment options"*).

Participants also regularly mentioned not using the Interest Explorer a lot, mainly because of the lack of control they have over the interest rate

(P5: *"I can not change it, but I do know I want to start repaying as soon and as much as possible, so in that case the interest is not that important"*, p8: *"It can be useful to make a worst case scenario, but you have no impact on it. The government determines it, whereas your income, expenses loan amount and repayment amount are influenced by your own actions, so that had my main attention"*). Others also mentioned they have no idea whether the interest rate will increase or decrease (p2: *"... it is hard because you have no idea what will happen in the future"*). A participant noted that the Interest Explorer would prove more beneficial when you anticipate changes in the interest rate (p8: *"I would use it when I know what change is coming to see how it impacts my loan plan."*). These participants were not inclined to see the effects of different interest rates. On average, participants compared the effect of 2.6 unique interest rates. Note that, compared to the interviews from the pilot study where the interest rate was often neglected, including the Interest Explorer in StudentViz did encourage some participants to investigate the impact of different interest rates.

Displaying the historical data in the Interest Explorer was evaluated positively by many participants, sometimes encouraging participants to try out different interest rates (p1: *"You saw that it was rising last years, because of that I changed it once to 3%"*). Some suggested that comparing the current situation with the past is challenging (p2: *"it is interesting that it was 6%, but it is hard to compare with now since there were different regulations. So it was useful to see, but it is hard to make future predictions based on that"*). Others also pointed out that the significant fluctuations in the interest rate over the past years make it difficult to make predictions (p7: *"On the one hand you could become pessimistic when you see that it fluctuates that much since you have no idea whether it will increase or decrease, on the other hand, it does give you a good understanding of the fluctuations and the impact of it"*). All in all the historical data did provide many participants with better insights into the fluctuations of the interest rate.

5.2.3.3 Comparison Table The experiences of participants with the comparison table were more uniformly positive. Every participant provided a highly positive evaluation of the comparison table, stating that it was intuitive and beneficial (p7: *"When you are a visual person like I am, this is easier to analyze than summed up text."*). For a lot of participants, the comparison table was the most useful element in the tool (p10: *"[The comparison*

table] was the most interesting for me. Because visually you can easily see what your repayment is and what the best plan is ... because they are presented below each other it is very easy to compare them."). The use of colors to represent each alternative was also evaluated positively (p1: *"This was very handy, mainly the colorized bars. And you can directly see the differences between the plans"*). This shows that the use of a tabular visualization technique is beneficial for comparing loan plans, even when there are a small number of alternatives.

The sorting and filtering functionality of the comparison table received mixed reviews. The sorting function was evaluated more positively and was also more used than the filtering option (p10: *"... sorting them on total paid or interest proportion was really useful"*). Many participants indicated that the filtering option was redundant because of the low amount of loan plans (p3: *"I didn't use it myself, but I can imagine that it would be handy when you really dive into it and you have 20 loan plans, but not so much with 5 plans because I can easily compare them directly"*). Others simply deleted loan plans whenever they were not advantageous (p2: *"[I used] filtering not that much, I just deleted alternatives that were clearly not advantageous. The sorting was handy when you quickly want to see the lowest or highest"*).

5.2.3.4 Line chart The line chart, displaying the progression of the debt over time, was not the main concern of most participants. Most participants were focused on the comparison table. It did support participants in comparing the final repayment date between loan plans. Due to the reduced interaction with the line chart, one participant suggested that the chart's placement could be altered (p3: *"The line chart is nice to have, but maybe should not be displayed this prominent on screen"*). All in all, the line chart does yield some benefits for comparing final repayment dates but is not the most important element in StudentViz.

5.2.3.5 Improvements Lastly, when asked what elements were most important and what the least, most participants indicated that every element has its own contribution (p10: *"Definitely keep the table. Actually, everything has an added value so I would keep everything."*). This shows that the different visualizations using the coordinated views technique complement

each other, each focusing on different parts of the loan plans.

Regarding the functionality of the tool, some points of improvement were mentioned. First, the ability to fill in the income and expenses of the average Dutch student per category. Currently, clicking on the "fill in averages" button enters the average in all fields, sometimes resetting the input of users. Second, one participant mentioned the desire to enter the final repayment date, and based on that determine the monthly repayment amount (p7: *"I only had one question whether you could set the monthly repayment based on the final date you would like to pay"*). These are small features that could easily be implemented in StudentViz.

Lastly, some participants indicated that the income of their side job changes a lot (p5: *"My side job fluctuates a lot per month, so maybe a range where you can enter a minimum and maximum value"*). As mentioned, one solution could be a range consisting of a minimum and maximum value. Boundaries representing the minimum and maximum scenarios could be plotted inside the line chart. However, with multiple loan plans, each with a minimum and maximum boundary, the charts would get cluttered very quickly.

Another possibility to account for changing variables is to allow for the planning of events. For example, when a user knows that in 6 months he/she can work more than before, this event could be added, automatically reducing the monthly loan amount after 6 months. This gives a more accurate estimation of the progress of the loan. The planning of events is discussed more in the next section.

5.2.4 Financial self-efficacy

The financial self-efficacy score of participants (M=5.76, SD=1.72) is a high score, indicating a high level of financial self-efficacy. However, interpretation of this score remains challenging when no direct comparisons can be made. Dare et al. investigated the relationship between financial self-efficacy and financial well-being. They found, using the same questionnaire with small alterations, a similar average self-efficacy score of 5.73 (SD=0.98). That study included 411 participants who were living in the UK, native English speakers with a mean age of 48 (SD=14.62). The participants in that study were much more diverse compared to the participants in this study. Still, one should be careful when comparing these results. The questions used in this thesis revolve around StudentViz, whereas the questionnaire used by Dare et

al. focuses more on the general trait. More research with more participants is needed to make meaningful comparisons and to further investigate how the visualization techniques used in StudentViz are related to financial self-efficacy.

6 Discussion

This thesis has focused on using effective data visualization to support students when making student loan decisions. A pilot study has revealed that students often neglect the future consequences of student loans, focusing too much on the present. StudentViz has been developed to overcome this problem by enabling users to compare different loan plans and visualize the future consequences of each loan plan. Results have shown that participants are most interested in the effects of different monthly repayment amounts, and evaluate loan plans mostly based on the total amount paid and interest proportion. The tabular visualization was most popular with participants and facilitated most insights. The Interest Explorer received mixed results. Some participants expressed curiosity about investigating the impacts of varying interest rates, while others did not, as they considered fluctuations in interest rates out of their control since the government determines it. The line chart was used by a few participants to compare the final repayment date but was not the main focus of participants.

6.1 Interest rate & interest proportion

One intriguing observation is the discrepancy between the interest in the Interest Explorer and the interest proportion. Participants were very much interested in the amount of interest they had to pay in total, but not so much in the specific interest rate. At first glance, this seems counterintuitive because the interest rate has the largest effect on the interest proportion. One possible explanation can be related to loss-aversion, discussed in section 2.1.1. The Interest Explorer displays the value of the interest rate which might be perceived as just an abstract number. The consequences of the interest rate are not yet clear. In contrast, the interest proportion is presented as a percentage of the total amount paid which implies a loss. Participants often referred to the interest proportion as 'thrown-away money'.

As we know, losses are evaluated very strongly and therefore have a big impact on decision-making [59]. It might be that because the interest proportion is perceived as a loss, it has a bigger impact on the decision-making compared to the abstract value of the interest rate. Individuals want to prevent or minimize losses, thus minimizing the interest proportion. This shows the importance of including the interest proportion and making users aware

of future losses.

Loss aversion might also contribute to why total debt is so important to students and is mentioned a lot in the singular insights, comparative insights, and interviews. It represents the loss students have built up during their loan period. Emphasizing the future losses caused by student loans makes students more reluctant to borrow excessive amounts of money, and may thus be an important step in minimizing one's total debt.

6.2 Planning

As discussed, StudentViz could be further improved by allowing the planning of certain events. This is something that the previously discussed tools in section 1.2 also did not allow. Besides using it to enter changes in income, it can also be used in StudentViz for changes in interest rates, expenses, and student grants for example. Each event can be visualized on top of the line chart, similarly as in Figure 15 in section 2.3.2. Being able to add events allows for visualizing a more tailored loan plan, where the effect of each event can be displayed.

For this to function effectively, it is essential to be aware of the impending change and its timing. This might be a problem for interest rates. Currently, when users select an interest rate in StudentViz, it is applied to the entire duration of the loan. In reality, the interest rate can change each year during the borrowing phase, and every 5 years during the repayment of the loan. Results have shown that users find it hard to make even one prediction about the interest rate, let alone to plan multiple changes. A simplified model as used in StudentViz, where one interest rate is applied to the entire loan, might be more suitable than planning multiple changes.

6.3 Visualization techniques in student loans

Line charts are a popular visualization technique used when displaying debt progress over time, and are incorporated in most of the discussed tools in section 1.2. Similarly, a line chart is also incorporated into StudentViz. Results have shown that the line chart is only used a few times to compare the final repayment date. In contrast, the tabular visualization was used more frequently and facilitated more insights. This might be because the tabular visualization holds more information about loan plans, and makes it easy to compare this information. Therefore, I suggest when tools are

designed for comparing different student loan plans, to primarily focus on the implementation of a tabular visualization instead of a line chart. Although the popular use of it, it might not be the most telling and useful visualization technique to use for making comparisons.

However, the tools discussed in section 1.2 do not focus on comparing various loan plans, instead, they focus on displaying information about one loan plan. Although results suggest that comparing various loan plans promotes more considerate decision-making, if the focus of the tool is to display loan information of one loan plan, including line charts might still be beneficial for users.

Although the filtering function was often redundant, the sorting function was used more frequently and facilitated several insights. Furthermore, the tabular visualization technique is easily understandable for a broad audience, as results have shown. This makes tabular visualization an excellent visualization technique to be used in the loan domain when comparing various loan plans.

6.4 Limitations

In the evaluation of StudentViz, all participants had experience with student loans using the Dutch policies. Therefore, one should be careful to generalize these findings. Recently, there has been considerable focus in the Netherlands on the abrupt increase in student loan interest rates. This might lead Dutch students to be more focused on interest rates, and in StudentViz on the Interest Explorer, compared to students of different nationalities.

Furthermore, StudentViz is developed with the Dutch loan regulations in mind. For example, the loan is paid out monthly with interest already being applied during the entire loan. In addition, during the borrowing phase of a student loan, the interest rate changes every year. This data is displayed in the Interest Explorer. The large fluctuations in the interest rate in The Netherlands probably influenced the interaction of participants with StudentViz, especially with the Interest Explorer. Other countries might have different student loan systems with different regulations and different fluctuations in interest rates which could influence results.

6.5 Future work

6.5.1 Locus of Control

As discussed, the Interest Explorer received mixed results. Some participants found it very useful and used it frequently, while others did not because they had no impact on it themselves. It would be interesting to investigate whether the use of the Interest Explorer is related to the Locus of Control (LoC). The concept of LoC pertains to an individual's fundamental belief system concerning the factors that shape the outcomes of their lives [94]. According to this theory, people fall into two categories: those with an internal LoC and those with an external LoC. It's important to note that, similar to other preferences, this is a spectrum.

Individuals with an internal LoC (internals) perceive a strong link between their actions and consequences, whereas individuals with an external LoC (externals) believe that they do not have direct control of their fate and therefore tend to attribute personal outcomes to external factors [82]. Internals might be more inclined to use the Interest Explorer since they believe that their actions affect their future. Externals might believe more strongly that they have no control over the interest rate, and are therefore not inclined to use the Interest Explorer. Identifying the relation between the LoC and the use of the Interest Explorer can be used to investigate how LoC affects visualization preferences.

6.5.2 Test individual visualizations

In this study, a whole new tool is developed consisting of different visualization elements. Future research could investigate the individual impact of each visualization element on the decision-making process and financial self-efficacy of students. The effect of each single visualization might differ from the whole tool. For example, omitting the line chart in StudentViz might direct even more attention to the comparison table and Interest Explorer. Investigating this increases the understanding of the impact of each separate visualization technique.

6.5.3 Younger participants

Participants in this study were either at the end of their study or had already completed their study. It would be interesting to replicate this study with participants who are about to take out a student loan. It is reasonable to expect that younger students would not be as interested in the effects of repayment as older students because it is more distant in the future. This group might be more focused on the monthly loan amount because they do not yet have an idea of an appropriate amount. In addition, small changes in the monthly loan amount have the biggest impact at the beginning of the loan. Therefore, including more younger students might give a more unified image of the effects of StudentViz.

7 Conclusion

This study has investigated how data visualization impacts decision-making and financial self-efficacy in higher education students. StudentViz, a newly created tool, has implemented several visualization techniques to allow users to compare different loan plans. Evaluating StudentViz revealed that users are most interested in how monthly repayments affect their loan situation. The interest rate and monthly loan amount are also frequently adjusted to assess their impact. The total amount paid and interest proportion are frequently used when comparing different loan plans.

Interviews have revealed that StudentViz is evaluated very positively. Especially the comparison table, which uses a tabular visualization to make multi-attribute comparisons, was perceived as very useful. The Interest Explorer received mixed results. While some were interested in examining the impacts of varying interest rates, others refrained from doing so as it was beyond their control. The line chart did support making comparisons based on the final repayment date but was not the main focus of users.

The use of a coordinated views technique, which combines the Interest Explorer with the line chart and comparison table, shifts the focus of students from the present to the future. In the pilot study, participants indicated to only think about how much they need each month while neglecting the future consequences of their choices. StudentViz has, by allowing to compare different loan plans, shifted the attention to important future aspects of the loan, helping students make more considerate loan decisions. By focusing on the future effects of student loans, excessive borrowing is discouraged which hopefully minimizes a wide range of negative consequences of having a debt. Participants scored high on the financial self-efficacy questionnaire, but more research is needed to further investigate how the data visualization techniques used in StudentViz affect the financial self-efficacy of users.

Student loans have been around for a while and will continue to exist. Student loans can have serious consequences when not handled carefully. The use of effective data visualization can assist students in navigating this critical decision, enabling them to invest in themselves while mitigating the potential negative outcomes associated with student loans.

8 Appendix

8.1 Interview questions

1. What is your name?
2. What is your age?
3. What is your gender?
4. What is your current occupation?
5. How many years have you gone to college?
6. When did you take out a student loan?
7. What led you to choose to obtain a student loan?
8. Did you use any tools to help you decide on the size of your student loan? If not continue to question 9
   (a) What tool did you use?
   (b) Describe the process you went through when using the tool.
   (c) What was the most important information present in the tool?
   (d) Did the tool miss any important information?
   (e) Was it presented in an understandable manner?
   (f) Did you have any frustrations when using the tool?
9. Were you aware that tools existed?
10. Please describe your decision-making process when taking out your student loan
11. In hindsight, could you have made the optimal decision?
12. In hindsight, are there factors you wish you took into account?
13. Did you experience cognitive overload when taking out your student loan?
14. Did you ever recalibrate your loan? If not, continue to question 15.

(a) How often have you recalibrated your loan?

(b) Did you take new information into account?

15. Design your own tool. What information would you include and how would you present it?

8.2 Financial Self-efficacy scale

1. This tool makes me fully capable of making personal financial decisions
2. This tool makes me confident in my ability to make personal financial decisions
3. This tool does not make me feel I am qualified for the task of making personal financial decisions.*
4. Using financial information available in this tool is well within the scope of my abilities
5. My past experiences increase my confidence that I will be able to successfully make personal financial decisions

*Reversed scored

8.3 Scenario and analytical tasks

Scenario
A student called Anne is planning to take out a student loan. She plans to borrow for a duration of three years since that is how long her bachelor's will take. To decide on the size of your student loan, she will try out the tool present before you. Below is an overview of her income and expenses.

Income

- Student grant (University and living on your own registered address) = €466.69
- Side job = €200
- Rental allowance = €0
- Healthcare allowance = €123

- External financial contribution = €150

Expenses

- Tuition = €120
- Study material = €20
- Healthcare insurance = €150
- Rent = €550
- Phone = €20
- Transport = €25
- Groceries = €350
- Clothes = €60
- Monthly subscriptions = €10
- Leisure activities = €180

Analytical tasks

1. Use the tool and fill in the income and expenses listed above
2. Using the recommended monthly loan amount, how much do you have to repay in total with a duration of 36 months, an interest rate of 2.5%, and a monthly repayment amount of €100?
3. How much less do you have to repay in total with an interest rate of 1%? (The other parameters remain the same)
4. Sort the alternatives from high to low based on interest proportion
5. Filter the alternatives on the interest proportion with a minimum of 0% and a maximum of 15%. How many alternatives are greyed out?

8.4 Interview questions tool evaluation

1. Why did you choose this exact student loan plan?
2. What do you think of the Interest Explorer? (easy to use? Did the historical data displayed increase your understanding of interest rates? Did you prefer dragging the horizontal line, or use the input?)
3. What do you think of the tabular visualization showing all the student loan plans? (Was it easy and understandable how to compare different student loan plans, sorting and filtering, use of colors)
4. Were you inclined to explore the effects of different interest rates? Why or why not?
5. Were you inclined to explore the effects of different monthly loan amounts? Why or why not?
6. Did you have any frustrations or moments of unclarity when using the tool?
7. Overall, What should we keep, and what should we drop from the tool?
8. Do you have any final remarks or questions?

8.5 Information sheets & informed consents

Universiteit Utrecht

Research Participant Information Sheet

Data Visualization in Higher education Financing: Aiding Student Loan Decisions

10-10-2023

1. Introduction

You are being asked to participate in an interview about student loans. The interview questions will ask about your personal experiences and opinions regarding student loans. The interview aims at understanding the decision-making process of students, and specifically what could be improved.

2. What is the background and purpose of this study?

Student loans are increasing rapidly. Having a student debt can have multiple negative impacts and is therefore important to minimize. This study aims to investigate how student can make the optimal decision about the size of their student loans based on their personal situation. This interview aims to understand the decision-making process of students when taking out a student loan. This includes what the most important factors are for students, but also how this information is presented to students. These insights will be used to create some sort of data visualization that will be tested later on.

3. Who will carry out the study?

This study is carried out by Lars van Dijk (l.vandijk1@students.uu.nl) as part of my master thesis under the supervision of Evanthia Dimara (e.dimara@uu.nl).

4. How will the study be carried out?

In this study, you will be interviewed about your personal experiences with student loans. The interview will take about 10-15 minutes. You will receive no financial compensation.

5. What will we do with your data?

If you consent to this, an audio recording will be made. This recording will be stored on a secure university server. The recording will be transcribed so that participants' opinions are captured into text. The audio recording will be securely deleted after transcription (within 2 months of the study). The transcribed text will be anonymized so that you will not be identifiable. My thesis, any publications based on this research, and the data repository will not include your name or any other individual information by which you could be identified.

6. What are your rights?

Participation is voluntary. We are only allowed to collect your data for our study if you consent to this. If you decide not to participate, you do not have to take any further action. You do not need to sign anything. Nor are you required to explain why you do not want to participate. If you decide to participate, you can always change your mind and stop participating at any time, including during the study. In this case, your data will be securely deleted and not used in this study. You will even be able to withdraw your consent after you have participated. However, if you choose to do so, we will not be required to undo the processing of your data that has taken place up until that time. The personal data we have obtained from you up until the time when you withdraw your consent will be erased (where personal data is any data that can be linked to you, so this excludes any already anonymized data).

Universiteit Utrecht

7. Approval of this study

This study has been allowed to proceed by the Research Institute of Information and Computing Sciences based on an Ethics and Privacy Quick Scan. The quick scan indicated this study is low-risk. If you have a complaint about the way this study is carried out, please send an email to: ics-ethics@uu.nl. If you have any complaints or questions about the processing of personal data, please send an email to the Faculty of Sciences Privacy Officer: privacy-beta@uu.nl. The Privacy Officer will also be able to assist you in exercising the rights you have under the GDPR. For details of our legal basis for using personal data and the rights you have over your data please see the University's privacy information at www.uu.nl/en/organisation/privacy.

8. More information about this study?

If you have any questions or concerns about this research please contact Lars van Dijk at l.vandijk1@students.uu.nl or my supervisor Evanthia Dimara at e.dimara@uu.nl.

Universiteit Utrecht

Consent form for participation in the research project

Data Visualization in Higher education Financing: Aiding Student Loan Decisions

Please complete the form below by ticking the relevant boxes and signing on the line below.

☐ I confirm that I am 18 years of age or over.

☐ I confirm that the research project ***"Data Visualization in Higher education Financing: Aiding Student Loan Decisions"*** has been explained to me. I have had the opportunity to ask questions about the project and have had these answered satisfactorily. I had enough time to consider whether to participate.

☐ I consent to the material I contribute being used to generate insights for the research project "**Data Visualization in Higher education Financing: Aiding Student Loan Decisions*".***

☐ I consent to audio recordings being used in this study as explained in the information sheet. I understand that I can request to stop recordings at any time.

☐ I understand that if I give permission, the audio recordings will be held confidentially so that only Lars van Dijk & Evanthia Dimara can access the recordings. The recordings will be held in a password-protected storage for up to two months. Once the recordings are transcribed, the original voice recording will be securely deleted. In accordance with the General Data Protection Regulation (GDPR) I can have access to my recordings and can request them to be deleted at any time during this period.

☐ I understand that in addition to the recordings, other personal data will be collected from me as explained in the information sheet and that this data will be held confidentially so that only Lars van Dijk & Evanthia Dimara have access to this data and are able to trace it back to me personally. The data will be held in a password-protected storage for up to five months after which period it will be securely destroyed. In accordance with the General Data Protection Regulation (GDPR) I can have access to my personal data and can request it to be deleted at any time during this period.

☐ I understand that my participation in this research is voluntary and that I may withdraw from the study at any time without providing a reason, and that if I withdraw any personal data already collected from me will be erased.

☐ I consent to allow the fully anonymized data to be used in future publications and other scholarly means of disseminating the findings from the research project.

☐ I understand that the data acquired will be securely stored by researchers. I understand that the University may publish appropriately anonymized data in appropriate data repositories for verification purposes and to make it accessible to researchers and other research users.

☐ I agree to take part in the above research project on ***"[Data Visualization in Higher education Financing: Aiding Student Loan Decisions]"***.

Name of participant	Date	Signature

Name of researcher	Date	Signature

Universiteit Utrecht

Research Participant Information Sheet

Data Visualization in Higher education Financing: Aiding Student Loan Decisions

1. Introduction

You are being asked to participate in a think-out-loud study and an interview about a tool designed for student loans. The think-out-loud session will record your interaction with the tool. The main goal of this session is to understand your decision-making process and interaction when using the tool. The interviewer will ask you about your personal experiences when using the tool. Finally, a questionnaire containing 5 questions will be presented to measure your financial self-efficacy.

2. What is the background and purpose of this study?

Student loans are increasing rapidly. Student loans allow students to pursue a college degree in their field of interest. On the other hand. Deciding on the size of your student loan can be challenging because of factors like a changing interest rate, not knowing the exact duration of your loan, and different repayment options. This study aims to evaluate the decision-making process using a new tool that is developed.

3. Who will carry out the study?

This study is carried out by Lars van Dijk (l.vandijk1@students.uu.nl) as part of my master thesis under the supervision of Evanthia Dimara (e.dimara@uu.nl).

4. How will the study be carried out?

In this study, you will first be presented with a video that explains how the tool works. Next, you are given a fictional scenario of a student, and some small tasks to verify you understand how the tool works. If you understand correctly how the tool works, you are asked to use the tool with your own data. Your screen and voice will be recorded to analyse your interaction with the tool. When using the tool, please narrate your actions and your thought process. Afterwards, in an interview you will be asked about your experiences and opinions on the tool. Lastly, you will be presented with a small questionnaire. In total, this study is expected to last around 35 minutes.

5. What will we do with your data?

The recordings will be stored on a secure university server. The recording will be transcribed so that participants' opinions are captured into text. The recordings will be securely deleted after transcription (within 2 months of the study). The transcribed text will be anonymized so that you will not be identifiable. My thesis, any publications based on this research, and the data repository will not include your name or any other individual information by which you could be identified.

6. What are your rights?

Participation is voluntary. We are only allowed to collect your data for our study if you consent to this. If you decide not to participate, you do not have to take any further action. You do not need to sign anything. Nor are you required to explain why you do not want to participate. If you decide to participate, you can always change your mind and stop participating at any time, including during the study. In this case, your data will be securely deleted and not used in this study. You will even be able to withdraw your consent after you have participated. However, if you choose to do so, we will not be required to undo the processing of your data that has taken place up until that time. The personal data we have obtained from you up until the time when you withdraw

your consent will be erased (where personal data is any data that can be linked to you, so this excludes any already anonymized data).

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Universiteit Utrecht

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☐ I confirm that I am 18 years of age or over.

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☐ I consent to the material I contribute being used to generate insights for the research project "**Data Visualization in Higher education Financing: Aiding Student Loan Decisions*".***

☐ I consent to audio recordings and screen recordings being used in this study as explained in the information sheet. I understand that I can request to stop recordings at any time.

☐ I understand that if I give permission, the audio and video recordings will be held confidentially so that only Lars van Dijk & Evanthia Dimara can access the recordings. The recordings will be held in a password-protected storage for up to two months. Once the recordings are transcribed, the original voice and screen recording will be securely deleted. In accordance with the General Data Protection Regulation (GDPR) I can have access to my recordings and can request them to be deleted at any time during this period.

☐ I understand that in addition to the recordings, other personal data will be collected from me as explained in the information sheet and that this data will be held confidentially so that only Lars van Dijk & Evanthia Dimara have access to this data and are able to trace it back to me personally. The data will be held in a password-protected storage for up to five months after which period it will be securely destroyed. In accordance with the General Data Protection Regulation (GDPR) I can have access to my personal data and can request it to be deleted at any time during this period.

☐ I understand that my participation in this research is voluntary and that I may withdraw from the study at any time without providing a reason, and that if I withdraw any personal data already collected from me will be erased.

☐ I consent to allow the fully anonymized data to be used in future publications and other scholarly means of disseminating the findings from the research project.

☐ I understand that the data acquired will be securely stored by researchers. I understand that the University may publish appropriately anonymized data in appropriate data repositories for verification purposes and to make it accessible to researchers and other research users.

☐ I agree to take part in the above research project on ***"[Data Visualization in Higher education Financing: Aiding Student Loan Decisions]"***.

Name of participant	Date	Signature

Name of researcher	Date	Signature

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